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A Brief Introduction of Microbiology and Its Scope

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***Abstract*— The study of creatures that are invisible to human sight is called microbiology. The structure, distribution, nature, categorization, occurrence, pathogenicity, physiology, and applications of microorganisms are all explained by this discipline of study. This lesson covers the definition, distribution, categorization, and general descriptions of bacteria as well as the microbiology of water, soil, and food**

***Keywords*— Asexual Reproduction, Cell wall, Nuclear Membrane, Plasma Membrane, Sexual Reproduction.**

I. INTRODUCTION

Microbiology is the study of organisms that are too tiny for the unassisted eye to see properly. These living things are collectively referred to as microorganisms or microbes since they can only be seen clearly under a microscope and have a diameter of less than roughly one millimeter. Therefore, the study of microorganisms is what is meant by the term "microbiology." This category includes a wide range of species, including bacteria, protozoa, viruses, fungus, and algae [1]–[3].

Unsatisfactory standards for the location of microorganisms in living things were not accessible until the late 1940s, when a more precise examination of interior cell structure was made feasible with the use of the electron microscope's potent magnification. These microbes were found to have two different sorts of cells. Although some creatures' cells had nuclear material that was not protected by a nuclear membrane, other organisms had clearly defined nuclei that were protected by a nuclear membrane. Prokaryotic and eukaryotic were the names given to these two patterns, respectively. These unique characteristics of microorganisms classify bacteria as prokaryotic, fungus, algae, and protozoa as eukaryotic. As viruses are acellular creatures, they are excluded from this condition.

The first person to thoroughly examine the microbiological composition of various natural substances under a microscope was Antony-van Leeuwenhoek (1632-1723). Water from rain barrels, rivers, wells, the sea, tooth scrapings, and naturally fermented materials like vinegar were among the many natural things that Leeuwenhoek researched. Others later corroborated his findings, but it wasn't until the nineteenth century that the scope and character of microbiological forms became clearer [4]–[6].

Microbes may be single-celled, multicellular, or non-cellular in nature. One cell makes for the unicellular types of protozoa, bacteria, certain algae, and fungus. Although most fungus and algae are multicellular in nature. Viruses are non-cellular particles that exist on the dividing line between living and non-living objects because they lack a cellular framework.

Microbes may be classified as either Prokaryotes or Eukaryotes depending on whether or not they have a nuclear membrane. The embryonic nucleus of prokaryotes is suspended in the cytoplasm. This includes bacteria. Eukaryotes are germs that have a nucleus that is well separated from the cytoplasm by a nuclear membrane, such as protozoa, algae, and fungus.

Bacterial general characteristics

The smallest, least differentiated microbes are bacteria. They are thought to be among the earliest extant primitive creatures with a prokaryotic cell structure. They can be found anywhere, making them ubiquitous. They are unicellular and may coexist in colonies with other species. Bacterial cells may range from 5 micron to 3 micron in size, shape, and organization. They have many different forms, including spheres (coccus), rods (bacillus), spirals (spirillum), and curved (vibrio), among others. They have an extremely hard cell wall that is not composed of the cellulose that makes up plant cell walls. Typically, it includes a lipopolysaccharide, lipid, and the peptidoglycan murein. The bacterial cells' form is governed by their stiff cell wall. A nuclear membrane does not encapsulate nuclear material. The cytoplasm often contains plasmids, which are additional chromosomal DNA. The 70s type ribosome and the mesozone, which are generated by the invasion of the plasma membrane, are cell organelles. Additional organelles such the centriole, Golgi body, endoplasmic reticulum, mitochondria, and lysosomes are not present. Flagella and pili are present as appendages, Sex pili are pili that are longer in certain bacteria and are referred to as such. The motility is caused by flagella, the cocci are not motile, although the bacilli and spirilla are. Hence, the bacterium may be motile or not. A bacteria is said to be atrichous if its flagella are lacking, the quantity and positioning of flagella varies in motile bacteria. The configuration can be monotrichous (one polar flagellum), lophotrichous (a cluster of polar flagella), amphitrichous (flagella at both ends, either singly or in cluster), cephalotrichous (two or more flagella at one end of the cell),

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or peritrichous (cell surface uniformly surrounded by several flagella). The flagella are hair-like or helical, made up of a single tiny filament that is composed of fibrils of the protein flagellin. A flagellum develops at its tip rather than its base, unlike hair [7]–[9].

Gram positive and Gram negative, In Gram staining, Gram positive bacteria keep their violet color whereas Gram negative bacteria show up as red. This results from the difference in their cell walls. In addition to techoic acid, gram positive bacteria's cell walls also include many layers of peptidoglycan and small amounts of lipid and lipoprotein. The cell wall of gram negative bacteria comprises a thick coating of lipoprotein and lipid and a thin layer of peptidoglycan, these bacteria don't produce techoic acid. On the surface of the cell wall, some bacteria have appendages that are shorter and thinner and resemble hair. They are referred to as pili or fimbrae. They serve to hold the cell to surfaces and sometimes aid in genome transfer to other bacterial cells. They are known as sex-pili. A cell envelope that is composed of a capsule, a cell wall, and a plasma membrane surround and protects a bacterial cell. Capsulated bacteria are those that are protected by a capsule. Nevertheless, non-capsulated bacteria are those that do not have a capsule. Bacteria may be either autotrophic or heterotrophic. Heterotrophic bacteria might be parasitic, saprophytic, or symbiotic. Autotrophs utilize CO_2 as their carbon source for sustenance, while heterotrophs require organic materials. There are three categories of bacteria according to their tolerance of temperature: Mesophilic bacteria thrive in temperatures between 250 and 400 degrees Celsius. Thermophilic bacteria thrive beyond 400 degrees Celsius. Psychrophilic bacteria thrive in temperatures below 250 degrees Celsius. Bacteria may be either facultative anaerobic or aerobic depending on the availability of oxygen. Oxygen is used by aerobic microorganisms to breathe. CO_2 is used by anaerobic microorganisms. Facultative anaerobes consume CO_2 in the absence of oxygen and use oxygen when it is present. Binary fission, budding, fragmentation, endospores, exospores, and conidiophores are all methods used by bacteria to reproduce. While here is no true sexual reproduction. Nevertheless, conjugation, transformation, and transduction are the three main methods of genetic recombination.

II. DISCUSSION

A. An Overview of Algae

1) Algae are simple multicellular or unicellular microorganisms that have chlorophyll, they are autotrophs since they have chlorophyll.

2) There are several types of algae, their sizes, habitats, and reproductive methods can be differ.

3) Algae are omnipresent and prolific in fresh water, salt water, and moist soil, on rocks, stones, tree bark, plants, and animals.

4) The thallus, the plant body of algae, lacks differentiation into root, stem, leaf, and true tissues.

5) Algae may be terrestrial or aquatic, yet, most of them live in water. They come in either connected or free-living forms.

6) A few types of algae are parasitic. Some algae have specific homes, such as parasites, thermophytes and symbiotic cryophytes.

7) Algae may be multicellular or unicellular, as Chlamydomonas or Spirogyra. Spirogyra and Volvox are two examples of multicellular algae that may take the shape of filaments or colonies.

8) Prokaryotes or eukaryotes may make up the algae. Prokaryotes are all types of blue-green algae.

9) The cell's components include the nucleus, cytoplasm, plasma membrane, and cell wall. Endoplasmic reticulum, mitochondria, plastids, ribosomes, and the Golgi complex are all found in the cytoplasm.

10) Algae possess three different kinds of pigments in their plastids:

Chlorophylls (a) several species of algae include one of five chlorophyll types (a, b, c, d, and e).

All types of algae include chlorophyll a.

(b) Carotenoids: Also known as carotenes and xanthophylls, these yellow and orange pigments are present in various concentrations in various algae.

(c) Biliproteins, also known as phycobilins, are pigments that are present in some species of algae. These pigments include phycocyanin, which is blue in color, and phycoerythrin, which is red in color.

11) Chloroplasts, which come in a variety of forms across various species, contain colors. One or more pyrenoids, which are spherical entities and the sites of starch synthesis, are found in the chloroplast.

12) Some algae have flagella and are mobile.

13) Algae have three different modes of reproduction: vegetative, asexual, and sexual.

Asexual reproduction occurs when asexual spores are produced, whereas vegetative reproduction occurs by fragmentation, fission, budding, etc. (motile or non-motile). The most popular way of reproduction under ideal circumstances is asexual reproduction. Under adverse circumstances, algae create gametes to reproduce sexually.

B. An Overview of Fungal

1) Eukaryotic thallophytes that are achlorophyllous and non-vascular are fungi.

2) They are heterotrophic non-green bacteria that take in food via the plasma membrane in a soluble form.

3) They survive as parasites, saprophytes, or symbionts because they are heterotrophic.

4) They are widely distributed and may be found in any environment that supports life.

5) There are over 100,000 different types of fungus.

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Vol 10, Issue 2S, February 2023

6) The mycelium, or plant body, of fungus is often made up of branching filamentous hyphae. The hyphal structure has undergone different modifications.

7) The hyphae are septate and unit, bi, or multinucleate in higher forms, compared to a septate and multinucleate in lower forms.

8) A unique chitin-based fungal cellulose cell wall continues to encircle the protoplasm. The cell wall is lacking in early slime molds, however.

9) Chlorophyll is completely absent in fungi, however carotenoids are often present. Endoplasmic reticulum, mitochondria, Golgi bodies, and other non-living materials like reserve food are all found in cytoplasm.

10) The reproductive cells (asexual spores and gametes) of lower fungus are mobile (uni or biflagellate). The higher fungi, however, lack motile cells and gradually lose sexuality.

11) There are two varieties of flagella: (1) whiplash (acronematic) flagella, which have a smooth surface, and (2) tinsel (pentonematic), which have countless tiny hair-like features on their surface.

12) The lack of chlorophyll makes fungi heterotrophic. As a result, they must rely on others for their meals. As a result, they might be any of the following:

Parasites eat other live plants or animals for nourishment. Some of them are obligatory parasites because they exclusively feed on living protoplasm. Others, referred to as facultative saprophytes, may thrive on dead organic materials in the absence of a live host.

Saprophytes ingest the dead, decomposing organic debris for nourishment. Among them, certain saprophytes, such Mucor, are obligatory saprophytes since they can only survive on dead organic debris. Yet, certain saprophytic fungi, such as Fusarium, have the ability to infiltrate living things and are referred to as facultative parasites.

Symbionts develop on other living things, benefiting both parties. Such a connection is referred to as symbiosis, and notable examples are lichens and mycorrhiza, in which the fungus partner exhibits a mutualistic interaction with the roots of higher plants and alga, respectively [10].

13) Unicellular fungi are known as holocarpic because the whole vegetative cell is converted into a reproductive unit, while in most fungi, only a portion of the vegetative mycelium transforms into a reproductive unit, with the remainder remaining vegetative. These fungi are classified as Eucarpic.

14) Fungi may reproduce vegetative, asexually, or sexually. Vegetative through fragmentation, fission, and budding (e.g., Rhizopus, Alternaria, etch) (e.g. yeast and Ustilago) When conditions are favorable, asexual reproduction takes place via the development of various conidia and spores. Spores may be multicellular or unicellular, as those seen in Aspergillus (e.g. Alternaria). They may either be exogenous (produced outside the body in pycnia or sporangia) or endogenous (developed outside on sporophores or conidiophores). Lower fungus often produce zoospores, which are mobile asexual spores. (For instance, Phytophthora), Non-motile conidia or aplanospores (e.g. Mucor, Rhizopus). These non-motile spores are known as conidia, oidia, or chlamydospores in higher fungi.

15) All groups of fungus, with the exception of the class Deuteromycetes, are capable of sexual reproduction. It is finished in three stages: (a) plastogamy (union of two compatible sex cell gametes' protoplasm); (b) karyogamy (fusion of two nuclei from two gametes to form Dikaryon). Meiosis, c) (after karyogamy reduction division takes place in diploid nucleus to form haploid stage). If (present, the sex organs are known as gamentangia, which may develop into gametes.

16) Sexual reproduction may occur in a variety of ways, and the suitable nuclei are brought together for plasmogamy using the following techniques:

Planogametic copulation is a. (fusion of two naked motile gametes) It might be either Isogamy (fusion of gametes with comparable morphologies), Anisogamy (fusion of gametes with physiological and morphological differences), or Oogamy (fusion of female and male gametes) (antherozoid). Contact with gametangia (Male and female gametangia come in close contact with the help of a fertilization tube). Gametangia copulation, which is the complete fusion of two compatible gametangia and the development of a zygote into a resting spore, such as Rhizopus or Mucor. Spermatization (sexual activity is carried out by tiny spore-like spermatia (male gamete) and specialized receptive hyphae (female gamete), such as Puccinia, in the absence of any sexual organs. Somatogamy, as in Morchella and Agaricus, in which the sexual organs are really not developed at all but rather taken over by two vegetative cells or two vegetative hyphae and fused together.

The range of 200C to 300C is ideal for the development of fungus. While light is not required for development, many species need some light for sporulation. Fungi have five primary life cycle types: diploid, haploid-diploid, haploid-dikaryotic, and asexual.

C. An Overview of Viruses

Viruses are really simple, filterable, intracellular particles that may reproduce within a live host. They vary in diameter from 20 nm to 300 nm and are very minuscule (smaller than bacteria). The viruses are active inside a living thing, where they eat, reproduce, grow, and migrate. But, when they are outdoors, they stay still and act like inanimate objects. They are also known as living chemicals since they exhibit chemical properties and may crystallize.

The main way in which viruses vary from cellular creatures is that they only have one kind of nucleic acid, either DNA or RNA. The nucleic acid might take the shape of circular or linear, single or double stranded DNA or RNA. Cellular components including the plasma membrane, mitochondria, Golgi complex, lysosomes, ribosomes, etc. are absent from viruses. Nucleic acid and a protein covering

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(capsid) make up their fundamental structure. The virioids, or tiniest viruses, are made up of a single strand of bare nucleic acid without a protein covering. The cashmeres, which make up the capsid, are made up of many similar protein subunits. These components are often organized in helical or polyhedral geometric configurations that are unique to each individual virus.

There are two kinds of cashmeres that make up a virus's capsid (protein coat): pen tamers (consisting of five identical monomers) and hexamers (having six monomers). With the aid of bonds, each monomer is joined to the adjacent monomers on each side. Similar to how cashmeres are attached to one another, although their ties are weaker. The viral particles are encased in an outer envelope when it has a complicated structure (such as the influenza virus, the herpes virus, and many plant viruses). Protein, lipids, and carbohydrates make up the membrane-like envelope. Viruses that have an envelope are referred to be enveloped, whereas those that don't (like TMV) are referred to as naked. Viruses reproduce in an assembly line fashion. They don't split apart. The virus's attachment to the host cell is one step in the cycle of multiplication. The cell's synthesis of viral components; penetration by genetic material. Release from the host cell. Cell assembly of new viral components.

Most metabolic functions need enzymes, which they lack. As viruses lack the machinery necessary for protein synthesis, they are also distinct microbes. These are obligate intracellular parasites of either plants or animals (including protozoa, insects, fish, birds, amphibians, and mammals including humans) (angiosperms, gymnosperms, ferns, and fungi). A large number of viruses are reliant on arthropods or other types of vectors, which have a tight biological link with them, to transmit from one host to another. Throughout the beginning of time, viruses have been recognized to cause several terrible illnesses in animals as well as highly serious diseases in agricultural plants, decorative plants, and forest trees.

D. An Overview of Protozoa

Protozoa are eukaryotic, motile, unicellular, non-photosynthetic microorganisms that resemble animals. They often consume other creatures via a mechanism known as phagocytosis to gain their sustenance. These microorganisms may be found in soil or freshwater, but most of them are parasites of other creatures, including humans. The microorganisms are classified into several categories according on how they move: Amoeboid protozoa lack flagella but do have a short-lived cytoplasmic protrusion known as a pseudopodium.

E. Protozoa that flagellate

These organisms may have a simple flagellum or a very sophisticated flagellar structure. Certain protozoa, such as Paramecium, have these structures covering their surface; their cilia are shorter than their flagella and move in unison. The cell's plasma membrane, cytoplasm, and nucleus are its three main components. Pellicles, shells, tests, or torica are some examples of the exterior protective coatings that the plasma membrane may have.

Protein molecules make up the cytoplasm, which is a more or less homogeneous mass. It has an inner endoplasm and an outside ectoplasm. Endoplasm is more fluid and voluminous than ectoplasm, which resembles gel. At certain points in their life cycle, some protozoa release a tough exterior from a cyst. This shields organisms from harmful surroundings. Moreover, it acts as a location for nuclear organization and a route of transmission for parasitic organisms.

Nucleus is eukaryotic in nature, it contains chromosomes, nuclear membrane, and nucleoplasm. Typically, there is just one nucleus (e.g., Amoeba). However whereas certain protozoa, such as ciliate species, have two distinct nuclei (one micro and one macro nucleus), other protozoa have two comparable nuclei. The larger macro nucleus regulates metabolic processes and tissue regeneration, whereas the smaller micro nucleus is in charge of sexual activity.

Protozoa may be classified as autotrophic, holozoic, or parasitic based on their nutritional needs. Amoeba employs pseudopodium, Paramecium cilia, and Suctorianus estentacles to obtain nourishment. Chlorophyll is present in autotrophic species and used for photosynthesis. Consider Euglena. Protozoa alongside other creatures may exhibit symbiotic relationships, Cyst development is linked to asexual reproduction in several flagellate and ciliate organisms.

Both asexual and sexual ways may be used to reproduce. Asexual reproduction may take place by binary, multiple, or budding fission, as in the case of amoebas. Conjugation is the method of sexual reproduction (e.g., Paramecium). Also, isogamy (e.g., Monocystis). Protozoa are particularly crucial to the ecological balance of many populations and play a significant role in the food chain and food web. Protozoa have been linked to both chronic and acute illnesses in both humans and other animals. These microbes have also developed into crucial research resources for biologists and biochemists.

III. CONCLUSION

Microbiology is the study of organisms that are too tiny for the unassisted eye to see properly. These living things are collectively referred to as microorganisms or microbes since they can only be seen clearly under a microscope and have a diameter of less than roughly one millimeter. Therefore, the study of microorganisms is what is meant by the term "microbiology." This category includes a wide range of species, including bacteria, protozoa, viruses, fungus, and algae.

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Microorganism Distribution in Various Environments

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Abstract— Microorganisms are found throughout the world. They may be found in every environment that can sustain life. The physiological variety they display is what accounts for their extremely broad natural distribution. The following physiological traits let them survive in a variety of habitats: They don't need light to develop in inorganic settings. They are capable of expanding quickly. Their metabolic rates are greater. They are independent of the presence of certain micronutrients in the environment. Some of them (bacteria and cyanobacteria), a capacity not known to exist in any other group, are able to utilize nitrogen.

Keywords— Bacteria Microorganism, Human Body, Microbes World, Soil Microbes, Tract Microbes.

I. INTRODUCTION

The microorganisms typically proliferate under favorable environmental circumstances and create spores, cysts, and resting cells [1]–[3]. In the following headings, we'll talk about how microorganisms are distributed:

1. Microbes in the soil.
2. Microbes in aquatic environments.
3. Microorganisms connected to plants.
4. Airborne microbes.
5. Food microbes.
6. Milk microbes.
7. Human body microbes.

A. Soil microbes

Man relies on the earth for his nourishment, and the fertility of the soil is dependent on the microorganisms. Without the soil's microbes, agriculture is impossible, the soil has five main categories of microorganisms. These are viruses, algae, bacteria, fungi, and fungi. There are 200–500 billion bacteria per gram of soil [4]–[6].

B. Bacteria

Among all the soil microorganisms, bacteria make up the largest category. Coci, bacilli, and spiral types of bacteria are found in soil. The bacilli are the most numerous of them and swim aggressively in the soil solution. Pseudomonas, Arthrobacter, Bacillus, Achromobacter, Clostridium, Micrococus, Flavobacterium, Chromobacterium, and Mycobacterium are some examples of prevalent soil bacteria. Bacteria in the soil may be either autotrophic or heterotrophic. As chemosynthetic autotrophic bacteria, many species of Thiobacillus, Ferrobacillus, Nitrosomonas, and Nitrobacter may also be found in soil.

The distribution of bacteria in the soil is influenced by environmental variables such as soil depth, pH, moisture content, and temperature. In the soil next to the oil wells, certain bacteria like Mycobacterium and Pseudomonas are often discovered. These microorganisms are in charge of oxidizing ethane. Escherichia bacteria are not often found in soil, but cellulose-rich soil contains a variety of cellulolytic bacteria, including species of Cytophaga and Sporocytophaga. Actinomycetes, part B In dry and warm soil, there are many actinomycetes. They are especially prevalent in soil that is rich in degraded organic matter. Some common actinomycetes found in soil include species of Streptomyces, Micromonospora, and Nocardia. They provide the distinctive musty or earthy smell of a newly plowed field, are capable of breaking down a variety of complex chemical compounds, and hence play a significant role in the soil environment

C. Fungi

In neutral and alkaline soils, several fungi exist and are crucial to the improvement of soil nutrients. The majority of soil fungi thrive on aerobic acidic soils. The depth of the soil and agricultural methods (such as crop rotation, the use of fertilizers and insecticides, etc.) also affect the fungus makeup [7]–[9]. Aspergillus, Botrytis, Cephalosporium, Penicillium, Alternaria, Monilia, Fusarium, Verticillium, Mucor, Rhizopus, Pythium, Chaetomium, and Rhizoctonia are a few significant soil fungi. Except in vineyard and orchard soils, yeasts are not particularly abundant in soil. The preservation of organic compounds in the soil is aided by several fungus, including Alternaria, Aspergillus, Cladosporium, and Dematium species.

The addition of organic matter to the soil encourages the growth of soil fungi. It should be emphasized that since their hyphae are intertwined, fungi's mycelium plays a significant role in binding soil particles. Certain phytopathogenic fungi also exist in soil, often as saprophytes. Examples include Spongospora of myxomycetes, which causes powdery scab on potato tubers, and Alternaria and Phytophthora species, which cause late blight and early blight on potatoes, respectively.

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D. Algae

Even in arid areas, algae are extensively populated in the soil. On the top of damp soils where there is enough light, there are plenty of algae. Algal development improves soil structure and helps preserve soil resources. Blue green algae are important for fixing nitrogen in rice fields. Members of the cyanophyceae and chlorophyceae, including Nostoc, Cylindrospermum, Anabaena, Chlorella, Chlorococcus, and Scytonema, are the most often found algae isolated from soil. A few other diatoms are also frequently found in soil, in addition to these.

E. Protozoa

Since they devour bacteria, protozoans, which are abundant in the top layer of soil, have a direct impact on bacterial population. Protozoans may be vegetative or cystic, depending on the soil's state. The class Mastigophora (species of Bodo, Cercobodo, Cercomonas Monas, Spiromonas, etc.), class Sarcodina (Amoeba, Biomyxa, Nuclearia, Trinema), and class Ciliata of protozoans found in soil include (Colpoda, Gastrostyla, oxytrichaetc).

F. Viruses

Viruses exist practically anywhere there is life, even inside prokaryotes. A virus that infects prokaryotes is known as a phage. Phages are thought to be the most abundant and varied creatures in the biosphere, outnumbering prokaryotic species. The soil contains a very tiny amount of viruses. Bacteriophages consume actinomycetes and bacteria, and some viruses infect the soil-dwelling fungi.

G. Aquatic environment microbes

The habitat in water is special for microorganisms. Before water reaches reservoirs like rivers, lakes, and the ocean, it is transported via a variety of sources with a vast number of microorganisms from the air and soil. Aquatic environments have a very low aerobic capacity. There are microorganisms at every level. Plankton is the name for the aquatic environment's abundant microbial life. The aquatic environment is home to a variety of microorganisms. These are a few notable examples:

H. Bacteria

Bacteria are heterotrophic organisms that may coexist closely with the aquatic algal flora. They thrive in the vicinity of submerged plants and just above the mud layer in both fresh and salt water. When there are no algae, anaerobic bacteria and a few fungus also flourish in the bottom sediments. Unpolluted water typically contains pigmented and non-pigmented microorganisms such Pseudomonas, Chromobacterium, Achromobacter, Flavobacterium, and Micrococus. The typical digestive tract-inhabiting bacteria Escherichia coli, Streptococcus faecalis, Proteus vulgaris, and Clostridium perfringens are also present in contaminated water [10].

The surface layers of seawater may include certain bacteria species including Pseudomonas vibrio, Favobacterium, and Achromobacter. Certain fungus, such as Saprolegnia, Manoblepharis, and Chytrids, live in well-aerated waters. These marine bacteria play significant roles in the nitrogen, sulphur, phosphorus, and carbon cycles within the sea.

These saprophytes are mostly found in freshwater areas and feed on dead algae and tiny animals. They play a significant role in aquatic habitats as decomposers. Certain water molds parasitize the fish's gills. The fungus Chytridium, Patersonia, and Ophiobolus species may be found in seawater. Algae many types of algae, both planktonic and benthic, may be found in a variety of freshwater and marine aquatic settings. Algae fall into the three types listed below based on their habitats in fresh and salt water. Epipelic algae are aquatic plants that develop on sediment deposits Oscillatoria and Navicula.

I. Epipsammic algae

Epipelic algae are smaller than other unicellular algae and thrive on inorganic or organic substrates. Algae clung to bacterial bacterial coatings on sand grains. For instance, fresh water plants like Fragilaria and Chaetophora as well as Raphoneis, Amphora, and Rivularia (Marine forms)

J. Plankotonic algae

planktonic algae that float freely. For instance, Rhizosolenia, Coratium, Chaetoceros, Peridium, and Anabaena, Pandorina, Chlamydomonas, etc (Marine forms). Planktonic algae provide the foundation of the food chain in a pond or lake. They are consumed by zooplankton, which provide food for fish. Ponds with plentiful planktonic algae may typically sustain greater populations of faster-growing fish.

K. Protozoa

Often, aqueous films that cover soil particles include protozoa. Freshwater ecosystems are contaminated by protozoans like Uroglenopsis, algae like Eudorina and Volvox, and other organisms. Planktonic varieties of aquatic protozoans are widely present in both freshwater and ocean water. Ciliates, flagellates, heliozoans, and other protozoans make up this group.

II. DISCUSSION

A. Microbes that interact with plants

Plant components such as leaves, stems, flowers, fruits, seeds, and roots actually have microbes of different types growing all over them. Among the frequent relationships between soil-microbes and plants are Rhizosphere. Which affect the root and its surroundings. They include (a) Legume Root Nodule, such as Rhizobium which is Associative nitrogen-fixing microorganisms, such as Azotobacter and Azospirillum. Mycorrhizae is a relationship between fungi and roots. Over 80% of all vascular plants have mycorrhizae

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in a symbiotic relationship with their roots. There are typically three different kinds of mycorrhizal associations:

B. Ectomycorhizal

In this system, the fungi form an exterior sheath around the root's tip with only a little amount of cellular penetration into the cortical portion of the root. Coniferous trees like oak, birch, beech, and birch are prone to this kind of relationship.

C. *Endomycorrhizal*

In this, fungi grow intracellularly and create coils, swellings, or tiny branches after penetrating the outer cortical cells of plant roots. Vesicles and arbuscules, two intracellular structures, are used to describe them. Because of this, they are referred to as vesicular-arbuscular mycorrhizae (VAM). This is present in numerous commercial crops and grasses, as well as in wheat, maize, beans, tomatoes, apples, and oranges. Ectendomycorrhizal Association, this kind of relationship is more durable. Cortical cell infections that are intracellular are mostly prevalent in the orchid family Orchidaceae.

D. Actinorrhizae

Actinorrhizae are actinomycete associations with plant roots. They are created from the union of frankia strains. Frankia strains are crucial to the survival of plants because they can fix nitrogen. Frankia-induced actinorhizal plant root nodules differ morphologically from rhizobia-induced legume nodules.

E. Tripartile association

This term refers to the link that develops between a plant and two distinct kinds of microorganisms. Examples of tripartite alliances include the following categories: Endomycorrhizae and rhizobia, such as Bradyrhizobium and Rhizobium.

1. Actinorrhizae and endomycorrhizae. Ectomycorrhizae and actinorrhizae are in group
2. Actinorrhizae and ectendomycorrhizae.

F. Microbes in air

In actuality, air is not a good environment for microorganism development, and studies show that the higher the altitude, the less microorganisms one can anticipate to discover. Microorganisms can't develop in the air by themselves; instead, they are spread by dust particles, moisture droplets exhaled by people as they speak, cough, or sneeze, or both. Due to rain washing them out of the air, microorganisms are more prevalent in dry weather than they are in wet weather.

Air above populous land regions contains a diversity of microorganisms. They include Bacillus and Clostridium spores, yeast ascospores, mold conidia, protozoan cysts, unicellular algae, Micrococcus luteus non-spore producing bacteria, non-pathogenic bacteria, gram negative rods (Chromobacterium), etc. Several harmful fungi, such as rusts, which cause crop diseases, plant pollen, and minute seeds, are spread from one location to another by air currents.

A variety of human illnesses, such as Diphtheria (Corynebacteriumdiphtheria) and Tuberculosis, are airborne and spread by infected dust (Mycobacteriumtuberculosis), Children's influenza caused by Haemophilies influenzale, whooping cough caused by Bordetella pertussis, etc. Microbes in Food Microbes and people are in direct competition for the nutrients found in food. Foods are thus excellent culture medium for microorganisms, and many food products are contaminated with bacteria via processing or preparation that originate from soil, the bodies of plants and animals, water, air, and equipment. Food-associated microorganisms may be categorized into the following groups: Beneficial organisms that cause good fermentations, such as those used to make cheese, vinegar, etc. Negative microbes that cause unfavorable fermentations and the degradation of organic matter-rich compounds. Pathogenic organisms that contaminate food and cause terrible illnesses with their poisonous secretions. Food is created by microorganisms themselves, such as single-cell proteins and mushrooms. The result is determined by the kind and quantity of bacteria as well as the type of food, such as whether it is cooked, preserved, or processed. To achieve a particular outcome, certain microorganisms may sometimes be given to meals. For instance, pickled cabbage (Lactobacillus plantarum). Foods high in proteins (meat, eggs, etc.), as well as those high in carbs (vegetables and fruits), are ruined by various microbes via the putrefaction and breakdown processes (e.g. Pseudomonas, Micrococcus and Bacillus).

G. Microbes in milk

One of nature's favorite foods, and its byproducts are home to a variety of microbes. While there are no bacteria within the udders, when the milk exits via the teat, it becomes contaminated because bacteria are constantly present in the udder's teat canals. Teat microflora is made up of streptococci and micrococci.

Pathogenic organisms may readily contaminate milk in a number of ways. Considering that germs may be found in hay, feeds, and the ground. The significant direct potential sources of contamination include milking implements, hay and other feeds, milkers' hands, cow and buffalo udders, and the animal skin. Milk contains a variety of microorganisms. The hygienic quality and manufacturing circumstances determine whether or not these organisms are present. The following are significant milk microbes: Bacteria the majority of microorganisms that thrive in milk are bacteria. Both harmful or unpleasant impacts as well as advantageous or desirable ones may result from them. Dairy bacteriology is the study of these microorganisms in connection to milk and dairy products.

H. Beneficial results

To manufacture fermented milk products, microorganisms are purposefully introduced to milk in order to develop new, palatable flavors and odors for meals. Streptococcus

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Vol 10, Issue 2S, February 2023

thermophilus and Lactobacillus bulgaricus are added to milk in a 1:1 ratio to create yogurt. Acid is produced by Streptococcus, while fragrance molecules are produced by Lactobacillus. One of the earliest meals consumed by human's dates to 5000 B.C., when cheese is said to have first appeared. There are around 2000 different types of cheese manufactured worldwide. Cheeses are categorized according to their hardness or texture as follows:

In milk and milk products, yeasts may be discovered. Acid and carbon dioxide are produced when they interact with lactose. Some of them cause gassy fermentation, whereas others function in a lipolytic manner. Some, including Torulalactis and Turulacremoris, contaminate milk via feed and soil. Moulds On the surface of butter, cream, khoa, and cheese, they contaminate and proliferate in vast numbers. The color might be either white, blue, grey, or black. They also emit an unpleasant odor. Some, including Penicillium sp., Cladosporium, and Gleotrichum, are proteolytic whereas others are lipolytic.

I. Bacteriophages

Bacteriophages in milk destroy the starter germs and thwart the fermentation process, which is necessary to create certain milk products like butter and cheese. Bacterial colony formation, location, and dispersion in dairy products are essential elements in the ripening and taste development of cheeses, yogurts, and soured creams. All types of bacteria, including starter, non-starter, spoilage, and pathogenic bacteria, become entrapped in the developing casein matrix of dairy foods.

J. Body-borne human microbes

Bacteria and other microbes are absent from the human fetus in the uterus. Throughout the first week or two after birth, it starts to develop a typical microbiota. After then, a wide range of microbes start to be connected to the human body. Many microorganisms naturally inhabit the human body, and there are thousands of them all around us.

K. Skin microbes

While airborne bacteria constantly come into touch with human skin, most of them are unable to proliferate due to bactericidal chemicals secreted by the skin. On the skin's surface, pathogenic bacteria such Staphylococcus, Streptococcus, Propioni bacteria, molds, and yeasts may be found. Epidermophyton, Microsporum, and Trichophyton are a few dermatophytic fungi that may colonize the skin and cause ringworm and athlete's foot.

L. Mouth cavity microbes

The mouth cavity consistently contains soluble nutrients and has a lot of moisture, which creates an ideal habitat for the development of bacteria. Staphylococcus aureus, S. epidermidis, S. mitis, Lactobacilli, Actinomycetes, Bacteroidesoralis, Candida albicans, Treponema dentalis, Mycobacteria, Entamoeba sp., Trichomonas, etc. are a few examples of common microorganisms.

M. Gastrointestinal tract microbes

The pharynx is home to a number of microbes, including staphylococcus aureus, S. epidermidis, Hemophilic influenza, and Neisseria. Due to the stomach's acidic pH, relatively few germs exist there. Due to the presence of gastric fluids, the stomach is free of microorganisms while it is functioning regularly. The duodenum has a large number of gram+ve facultative bacteria in addition to Candida albicans. Similar to this, the large intestine is home to many microorganisms (colon). Gram (-) ve and gram (+) ve bacteria, Enterobacter, Escherichia coli, Proteus, and Candida albicans are among them. Trichomonashominis, Entamoeba hartmanni, and other specific protozoans are also found. Microbes that live on the eye's mucous membrane is Mycoplasmas, Comybacterium xerosis, and Staphylococcus albus are often linked to the mucous membrane of the eye.

N. Respiratory tract microbes

We breathe in a lot of dust particles and microorganisms that have been adsorbed. The majority of them are confined to the nasal passages. The nasal cavity is home to a few Staphylococci, aerobic Corynebacteria, as well as various cocci and bacilli.

O. Genito-urinary tract microbes

The kidneys, ureters, and urine bladder make up the upper genitourinary tract, which is often devoid of germs. In the distal part of the urethra of both males and females, a few bacteria like Staphylococcus epidermidis, Streptococcus faecalis, and Corynebacterium sp. are often present. Acid-tolerant Lactobacillus sp., Bactericides sp., aerobic corynebacteria, Peptostreptococus sp. and Enterococci, Mycobacterium smegmatis, and mycoplasmas are the main microbes in the adult female vaginal tract.

III. CONCLUSION

The majority of the bacteria found inside of us are commensals, which means they don't damage us. They feed off of the bodily secretions and excretory wastes of people. Some bacteria are helpful to the host or operate as scavengers by consuming excretory byproducts. For instance, certain gut bacteria produce vitamin E and K, while others shield the host from harmful microorganisms. The microorganisms typically proliferate under favorable environmental circumstances and create spores, cysts, and resting cells.

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Brief Classification of Microbiological Entities

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Abstract*— Aristotle provided the conventional taxonomy of living things at the beginning of the 19th century. Aristotle divided all living things into the two kingdoms of Plantae and Animalia. Algae, fungus, bacteria, and other plants are included in Plantae. Members of this Animalia Kindom are eukaryotic, multicellular, heterotrophic, lack a cell wall, and are generally motile. All animals, including protozoa, are included in the kingdom Animalia. In this chapter, we discussed the classification of microbiological entities

Keywords*— Blue Green, Cell Wall, Nucleic Acid, Slime Molds, Unicellular Organism.

I. INTRODUCTION

E. Haeckel provided a three-kingdom categorization in 1866. He categorized living things in the following ways, including the third kingdom of Protista:

1. One protozoan (Algae, fungi, bacteria, and Protozoa)
2. Plantae (excluding unicellular algae and fungi)
3. Three Animalia (excluding protozoa.)

Subsequently, Copeland (1956) proposed a four-kingdom categorization scheme for living things. He assigned mushrooms to the third kingdom Protista and bacteria and blue-green algae to the fourth kingdom Monera [1]–[3]. Whittaker presented a five-kingdom framework for classifying biological things in 1969. The following categories apply to him:

1. Monera (Bacteria and Cyanobacteria)
2. Protista (unicellular algae, slime molds, and protozoa)
3. Fungus
4. Plantae 4(Eukaryotic multicellular plants)
5. Animalia (excluding protozoa)

In 1971, Hawker and Linton divided microorganisms into three heads:

1. Viruses: Particular class of sub-cellular parasitic obligates
2. Prokaryote: an organism having a prokaryotic structure. Among them were

(a) Bacteria (unicellular forms without a definite nucleus).

(b) Increased Bacteria (filamentous actinomycetes to filterable mycoplasmas).

(c) (Parasitic bacteria having the appearance of tiny rod-shaped or spherical resembling bacteria and viruses).

(d) (Photosynthetic forms of prokaryotic organization)

A. Eukaryote

(A) Eukaryotic creatures have unicellular eukaryotic algae that are members of the Chlorophyceae, Chrysophyceae, and Euglenophyceae families.

(B) Molds and fungus (fungi with unicellular to multicellular hyphae with cottony growth belongs to Phycomycetes, Ascomycetes, Basidiomycetes, and deuteromycetes).

(C) Slime molds, (organisms with a slimy mass of naked motile protoplasm called plasmodium).

(D) Protozoa, which are classified as sarcodina, sporozoa, ciliophora, and mastigophora and are unicellular organisms lacking chlorophyll.

(E) Multicellular thread-like cylindrical worms [4].

Microorganisms are now divided into two main categories:

B. Microorganisms without cells

They are referred to as acellular creatures because they lack the three essential components of a cell: a membrane, genetic material, and metabolic machinery. The following categories of these are:

C. Viral agents

Obligate parasites that are very small and formed of nucleic acid do not have cytoplasm or other cell organelles, and they can only reproduce inside of a live host cell. Virus nomenclature scheme suggested by Lwoff, Horne, and Tournier, led by a provisional committee (1962) [5]–[7]. This classification scheme places all viruses into the phylum Vira, which is further broken down into subphyla, classes, orders, suborders, and families. based on the following characters: The DNA or RNA type of nucleic acid. Viral or symmetric helical Cuboidal. If the capsid is encased in an envelope or not. The cuboidal viruses' helical nucleo capsids' diameter and the quantity of capsomeres they contain.

D. Viroids

These little RNA molecules are unadorned. Diener made the first discovery of them (1971). They independently reproduce. The majority of viral RNA is single stranded, circular, and has a very low molecular weight. Viroids are known to cause a variety of plant diseases, including cucumber pale fruit, citrus exocortis, chrysanthemum stunt, and potato spindle tuber (via PSTV).

E. Prions

S.B. Prusiner, who received the 1997 Nobel Prize in Medicine, termed these rod-shaped proteinaceous infectious particles lacking nucleic acid. Many mammalian neurological disorders are caused by prions. They are

classified as transmissible spongiform encephalopathies and are often deadly (TSES). They include illnesses like scraple, a disease of sheep, as well as Kuru, a disease that affects humans. Bovino spongiform encephalopathy and madcow disease are both caused by prions (BSE).

F. Virusoides

Another name for them is satellite RNA. Plant viruses that have a viral genome attached to them enclose them. They need an accompanying virus to multiply since they are unable to do it on their own.

G. Cellular microorganisms

While their cells have a membrane, genetic material, and metabolic machinery, these microbes are cellular. Based on the presence or lack of the nuclear membrane, there are two different kinds. Prokaryotic and eukaryotic microorganisms are first [8]–[10].

H. Prokaryotic organisms

These microbes have just one cell. They exhibit prokaryotic cell structures. Once again, prokaryotic microorganisms are classified into two categories:

I. Arche bacteria

They are the most basic types of bacteria, lacking muramic acid in their cell walls and having ether-linked aliphatic branching chains in their membrane lipids. These RNA polymerase enzymes are particular to them. Also, their ribosomes are diverse in content and form. Extreme halophiles, thermoacidophiles, and methanogenic bacteria are the three groups into which these microbes fall. The great majority of bacteria belong to the group Eubacteria, or "true bacteria." Muramic acid is found in the cell wall of the peptidoglycan. Straight-chained fatty acids with ester links make up the membrane lipids. They are separated into the following categories:

J. Spirochetes

These chemohetrotrophic, gram-negative bacteria may be identified by their shape and motility. Despite not having exterior spinning flagella, they are nonetheless capable of moving through very viscous liquids and may creep or crawl when in contact with solid surfaces. The existence of an axial filament account for their particular kind of movement. Periplasmic flagella, which may number two or more than one hundred, protrude from the cylinder's two ends and often round one another. Spirochetes may be either facultatively or absolutely anaerobic. Treponema pallidum, Borrelia burgdorferi, and Leptospira, which cause syphilis, Lyme disease, and Leptospirosis, are a few pathogenic types.

K. Rickettsias

They are a member of the Rickettsiales phylum, these are a collection of parasitic intracellular Gram-negative bacteria. They are very tiny and live within cells, which makes them resemble viruses. Having both DNA and RNA, a plasma membrane, a ribosome, enzymes, etc. sets them different from viruses. They fall in between viruses and bacteria. Many significant pathogenic forms include: The bacteria Rickettsia prowazeki, Rickettsia rickettsii, Rickettsia orientalis, and Rickettsia burnetti all cause typhus fever, rockey mountain spotted fever, scrub typhus, and Q fever, respectively Mycoplasma (Mollecutes).

Prokaryotes without cell walls, or molecules (Mollis = Soft cutis = skin), are what we refer to as mycoplasmas. They may take on any form, including spherical, pear-shaped, branching, and helical threads. They are pleomorphic. Although not moving, they may float on surfaces with liquid on them. While many of them are facultative anaerobes, others are obligatory anaerobes. One of the tiniest prokaryote genomes, measuring between 5 and 10 x 108 daltons, may be discovered in them. They exist as diseases, parasites, or saprophytes of humans, animals, plants, and other organisms. Mycoplasma pneumoniae (which causes mycoplasmal pneumonia), Mycoplasmamycoides, and gallisepticum, which cause infectious bovine pleuropneumonid in cattle and chickens, respectively, are frequent examples of mycoplasma. Genital infection is brought on by Mycoplasma urealyticum.

L. Cyanobacteria (Blue-green algae)

Blue-green bacteria or blue-green algae are cyanobacteria. They serve as a bridge between bacteria and plants. Prokaryotic describes them. They contain chlorophyll, which is found in thylakoids, making them photoautotrophs. Since they have phycobilin proteins, which are accessory pigments like red algae, their photosynthetic system closely matches that of eukaryotes. Cyanobacteria come in a wide range of shapes and aesthetics. They may be multicellular and create trichomes or they can be unicellular and live in colonies of different forms. Man is not poisonous to cyanobacteria. Carboxysomes and phycobilins are found in the cytoplasm. They have heterocysts, which are cells with particular functions for fixing nitrogen, and akinetes, which produce spores. Anabaena, Nostoc, Chlorococcus, Oscillatoria, Stigonema, etc. are typical examples.

M. Actinomycetes

These bacteria that resemble fungi include actinomycetes, Mykes is a fungus, whereas Actis is a ray. These gram-positive, aerobic bacteria develop branching, often non-fragmenting hyphae, and produce asexual spores. Actinomycetes are often not mobile. Only flagellated spores may be aggressive. They can break down a wide range of organic molecules and are mostly soil dwellers. Actinomycetes are chemoorganotrophs since they get their energy from organic compounds. Because of their production of around 85% of all known antibiotics, these organisms are very important economically.

The following are significant actinomycetes: Erythromycin, Chloramphenicol, Tetracycline, and Micromonospora are all produced by Streptomyces, which

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Vol 10, Issue 2S, February 2023

also manufactures streptomycin. Certain actinomycetes live symbiotically and fix atmospheric nitrogen (e.g. Frankiasp). A few actinomycets are pathogens that affect people, animals, and plants. For example, Thermoactinomyces vulgaris causes Farmer's lung, a respiratory condition that affects people. Microorganisms possessing eukaryotic organization are known as eukaryotic microbes. These creatures fall into one of three categories:

1. Unicellular Eukaryotic Microorganisms
2. Multicellular Eukaryotic Microorganisms (Fungi), Helminthes.

II. DISCUSSION

A. Unicellular Eukaryotic Microbes

They are eukaryotic, unicellular microorganisms that may live alone or in colonies. They might be motile or non-motile and are typically aerobic types. Cilia, flagella, or pseudopodia cause motility. The following kinds are separated among them:

B. Photosynthetic protists (algae with a single cell)

It contains unicellular photo-synthetic organisms from the Chlorophyceae, Euglenophyceae, Xanthophyceae, Pyrrophyceae, Bacillariophyceae, and Chrysophyceae families among others. The main groups of this include

C. Dinoflagellates

These are Chrysophyceae plants. They have cellulose cell walls and are unicellular. There are two flagella on them. They solely have asexual reproduction. Unknown sexual reproduction. Some species, like Gonyaulax, emit a poison known as "red tide" that kills aquatic life like fish. Because of the phosphorescence of certain Dinoflagellates, the sea's Scarface glows at night. Diatoms are Bacillariophyceae organisms. They don't have flagella. As they are diploid, diatoms may reproduce both sexually and asexually. Since silica has been deposited in the cell walls of diatoms, they are almost indestructible. They leave behind a significant quantity of diatomaceous earth, which is a cell wall deposit.

D. Euglenoids

These protists resemble Euglena. They live lifestyles akin to those of plants and animals. These are free-living organisms that may be found on moist soil in freshwater ditches and ponds. Their cell wall is absent. Before the cell splits, the flagellum is duplicated, as in the case of Euglena.

E. Consumer-Decomposing Protists

They resemble mushrooms in appearance and lifestyle, but their cellular structure, sexual reproduction, and life cycle are more similar to those of protists. They consist of cellular slime molds (Myxomycota) are masses of multinucleate protoplasm without a cell wall, such as Physarum. On rotting logs or leaves, it gently streams or glides. The term "plasmodium" refers to this strand of protoplasm. Phagocytosis is used for feeding.

F. Cellular slime molds

There is a great deal of different amoeboid cells that group and move like a mass of protoplasm. The cells do not fuse together. The term for this is pseudo plasmodium. e.g.Dictyostelium.

G. Water mold (Oomycota)

They are made of hyphae, which are tiny, delicately branching filaments. Glucan and cellulose make up their cell walls. Chitin is very seldom discovered in very tiny amounts. They may reproduce asexually via biflagellate zoospores and sexually by a big egg cell and a tiny antheridium. These are parasites or saprophytes (e.g. Phytophthora infestans). The wall protein's inclusion of the hydroxyproline amino acid is another noteworthy characteristic of this category.

H. Protozoan Protists

Protozoa are eukaryotic, motile, unicellular microbes that resemble animals. They share morphology and physiology with multicellular creatures. Some of them create cysts and exude a tough covering that shields organisms from harmful conditions. These creatures have cilia, flagella, or pseudopodium for movement. They can reproduce both asexually and sexually. They are crucial to both food webs and chains of alimentation. Several of them affect both people and animals as parasites.

I. Multicellular Eukaryotic Fungi

This class of organisms comprises those that Whittaker classified as belonging to the kingdom Fungi. They are most often seen as filamentous hyphae. They cannot create chlorophyll and can only reproduce asexually, sexually, or in both ways. They are crucial decomposers and participate significantly in the recycling of minerals, making them very essential to humans in both helpful and detrimental ways.

Helminthes: The country helminths are the sole class of microscopic creatures found in Animalia. Helminthes are a term used to describe roundworms, tapeworms, and flukes as a group. Based on morphological shape, parasitic helminths may be divided into two categories. These are roundworms belonging to the phylum Aschelminthes with an elongate, cylindrical, unsegmented body plan and flatworms belonging to the phylum Platyhelminthes with a very thin segmented body.

III. CONCLUSION

Microbes are little organisms that cannot be seen with the human eye yet exist all around us. They can be found in water, soil, and the air. Microorganism includes bacteria, virus, fungi, protozoans, algae, etc. Bacteria can survive in a wide range of temperatures since they are present practically everywhere on the planet. Bacterial cellular structures are similar to prokaryotic cell walls but with the absence of most cell organelles. Multicellular creatures make up all helminths. The majority of worms may regenerate and complete their life cycle on two hosts, absorbing nutrition via

their body wall while residing in the host gut.

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Determination of Major Microbes and Their Significance

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Abstract— Food is an essential component of all living things. All food products have some kind of relationship with bacteria. Microorganisms are present in every food, including naturally occurring foods like fruits and vegetables. Despite the astounding diversity of microorganisms, they can all be divided into five broad categories: viruses, bacteria, organisms such as arch fungi, and protozoa. In this chapter, we discussed the significance of the microorganism.

Keywords— Food Poisoning, Microbial Diseases, Nitrogen Fixing Bacteria, Pathogenic Microorganisms, Water Microbes.

I. INTRODUCTION

Certain microbes are enticing to consume which are Exotoxins that bacteria in the food release cause food poisoning when consumed. Since the symptoms of poisoning do not need the development of disease-causing microbes, they manifest right away after eating tainted food [1]–[3]. The following section includes some of the main food-toxic disorders, the causing organisms, and the foods involved.

A. Significant

The physical environment of water is distinct and favors the presence of several species of microorganisms that are uncommon in soil. There are microorganisms at every level. Microorganisms are abundant in the sediments at the bottom and on the surface coating. Plankton, which is made up of phytoplankton and zooplankton, is the term for the aquatic environment's drifting microbial life. The majority of the different types and numbers of benthic microorganisms are found in the water's bottom area. The spread of microbes is impacted by the movement of water caused by wind, tide, and currents [4]–[6].

B. Pond and lake major microorganisms

Temperate lakes and ponds exhibit temperature stratification, which affects the microbial community throughout the year. Pseudomonas, flavobacterium, aeromonas, acaligenes, clostridium, thiothrix, and thiobacillus are typical freshwater microorganisms. In addition to this, both Cyanobacteria and many algae contribute to significant water blooms. Diatoms, cyanobacteria, silicoflaellates, dinoflagellates, etc. are some of the major marine microbes.

The important phytoplanktons are chlamydomonas. Many microorganisms, in particular algae and cyanobacteria, are to blame for the phenomenon known as red tides in the Red Sea. The coloration of brown, amber, or greenish yellow is also caused by a large number of microorganisms. Many protozoa and fungal species, as well as the common marine forms vibrio, Actinobacteria, Flavobacterium, Pseudomonas, Staphylococcus, various species of Phycomycetes, Deuteromycetes, and Myxomycetes, may be found in seawater.

C. Household water microbes

Domestic water is sourced from lakes, ponds, dams, rivers, streams, wells, and bore wells. In addition to bacteria and viruses, household water contains algae, protozoa, fungus, and bacteria. Bacteria include Salmonella, Bacillus, Micrococcus, Shigella, Proteus, Klebsiella, Pseudomonas, Alginomonas, Xanthomonas, *Streptococcus faecalis*, *S. bovis*, *S. equines*, Pseudomonas, Alginomonas, and *Escherichia coli*.

D. Sewage or wastewater microbes

Coliform bacteria and other microscopic creatures are examples of major microorganisms. Other significant microorganisms include Bacteria like Sphaerotilus and Gallionella (Iron bacteria); *Streptococcus faecalis*, *S. faecium*, *S. bovis*, and *S. equines*; certain slime-forming bacteria; (Sulphur bacteria). Algae like Microcytic, Spirulina, and others create obtrusive traits as well as hazardous substances.

E. Water-borne pathogenic microorganisms

Certain bacteria, viruses, and protozoan diseases may live in the water and spread disease to people. There is the following description of the several water-borne diseases:

F. Prominent Soil Microbes

The soil has five main categories of microorganisms. They are bacterial, fungal, algal, protozoan, viral, and fungus. Bacteria the majority of soil microorganisms belong to this category. Almost every kind of bacterium may be found in soil. Prominent types of bacteria found in soil include:

G. Real bacteria

True bacteria are the most prevalent microorganisms in soils. The bacteria that are most often isolated from soils are

ISSN (Online) 2456 -1304
International Journal of Science, Engineering and Management (IJSEM)
Vol 10, Issue 2S, February 2023

Gram-negative bacilli, such as pseudomonas, agrobacterium, acetobacter, rhizobium, and flavobacterium [7]–[10]. Gram-positive non-sporing bacteria, including Cellulomonas, Arthrobacter, and Corynebacterium Gram-positive cocci include Sarcina and Micrococcus. Gram-positive bacteria that generate spores include Bacillus (aerobic) and Clostridium (anaerobic)

H. Microorganisms that fix nitrogen:

(a) Symbiotic bacteria, such as *Rhizobium spp*., are found in the roots of legumes (*Rhizobium leguminosarum* on peas, lentils etc, *R. japonicum* on soyabeans, *R. phaseoli* on beans, *R. trifoli* on Red, White and other clovers etc.

(b) Free-living non-symbiotic bacteria, such as Azobacter (aerobic), and Clostridium, may be found in soil (Anaerobic)

(c) Sulfuroxidizer: Desulfovibriodesulfuricans and Thiobacillusthiooxidans

(d) *Bacillus cereus*, *Pseudomonas fluorescens*, *Proteus vulgais*, and *Clostridium hystolyticum* are examples of proteolytic bacteria.

(e) The nitrification-related bacteria Nitromonas, Nitrosococcus, Nitrosospira, and Nitrocystis. In addition to the microorganisms already described, certain soil-dwelling bacteria are harmful and cause plant illnesses. For instance, Erwinoa sp. and Agrobacterium induce galls and dry necrosis in carrots, potatoes, and cucumbers, respectively.

I. Actinomycetes

The soil contains a variety of actinomycetes, such as Streptomyces, Nocardia, and Micromonospora. The odor-causing substance geosmin is produced by the filamentous actinomycete Streptomyces. The bacteria Streptomyces are the cause of potato scab.

J. Cyanobacteria and other Algae

Many cyanobacteria, such as Anabaena, Nostoc, *Cylindrospermum microcystis*, Oscillatoria, etc., are common in wet soils. They increase soil fertility by fixing molecular nitrogen that is present in the air. They serve as biological fertilizers. Several algae taxa besides Cyanophyceae are also found in soil. Chlorella, Chlorococcum, Cladophora, Botrydiopsis, and Bumilleria are among examples. Pinnularia, Navicula, Fragilaria, etc.

K. Fungi

Vineyard and orchard soils often include Mucor, Rhizopus, Pythium, Penicillium, Aspergillus, Alternaria, Hormodendron, Cladosporium, and yeasts. Certain types of soil fungi work well as soil binders. Such as Rhizopus, Aspergillus, Cladosporium, and Penicillium. Some are disease-causing pathogens. For instance, Alternariasolani causes early potato blight.

L. Protozoa

The soil contains a variety of different Protozoa species. Major soil protozoans include: There is no significant role for protozoa in the soil. They consume bacteria and help to keep the soil's bacterial ecology somewhat balanced.

M. Viruses

Soil contains plant and animal viruses in addition to bacterial viruses (Bacteriophages). By transduction, viruses spread genetic material from one bacterium to another. The ecology of the bacteria is also somewhat impacted by the bacteriophages

II. DISCUSSION

A. The bacteria in the rhizosphere

The soil surrounding the root system is known as the rhizosphere. The rhizosphere is separated into the endorhizosphere and exorhizosphere based on how closely microbes are associated with the root system. The rhizosphere is populated by microorganisms that use it as food. Mycorrhiza, a symbiotic relationship between some fungi and roots, is formed. Below are some examples of rhizosphere microorganisms: - Fungi: *Cladosporium herbarum*, *Fusarium oxysporum*, *F. solani*, *Aspergillus flavus*, *A. niger*, *A. fumigates*, and *A. terreus*. Pseudomonas, Rhizobium, Bacillus, Agrobacterium, Micrococcus, Azobacter, and Mycobacterium are among the bacteria.

B. Biofertilizers

Biofertilizers are made from microorganisms are the biologically derived nutrients that are given to the soil to increase its fertility. Rhizobium, Azospirillum, Azotobacter, Azotococcus, Anabaena, Nostoc, Plectonema, and Tolypothrix are among the organisms employed as biofertilizers. *Bacillus megaterium*, Xanthomonas, Pseudomonas, Aspergillus, and *Pencillium digitatum* are bacteria that may dissolve phosphate. As VAM biofertilizers, the spores of VAM fungi such as Glomus, Gigaspora, *A. caulospora*, Sclerocystis, and Endogone are utilized. Microbes exist in the natural environment, where they are polluted and coexist with various different living forms. For this reason, we must isolate microorganisms and develop them in artificial environments in order to study each one separately and learn more about them. Cultivation is the process of cultivating microorganisms in a synthetic environment.

C. Commercial use of microorganisms

Wine, acetic acid (vinegar), and alcohol are all produced on a big scale using microorganisms. Wine and alcohol are produced commercially using yeast. Yeast is produced for this purpose on the natural sugars found in cereals like barley, wheat, rice, crushed fruit juices, etc.

D. Medicinal use of microorganisms Vaccine

Our bodies manufacture antibodies to fend against disease-causing microbes when they invade. Additionally, the body retains its defense mechanisms in case the microbe re-enters. When healthy organisms are exposed to weak or

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International Journal of Science, Engineering and Management (IJSEM)
Vol 10, Issue 2S, February 2023

dead microorganisms, the organism fights and eradicates the invaders by creating the necessary antibodies. We are safeguarded since the antibodies are still in the body. It is crucial to safeguard all kids from these illnesses. The local hospitals stock the necessary immunizations.

E. Disease-causing Microorganisms in Humans

The water we drink, the food we consume, and the air we breathe all allow pathogens to enter our bodies. Additionally, they can be spread by animals or by direct contact with an infected human. Communicable diseases are microbial illnesses that can transmit from an infected person to a person in good health by air, water, food, or personal contact. These illnesses include TB, the common cold, chicken pox, and cholera.

When a person with the common cold sneezes, tiny moisture droplets containing millions of viruses are released into the atmosphere. A healthy individual may get the virus while inhaling and become ill. Some animals and insects serve as reservoirs for pathogenic microorganisms. The carrier Housefly is one example. The trash and animal waste are covered with flies. They attract pathogens to their body. These flies may spread the infections when they rest on uncooked food. Anyone who consumes the infected food is likely to get ill. Therefore, it is wise to constantly cover food. Eat food that has not been coated. The female Anopheles mosquito which harbors the malaria parasite Plasmodium, is another example of a carrier.

F. Food Poisoning

Consuming food tainted by certain germs may result in food sickness. In our food, microorganisms may sometimes develop poisonous compounds. These render the food toxic, resulting in severe disease and even death. Therefore, it is crucial that we preserve food to stop it from spoiling.

G. Chemical Method

The most frequent substances used to stop the development of germs are salts and edible oils. They are referred to as preservatives as a result. To pickles, we add salt or acid preservatives to stave against microbial invasion. Common preservatives include sodium benzoate and sodium met bisulfite. To prevent spoiling, they are also added to jams and squash.

H. Nitrogen cycle

There is 78% nitrogen gas in our atmosphere. All living things need nitrogen since it is a component of proteins, chlorophyll, nucleic acids, and vitamins. Plants and animals cannot directly absorb atmospheric nitrogen. In the soil, certain bacteria and blue-green algae fix nitrogen from the atmosphere and transform it into nitrogen compounds. After being transformed into these useful chemicals, nitrogen may then be absorbed by plants from the soil through their root systems. The production of plant proteins and other substances then uses nitrogen. These proteins and other nitrogen molecules are obtained by animals that consume plants. When plants and animals die, soil-dwelling bacteria and fungus turn the nitrogenous wastes into nitrogenous chemicals that plants may utilize once again. Some of them are partially converted by other bacteria into nitrogen gas, which is released back into the environment. As a consequence, there is a rather consistent amount of nitrogen in the atmosphere.

I. Microbes and Disease

A few hazardous germs, for example, less than 1% of bacteria, may infect our body (the host) and make us unwell. Microbes cause infectious illnesses such as flu and measles. There is also considerable evidence that bacteria may contribute to several non–infectious chronic illnesses such as various kinds of cancer and coronary heart disease. Different illnesses are caused by different kinds of microorganisms. Microbes that cause illness are termed pathogens. it is vital to note that:

1. A pathogen is a micro-organism that has the ability to cause illness.
2. An infection is the invasion and proliferation of harmful microorganisms in a person or group.
3. The disease occurs when an infection causes harm to the individual's critical processes or systems.
4. An infection may not necessarily result in illness.

Microbiology is vital to food safety, manufacturing, processing, preservation, and storage. Microbes such as bacteria, molds, and yeasts are utilized for food production and food components such as the manufacturing of wine, beer, pastry, and dairy products. On the other hand, the development and contamination of spoilage and harmful microorganisms is recognized as one of the leading contributors of the loss of foodstuff today. Although technology, sanitary methods, and traceability are significant variables to avoid and delay microbial development and contamination, food remains prone to deterioration and activity of disease microorganisms. Food loss by either rotting or contaminated food impacts food businesses and consumers resulting in economic losses and higher healthcare expenses. This chapter focuses on general aspects, traits such as and importance of main microorganisms (bacteria, yeasts, molds, viruses, and parasites) involved in food spoilage or contamination: dubbed and recently discovered species; defects and alterations in foodstuff; most common food associated to every foodborne disease; resistance to thermal processing; occurrence in different countries; outbreaks; and associated symptoms.

Food preservation, since ancient times, plays a crucial role in the survival of humans boosting the safety and stability of diverse foodstuffs. Traditional practices used to prevent food degradation in the past like salting, drying, fermenting, and

heating remain in the current food business. The understanding of the primary causes of deterioration has expanded greatly since then and losses due to spoilage and food contamination were decreased.

The knowledge about the arrangement, origin, pH, and water activity of food and storage conditions (e.g., temperature, surroundings, and pressure) along with the information about the characteristics of the most widespread and resistant microorganism predicts the composition of microflora during processing and storage. From this scenario, the adequate use of technology (such as pasteurization and sterilization), hygienic strategies (including good hygiene practices and good manufacturing practices), and tracking (prevent and reduce the distribution of unsafe and poor-quality food) can prevent and delay the establishment of spoilage and pathogenic microorganisms in foodstuff. However, food remains prone to deterioration and infection of harmful bacteria throughout the food chain, retail stores, restaurants, and residences of consumers.

III. CONCLUSION

Microorganisms are grown in laboratories under ideal environmental circumstances, such as nutritious sources of energy, suitable temperature, oxygen, and pH, among others. As several kinds of microorganisms coexist in an environment where they may thrive, a variety of isolation procedures are used to produce pure cultures of only one species of microbe. Microbes play a significant role in digestion, the production of vitamin K, the development of the immune system, and the detoxification of toxic compounds. Apart from that bacteria are required for the production of many things such as bread, cheese, and wine

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Vol 10, Issue 2S, February 2023

Impact of Sterilization and Culture Medium on Microorganisms

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***Abstract*— Sterilization is described as a process of full removal or annihilation of all forms of microbial life and is carried out by different physical and chemical means. The culture medium is mainly consisting of basic components (water, nutrients), which must be added to various growth agents that will be particular to each bacteria and required for their development. In this chapter, we discussed the different sterilization technology.**

***Keywords*— Culture Medium, Heat Sterilization, Milk Pasteurization, Pure Culture, solid media.**

I. INTRODUCTION

Sterilization is a crucial concept in microbiology since it refers to the process of purging something of all life. One requires a pure culture of the organism in order to investigate microorganisms in depth. It is acquired by using extreme caution to prevent contamination of the environment, glassware, media, or other tools employed in the culture procedure. Contamination is the process of undesired bacteria growing in a culture; these microbes are also known as contaminants [1]. Many precautions are taken to avoid contamination during sterilization, and the process of producing an aseptic state is known as the aseptic condition. The following three sterilizing techniques are available:

1. Physical
2. Chemical
3. Gaseous

A. Physical Techniques:

1.1 Sterilization by Heat

1. Dry Heat Sterilization
2. Wet Heat Sterilization is the two most used physical techniques.
3. Filtration-based sterilization
4. Use of ultraviolet radiation to sterilize
5. Ionizing radiation sterilization

1.2 Dry heat sterilization

A simple method of sterilization involves directly heating the equipment in a flame. Commonly, direct heat is used to sterilize inoculating needles, scissors, forceps, and scalpels, while the flame is also used to disinfect the neck and mouth of culture tubes, flasks, and specimen tubes. Flaming is the term used to describe the flame sterilization procedure. Maintaining completely cleaned and dried glassware, such as Petri dishes, beakers, flasks, culture tubes, etc. within a thermostatically controlled electric oven is another way of dry heat sterilization, maintaining the oven at 1600C for a minimum of 4 hours is necessary for complete sterilization [1].

1.3 Wet heat sterilization

Wet heat (steam) is a recommended technique for sterilizing the medium used for cultivating microorganisms since it is more effective. The most frequent applications of wet heat in laboratories are boiling, pasteurization, tantalization, and autoclaving. Boiling is a standard technique for sterilizing, all growing tools are stored in a pot with distilled water that has been left to boil for at least 15 minutes. The items should be kept in a sterile container if they won't be utilized right away.

1.4 Pasteurization

Pasteurization is the unregulated heating of several substances, including milk, to temperatures much below boiling. Pasteurization is the name given to this procedure. Most drinks, including milk, beer, and many others, are pasteurized. While a beverage is not sterilized via this procedure, any pathogens are killed. There are two techniques to pasteurize milk: the traditional approach, which involves heating the milk to 630°C for 30 minutes, Rapid pasteurization involves 15 seconds, fast heating to 720C, and rapid cooling [2].

Tantalization, also known as fractional steam sterilization, is a technique used sometimes to sterilize a material that is sensitive to heat. Three days in a row, the container containing the item to be sterilized is heated at 90 to 1000 C for 30 minutes each day, followed by incubation at 370 C. Except for bacterial endospores, all organisms will be eliminated during the first heating. When incubated at 370C, the majority of them germinate; the second heating kills them. The second incubation and third heat treatments, namely the liquid medium for microbial cultures, kill any leftover spores.

ISSN (Online) 2456 -1304
International Journal of Science, Engineering and Management (IJSEM)
Vol 10, Issue 2S, February 2023

1.5Autoclaving

This type of sterilization, which uses steam under pressure to sterilize objects more effectively, is referred to as autoclaving. A cylindrical, metallic, double-walled container is an autoclave. In use now are many different kinds of autoclaves.

1.6Basic autoclave

This device has a cylindrical, gun-metal body that is closed at one end by a hinged door. There is a gasket seal between the door and the cylinder. It is temperature resistant. Inside the barrel is a perforated metal tray that is used to store the items that need to be sterilized. An electric heater boils the water that is present underneath the perforated tray to create steam.

A steam-jacketed autoclave is a standard autoclave modified. Much heat is lost from the barrel surface in basic autoclaves. A steam jacket is placed around the barrel in a big autoclave to verify this. The temperature and steam pressure within the autoclave rise in direct proportion. Typically, autoclaving takes place for 15 minutes at 15 lb of pressure. Most of the solid and liquid media used for microbial cultures are sterilized in an autoclave [3].

B. Filtration-based sterilization

The solutions of heat-sensitive materials may be sterilized using this method the best. Instead of immediately eliminating the bacteria, this approach only eliminates them. Filters come in two varieties.

C. Depth filters

They are made of granular or fibrous materials that have been cemented into a thick layer and are filled with narrow, twisting channels. Under vacuum, the microbial-contaminated solution is drawn through this layer, where the microbiological cells are physically removed. Depth filters are often constructed of diatomaceous earth, unglazed porcelain (chamberlain filters), asbestos filters, etc. Membrane filters, or group b, have taken the role of depth filters. These filters are spherical porous membranes constructed of synthetic materials including polycarbonate, polyvinylidene fluoride, cellulose acetate, and cellulose nitrate [4].

D. Filtration-based air sterilization

Filtered air may also sterilize, two typical examples of air-infiltration barriers that keep germs out but admit air in are surgical masks and cotton plugs on culture vessels. High-efficiency particulate air (HEPA) filters used in laminar flow biological safety cabinets remove 99.97% of airborne particles.

E. Radiation

The main source of radiation on Earth is sunlight. It consists of radio waves, visible light, ultraviolet (UV) radiation, and infrared rays. There is hardly any UV radiation on Earth's surface. The ozone layer, which is present 25 to 30 miles above the surface of the planet, absorbs some more intense UV radiation. As UV is so harmful to living things, its eradication is essential. Due to their short wavelength and great intensity, UV rays successfully destroy many types of bacteria but do not penetrate glass, dirt films, water, and other materials particularly well [5] [6].

Microorganisms are very vulnerable to a variety of electromagnetic radiation types. Gamma and x-rays are far more energetic than visible light and infrared rays, for example, when the wavelength of electromagnetic radiation falls. A stream of energy packets known as photons is how electromagnetic radiation behaves. Each photon has a quantum of energy, the value of which is determined by the radiation's wavelength. Ionizing radiations induce the loss of electrons in atoms because of their very short wavelength or high energy. There are two main ionizing radiations:

1. A radioactive decay of an ionizing radioisotope releases gamma rays, which are two types of artificially manufactured X-rays. Higher doses of ionizing radiation are immediately fatal, whereas lower levels produce mutations and may indirectly end in mortality.

2. Ionizing radiation is a powerful sterilizer that may reach deep inside of items. Pasteurization of meat and other foods has also been accomplished using gamma radiation.

F. Chemical Methods

This is a rapid way to sterilize glassware, tools, and other items utilized in the culture process. Due to their inability to quickly eliminate bacterial endospores, the chemicals often function as disinfectants. Many substances are recognized for their ability to be:

(a) Disinfectants or germicidal (germ-killing), such as Lysol, Cresol, etc.

(b) Antiseptics (blocking the development of microorganisms), such as ethyl and isopropyl alcohols.

(c) Sanitizers, such as silver nitrate, mercuric chloride, and several other mercury compounds, lower microbial populations to safe levels.

G. Gaseous Methods

Nowadays, ethylene oxide gas is used to sterilize many heat-sensitive objects, including disposable plastic syringes, Petri dishes, catheters, heart-lung machine components, etc. It has sporicidal and microbicive effects. By combining with cell proteins, it causes death. Since it quickly penetrates packaging materials, including plastic wraps, it is an extremely efficient sterilizing agent. Serums and vaccines are sometimes sterilized using betapropiolactone (BPL). Moreover, it eliminates bacteria more quickly than ethylene oxide, although it is less effective at penetrating materials and might be carcinogenic. As a result, BPL has not been widely used [7][8][9].

ISSN (Online) 2456 -1304
International Journal of Science, Engineering and Management (IJSEM)
Vol 10, Issue 2S, February 2023

II. DISCUSSION

A. Culture Medium

On appropriate culture medium, the organisms are cultivated. A culture medium is a nutritional solution that offers a well-balanced combination of the necessary elements in quantities that will promote healthy microorganism development.

The following categories of cultural media are often found:

I. Media of living culture.
II. Natural culture medium
III. synthetic culture media

1.1 Non-Synthetic or complex medium

Culture-related media may be broadly categorized as:

Based on the composition:

1.2Live culture media:

These media need the microbes to be cultivated to parasitize living cells, tissues, or calluses. Some viruses are often grown in chick embryos.

B. Natural or Empirical Culture Media

Natural or empirical culture media mostly include one or many in gradient. The precise makeup of such a medium is not known. Natural media are practical and reasonably priced. For many creatures, they are not the best medium, however. Among the natural media are milk, skim milk, wine-diluted blood, and vegetable juices.

1.1 Synthetic media

A synthetic medium is made by combining a variety of ingredients in a certain proportion. The medium's precise chemical makeup is known in this. Very pure organic and inorganic substances are present in such mediums. A synthetic medium is called nutrient agar.

1.2 Complex Media

These are those materials whose chemical makeup is not well understood. These media are not artificial. This medium may be used to cultivate a wide range of microorganisms. In complex media, peptone, yeast extract, meat extract, beef extract, etc. are employed.

Based on the physical state

1.3Liquid media

Liquid media are described as water-based solutions that flow freely when the container is tilted and do not solidify at temperatures above freezing. Several solutes are dissolved in distilled water to create these media. Broths, milk, and infusions are the names for the liquid media.

1.4 Semisolid Media:

Semi-soiled media are those that, at room temperature, have a clot-like consistency. They don't move naturally. They thicken but do not form a rigid substrate because they include a solidifying ingredient like agar or gelatin. They are used to pinpoint a reaction's location at a particular place and gauge the motility of bacteria.

1.5 Solid Media

Solid media is a term used to describe a medium that offers a hard surface on which cells may form distinct colonies. They help separate and grow bacteria and fungi in smaller cultures. They come in two varieties. Liquefiable solid media are also known as reversible solid media and include a thermoplastic ingredient that solidifies them. Agar-agar is the most extensively used agent. Agar is flexible and moldable, yet it is solid at normal temperatures. It has the ability to store nutrients and moisture. For the vast majority of bacteria, it is an indigestible nutrient. Solid media that cannot be liquefied are not thermoplastic. They consist of things like cooked beef, potato pieces, and rice grains (used to cultivate fungus). These media are solid at first and stay that way after being heated to sterilize them.

C. Based on functionality (Functional Types)

1.1 General Purpose Media

General-purpose media are those that can sustain the development of several microorganisms. They are natural and include a variety of nutrients that could encourage the development of pathogens and non-pathogens.

1.2 Enriched Media

The term "enriched media" refers to media that have been carefully reinforced. They include complex organic molecules that certain microbes need to develop, such as blood, serum, hemoglobin, or specific growth factors like vitamins and amino acids. Fastidious bacteria are those that demand complicated nutrition and growth stimuli (e.g.: *Streptococcus pneumonia*). Specialized microbial groupings are intended for these selective and differentiating mediums. They aid in the initial, one-step identification of a genus or even a species.

1.3 Selective Media

They include one or more ingredients that stop certain microorganisms from growing but not others, such as Gram-negative bacteria thrive when colors like basic fuchsin and crystal violet are used. Strong inhibitory chemicals may be found in certain selective media. For instance, oral streptococci may be extracted from saliva using Telluride. Some nutrients are employed particularly in the medium, such as cellulose for cellulose-digesting bacteria.

1.4 Differential media

These media are used to cultivate a variety of microorganisms but also to distinguish between various microbe groups. Based on their biological variances, they are also used to attempt to identify microbes. There may be variations in colony size and color, medium color changes, bubble formation, and precipitation characteristics. These variances result from the substances used and how the cells

respond to them. Blood agar is an enriched and differential media. It makes a distinction between germs that are hemolytic and those that are not. By destroying red blood cells, hemolytic bacteria create clear zones surrounding their colonies.

1.5 Selection of Other Media

A reducing medium includes a chemical called cystine, which absorbs oxygen and lowers its availability. These media help grow anaerobic bacteria and for figuring out how much oxygen is needed. Sugars that can be fermented are present in these mediums for the fermentation of carbohydrates.

1.6 Transport Media

They are used to keep specimens alive and intact for a while until a clinical assessment. They are also employed to maintain fragile species that, if not maintained in a steady environment, die off quickly.

1.7Assay Media

They are used to evaluate the impact of antimicrobial medications, antiseptics, cosmetics, and preservatives on the development of bacteria.

1.8Enumeration Media

Industrial and environmental microbiologists use them to count the variety of organisms present in milk, water, food, soil, and other samples.

1.9Distribution of the Medium

The act of dispensing involves pouring the medium into Petri dishes, culture tubes, and sterile flasks. The semiautomatic syringe, funnel, and automated filter are often used to automatically pour the unsterilized media into the flasks and culture tube. A nonabsorbent cotton wool plug is used to seal culture tubes or flasks before adding the liquid medium (broth). Typically, the sterilized medium is poured onto Petri plates that have previously undergone sterilization in specialized sterilized inoculation chambers.

D. Ways to Access Pure Culture

Pure Culture

A pure culture is one that only contains a single species of microbe. Since germs are present all throughout nature, they only appear in mixed forms. A mixed culture of microorganisms grows when culture mediums are injected with substances like dirt, water, or excrement. This is because several different kinds of organisms proliferate at once. A pure culture of the targeted microorganism is necessary for the research of that organism. A single live microbe must be isolated and allowed to proliferate in an appropriate culture medium before any technological approach for producing pure culture can be used. Robert Koch developed the first effective technique for separating pure cultures in 1881, and his hypothesis is known as

1. While examining all sick plants, the pathogen or organism must always be linked to the disease's symptoms.
2. A pure culture of the pathogen must be cultured on a nutritional medium after being separated.
3. The pathogen from pure culture must be separated and injected into disease-free plants of a particular species. it must cause the same disease manifestation in plants that have received the vaccine.
4- The pathogen has to be isolated in pure culture once again, and its culture and traits need to mimic the prior culture. So that the disease's isolated pathogen may be found and linked to it.

III. CONCLUSION

Culture medium aids in the development of cells and microorganisms in laboratories by providing nutrients and minerals. Different organisms, however, have different nutrient requirements and living conditions. In the laboratory, bacteria may proliferate and form separate colonies on nutrient agar if it is injected with fluid, hardened, and stored at an unfavorable temperature. If the colonies are not packed tightly together, a pure culture may be made by inoculating a colony in a new culture media after contacting it with the tip of a sterile needle. For the growth of a single type of bacteria, some Decontamination methods including disinfection and sterilization are required. Disinfection is the process of removing or decreasing hazardous bacteria from inert objects and surfaces, while sterilization is the process of destroying all microorganisms.

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Methods of Isolation Cultivation and Culture

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***Abstract*— The pure culture method is the separation of one kind of microbe from a mixture. The Petri dishes or flasks are injected with an organism and put in a culture chamber to allow it to grow. The needles are sterilized. Before administering the vaccine, cotton wool dipped in alcohol is used to sanitize the hands, inoculation tools, etc. In this chapter, we discussed the methods for the isolation of the pure culture of the microorganisms.**

***Keywords*— Culture Tubes, Dilution Factor, Mixed Culture, Sterile Water, Serial dilution.**

I. INTRODUCTION

A. Pour plate method

With this technique, melted agar media is introduced to culture tubes after the mixed culture has been diluted in a sterile medium. The tubes' contents are then transferred to a sterile Petri dish and given time to set. After that, the plates are incubated. Different microorganisms' cell types form colonies, and cells from each colony are selected for further cultivation [1]–[3].

Streak Plate Technique: Streaking is the most popular isolation technique. The best cultures for this approach are bacteria and fungi. The mixed culture is placed on a sterile wire loop (inoculum) and dragged back and forth over a solid agar medium in a Petri dish for the streak plate technique. The culture is suitably thinned by the subsequent streaks. This technique involves depositing isolated individual cells onto a specific area of the plate. After each streaking, the needle is flamed and allowed to cool. There are many of these streaks produced in the media. The streaking follows a certain pattern. While using the streaking technique, extreme caution must be used to avoid breaking the medium's surface as each cell develops into a colony.

B. Serial Dilution Method

Serial dilution is the dilution of a sample in a series of steps. The bacteria and fungi that are difficult to isolate using the streaking approach are best suited for this procedure. The microorganism combination is serially diluted in sterile medium culture tubes until the last tube contains only one organism. This approach involves a regular increase in the dilution factor, such as 1/10, 1/100, 1/1000, etc.

In this procedure, a culture tube containing 9 ml of sterile water is filled with 1 ml of sample. This results in a tenfold dilution, which is denoted by the dilution factor 1/10 or 10-1, now, 1 ml. of the sample is removed from this 10-fold dilution and is added to 9 ml. of sterile water that was obtained in a second culture tube. Now, a 100 fold dilution is present in the second tube, and the dilution factor is denoted as 1/100 or 10-2.

In a third culture tube, 9 ml of sterile water is obtained, and 1 ml of sample from tube two is added. Now, the 1000 times dilution factor in the third tube is shown as 1/1000 or 10-3. The preparation of culture tubes 4 and 5 is done similarly. Both tube 5 and tube 5 offer a 10-4 and 10-5 dilution, respectively. As a control, a sixth tube is created and only contains 10 ml of sterile water.

Then, 1 cc of each tube's diluted material is removed and put on an agar plate (a Petri dish containing 10 to 15 ml. of melted agar medium). The six agar plates are incubated for 24 hours between 25 and 300 C. Most of the bacteria develop in a luxuriant state. The likelihood of a dominant organism in a pure state in the culture is increased by serial dilution. Finally, a small amount of the suspension is pipetted out and applied to the Petri dish medium [4]–[6].

C. Spread plate technique

It is a modification pour plate method. In this method, the mixed culture is serially diluted in sterile distilled water. A small amount of diluted mixture is then poured on the surface of the agar plate and it is spread evenly using a sterile bent glass rod. The isolated cells grow into colonies.

D. Single-cell method

In this method, a suspension of microbes is placed on the cavity slide. Thereafter, a single cell is removed with the help of a sterile micropipette with the aid of a microscope. The cell is then transferred to sterile culture. The colony obtained originated from a single cell.

E. Enrichment culture method

In this method, a particular nutrient, which favors the growth of the desired bacterium, is added to the medium. When the mixed culture is placed in this enriched medium, the desired bacterium will grow dominantly.

F. Selective culture method

In this method, a selective medium is taken which contains a chemical, which suppresses undesirable species. Crystal violet inhibits gram-positive bacteria, when crystal violet is added to the medium, the medium will select the gram-negative bacteria.

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Vol 10, Issue 2S, February 2023

G. Differential culture method

In this method specific chemicals are used in the medium and different microorganisms are isolated based on their color in the eosin-methylene blue agar medium, coli will produce colonies with a brilliant green metallic color and Acrobactor acrogens will produce pink colonies with dark centers.

After obtaining the pure culture of a desired microbe, it may be grown and maintained as a pure culture. This pure culture can be maintained by transferring the organisms from one to another culture tube. This process is called subculturing.

H. Cultivation of viruses

Viruses are unable to reproduce independently, so, they cannot be cultured like other microorganisms. These are cultured in different ways depending upon the type of living host which they require for multiplication.

I. Cultivation of plant viruses

Plant viruses can be cultivated in various ways. Plant tissue cultures, cultures of separated cells, or cultures of protoplast may be used for cultivating plant viruses, Viruses can also be grown in whole plants. Leaves of a healthy plant are mechanically inoculated when rubbed with a mixture of viruses and an abrasive such as carborundum orc elite. When the cell walls are broken by the abrasive, the viruses come in direct contact with the plasma membrane and infect the exposed host cells.

The localized necrotic lesion often develops due to the rapid death of cells in the infected area. Even when lesions do not appear, the infected plant may show other symptoms such as a change in color or leaf shape. Some plant Viruses are transmitted only if a diseased part is grafted into a healthy plant.

J. Cultivation of animal viruses

In the past animal viruses were cultivated by inoculating suitable host animals or embrocated eggs, usually six to eight days after laying. Before inoculation, the shell surface of the egg is disinfected with iodine and penetrated with a small sterile drill. After inoculation, the hole is sealed with gelatin and the egg is incubated. Because viruses reproduce only in certain parts of the embryos, so they must be injected into the proper region. The virus infection produces a local tissue lesion called pock appearance which varies and is characteristic of the virus.

Nowadays, animal viruses are grown in tissue culture on the monolayer of animal cells. This technique evolved with the development of growth media for animal cells and the discovery of antibiotics for the prevention of bacterial and fungal contamination.

K. *Cultivation of Bacteriophages*

Bacteriophages are cultivated in either broth or agar cultures of young, actively growing bacterial cells. The number of host cells destroyed is so large that turbid bacterial cultures may clear rapidly as a result of cellists. For preparing agar culture the bacteriophage sample is mixed with cool, liquid agar and a suitable bacterial culture. This mixture is then quickly poured into a Petri dish containing a bottom layer of the sterile layer. Wherever a vision comes to rest in the top agar, the virus infects an adjacent cell and reproduces eventually. Bacterial lysis results in an opaque layer. The appearance of plaque is characteristic of the phage being cultivated

II. DISCUSSION

A. Culture Techniques

Microbiologists cultivate, handle, analyze, and describe microbes using five fundamental methods, sometimes known as the "five I's." Which are:

1. Inoculation
2. isolation,
3. isolation from others incubation
4. inspection

identification of all microbiologists employs these methods, whether they are clinical microbiologists seeking to determine the source of a patient's illness or beginning laboratory students or researchers trying to isolate a beneficial bacteria from the soil. Hence, these methods aid in managing and keeping microbes as distinct entities.

B. Immunization

Immunization is the act of transferring inoculum, or a sample containing microorganisms, into a container of nutritional media, which creates a growth environment for them. You may get inoculum via the air, food, water, sewage, soil, and inanimate items. Inoculum is taken from bodily fluids (blood, cerebrospinal fluid), discharges (sputum, urine, feces), or sick tissue to determine the source of an infectious illness.

With implements like loops, needles, pipettes, etc., the culture containers (culture tubes, conical flasks, or Petri dishes) holding the correct culture medium are infected. Sterilization of the glassware, equipment, and culture material is required for a well-controlled experiment. This indicates that a sterile media must be used to begin the inoculation. Sterilization is required for all culture and inoculating equipment. During inoculation, precautions are also made to avoid the admission of unwanted bacteria. UV lights are used in dedicated rooms where this operation is performed. Nowadays, specialized laminar flow (biological safety chambers) equipped with HEPA filters are utilized for inoculation.

C. Process of making agar slants

Agar media is liquefied and placed into culture tubes. The culture tubes are autoclave sterilized after being filled with cotton wool. The sterilized tubes are removed, positioned slantwise, and then left to cool. The sloppy surface gives the

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Vol 10, Issue 2S, February 2023

agar media in the culture tube the most surface area for microorganism growth transferring the vaccine.

The inoculation is carried out in an ultraviolet-light-sterilized inoculation chamber. Repaired spirits should also be used to disinfect and sanitize the hand. While inoculating culture tubes, the inoculating needle is held in one hand while the tube with the inoculum is held in the other. In front of the flame of the spirit lamp, the cotton plugs of the tubes are removed with the aid of fingers. With the use of a needle, the inoculum is extracted and then put into the tube's agar surface. To prevent contamination, the tube is promptly sealed up. While inoculating a Petri dish, the cover is removed as little as possible, and the inoculation is carried out in the dish's center. Finally, the Petri dishes or tubes that have been infected are incubated at the chosen temperature.

D. Isolation

Isolation is the process of removing the pathogen from the host tissue, a mixed culture, or culture medium. A tiny number of cells are injected into a large volume or region of media in order to achieve appropriate isolation. A hard surfaced medium, a petri plate (a transparent flat dish with a cover), and an inoculating loop are often needed. To produce pure

E. Incubation

To promote multiplication, a culture vessel containing medium is put in a temperature-controlled room or incubator after being infected. It is known as incubation. They are often cultured in laboratories between 20 and 400C. The amount of atmospheric gases, such as oxygen and carbon dioxide that may be necessary for the development of bacteria may also be regulated in incubators. The microorganism multiplies and shows some signs of growth throughout the incubation phase.

F. Inspection

It is crucial to macroscopically examine a culture at different phases of inoculations. Microorganism colonies are easily observable, particularly when bacterial and fungal colonies are present. In reality, colonies are large clusters of adhering cells. There are differences in the colonies' sizes, shapes, colors, and textures. Microbiologists may detect bacteria with the aid of colony formation on an agar surface. Creating a second level after isolating a microbe is a common procedure. A subculture is a cultural term. This is accomplished by taking a tiny sample from a single, well-isolated colony and placing it in a different medium container. A colony produces a pure color or axenic culture that may be used for further analysis and identification since it only contains one species of the bacterium [7]–[9]. A microscope is also used for cultural examination. This provides facts on a variety of cell microbiological traits, including size, shape, and specifics on internal and exterior structures.

G. Identification

The isolated microorganisms are recognized by a combination of their macroscopic and microscopic features. They may be used to distinguish between smaller, simpler prokaryotic cells and bigger, more complicated eukaryotic cells. Yet, due to identical morphologies, appearance is useless in identifying bacteria. Several methods that describe their cellular metabolism are used for their identification. They include biochemical tests that may identify basic chemical properties including dietary needs, products released during growth, required temperature and gas composition, and energy generation techniques.

H. Preservation of culture

A culture of the microorganism is kept for future research. A line of stock cultures is necessary for many research facilities. Stock cultures are organisms that are regularly maintained and serve as "living catalogs." American Type Culture Collection in Rockville, MD, USA, is the biggest cultural collection. It preserves fungal, bacterial, viral, and algal cultures that are frozen or freeze-dried [10]. Certain cultures pose a risk to one's health. They must thus be disposed of immediately and properly. There are two methods for getting rid of microbial cultures:

(1) Steam sterilization using an autoclave, and
(2) Cremation (burning).

III. CONCLUSION

A profile is created by combining macroscopic and microscopic traits with the findings of biochemical testing, and it is then used to make the final identification of a bacterium. Microorganisms are so classified according to their microscopic features, metabolic processes, genetic traits, and macroscopic form. In summary, pure culture may be achieved utilizing numerous ways, including the technique known as the streak plate, the spread plate method, and the pour plate method. Separation of bacterial colonies, colonial traits, and cellular features may all be compared using pure culture.

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Instruments Used in Microbiological Studies

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Abstract*— Microbiology is the study of microbes, or very tiny living entities. Such little creatures need specialized equipment to examine. Instrumentation is a strong tool for investigating the internal structure of microorganisms. Microscopes, slides, test tubes, petri dishes, solid and liquid growth media, inoculation loops, pipettes and tips, incubators, autoclaves, and laminar flow hoods are all examples of microbiology equipment. In this chapter we discussed the different instruments used in the microbiological studies.

Keywords*— Autoclave Equipment, Bacterial Inoculation, Laminar defect, Microbiological, Mobile Wall.

I. INTRODUCTION

Culture containers conical flasks Petri dishes culture tubes are the most common types of culture containers used to hold culture medium. They are constructed with premium corning glass. Special cultural foods known as "petri dishes" were created by Julies Richard Petri. These dishes were created by Petri in 1887. They are made up of two overlapping, circular parts with the upper half. The smaller culture tubes have no rim, but the larger ones have. For microbial cultivation, flasks of almost any size, ranging from 50 ml to 1000 ml, are used. They are used for both the pre- and post-sterilization storage of culture media as well as for the liquid or semisolid pathogen culture [1]–[4]. Cotton wool is usually used as a plug to filter any air that enters medium or culture-containing tubes and flasks of any potentially contaminating microorganisms. A plug should have a tuft that extends outside the tube and projects into the tube by approximately an inch so that it may be removed. The plug should be precisely and firmly in place, but not so firmly that it cannot be pulled out when held between any two fingers of one hand. The plug should also maintain its form so that it may be easily reinserted following withdrawal.

A. Inoculation tools

Syringes, inoculating loops, inoculating needles, and other equipment are utilized during inoculation. Platinum wire or chrome wire is placed onto a metal or glass rod at one end to form the inoculating needles or loops. Whereas the free end of the wire in inoculating loops is bent into the shape of a loop, the wire in inoculating needles is straight.

B. Equipment for IV sterilization

Glassware and culture media are sterilized using the tools listed below: Laminar flow biological softy cabinets Oven for dry sterilization, Autoclave for steam sterilization Filter sterilization Equipment, Sterile rooms or inoculation chambers and Oven for dry sterilization

Sterilizing glassware or other heat stable materials mostly requires dry heat. The items are covered in aluminum foil and heated in an oven to 1700C for 90 minutes. It is a machine that runs on electricity. It has a large chamber with insulated walls, electrical heaters to increase the temperature, and a thermostat to keep the temperature where it should be [5]–[7].

C. Autoclave

An autoclave is a device that uses high pressure steam that develops within a sterilizing chamber as a result of boiling water to sanitize culture medium, glassware, and other instruments. During longer heating times, the steam pressure within the chamber rises. The autoclave's body is composed of a thick, double-walled cylinder. An electric immersion rood is mounted within the cylinder at its bottom. A thick, firmly fitting cover is attached to the mouth of the cylinder. To keep track of the pressure within the cylinder, a pressure gauge is fastened to the lid.

The lid also has an output valve connected to it. Often, laboratory autoclaves are run at a temperature of 1200C, or a steam pressure of 15lbm2 above atmospheric pressure. At 1200C, even bacterial spores that may withstand many hours of boiling are quickly destroyed. To completely sterilize the area, the temperature at 15 lb pressure for 15 minutes is adequate to kill any creature. If an autoclave is not accessible, sterilization may be accomplished using pressure cookers.

D. Equipment for filter sterilization

Filtration via filters that may hold bacteria allows solutions of heat-labile materials to be sterilized. The following are the most typical filters:

1. Membrane filters (Millipore filters): They are made of cellulose esters-based porous discs.
2. Seitz filters, which are made up of asbestos-cellulose discs.
3. Sintered glass filters: They are made by melting small glass shards together.
4. These ceramic candle filters are manufactured without a glaze.

The filter is correctly installed on a structure that resembles a funnel. The receiving flask receives the mounting. Heat sterilizes the whole assembly. The filter is filled with the solution to be sterilized. Pressure on the unfiltered liquid or

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Vol 10, Issue 2S, February 2023

suction on the receiving flask both speed up the liquid's passage through the filter.

The inoculation process takes place in sterile rooms, often known as inoculation chambers. They are equipped with ultraviolet bulbs or lamps that produce UV light with a 260 to 270 mm wave length. They are helpful for eliminating microorganisms on surfaces of objects and in the air.

E. Laminar defect

Laminar defect cabinets can in various sizes. Biological Safety Cabinets These may be put anywhere is necessary, doing away with the requirement for a separate space. One of the most significant air filtering systems is this one. A researcher is shielded from pathogens being handled within a laminate defect cabinet by a vertical curtain of sterile air that is projected over the cabinet entrance by HEPA fitters, preventing room contamination.

F. Incubators

The majority of fungi grow relatively well at room temperature, but higher or lower temperatures are necessary to induce maximal development and, in certain circumstances, to encourage the creation of specific types of spores and fruiting structures. One tool used for this is an incubator. It is an electrical device that functions and is built similarly to hot air ovens. The temperature range ranges from room temperature, which is typically between 200°C and 50°C or 600°C. In these chambers, the microbe cultures are nurtured at the proper temperature. Colony counters are a tool used to tally the number of microbial colonies growing on a culture plate. They often come in two types:

G. Quebec colony counter

There is a platform with a cross ruling in the Quebec colony counter (small squares). Underneath the platform, there is an illuminated to illuminate the colonies, and a magnifying lens is located above the platform. The colonies are enlarged by this lens, which makes counting easier. The culture plate is fixed on the platform and lighted from below for the purpose of counting the colonies. In contrast to a background of tiny squares, the colonies are readily counted.

H. Electrical colony counter

When a colony is contacted by the electrode, which is used to indicate the position of each colony, the colony's location is automatically registered in the electrical colony counter. D. Counting Chambers: Counting chambers are used to determine the composition of the microbial community by direct counting. They are simple, affordable, and quite fast. Moreover, it provides details on the size and morphology of the creatures that are being enumerated. Bacteria are counted using Petroff counting chambers. Large eukaryotic microbes are counted using hemocytometers. Using electric counters like the Coulter counter, large microorganisms like protozoa, algae, and yeasts (non filamentous forms) may be directly counted. It is often used to count red and white blood cells and provides reliable findings with bigger cells. Because of tiny debris fragments, filament development, etc., it is useless for counting bacteria [8]–[10].

II. DISCUSSION

Natural surroundings include microorganisms, which are polluted and combined with many different forms of life. Microorganisms must be taken out of their mixed forms and cultured or grown in artificial environments in order to be studied separately. Since they are common and undesired bacteria, they could get into an experiment and provide false findings. Sterilization, pure culture, and other techniques are used to address this issue. To generate an aseptic environment for microbial growth, numerous sterilizing techniques are required. Contaminations must be avoided while isolating microorganisms for in-depth investigation.

Bacteria Microscopically small unicellular prokaryotic organisms known as bacteria are distinguished by the absence of membrane-bound organelles and a nucleus. Bacteria, formerly thought to be a component of the plant kingdom, were later given their own kingdom, Monera. The two types of bacteria are Eubacteria and Archaebacteria, which include extinct species considered to have developed independently from other bacteria. The Archaebacteria, also known as the Archaea, and the Eubacteria, also known as the Bacteria, are categorized as significant groups (also known as domains) above the kingdom level under a newly suggested classification.

For two billion years, bacteria were the sole form of life on planet. The study of bacteria as an applied science started to emerge in the late 19th century as a consequence of studies in medicine and fermentation processes, particularly by Louis Pasteur and Robert Koch. They were initially noticed by Antony van Leeuwenhoek in the 17th century.

These bacteria have an amazing capacity for environmental adaptation. They can be found everywhere on the planet, including in the bodies of all living things, the surface of the ocean, the depths of the land, the arctic ice and glaciers, hot springs, and even the stratosphere. The discovery of bacteria that can only exist at very high temperatures and pressures near hydrothermal vents on the ocean bottom as well as species that can survive without sunlight in these conditions has improved our knowledge of bacteria and their metabolic activities. There are more bacteria than any other sort of life, and one gram of fertile soil may contain up to 2.5 billion germs.

Bacteria come in a huge variety of sizes and forms. Their cells generally range in size from 0.5 to 5.0 micrometers, or approximately one-tenth the size of eukaryotic cells. Certain species, such Thiomargarita namibieniensis and Epulopiscium fishelsoni, are just a fraction of a millimeter long and are not visible to the human eye; E. fishelsoni grows to a length of 0.7 mm. Members of the genus Mycoplasma are among the tiniest bacteria; they have a diameter of just 0.3 micrometers, which is comparable to the size of the smallest

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Vol 10, Issue 2S, February 2023

viruses. Even tiny bacteria may exist, but nothing is known about these ultra-microbes.

The majority of bacterial species are either rod-shaped (called bacilli) or spherical (called cocci; singular: coccus; from Greek kókkos, grain, seed) (sing. bacillus, from Latin bascules, stick). Swimming is connected to elongation. Certain bacteria, known as vibrio, have comma- or rod-like shapes; others might have spiral or tightly w6ound shapes, known as spirilla or spirochaetes. A few species even possess tetrahedral or cuboidal forms. More recently, bacteria with a star-shaped cross section that develop as branching filamentous kinds were found deep inside the Earth's crust. These bacteria may have an advantage in nutrient-deficient situations due to the huge surface area to volume ratio of their morphology. The large range of forms that bacteria may take is essential because it can affect how well they can absorb nutrients, adhere to surfaces, float through liquids, and avoid predators. These shapes are governed by the bacterial cell wall and cytoskeleton.

Many bacterial species only live as solitary cells, while others develop distinctive associations in pairs, chains, and "bunch of grapes" clusters, such as Neisseria, Streptococcus, and Staphylococcus. Actinobacteria, for instance, may grow longer to produce strands of bacteria. Filamentous bacteria often have a sheath around them that is made up of several distinct cells. Certain varieties, including members of the genus Nocardia, even produce intricate, branching filaments that resemble fungus mycelia.

Bacteria often adhere to surfaces and gather in large groups to create biofilms or bacterial mats these films may include various types of bacteria, protists, and archae, and their thickness may vary from a few micrometers to up to half a meter. Micro colonies, which are secondary structures formed by bacteria living in biofilms, are intricate arrangements of cells and extracellular components that allow for greater nutrition transport. The majority of bacteria are attached to surfaces in biofilms in natural settings like soil or plant surfaces. Moreover, biofilms are crucial in medicine because the bacteria they protect are considerably more difficult to eradicate than isolated, individual germs. These structures are often present during persistent bacterial infections or in infections of implanted medical equipment.

Sometimes, morphological alterations might even be more complicated. For instance, when deprived of amino acids, Myxobacteria engage in a mechanism known as quorum sensing to identify neighboring cells, travel in the direction of one another, and aggregate to create fruiting bodies up to 500 micrometers long and containing around 100,000 bacterial cells. The bacteria in these fruiting forms carry out various functions; this kind of collaboration is a basic sort of multicellular organization. For instance, a large number of cells go to the top of these fruiting structures and develop into myxospores, a specific kind of latent state that is more resistant to drying and other unfavorable environmental factors than regular cells.

III. DISCUSSION

A. Infectious surface

1.1 Mobile Wall

The plasma membrane and cell wall make up the cell envelop. The bacterial cell wall gives the cell its structural integrity, much as in other species. The main purpose of the cell wall in prokaryotes is to shield the cell from internal turgor pressure, which is brought on by the considerably greater concentrations of proteins and other molecules within the cell than in the surrounding environment. Since peptidoglycans, which are found just outside of the cytoplasmic membrane, are present in the bacterial cell wall, it varies from the cell walls of all other species. The polysaccharide backbone of peptididoglycan is composed of equal numbers of N-acetylglucosamine (NAG) and N-acetylmuramic acid (NAM) residues alternated. The bacterial cell wall's stiffness and the choice of cell shape are both governed by peptididoglycan. It is thought not to be a permeability barrier for tiny substrates since it is rather porous.

All bacterial cell walls contain peptidoglycan, however not all cell walls have the same features (a few exceptions include extracellular parasites like Mycoplasma). While the bacterial cell wall is necessary for life, some medicines work to prevent bacterial infections by impeding cell wall formation. Gram-positive and gram-negative bacteria have various kinds of cell walls, which may be identified by their ability to stain with different colors using the Gram staining method.

Particles smaller than 2 nm can get through the peptidoglycan for both of these kinds of bacteria. A protoplast is a bacterial cell wall that has been completely destroyed, while a spheroplast is a bacterial cell wall that has been partly removed. Penicillin and other -lactam antibiotics prevent the peptidoglycan cross-links from forming in bacterial cell walls. Human tears include the enzyme lysozyme, which breaks down bacterial cell walls and serves as the body's principal line of defense against eye infections.

1.2 The wall of the gram-positive cell

In certain gram-positive bacteria, the peptidoglycan layer makes up over 95% of the cell wall, but in gram-negative bacteria, it only makes up 5–10%. Gram-positive bacteria have thick cell walls. Certain gram-positive bacteria's cell walls are totally dissolvable by lysozyme. The walls of other gram-positive bacteria, such Staphylococcus aureus, are resistant to lysozyme's activity. Teichoic acids or polysaccharides may be the matrix components in the walls of gram-positive bacteria.

The latter are quite common and are exclusively present in gram-positive bacteria. Teichoic acids come in two primary varieties: glycerol teichoic acids and recital teichoic acids. The latter is the more typical one. These acids are exclusively found on the surface of many gram-positive bacteria and are

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Vol 10, Issue 2S, February 2023

polymers of glycerol phosphate and recital phosphate, respectively. Teichoic acid's precise role is not yet completely known. Lip teichoic acid is a crucial component of the gram-positive cell wall. Its ability to serve as an antigenic is one of its goals. The membrane contains the lipid element, which helps the membrane hold it in place with the help of its adhesive capabilities.

1.3 Gram-negative cells outer layer

Unlike gram-positive cells, which have thicker cell walls, gram-negative cells have a thin coating of peptidoglycan next to the cytoplasmic membrane. Many of the antigenic traits of these strains are caused by the lipopolysaccharide composition of the outer membrane, which is often specific to certain bacterial subspecies.

Lipopolysaccharides, commonly known as endotoxins, are made up of polysaccharides and lipid A and are the main cause of gram-negative bacteria's toxicity. It is made up of distinctive lipopolysaccarides that are incorporated into the membrane.

1.4.Plasma Membrane

Made up of a phospholipid bilayer, the plasma membrane, also known as the bacterial cytoplasmic membrane, performs all the general duties of a cell membrane, including acting as a permeability barrier for the majority of molecules and being the site of the transport of molecules into the cell. Prokaryotic membranes serve as the site where a proton motive force is produced in addition to these roles in energy conservation.

With a few exceptions, such as Mycoplasma and methanotrophs, bacterial membranes typically do not contain sterols, in contrast to eukaryotes. Hopanoids, which have a similar structural makeup and probably serve the same purpose, are present in many microorganisms. In contrast to eukaryotes, bacteria's membranes may contain a broad range of fatty acids.

Bacteria may include fatty acids with extra methyl, hydroxyl, or even cyclic groups in addition to the usual saturated and unsaturated fatty acids. To keep the membrane as fluid as possible, the bacteria may adjust the relative quantities of these fatty acids. The lipid part of the outer membrane is impermeable to charged molecules due to its phospholipid bilayer structure. Nonetheless, the outer membrane contains poring channels that enable the passive translocation of many ions, carbohydrates, and amino acids. As a result, these molecules may be found in the periplasm, which is the space between the cytoplasmic and outside membranes.

The peptidoglycan layer and several proteins involved in substrate binding, hydrolysis, and extracellular signal receiving are found in the periplasm. Because of the substantial amounts of proteins and peptidoglycan present there, the periplasm is assumed to exist in a gel-like condition as opposed to a liquid one. Signals received and substrates bound are accessible and carried across the cytoplasmic membrane via transport and signaling proteins embedded there because of its placement between the cytoplasmic and outer membranes.

1.5 Flagella

Several bacterial species possess thin, stiff, helical flagella made by the flagellin protein. These flagella are very thin, barely 10 to 20 nanometers thick, and vary in size from 3 to 12 micrometers. They serve as a propeller, spinning or dragging the bacteria through the water. They are attached in the cell wall. Bacteria have different flagella numbers and positions. It can be monotrichous (one polar flagellum), lophotrichous (a cluster of polar flagella), amphitrichous (flagella at both ends either singly or in cluster), cephalotrichous (two or more flagella at one end of the bacterial cell), peritrichous (cell surface uniformly surrounded by several lateral flagella), or atrichous.

The basal body, hook, and filament are the three fundamental components of a flagellum. The flagellum is connected to the cell wall and plasma membrane via the basal body. It consists of a tiny central rod that is put into a number of rings. Whereas gram negative bacteria have two pairs of rings (the proximal and distal) joined by a central rod, gram positive bacteria only have one distal (inner) pair of rings. Outside of the cell wall, the flagellum's hook joins the filament to the basal body. It is made up of several proteins. Compared to gram negative bacteria, gram positive bacteria have a somewhat longer hook. Filament refers to the lengthy, outermost portion of the flagellum. It is composed of flagellin, globular proteins that form a helix around a hollow center and are organized in many chains. The prokaryotic arrangement of bacterial cells is their most basic feature. The considerable functional compartmentalization seen in eukaryotic cells is absent from bacterial cells.

1.6 Internal membranes

Many bacteria have plasma membrane segments that have been invaded and are used for respiration or photosynthesis. Mesosomes are what they are. The respiratory process takes place at these structures. Many metabolic processes also take place at the cytoplasmic membrane; for example, permeases pass through the plasma membrane to transport both organic and inorganic substances. It is made up of the biosynthesis pathway enzymes that produce the various cell wall building blocks such peptidoglycogen, techoic acid, phospholipids, and polysaccharides.

Bacterial cells have thick, semi-transparent cytoplasm. In bacterial cells, there is no cytoskeleton and no cytoplasmic streaming compartmentation of cell organelles. Certain bacteria have cytoplasmic concentrations of particular chemicals that may be detected. Certain bacteria include volutin granules, which operate as a phosphate store. Aerobic bacteria also have a reserve carbon and energy source known as polybeta-hydroxybutyrate. By using electron microscopy, it is possible to see brilliant refractile entities that are hollow, have a regular form, and have more or less conical ends in

certain bacteria that inhabit aquatic environments. These gas vacuoles are what give the body buoyancy.

Bacteria lack nuclei and do not have the intricate chromosomes that are a feature of eukaryotes. Instead, a single double-stranded DNA ring that is squeezed into the nucleoid area of the cell contains all of their genes. Plasmids are tiny DNA rings that can replicate themselves independently and are found in a variety of bacterial organisms. Just a few genes, often not necessary for the survival of the cell, may be found on plasmids. They are best understood as a section of the bacterial chromosome that has been removed.

Ribosomes: Compared to eukaryotes, bacteria have smaller ribosomes that contain different amounts of RNA and protein. Tetracycline and chloramphenicol, two antibiotics that attach to bacterial ribosomes and prevent protein synthesis but do not bind to eukaryotic ribosomes, may be used to examine the distinction. Two subunits, a bigger 50 s subunit and a smaller 30 s subunit, make up ribosomes. Each is made up of ribosomal RNA and proteins.

By giving organisms names and classifying them according to similarities, classification is used to describe the variety of bacterial species. Bacteria may be categorized based on changes in cell components such DNA, fatty acids, pigments, antigens, and quinones as well as cell structure and metabolism. While these systems enabled for the identification and categorization of bacterial strains, it was unclear whether the variations between strains of the same species or between other species constituted diversity.

The absence of distinguishing features in the majority of bacteria and lateral gene transfer across unrelated species were the causes of this ambiguity. Some closely related bacteria may have remarkably diverse morphologies and metabolisms as a result of lateral gene transfer. Modern bacterial classification, which emphasizes molecular systematics, uses genetic techniques like guanine/cytosine ratio determination, genome-genome hybridization, as well as sequencing genes that have not undergone significant lateral gene transfer, like the RNA gene, to get around this uncertainty.

Publication in the International Journal of Systematic Bacteriology and Bergey's Handbook of Systematic Bacteriology serve as the basis for bacterial classification. The International Code of Nomenclature of Bacteria is governed by international standards, which are upheld by the International Committee on Systematic Bacteriology (ICSB). These standards include the naming of bacteria, the classification of taxonomic groups, and their ranking.

Formerly, the word "bacteria" was used to refer to all single-celled, tiny prokaryotes. Nevertheless, molecular systematics revealed that prokaryotic life is divided into two distinct domains that developed separately from a common ancestor and were previously referred to as Eubacteria and Archaebacteria (now known as Bacteria and Archaea). The three domain system, presently the most popular categorization scheme in microbiology, is based on these two domains as well as Eukarya. Nonetheless, bacterial classification continues to be an evolving and growing discipline because of the relatively recent development of molecular sequencing and a fast expansion in the number of genome sequences that are accessible. For instance, some scientists argue that Gram-positive bacteria were the ancestors of the Archaea and Eukaryotes.

In medicine, where the kind of bacteria causing an illness determines the best course of action, laboratory identification of bacteria is very important. Hence, one of the main driving forces for the development of methodologies to detect bacteria was the necessity to identify human infections.

Based on the structural features of their cell walls, bacteria are characterized by the Gram stain, which Hans Christian Gram created in 1884. The "Gram-positive" cell wall's thick peptidoglycan layers show purple staining, whereas the "Gram-negative" cell wall's thin layers show pink coloring. Most bacteria may be divided into one of four types by combining their morphology and Gram-staining (Gram-positive cocci, Gram-positive bacilli, Gram-negative cocci and Gram-negative bacilli. Certain organisms, especially mycobacteria or Nocardia, which exhibit acid-fastness on Ziehl-Neelsen or comparable stains, may be better recognized by stains other than the Gram stain. The development of additional organisms in particular medium or the use of other methods, such serology, may be required for their identification.

Although limiting the development of the other bacteria in the sample, culture methods are intended to encourage the growth and identification of specific bacteria. These methods are frequently created for particular specimens; for instance, a sample of sputum may be treated to identify organisms that cause pneumonia, while a stool sample may be cultured on selective media to identify organisms that cause diarrhea while inhibiting the growth of non-pathogenic bacteria. Blood, urine, and spinal fluid specimens that are often sterile are cultivated in environments created to support the growth of any kind of creature. Once a pathogenic organism has been isolated, its morphology, growth patterns, hemolysis pattern, and staining can be used to further define it.

Similar to bacterial categorization, molecular techniques are being used more often for bacterial identification. In contrast to culture-based techniques, DNA-based diagnostics, such as polymerase chain reaction, are becoming more and more used because of their specificity and speed. Moreover, these techniques enable the identification of "viable but nonculturable" cells, which are metabolically active but do not divide. The overall number of bacterial species is unknown and cannot even be confidently determined using these enhanced approaches. Prokaryotes, which include bacteria and archaea, are currently classified as having slightly fewer than 9,300 known species. However, estimates of the true number of bacterial diversity have

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Vol 10, Issue 2S, February 2023

ranged from 107 to 109 total species, and even these diverse estimates may be off by many orders of magnitude.

B. Nutrition

Bacteria have a very diverse range of metabolic processes. The taxonomy of a collection of bacteria has historically been determined by the distribution of their metabolic properties, although these features often do not match up with current genetic classifications. Based on three main factors—the kind of energy needed for growth, the supply of carbon, and the electron donors used for development bacterial metabolism is divided into nutritional groups. The electron acceptors employed for aerobic or anaerobic respiration are other criteria of respiratory bacteria. Bacteria either utilise organic carbon molecules as carbon sources in heterotrophic metabolism or receive their cellular carbon by fixing carbon dioxide in autotrophic metabolism.

Bacteria are further split into lithotrophs, which utilize inorganic chemicals as electron donors, and organotrophs, which use organic substances. Whereas phototrophic organisms exclusively employ the corresponding electron donors for photosynthesis, chemotrophic species use them for both biosynthetic processes (such as carbon dioxide fixation) and energy conservation (via aerobic/anaerobic respiration or fermentation). By collecting electrons from the reduced substrate and transferring them to a terminal electron acceptor in a redox reaction, respiratory organisms utilise chemical substances as a source of energy. Energy that can be utilized to create ATP and power metabolism is released by this process.

Oxygen is employed as the electron acceptor in aerobic organisms. Some inorganic substances, including nitrate, sulfate, or carbon dioxide, are employed as electron acceptors in anaerobic organisms. This results in the ecologically significant processes of acetogenesis, sulfate reduction, and denitrification, respectively.

In the absence of potential electron acceptors, fermentation is another method of life for chemotrophs. During fermentation, electrons from reduced substrates are transferred to oxidized intermediates to produce reduced fermentation products. Since more energy is present in the substrates than in the products, which enables the organisms to synthesize ATP and power their metabolism, fermentation is feasible.

The biological responses to pollution are also influenced by these processes; for instance, the extremely poisonous forms of mercury that are produced in the environment are mostly due to sulfate-reducing bacteria. Non-respiratory anaerobes produce energy and reducing power via fermentation and secrete waste products from their metabolic processes. Depending on the environmental circumstances they are in, facultative anaerobes may alternate between fermentation and other terminal electron acceptors.

Inorganic materials may serve as a source of energy for lithotrophic bacteria. Hydrogen, carbon monoxide, ammonia, ferrous iron and other reduced metal ions, as well as a number of reduced sulfur compounds, are typical inorganic electron donors. Methanotrophic bacteria may utilise methane gas as a carbon anabolic substrate and an electron source under certain conditions. In contrast to anaerobic circumstances, which employ inorganic substances as their terminal electron acceptor, aerobic phototrophy and chemolithotrophy both require oxygen. Although the majority of organotrophic species are heterotrophic, lithotrophic organisms are often autotrophic.

Using the enzyme nitrogenase, certain bacteria use sunlight to fix nitrogen gas in addition to carbon dioxide. Almost all of the metabolic categories of bacteria mentioned above possess this significant property, although not all of them. The bulk of bacteria can only take in raw materials in the form of relatively tiny molecules, which enter the cell through diffusion or through molecular channels in cell membranes, regardless of the sort of metabolic activity they use. Recently, it has been shown that Gemmata obscuriglobus is capable of ingesting big molecules by a process that mimics endocytosis, the mechanism employed by eukaryotic cells to absorb extracellular objects.

Growth of bacteria goes through four stages. The cells of a colony of bacteria must adjust when it first enters a high-nutrient environment that promotes growth. The lag phase, which is the initial stage of development, is a time of sluggish growth during which the cells adjust to their surroundings of abundant nutrients and become ready for rapid growth. Due to the production of the proteins required for fast development, the lag phase exhibits high rates of biosynthesis. The log phase, also referred to as the exponential or logarithmic phase, is the second stage of growth. Rapid exponential phase characterizes the log phase.

The generation time is the period of time it takes for the cells to double in size, and the growth rate (k) is the pace at which they expand during this phase. During the log phase, nutrients are metabolized as quickly as possible until one of them runs out and begins to impede development. The stationary phase, the third stage of growth, is brought on by nutrient depletion. The cells eat extracellular proteins and slow down their metabolic rate. The expression of genes associated in DNA repair, antioxidant metabolism, and nutrient transport is elevated during the stationary phase, which marks a change from fast growth to a stress response state. The bacteria eventually run out of nutrition and die in the death phase.

C. Reproduction

In contrast to multicellular creatures, unicellular organisms have a close relationship between changes in cell size and reproduction via cell division. Binary fission, an asexual method of reproduction, is the method used by bacteria to reproduce after reaching a set size. Bacterial populations may double every 9.8 minutes when circumstances are ideal, and they can multiply and divide incredibly fast. Two identical clone daughter cells are created during cell division. Although still reproducing asexually, certain bacteria

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Vol 10, Issue 2S, February 2023

develop more intricate reproductive structures that aid in the dispersal of freshly created daughter cells.

Some bacteria move genetic material from one cell to another. Three basic scenarios may lead to this. Secondly, via a process known as transformation, bacteria may take up exogenous DNA from their surroundings. Genes may also be passed on via the transduction process, which occurs when a bacteriophage integrates foreign DNA into a chromosome. Conjugation is the third way of gene transfer, in which DNA is delivered via direct cell contact.

Instead of being a result of bacterial adaptation, bacteriophage transduction of bacterial genes seems to be the result of occasional mistakes made during intracellular assembly of virus particles. Conjugation is an adaptation for moving copies of the plasmid from one bacterial host to another in the well-researched E. coli system. Seldom does a conjugative plasmid integrate into the chromosome of the host bacterial species and then pass on some of the host bacterial DNA to a different bacterium. Moreover, the transfer of host bacterial DNA through plasmids does not seem to be a result of bacterial adaptation but rather an unintentional event.

Transformation is unquestionably a bacterial adaptation for DNA transfer since, unlike transduction or conjugation, it requires a large number of bacterial gene products that interact specially to carry out this intricate process. A bacteria must first reach a unique physiological condition called competence in order to bind, take up, and recombine donor DNA into its own chromosome. Around 40 genes are needed for competence development in Bacillus subtilis. The amount of DNA that is transferred during the B. subtilis transformation may range from one-third to the whole chromosome in length. At least 60 different bacterial species are now known to have the natural capacity to develop into competent for transformation, suggesting that transformation seems to be frequent among bacterial species. Competence in nature appears to be an adaptation for aiding DNA damage repair in recipient cells and is often linked to severe environmental situations.

DNA is transferred between individual bacteria of the same species through transduction, conjugation, and transformation. Nevertheless, rarely, DNA may be transferred between bacteria of different species, which may have serious repercussions, such as the spread of antibiotic resistance. Under these circumstances, gene acquisition from other bacteria or the environment is referred to as horizontal gene transfer, which may be typical under natural circumstances. As it enables the quick transfer of resistance genes across various pathogens, gene transfer is especially significant in the context of antibiotic resistance.

1.1 Economic Criticism

Bacteria are crucial to many industries, including agriculture and manufacturing. Below are a few of them:

1.2 Agriculture's function

Saprophytic bacteria feed on organic waste like animal excrement, dead leaves, meat, etc. a) Scavenging Function Via the aerobic or anaerobic activity of digestive enzymes, they breakdown these compounds (known as fermentation). They are sometimes referred to as scavengers since they contribute to the cleaning of nature. Such as Pseudomonas

1.3 Nitrification

Rhizobium bacterium, which coexists symbiotically with leguminous plants in their root nodules, aids in fixing atmospheric nitrogen. Similar processes are used by Nitrosamines and Nitrococcus to create nitrites from ammonium salt. Nitrobacteria and Nitrocystis further transform nitrates into nitrates. It makes it possible for plants to absorb nitrogen.

D. Creation of Organic Manure

Saprophytic bacteria aid in the breakdown of complicated organic compounds into simpler ones. Consequently, they contribute to the process of turning agricultural waste, dung, and other wastes into manure. Ensilage is preserved cow feed that is made by packaging freshly cut feed that has been dusted with molasses. Lactic acid, which serves as a preservative in ensilage, is produced by bacteria's fermentation activity.

Fuel generation Bacteria aid in the creation of fuel by turning animal dung and other organic wastes into manure. One example of this procedure is the Gober gas plant. Sewage disposal: By digesting sewage, bacteria aid in its disposal and promote environmental cleanliness in the industry

1.1 Dairy Industry

Lactose, a milk sugar, is converted by bacteria like Streptococcus lactic into lactic acid, which coagulates casein (milk protein). Later milk is transformed into curd, yoghurt, cheese, and other products required by industry.

Production of Organic Compounds: During the fermentation process, which involves the breakdown of carbohydrates in the absence of oxygen, a variety of bacteria create organic compounds such as lactic acid (produced by Lactobacillus), acetic acid (produced by Acetobacter acetic), acetone (produced by Clostridium acetabutylicum), etc.

1.2Fiber Retting

Certain bacteria, such as Clostridium and Pseudomonas, operate to separate the stem and leaf fibers of plants from other softer tissue.

1.3 Curing

Certain bacteria, such as Bacillus megatherium, work to remove the bitterness from tea, tobacco, coffee, and coca leaves and beans.

1.4Manufacture of Antibiotics

Mycelia bacteria are the source of several anti-bacterial and anti-fungal antibiotics, including Hamycin, Polymyxin,

and Trichomycin (like Streptomyces). Similar to that, Bacillus is used in the manufacturing of antibiotics like Bacitracin and Gramicidin.

1.5Vitamin Production

A variety of vitamins, including riboflavin from Clostridium butylicum, vitamin B12 from Bacillus megatherium, and vitamin K and B-complex from Escherichia coli, are created by bacteria.

IV. CONCLUSION

Microscopically small unicellular prokaryotic organisms known as bacteria are distinguished by the absence of membrane-bound organelles and a nucleus. For two billion years, the only life on earth was bacteria. More bacteria exist as individual organisms than any other sort of life; one gram of rich soil may contain up to 2.5 billion bacteria. Some instruments need specific gear to cultivate, detect, image, and identify microbes. Microbiology equipment and devices are essential tools for every scientific laboratory that works with microorganisms.

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Vol 10, Issue 2S, February 2023

Viral Disease II: Plant Diseases Caused by Viruses

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Abstract*— A virus is a nucleoprotein that reproduces in living cells and may harm both plants and animals in addition to causing sickness in them. Plant viruses exhibit typical symptoms on sick plants and vary in numerous ways from all other plant pathogens. Almost all viral infections result in the whole plant being stunted and dwarfed, as well as a decrease in output. They may spread from plant to plant in many different ways. Spraying pesticides to reduce the number of insect vectors may help manage sickness brought on by viruses.

Keywords*— Non-Infectious Illnesses, Plant Diseases, Plant Growth, Tomato Mosaic, Viral Disease..

I. INTRODUCTION

The production of potatoes, especially in Europe, is linked to the spread of this virus. It affects a variety of hosts, such as ornamental plants and crops. The PVX incidence may reach 40–50% in an uncared crop since it is carried symptomless and spreads easily via touch. PVX may result in yield losses of more than 10% to 15%, with the severity changing according to the strain, the climate, and the cultivars. All cultivated solanaceous plants, including weeds, are affected. Informal organism. The Poxvirus genus includes Potato Virus X (PVX). This virus is extremely easily mechanically transmitted, for example via tools or clothing. It could also be spread by insects that chew, such as grasshoppers [1]–[3].

A. Symptoms

The majority of PVX strains in popular potato cultivars are asymptomatic. This virus sometimes produces extremely weak, fleeting mosaic that is modest or undetectable. Vein banding, also known as bands of dark green tissue, ring spots, or necrotic bright grey patches, May all be seen along the veins. When PVY is also infected, further harm is sometimes seen. With a light microscope, a great number of many amorphous inclusions caused by PVX infection may be seen.

Such inclusions exhibit virus particles scattered between alternating layers of bent or rolled laminate inclusion components under electron microscopy. Its symptoms vary significantly depending on the strain, type, and location. The key signs of PVY strains are severe or rugose mosaic, bunching and twisting of leaves, and stunting. PVY is usually moderate in potatoes, although some strains may produce severe mosaic and veinal necrosis. The PVY strains are all flexible rods of various lengths. In the systemically infected tissues of potato plants, PVY causes pinwheel inclusions that may be detected under an electron microscope [4]–[6].

B. Y Potato virus pathogen (Poxvirus genus)

The three most significant aphid vectors for PVY are Myzus persicae, Macrosiphum euphorbiae, and Aphis gossypii. PVY is mostly spread by infected tubers or virulent vector aphids. These viruses are transiently carried by aphids.

C. Control Techniques

While producing the nucleic/foundation seed supplies, clonal selection and serological testing are often used to control the mosaics. The best strategy for controlling potato mosaics is to implement the following comprehensive schedule of procedures:

Start with dependable virus-free seed tubers, and if at all possible, choose resistant kinds.

1. Spray weed killer(s) and raise a blind earthling.
2. Use systemic (soil foliar) pesticides to reduce the aphid population.
3. Start your plants early. As soon as it is discovered, all contaminated plants should be removed.

D. Mosaic of a tomato ring

Tomato mosaic virus is the name of the virus that causes the common tomato mosaic (tobamovirus group). A synonym is Lycopersicon virus, there are several viral strains that cause various symptoms, many of which have been labeled as distinct illnesses. These strains include tomato rosettes, tomato ringspots, tomato aucuba mosaic, and tomato enation mosaic [7].

E. Pathogen

Lycopersicon virus 1 is a synonym for tomato mosaic virus (tobamovirus group).

Because of its high stability, the tomato mosaic virus may survive in dry contaminated soil, infected tomato debris, on, or in the seed coat. The virus is easily spread mechanically from plant to plant.

F. Symptoms

Tomato mosaic symptoms are often regulated by a number of variables, including tomato type, virus strain temperature, day length, light intensity, and plant age. A viral infection on tomatoes results in the leaves having spots of bright and dark green on them. The sunken green patches give the leaf a rough look. Young plants sometimes stunt and have their

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Vol 10, Issue 2S, February 2023

leaves deformed into tendril or "fern leaf" shapes, albeit there may be very little mottling.

In severe instances, the lamina of both old and young leaves nearly completely turns light yellow to white, with sporadic little islands of green that stand up like blisters. Some viral strains may induce fruit mottling, streaking, and necrosis [4]–[6], [8].

1. Infected seedlings might result in plant death.
2. Fruits are scarcer, smaller, and often malformed.
3. Stems, petioles, leaves, and fruits may all develop necrosis under particular circumstances. The plant's growth is slowed down but it is not destroyed.

The virus causes pollen sterility, which has the effect of reducing fruiting and yield (Giri and Mishra, 1992).

G. Bunchy banana top

The most harmful illness to bananas is a blotchy top. The condition known as the banana bunchy top is prevalent in places where bananas are grown. The infected plant develops a cluster of leaves at the apex known as a rosette as a result of the viral infection caused by Banana virus I. In 1879, a case of the banana bunchy top sickness was discovered in Fiji. The illness was initially identified in India in 1940 from Kerela State Symptoms.

Every stage of plant development might experience the illness and its bunchy top symptoms. A rosette-like look is created when the leaves of a severely diseased plant are clustered together at the apex of the pseudo stem. The first outward indication is the emergence of erratic, brown streaks along the secondary veins. Streaks of chlorosis may be seen along the midrib section of the leaf. Furthermore, dark streaks appear on the leaf petiole. The width and breadth of the leaf decrease. The sick plant has a rosette-like collection of leaves at the tip. The affected plant grows slowly. The diseased plants often don't produce any fruits. The diseased plant's phloem is rather disordered [9] [10].

II. DISCUSSION

Plant viruses exhibit typical symptoms on sick plants and vary in numerous ways from all other plant pathogens. Almost all viral infections cause the whole plant to become smaller, stunted, and produce less. They may spread from plant to plant in many different ways. Spraying pesticides to reduce the number of insect vectors may help manage sickness brought on by viruses. The Potexvirus genus includes the Potato virus X (PVX). Many hosts, including attractive plants and crops, get infected. Tomato mosaic virus is the name of the virus that causes the common tomato mosaic (tobamovirus group). The most harmful illness to bananas is a blotchy top. The bunchy top disease of bananas is common in nations where bananas are grown. The genus Echovirus includes the tobacco necrosis virus (TNV). The aquatic fungus Olpidium brassicae spreads the virus.

A. Brinjal root knot disease

The endo-root parasite known as the root-knot nematode, Meloidogyne sp., lives in soil and is found all over the globe. It affects almost every plant known to man from the nursery stage. Severity of Meloidogyne spp.-caused root-knot disease in brinjal.

B. Symptoms

Little tubercles are the first signs of nematode infection on the root, but intense and localized infestations cause excessive cell proliferation, which results in gall development. If the infection was severe and early, the plants grow slowly and seem stunted. The leaves, which range from yellow to yellowish green, often droop and unexpectedly wilt. In every instance, the primary roots and the laterals produce spherical to elongated galls by contagious microorganisms such nematodes, bacteria, viruses, and fungus. They may also be harmed by non-infectious elements including soil, water, etc., leading to issues that are collectively known as "abiotic illnesses" or "abiotic disorders."

Abiotic conditions that may harm or even kill plants include unfavorable soil conditions, nutrient imbalances, moisture and temperature extremes, chemical toxicity, physical injuries, air pollution, genetic abnormalities, and other issues. Deficits in macro- and micronutrients as well as an overabundance of certain chemical molecules, such as O3, PAN, SO2, Hf, etc., may potentially harm plants. The numerous non-parasitic illnesses are covered in this section.

C. Diseases of plants caused by abiotic factors

Soil composition

The soil's capacity to store water, nutrients, and oxygen and make them accessible to plants depends on its structure. Compaction is the most frequent problem with soil structure because it leaves insufficient pore space for root development. Due to their smaller pore size and

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Vol 10, Issue 2S, February 2023

smaller particle size, clay soils are more likely to become severely compacted. Traffic (especially from large agricultural or construction equipment), raindrop impact, tilling activities (plow layer), and insufficient crop rotation are only a few of the factors that may cause compaction. Since runoff happens more often in compacted soil and there is a limited amount of pore space available to store water, reduced water availability is an evident result of compaction. However, a negative impact of constrained soil pore spaces might also be insufficient oxygen availability for root respiration.

D. pH of the soil

The H+ ion activity in the soil solution is gauged by the pH of the soil. Acidic soil is caused by high H+ activity, whereas alkaline soil is caused by low H+ activity and a preponderance of OH- activity. It is widely accepted that a slightly acidic pH range of 6-7 is most conducive to plant development, even though certain plant species have preferences for more severe acidic or alkaline soil conditions. Outside of this range, soil pH may significantly affect the solubility and hence availability of plant nutrients. The availability of calcium (Ca), magnesium (Mg), and phosphorus (P) is often reduced in soil with a pH below 5.5, whereas the solubility of aluminum (Al), iron (Fe), and boron (B) is typically enhanced (B). These three nutrients are often present in high concentrations in low-pH soils, which may cause plant poisoning symptoms. Ca and Mg are highly available in soils with pH values over 7.8, but P, B, Fe, manganese (Mn), zinc (Zn), and copper are less so (Cu). These alkaline soils often cause nutritional deficiencies in the plants that are planted there.

E. Extremes of moisture

Water is a crucial component for plant development and survival. Depending on the type and climate, plants' water requirements may vary substantially. The physiology and biochemistry of any specific type of plant are impacted if water needs are not sufficiently supplied. Plants may suffer damage from both much and insufficient water. The damage may sometimes be acute (lasting a few hours) or persistent (chronic days or weeks). When an injury is short-lived, plants may heal, but as the time period goes on, the chance of recovery reduces since the general function and development of the plant will continue to be negatively impacted.

F. Deficiencies in the water supply

There are two types of low water status in plants: acute and chronic. A brief water shortage could only have minimal consequences on the plant, like wilting leaves or shoots. These signs and symptoms, which manifest during the hottest portion of the day when transpiration rates are at their peak, may only last a short while. The signs of low water status may go away after the environmental pressures are removed (i.e., the air temperature drops, supplementary irrigation is used, a rain event takes place, etc.).

G. Damage from high temperature

High temperatures may be quite stressful for certain plant species. Physiological changes may occur in plants that are acclimated to colder climes in reaction to abnormally high temperatures. For instance, if high temperatures persist for a long time, shoots and/or roots may cease developing. Roots may perish. High temperatures and poor soil moisture may cause blistering on the leaf edges, early leaf loss, and in extreme situations, complete plant death in plants. Physiological changes may sometimes cause aberrant growth patterns or color. For instance, freshly formed leaves of geraniums (Pelargonium spp.) get "bleached" or white when exposed to temperatures exceeding 95°F (35°C). The influence of high temperatures on pollination is another frequent event. When temperatures are high, several kinds of food crops are particularly vulnerable to inadequate pollination.

H. Injury from low temperature

Ice crystals that form in plant cells harm cell membranes and organelles, which is usually how damage from low temperatures manifests. Low temperatures might also lead to dehydration or poor water status. Several tropical native plants are susceptible to chilling injury, which kills them if subfreezing temperatures persist for an extended length of time (damage occurs above 32°F 0°C).

ISSN (Online) 2456 -1304
International Journal of Science, Engineering and Management (IJSEM)
Vol 10, Issue 2S, February 2023

It's possible that some plants are better suited to cold climates and won't suffer harm until temperatures are at or below freezing (32°F 0°C). For instance, Bermuda grass is evolved to grow in the southern regions of the United States, but somewhat further north, Bermuda grass has a long time of winter hibernation and is also susceptible to death from persistently subfreezing winter temperatures.

I. Chemical Damages

Herbicides, insecticides, fungicides, and plant growth regulators are just a few of the agricultural chemicals utilized in the cultivation and maintenance of plants. Before using a pesticide, always read the label. These substances are used on plants to ward off pests and enhance plant health, although exposure to ineffective substances, excessive doses, or certain product combinations might result in serious issues. It is advisable to test on a limited scale initially before utilizing a substance or combination for the first time.

J. Herbicides

Herbicides are used to suppress weeds, but contact with plants that are not their intended targets may be fatal. Herbicides may be selective or nonselective, affecting certain plant types or all plants (e.g., broadleaf plants or grasses). Within certain groups, they could be even pickier. Several herbicide mechanisms of action include hormone mimics, membrane disruptors, amino acid biosynthesis inhibitors, lipid biosynthesis inhibitors, and respiration inhibitors. Photosynthesis, root and shoot development, as well as other elements of plant growth, may all be impacted by these modes of action.

Certain herbicides may produce root swelling or stunting, which might be mistaken for nematode damage. Some herbicides may produce necrotic/chlorotic blotches or patches that resemble foliar diseases. Certain herbicides may produce distorted or banded veins, mottled hues, or other symptoms that resemble viral diseases. For instance, grapes, cotton, tomatoes, and many other plants exhibit deformation brought on by the phenoxy herbicide 2,4-D, a synthetic auxin that may be mistaken for a viral illness. Diuron may produce vein discoloration in grapes, which can be mistaken for a viral infection or a dietary issue.

K. Fungicides and Insecticides

While fungicides and insecticides are intended to protect plants from ailments and arthropod pests, the application of them at the wrong dosages or in the wrong tank mixtures might result in issues. There is ample evidence of the phytotoxic effects of several fungicides. Tissue bronzing may be caused by copper materials. Many crop varieties, like grapes, have certain cultivars that are more susceptible to copper or S. Some pesticide mixtures, such as captan or sulfur with certain oils, might be harmful, particularly in warm weather. Labels and extension papers for fungicides often include known incompatibilities.

L. Plant growth control agents

Chemicals called plant growth regulators (PGRs) change the physiology of plants by impacting blooming, elongation, root development, and other processes. They are used to produce a wide variety of crops. For instance, PGRs are employed in various fruit crops to increase fruit quality, thin fruit to the proper levels, and minimize vegetative development. Gibberellin inhibitors are used on ornamentals as substrate drenches or foliar sprays to prevent shoot elongation, which results in plants that are more robust, compact, and high-quality overall. In turfgrass, cell division inhibitors are used to lower seed head production whereas cell elongation inhibitors are used to lower the frequency of mowing.

Sadly, PGRs may also have unfavorable impacts. For instance, ornamentals may experience brief chlorosis if chlormequat chloride, a gibberellin inhibitor, is applied topically to the leaves. The results may be severe, with long-lasting discoloration, stunted development, or other symptoms, if applied at the incorrect rate, at the incorrect time, or under certain environmental circumstances (such as intense light or high temperature). Certain fungicides also have detrimental effects on growth regulation, which

ISSN (Online) 2456 -1304
International Journal of Science, Engineering and Management (IJSEM)
Vol 10, Issue 2S, February 2023

may be more pronounced in some species or cultivars or during hotter temperatures.

M. Ice melt salts

The use of deicing salts to reduce the melting point of ice on sidewalks and roads may seriously harm nearby trees, grass, and landscaping plants. For instance, when sodium chloride salt (NaCl) is dissolved in water, it separates into sodium (Na) and chloride (Cl), both of which are harmful to plants in large quantities. By competing with other nutrients at the root exchange sites, sodium affects the availability of nutrients, especially Mg and K. Furthermore, absorbed by plants, the disassociated chloride ion builds up in leaves where its concentration might become hazardous.

In addition to absorbing water, salt modifies the osmotic potential of the soil solution, causing water to drain from the root rather than enter it. These elements work together to produce the "burn" symptom, which is often described as a chlorotic scorch symptom of leaf blades, with or without a clearly defined lesion border. Once the snow melts in the spring, reports of the initial observations of salt toxicity are often made. Knowing how close a plant is to a road or sidewalk surface and seeing a reduction in plant symptoms as salt source distance rises are both very helpful in making the diagnosis of salt harm.

N. Mechanical Damage

Storms, equipment abuse, animal activity, and other factors may all cause mechanical damage. The majority of injuries of this kind are related to a particular incident, and the onset of symptoms is often related to the period of the incident. Simple signs of mechanical damage include tree trunks with ripped bark, flattened tree tops, and broken limbs. Yet, when the root system is impacted, subtle signs of general deterioration might emerge. Mechanical harm to plants may result in open wounds that serve as entrance sites for diseases, induce a sluggish decline, or even result in their complete death.

O. Strange plant growths

Variegated plants, sloughing bark, and strange growths are other signs that might be mistaken for plant diseases but are truly abiotic in nature. In the horticulture sector, plants that have variegated leaves are often propagated. For instance, many gardens often include variegated hostas. These plants' whitish tissue in the leaves lacks chlorophyll. A genetic mutation caused this illness. Because of the trait's instability over the course of conventional seed production, these plants are typically grown vegetatively. Since they generate less chlorophyll than their solid-green counterparts, variegated plants often grow to be smaller.

Concern should be expressed if a tree's bark seems particularly harsh or separates from the wood. The concern is likely justified if this is a recent occurrence. That is more probable a natural occurrence if the tree loses its bark every year. Early in the summer, sycamore trees often shed their bark after a period of fast development. Sometimes the bark disappears gradually, and other times it seems to blow off in a matter of days. The health of the tree is unaffected by this typical process.

Burls, bumpy bark, and other strange plant growths can resemble the signs of contagious illnesses. Burls, lignotubers, and other growths on trees, however, are often brought on by an injury. Burls typically range in size from little to enormous. The burl is covered by the bark, which doesn't look broken or sunken and is still whole. In the spring, lignotubers typically include a group of buds that shoot quickly. While these gnarled growths seem strange, they don't appear to have a significant effect on the tree's health.

P. Animal injury

While technically not "abiotic," damage caused by animals and birds is featured here as another example of wounds that can be mistaken for disease signs. Animal damage may also make plants more susceptible to disease by making them weaker and opening up entrance routes for infections via wounds. The importance of insect and arthropod feeding on the health of the plant as a whole is not discussed here. Voles and rabbits eat bushes, young or thin-barked trees, and a lot of snow during harsh winters. During the peak of the

ISSN (Online) 2456 -1304
International Journal of Science, Engineering and Management (IJSEM)
Vol 10, Issue 2S, February 2023

snowpack, little plants may be cut off, and overfeeding can cause girdling and plant death. For addressing this kind of damage, habitat alteration, protective barriers, and live traps are the best solutions.

Animals like squirrels and porcupines may harm trees by removing their bark. On the ground, there may be a few small, trimmed twigs. In most years, squirrel damage to trees in urban landscapes is minor. Yet, during difficult years, squirrels might remove enough bark to result in branch dieback in the tree. By erecting a 2-foot-wide collar of metal hardware cloth approximately 6 feet from the ground, individual trees may be protected. Squirrels may also be captured using live traps.

Deer graze by nibbling on buds and young stems, which may give certain plants a bushy look. This could have an impact on the plant's visual appeal. Male deer are more harmful because they often break limbs when they brush the velvet off of their antlers. Trees may be permanently deformed and rendered feeble by this harm. The main management techniques for avoiding this kind of harm are fencing and repellents. In addition to eating several horticultural and agronomic agricultural plants, deer may be a problem for many farmers. Several holes in a straight line that are either vertically or horizontally oriented on tree trunks are a sign of sapsucker damage. Yellow-bellied sapsuckers belong to the family of woodpeckers. They consume insects, much like other woodpeckers, but they can also consume tree sap thanks to their tongues that resemble brushes. Sapsuckers eat a variety of ornamental and fruit tree species, including cherry and apple as well as pine, maple, birch, hemlock, Atlas cedar, and mountain ash.

Trees that have suffered severe damage will be less tenacious and more vulnerable to environmental stress, disease, and pest issues. It is unlawful to kill yellow-bellied sapsuckers since they are protected by the Migratory Bird Treaty Act, which is governed by both state and federal law. It may be possible to decrease their feeding activity by using barriers, repellents, or scare techniques.

Q. Many non-infectious illnesses

Damaged blooms may fall off their little stalks and become dry, brown, and fruitless (pedicels). Environmental pressures and poor soil fertility that prevent floral pollination have been linked to blossom drop. Blossom decline is linked to extended periods of high temperatures (over 90°F) and wind throughout the day. Yet, for efficient flower pollination, nighttime temperatures may be most crucial. Outside of this range, the nighttime temperature inhibits efficient pollination and encourages flower drop. Over-fertilization with nitrogen promotes luxuriant vegetative growth while reducing flowering and/or pollination.

Applying fertilizer at the appropriate rates for tomatoes minimizes blossom drop, although nothing can be done if extreme heat and wind arise during blooming. Recently, heat-tolerant cultivars have been created, which might lessen bloom drop brought on by high temperatures. While shading and overhead irrigation may lower temperatures, their effectiveness wanes over extended hot spells.

R. Blossom-end rot

A tomato disease that is simple to identify is blossom-end rot. Fruit is most often harmed when it is approximately halfway through its growth cycle. The first signs appear as a little, tan, water-soaked patch close to the fruit's bloom end. The area becomes bigger, darker, sunken, and leathery. Fruit that has been infected often ripens too early and is vulnerable to secondary diseases that cause fruit rot.

A condition known as "flower-end rot" is considered to be brought on by a localized calcium deficit in the fruit's blossom end. Calcium is essential for plant growth because without enough calcium, tissue breakdown occurs in fast-developing fruit. As calcium is water soluble, it travels with the water stream in the plant. Water moves quickly and is used more often when it's hot and windy. Calcium availability to the outer parts of fruit is limited because fruit does not transpire water as well as leaves do. As a result, blossom-end rot is encouraged by extreme heat and wind, drastically changing water supply and drought stress. In contrast, extended periods of high soil

moisture might harm the root system and its capacity to absorb calcium. In Oklahoma, blossom-end rot is seldom directly caused by a calcium deficit in the soil. On the other hand, excessive growth brought on by increased nitrogen fertility may also encourage blossom-end rot.

S. Control

It is important to follow the suggested soil fertility techniques for growing tomatoes in Oklahoma. Blossom-end rot may be lessened by using nitrogen fertilizer in the nitrate form rather than the ammonium form, which may hinder calcium absorption. Roma tomato types should be avoided since they are quite prone. Keep appropriate and consistent soil moisture levels by irrigation, especially during dry spells and high temperatures. Maintaining a consistent and stable soil moisture profile is made easier by drip irrigation and the use of plastic or organic mulches. Applications of agricultural lime or gypsum should be applied prior to transplanting in the uncommon event that a soil test result reveals a calcium deficit. Because of limited absorption and poor transport to fruit, where it is required, foliar sprays containing soluble forms of calcium are of little use

The phrase "cat face" refers to fruit that is deformed and has scars on the blossom end. Fruit that is deformed may take on numerous forms than the typical kidney shape. Brown scar tissue bands may develop in between the fruit's enlarged regions. Deep indentations or cavities may be seen on the fruit. Catface, which most often affects newly formed fruits, causes uneven ripening and decreased market quality in the affected fruit. The most vulnerable tomato cultivars are those with exceptionally huge fruit. The pistil of the flower, which finally develops into the fruit, exhibits aberrant development, leading to cat face. Cat face is a condition that is known to be brought on by low temperatures (below 58°F) during flower growth and bloom and by exposure to hormone-type, phenoxy herbicides like 2,4-D.

Solar calamity Sunscald typically occurs in mature green and breaker-stage (first pink) fruit that is exposed to bright sunshine. During ripening, affected fruit develops white, bleached regions on exposed sections (often the shoulders of the fruit). Later, sunken patches with a paper-like surface form. Control: Keeping healthy foliage is crucial to preventing sunscald on growing fruit. Premature defoliation must be avoided by managing foliar bacterial, fungal, and spider mite infections as well as spider mite damage. Tomatoes that are caged experience less sunscald than those that are allowed to grow on the ground or stalks. In situations where fruit will likely be exposed to direct sunlight, artificial shading may be advantageous.

Yellow shoulder, also known as heat ripening or persistent green shoulder, is a tomato fruit ripening disorder. Fruit that is impacted is green or ultimately becomes yellow rather than red on the shoulders. It may impact the whole shoulder or just a strange region. The top fruit's inside is still firm and white. The exact etiology of the yellow shoulder is unknown. It seems that this illness is expressed in fruit that has been exposed to high temperatures during fruit ripening and maturity. The vulnerability of tomato types to yellow shoulders varies, with varieties with dark green shoulders being more vulnerable than those with uniform ripening. Using cultivars resistant to yellow shoulders can help you obtain optimum control. When fruit is harvested at the breaker stage (initial pink hue) and left to mature at room temperature during hot spells, a lesser incidence of yellow shoulder might be anticipated.

III. CONCLUSION

Crop and ornamental plants may suffer damage from high micronutrient levels as a consequence of over-applying fertilizers or manures. In hot, dry circumstances, nitrogen toxicity is most common, and plants develop an excessively dark shade of green. Annual seedling stem lesions are frequent and may be mistaken for canker infections. Similarly, mature tomato plants suffering from ammonium toxicity may exhibit twisting and distortion that resembles viral symptoms. Since greenhouse soils lack certain bacteria that convert ammonium to nitrite and ultimately to nitrate, ammonium toxicity may be a concern.

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A Brief Overview of the Structure of Viruses

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***Abstract*— A virus is an infectious microorganism made up of a protein-coated segment of nucleic acid (either DNA or RNA). Viruses possess a variety of forms, including rod, spherical, and helical. Viruses may be considered as mobile genetic components, most likely of cellular origin, and distinguished by a protracted co-evolution of virus and host. A virus can't multiply by itself; it has to infect cells to utilize the host cell's components to generate copies of itself. In this chapter, we discussed the structure of the virus.**

***Keywords*— Host Cell, Genetic Material, Phage Particle, Viruses Infect, Viruses Structure.**

I. INTRODUCTION

Viruses are no longer regarded as the most basic kind of life. The peculiarity of viruses, a special class of infectious organisms, lies in their straightforward, acellular structure and mode of replication. One or more DNA or RNA molecules wrapped in a protein sheath make up the basic, acellular components of viruses (and sometimes, in addition, substances such as lipids and carbohydrates. These are strictly intracellular parasites that can only replicate inside live cells. These are straightforward obligate parasites, which consist of a protein coat and nucleic acid (DNA or RNA. Although more basic than cellular organisms, viruses are quite significant and deserving of thorough study. The field of molecular biology has greatly benefited from the study of viruses [1]–[3].

In 1898, Dutch bacteriologist Beijerinck. He found that TMV could be precipitated from an alcohol solution without losing its infectious properties and that the fluid could diffuse through agarose gel during his experiment. These qualities were not shared by bacteria or any other kind of living being. Viruses are the root cause of a wide range of serious disorders. Smallpox, polio, influenza, hepatitis, HIV/AIDS, hepatitis, measles, and the SARS coronavirus are among the most well-known human viruses.

Antibiotics are particularly efficient against illnesses brought on by bacteria, but they are useless against viruses throughout antiquity, there have been confirmed claims that river waters may treat contagious illnesses like leprosy. Ernest Hanbury Hankin wrote in 1896 that a substance found in the waters of the Ganges and Yamuna rivers in India had a notable antibacterial effect against cholera and could pass through a very fine porcelain filter.

Frederick Twort, a British bacteriologist and director of the Brown Institute in London, discovered a tiny agent that could both infect and kill bacteria in 1915. In his opinion, the causative agent must be either a stage in the life cycle of the bacteria, an enzyme generated by the bacterium, or a virus that infected and killed the bacteria [4]–[6]

Control strategies focus on vaccinations (antibodies produced against a specific viral component) or symptom alleviation to support the body's natural defensive mechanism. Viruses also contribute to several serious plant diseases and significantly lower food yields and quality around the globe. Depending on the disease, infected plants may exhibit a variety of symptoms, but often exhibit leaf yellowing (either of the whole leaf or in a pattern of stripes or blotches), leaf deformation (such as curling), and/or other growth deformities (e.g. stunting of the whole plant, abnormalities in flower or fruit formation).

A. Classification

It is particularly challenging to identify viruses because of their ultramicroscopic size, the existence of both living and non-living characteristics, and the lack of fossil records. Clinical, epidemiological, and pathological signs of viruses are divided into the following four categories based on their host range:

B. Plant viruses

These viruses exclusively infect plants, and they are separated into bacterial viruses, algal viruses, fungal viruses, etc. based on their hosts.

C. Invertebrate viruses

Invertebrates may get these viruses. The order Mononegavirales, the families Orthomyxoviridae, Bunyaviridae, and the unnamed genus Tenuivirus all share many traits. These viruses contain a single-stranded negative RNA genome with one to eight components.

D. Vertebrate viruses

1. They harm creatures that are vertebrates.
2. Viral agents that infect two of the aforementioned hosts are known as dual-host agents.

Holmes grouped all viruses into a single order in 1948. Three suborders of the variables include:

E. Phagineae

Bacteriophages belong to this suborder. Viruses that infect plants are included in the suborder Phytophagineae.

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F. Zoophagine

Viruses that infect animals are included in this suborder.

G. Structure and size

Because of the importance of viruses and their straightforward structure, morphology has been studied for decades, and advancements have been made thanks to the application of a number of cutting-edge techniques, including X-ray diffraction, immunology, SEM, TEM, biochemical analysis, and electron microscopy. A basic viral particle, or vision, has a nucleic acid core that contains genetic information and is encased in a protein shell. Between 60 and 95 percent of viruses are made of protein [7]–[9].

Until recently, the size of a virus was estimated by filtering it through a collodion membrane with a predetermined porosity, but thanks to technological advancements, ultracentrifugation, and electron microscopy are now used. The range of sizes is between 10 and 300 or 400 nm. Enteroviruses, which have a diameter of less than 30 nm, are the tiniest kind of virus. The orthodox virus is the biggest, measuring between 240 to 300 nm, or roughly 1/10 the size of a red blood cell. Bacteriophages range in size from 65 to 200 nm. The genetic material of viruses is composed mostly of nucleic acids, which may either be DNA or RNA. Deoxy viruses are viruses that include DNA, while rib viruses are viruses that contain RNA. single-stranded RNA is present in all plant viruses.

1. Double-stranded DNA or single or double-stranded (rarely) RNA are both present in animal viruses.
2. Double-stranded DNA makes up the majority of bacterial viral DNA, however, single-stranded DNA or RNA may also be present.
3. Although only a few insect viruses include DNA, the majority of them possess RNA. A molecule ranges from 1,000 to 250,000 pairs.

H. Coat of protein

The capsid, a protective portion coat, surrounds the nucleic acid core. A number of identical protein components, called capsomeres, make up each capsid. The proteins might be of one kind or several. The quantity of proteins and the configuration of capsomeres are distinguishing characteristics of viruses and may help identify and categorize them. The capsomeres maybe pen tamer or hexamer shaped.

The capsid of certain complex organisms, such as influenza and herpes viruses, is encased in an envelope. Typically, it contains a mix of lipids, proteins, and carbs. Many viruses have projections on their envelopes called spikes that are in charge of attaching to the host [10], [11].

Bacteriophage viruses, sometimes referred to as bacteria viruses, are those that infect bacterial cells. The first discoveries of bacteriophages were made in 1915 by F. Twort in England and in 1917 by F. d'Herelle in France. Bacteriophage is the phrase D' Herelle used (eaters of bacteria). Bacteriophages may thrive as obligatory parasitic parasites in any environment where bacteria can. They may be found in milk, vegetables, fruits, sewage water, soil, milk products, fruit, and legume root nodules. Moreover, certain phages have been discovered in the intestines of mammals and birds. Phosphates may be detected in the colon, urine, blood, saliva, pus, and nasal discharge of humans.

A virus that infects bacteria is known as a bacteriophage. Phage is a frequent abbreviation for the word. Bacteriophages have a wide variety of forms and functions, much as viruses that infect eukaryotes (plants, animals, and fungi). They are generally constructed from an exterior protein shell containing genetic material. The genetic material may be circularly or linearly arranged single-stranded RNA, double-stranded RNA, single-stranded DNA, or ssDNA that is between 5 and 500 kilobase pairs long. Bacteriophages typically range in size from 20 to 200 nanometers. Phages are pervasive in the environment, and people habitually consume and drink large doses of them without suffering any negative effects.

I. Varieties of phages

1. T-phages

They have the greatest clusters of phages with ds DNA and are distinguished by the presence of a tail. T2, T4, and T6 (T-even phages) are examples; they are also known as virulent phages. The bacterial cell is fully killed soon after the viral genome replicates. This is known as virulent infection, and it is often employed in phage treatment.

2. Virulent and temperate phages

Phages are viruses that infect microorganisms, whereas bacteriophages are viruses that infect bacteria. A virus may be compared to genetic material enclosed in a protein covering. This genetic material may modify the host after being injected into a cell, causing the host cell to eventually perish since all of its energy and metabolism are focused on producing other virus particles. Certain phages are constantly searching for cells to multiply in. Some phages may bind to the chromosome of the bacterial cell and hang around there inactively for a long period. A virulent phage is active.

The inert ones are referred to as temperate or lysogenic; they may become virulent if the system is jolted by an occurrence like a temperature or pH shift, but some host cells survive and continue to grow. Temperate phages have no noticeable impact on their hosts when they are not in their virulent state. One of the numerous dangerous phages that infect E. coli is T4. It attaches to the cell wall with its sheath, and constriction drives some phage DNA (some phages are RNA) into the cell, turning it into a facility for producing other phage particles.

II. DISCUSSION

A. Bacteriophage structure

As bacterial filters cannot distinguish between bacteriophages, electron microscopic examinations of certain

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Vol 10, Issue 2S, February 2023

bigger particles (T-even group) that infect the bacterium E. coli are used to determine the bacteriophages' structural features. The phage has a head and a tail and resembles a tadpole or spermatozoid in appearance. The head might be hexagonal or prismed (T, T2, or T6) (T3 and T7) the filamentous phages do not differentiate between a head and a tail. The head measures around 950 by 650 millimeters. The collar refers to the extended portion between the head and the tail. The tail has an 80-millimeter diameter and is the same length as the head. A 200 thick hexagonal end plate with six tail pins (fibroin) on its underside (each measuring around 1500) is found at the proximal end of the tail. The phage particle is attracted to the surface of the bacterium by the tail pins, and the enzymes produced by the tail pins are what cause the lysis of the bacterial cell wall.

B. Chemical structure

1.1 Replication

While all viruses share a fundamental mechanism for penetration and reproduction, bacteriophages are the ideal study subject for this process. They multiply via two additional techniques:

1.2 Lysogenic cycle

Lytic cycle T-even bacteriophages reproduce by lysis. Four stages are included in this cycle:

1. An infection
2. Phage component synthesis in host cells.
3. Synthesis of a fresh phage particle.
4. Phage particles are released from the host cells.

1.3 How the infection begins:

The infection begins with the transfer of phage nucleic acid into the host cell and the phage's adsorption on the host bacterium with the aid of its tail fibers. The phage and bacterium's shared affinity determines the adsorption. Some phages only adsorb at certain sites, whereas others infect a specific bacterium (receptor site).

Phage components are synthesized in the host cell: Within the bacterial cell, the phage nucleic acid commandeers the organism's system for synthesizing proteins. It inhibits bacterial protein synthesis and instructs the cell's metabolism to create the proteins for the phage particle. This is achieved by the production of viral-specific m-RNA, which instructs the host cell to produce proteins that serve as components of the phage particle's protein coat. They are referred to as late proteins. Phage lysozyme, a late protein, is produced when phage nucleic acid replication nears its conclusion.

1.4 New phage particle assembly

The process of assembling late proteins and nucleic acids into new phage particles is known as maturation. The viral genome is in charge of this process. It involves the crystallization of nucleic acid, the gathering of protein subunits around DNA to create the head, the connection of the core tube to the tail plate, the attachment of the tail to the head, and the attachment of the tail fibers to the end plate.

Phage particles are released from the host cells by lysis, which is necessary for this process. Lysozyme released by the phage DNA in the host cell helps to promote it. Lysis causes the host cell to burst, releasing the phage particles Between 30 and 90 minutes, the full phage development cycle is finished. A bacteria that is infected produce 7-8 phage particles every minute, for a total of roughly 200 phages.

1.5 Cycle of lysogenesis

Some phages demonstrate a lysogenic cycle but do not induce lysis of the host cell. Lysogenic phages, also known as temperate phages, are phages that reproduce in this way, and lysogenic cells are the host cells that support them. DNA from the phage is injected into the host cell. Through recombination, the linear phage DNA transforms into circular and fuses with the bacterial chromosome. Prophage is the name given to the implanted phage DNA. Two repressor proteins that are produced by phage genes inhibit the activation of prophage genes. This examines if fresh phages are being produced within the host cell. The prophage multiplies together with the bacterial chromosomes each time a bacterial cell divide. Inside the progeny cells, the prophage is still dormant.

C. Economic criticism

All cellular eukaryotes (vertebrate animals, invertebrate animals, plants, fungi) and prokaryotes are infected by viruses (bacteria and archaea). They only reproduce in living things because they are obligate parasites. As a result, we must comprehend the nature of viruses, how they reproduce, and how they cause illness. These creatures are crucial. The creation of vaccinations, diagnostic tools and methods, and antiviral medications, this information enables the development of efficient methods for the prevention, diagnosis, and treatment of viral illnesses. The discipline of virology heavily relies on these medicinal applications.

D. Effects of viruses negatively

The economic effect of several viruses that cause illness in domestic animals and agricultural plants, such as the foot and mouth disease virus and the rice yellow mottle virus, makes veterinary virology and plant virology essential as well. In the dairy business, where phages may infect the lactic acid bacteria responsible for the fermentations that generate cheese, yogurt, and other milk products, viruses can also inflict economic harm. Many human illnesses, from minor (such as common colds) to fatal (such as rabies), are caused by viruses. Viruses also play a part in the development of a number of cancers. The health of societies may also be impacted by virus illnesses. AIDS is having a significant effect now, much as smallpox did in the past.

III. CONCLUSION

One or more DNA or RNA molecules wrapped in a protein

sheath make up the basic, acellular components of viruses (and sometimes, additional, substances such as lipids and carbohydrates). A basic viral particle, or vision, has a nucleic acid core that contains genetic information and is encased in a protein shell. Between 60 and 95 percent of viruses are made of protein. The genetic material of viruses is composed mostly of nucleic acids, which may either be DNA or RNA. Deoxy viruses are viruses that include DNA, while rib viruses are viruses that contain RNA.

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Characters, Economic Importance, Classification, and General Account of Major Classes of Fungi

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***Abstract*— Eukaryotic creatures known as fungi include yeasts, mounds, and mushrooms as well as other microbes. These organisms fall under the category of fungus. The creatures that make up the Kingdom Fungi are pervasive and have a cell wall. They fall under the category of heterotrophs among living things. In this chapter, we discussed the classification and economic importance of the fungi.**

***Keywords*— Cell Wall, Diploid Nucleus, Fungi Hypha, Germ Tube, Higher Fungi..**

I. INTRODUCTION

Man's fascination with fungi was first aroused by the sight of attractive, umbrella-shaped mushrooms and toadstools growing on soils forming fairy rings. Lower plants have a special class of organisms known as fungi (plural, fungus). The term "fungi" derives from the most famous examples, which are mushrooms (Greek- mykes, Latin- fungus). They are eukaryotes, like plants, and share features including a cell wall, liquid-filled intracellular vacuoles, microscopically visible cytoplasm streaming, and immobility. Despite this, they lack photosynthetic pigments and are chemo-organotrophs. Most of them grow aerobically and get their energy by oxidizing organic matter. Unlike to plants, which are divided into stems, roots, and leaves, fungi vary very little physically and nearly nothing functionally [1]–[3].

There are many different types of fungi. An estimated 70,000 distinct kinds of fungi exist (and probably 10 to 20 times more undiscovered species). They may be found in a range of environments, such as deserts, oceans, and tropical forests. Nonetheless, they are often terrestrial heterotrophic creatures whose primary job is to break down organic materials, together with bacteria. They are known as saprophytes because they often eat inorganic particles. As a consequence of their metabolism of organic resources, fungi create waste products that are released back into the environment where they may be used once again by other organisms. Some fungi are parasites as well as pathogens of both plants and animals.

Fungi have a big economic influence because of both their good and bad effects. Many fungi cause havoc on our vital crops, wood trees, and many other food product lines. In addition to assaulting humans, they also harm living things. Yet, none of them are hazardous to humans since the vast majority of species encourage the decomposition of animal wastes and plant and animal dead bodies. They also contribute to the development of useful products like new-age medicines.

A. Thallus structure

With just one cell, Thallus some smaller fungi, such as Chytrids, have thallus structures that are basically spherical, single-celled organisms. When reproduction occurs, it changes into a reproductive unit. The latter produces either sexual or asexual cells. Holocarpic fungi are these types of fungi. This kind of fungus's vegetative and reproductive phases do not coexist in the same thallus. The naked multinucleate amoeboid mass of protoplasm that represents the vegetative phase of Plasmodiophora is distinctive. It's called a plasmodium. The unicellular holocarpic forms, like Synchytrium, lack mycelium. Yeast and olphidium are two examples of non-mycelial fungus that are basically single cells with actual cell walls. Yeast often has unicellular thalli that successively form bud cells. These bud cells could still form an easily breakable chain when connected together. The word for this collection of bud cells is pseudo mycelium [4]–[6].

The thallus has strands the bulk of true fungi have filamentous, hyphal-based thallus structures. The mycelium is a web of hyphae that are arranged randomly. The hyphae may be hyaline or may be colored differently. Each hypha may range in overall length and diameter, with the latter ranging between 0.5 and 1mm. The provision of growth-promoting elements, differentiation, and elongation all occur in the region just below the thin-walled hyphal tip. The branching of the hyphae is dichotomous when the tip of the hyphae stops developing and splits into two equal branches. The leading hyphal apex is usually freed to continue expanding by subapical and lateral branching. These branching patterns include dichotomous, verticillate, racemose, and compose. Depending on whether or not they include septa, the hyphae of mycelial fungus may be separated into two types.

In oomycetes and zygomycetes, where the mycelium contains several nuclei packed together in a single mass of cytoplasm, similar to Phycomycetes, nonseptate or aseptate hyphae are common. This condition is coenocytic. There are

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no cross walls in the hyphae. Nevertheless, septa may form during organ development to separate reproductive organs from the remainder of the vegetative hyphae. Pseudosepta are found in Allomyces.

B. Septate Hyphae

They may have one, two, or more nuclei in each segment and are characteristic of the Ascomycotina, Basidiomycotina, and Deuteromycotina. There are two separate septa: Primary septa, which form in tandem with mitotic or meiotic nuclear division, divide the daughter nuclei. These septa are found in Ascomycotina, Basidiomycotina, and their asexual stages.

C. Adventitious septa

Adventitious septa are formed without meiosis or mitosis taking place, and they are often linked to changes in the local concentration of cytoplasm. They belong to the lower fungal groups Mastigomycotina and Zygomycotina. Except for slime molds, the protoplasts are seldom surrounded by a strong, rigid cell wall in fungi (Myxomycotina).

Cell wall: In fungi, the cell wall serves a number of essential roles. It creates a cell's unique shape. The wall acts as a partition between the protoplasts and the environment, protects the cell from osmotic lysis and maybe from the metabolites of other species, and acts as an enzyme binding site. The chemical composition of the cell wall varies across various fungus. The composition of the cell wall seems to be a key element in establishing a fungal attachment. this pattern is shown. Chitin is a component of the cell walls of the majority of fungi. There are several differences between animal and fungal chitin and the formula. It has been suggested for fungal chitin: It is a polymer of N-acetylglucosamine. Using electron microscopy, scientists have discovered that cellulose and chitin exist as elongated microfibrillar units

The fungus's mycelium often consists of a mass of hyphae that are only weakly attached. In contrast to the free hyphae that often make up a thallus, the mycelium of the majority of fungi organizes into loosely or densely woven tissues at certain times in their life cycle. The term "plectenchyma" refers to all organized tissues (a weaved tissue). Two distinct broad types of plectenchyma are recognized: It is simple to recognize the component hyphae of prosenchyma (approaching a tissue) since they are practically parallel to one another on their typically elongated cells. Pseudoparenchyma, also known as false parenchyma, is a kind of plant tissue that is composed of tightly packed, isodiametric, or oval cells that mimic the parenchyma cells seen in higher plants. In this kind of fungal tissue, the hyphae have lost their distinguishing characteristics and cannot be recognized as such.

The components prosenchyma and pseudo parenchyma are found in many types of somatic and reproductive structures. Such somatic forms include the stroma and the sclerotium. A tiny, mattress-like somatic structure called a stroma is where fructifications are often produced. Sclerotiums are strong resting bodies that can withstand harsh conditions; they may be dormant for a very long period and then reawaken in the presence of favorable circumstances.

D. Specific somatic structures

Rhizoids - Rhizoid, a tiny, filamentous branch that mimics a root, often forms tufts at the base of the thallus. Rhizoids may be found in both mycelial (Rhizopus) and unicellular chytrids (Rhizophydium) thalli and act as anchoring and absorbing structures. The fungi known as rhizomorphs produce a growing point that resembles the tip of a root and have hyphae that band together, function as a coordinated unit and form a root-like strand in a dense, hard cortex. This kind of structure is known as a rhizomorph, and its main function is absorption. The rhizomorph may also withstand difficult circumstances, and its growth may resume when favorable circumstances return.

A terminal single or lobed swelling mucilaginous structure of germ tubes or infecting hyphae that adheres to the surface of the host or another substratum and facilitates the penetration of the infection hyphae is referred to as a "appressoria" (from the Latin "appressorium"). They are produced by parasitic fungi like powdery mildew and rust.

Haustoria (Sing. haustorium) - The haustorium is an organ that arises from a hypha and is often used for absorption. These characteristics are shared by the obligatory parasite orders Uredinales, Erysiphales, and Peronosporales. They feature an extracellular sac-like filamentous or branching structure. They may be extended, finger-like, branched, or knob- or button-shaped, among other forms. They exude specific enzymes that digest the protein and carbohydrates in the host plant.

E. Haustorium

Haustoria are incredibly diverse parasitic plant structures. Haustoria are readily spotted on exposed roots in root parasites. They manifest as swollen tissue at the place of contact between the parasite and the host. Haustoria in dodders resemble pegs or suction cups that link the host and parasite. Predatory fungi create hyphal traps or snares, which are networks of sticky hyphae or sticky hyphae. They support the capture of nematodes.

F. Stromata

These tiny somatic structures resemble mattresses. Usually, fructifications grow on or inside of them. Fungi have a heterotrophic feeding strategy since they lack chlorophyll. Because of this, they are unable to make ready-made carbohydrates from inorganic materials or get them from outside sources. They are often classified as saprophytes, parasites, necessary parasites, facultative parasites, etc.

II. DISCUSSION

Fungi cannot make their own food since they lack chlorophyll, thus they must eat already-prepared food to exist. Yet, if given carbs (glucose or maltose) in some form,

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the majority of fungi can produce their proteins. They do this by using various mineral elements required for their growth as well as inorganic or organic sources of nitrogen. Saprophytic fungi are those that consume dead and decomposing organic matter. For instance, rotting fruits and vegetables, wet leather, bread, jams, jellies, pickles, wood, and dung all support the luxuriant growth of M6ucor, Rhizopus, Aspergillus, and Penicillium. Some of them cannot develop into living creatures and can only exist as saprobes. They are referred to as "obligate saprophytes".

certain saprophytes may parasitize a suitable animal if they discover good environmental conditions for their typical existence as a saprophyte. Certain fungi, including Pythium debaryanum, are categorized as facultative parasites or hemisaprophytes. Certain fungi are easy to grow on artificial media. They consume the living hosts that they infect. They have the potential to spread a number of harmful plant diseases, including rust, smuts, mildew, and blight. They do a lot of harm. Obligate parasites are those that can only exist in the presence of a living host and cannot be grown on an artificial medium. Examples include Puccinia, Albugo, and Peronospora. Although most fungi have parasitic lifestyles, some may thrive as saprophytes under appropriate environments. They may also be hem parasites or facultative saprophytes, which are organisms that can survive on saprophytic substrates [7]–[9].

Parasitic fungi have a variety of methods for obtaining food from the host. Ectoparasites are parasitic fungi that live on the surface of the host (e.g. Erysiphe, Sphaerotheca). As many fungi live within their hosts, they are referred to as endoparasites (e.g., Synchytrium). Mycelium from fungi like Albugo and Pythium may be intracellular or intercellular. In the first scenario, the mycelium is confined to the intercellular spaces of the host cells, like Albugo spp. For instance, it is present in the latter in Pythium spp. host cells. The parasitic fungus develops haustoria in order to take nutrients from the host cells. In Peronospora, the haustoria may have multiple branches, whereas, in Albugo, they can be small, spherical, and button-like.

A distinct group of parasites called predacious fungus design mechanisms for capturing minute species like rotifers, protozoa, or eelworms (smaller nematodes less than 1/20th of an inch, as well as larger organisms like nematodes. Scavenger fungus feeds on these organisms. The presence of viscid fluid causes the hyphae to produce several small loops that join to form a network and become sticky. Such hyphae become immobile when they come into contact with the eelworms. From the hyphae, a very little branch emerges that penetrates the eelworm's body, swells, and develops into an infection bulb. This infected bulb gives rise to many branches like *Arthrobotrys oligospora* and *Dactyllella cionopaga* that fill the eelworm's body and absorb nourishment. Fungi called mycoparasites, like the Piptocephalis species, feed on other members of their species. Parasitizing the Mucorales order's Mucorales order and other similar genera.

The symbionts when fungi live near other species and do so in a manner that benefits both, this relationship is referred to as a symbiotic relationship. The phenomenon is referred to as symbiosis. Mycorrhiza and lichens are two typical instances of fungus symbiosis. Lichens are made when an alga and a fungus live in symbiosis. The alga creates food, while the encamping fungus collects rainfall and provides it to the alga along with mineral nutrients.

Mycorrhiza, which may be ectotrophic or endotrophic and is produced by certain fungi, coexists intimately with the roots of higher plants, notably forest trees. In an ectotrophic mycorrhiza, the mycelium covers the whole surface of the root and sometimes even penetrates it. The mycorrhizal link expands the root system's surface area. A few of the mycorrhizal fungi that make up the ectotrophic mycorrhiza include Amanita, Boletus, Tricholoma, and Russula. They increase the host's ability to absorb nitrogen at the roots. These linkages are often seen in members of the Orchidaceae and Ericaceae families of plants.

Several animals carry fungi that they sometimes feed and defend (without being harmed by them). This circumstance is referred known as commensalism. Saprophytic, parasitic fungi feed on the rhizoids, haustoria, and cell walls of the hyphal organism. The hyphal walls are permeable, while the plasma membrane is semi-permeable. Several fungi create enzymes that disintegrate the cell wall and hydrolyze the materials so the fungus may access them.

A. Reproduction

In fungi, both asexual and sexual reproduction are conceivable. The essential elements in each of these procedures are spores (in mycology the term spore is used for any reproductive unit and is not necessarily the one after meiosis as in higher cryptogams). As opposed to mitospores, which are formed by mitosis, meiospores are spores produced by meiosis. Slime mold ascospores, basidiospores, and sporangiospores fall under the meiospores group, whereas mitospores include zoospores, aplanospores, conidia, and uredospores.

The diploid organism produced as a result of sexual union is known as a zygote. It is also referred to as a resting spore, oospore, or zygospore in lower fungi. In higher fungi, the zygote is symbolized by a cell-produced diploid nucleus (ascus or basidium). This diploid nucleus undergoes meiosis when it produces haploid nuclei that serve as the centers for the haploid sexual spores known as ascospores and basidiospores. It is possible to reproduce asexually in the following ways:

B. Fragmentation

The splitting of hyphae into smaller fragments or pieces due to external force or accident. When given the right conditions, each fragment germinates to produce a new mycelium. Fission is a process that involves making a constriction and then constructing a cell wall to divide a cell

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International Journal of Science, Engineering and Management (IJSEM)
Vol 10, Issue 2S, February 2023

into two daughter cells. This is the method of vegetative development that bacteria and yeasts employ the most often.

C. Budding

This process entails the development of a small bud from the parent cell, which enlarges with time and picks up a piece of the nucleus. The development of a cell wall separates the daughter cell from the parent cell. Each bud separates from the parent cell and develops into a unique person. This is how yeast typically reproduces. Sclerotia are enduring structures comprised of thick masses of interconnected hyphae. If the correct conditions are present, Sclerotia may germinate and give rise to new species like Claviceps and Sclerotinia.

Extended mycelial strands that mimic roots are called rhizomorphs. When conditions are good, they develop into new mycelium, and when they are not, they remain dormant. The term "vegetative reproduction methods" is occasionally used to refer to all of the aforementioned reproductive methods. The spore may be split into two categories: internal spores and exterior spores. Natural spores are produced in the sporangium, a sac-like structure that may be intercalary or terminal in location and which generates spores. Sporangia are produced on sporophores, also known as sporangiophores. It is conceivable for sporangiophores to be both branched and unbranched. When the whole or a part of the sporangium is converted into spores, sporangiospores are produced. Either the spores migrate or they don't. Zoospores are mobile, but aplanospores are not.

The lower fungus Achlya, Saprolegnia, Pythium, Phytophthora, and Albugo often contain zoospores (Greek: zoon = animal + spores = seed, spore). They are naked spores that encyst, form a cell wall, and then swarm to form a thallus through a germ tube. One or two flagella are present (plural of flagellum; Latin for whip). They come in two distinct types of fungus: whiplash and tinsel. As its name indicates, the whiplash flagellum serves as a "whip," and riders often use it. It has a stiff basal part and a short, flexible top region. A lengthy rachis with hair-like characteristics on each of its four sides makes up the long, hairy tinsel flagellum. The blepharoplast, a granule-like structure deep within the rhinoplasty (Greek: Rhiza = root + plastid), is where the flagella form. The flagellum is made up of 11 parallel fibrils, nine of which form a cylinder around the two central ones. Each fibril is made up of sub-fibrils. The whip is created by the two center fibrils of a whiplash flagellum, which are longer than the periphery ones. The blepharoplast is created when the bases of these two center fibrils are folded together within the zoospore. External spores – Conidia. Any asexual spores (including zoospores and aplanospores) other than sporangiospores are referred to as conidia. Conidiophores, which are branched or unbranched hyphal tips, are where they are outwardly created. Conidia may grow alone or in groupings known as chains. Conidial chains may follow either a basipetal or an acropetal order. Conidia may have one or more nuclei. Deuteromycetes seem to have a stronger tendency toward the latter sort. Conidia may be used to distinguish a variety of fungi because of their broad variation in size, shape, and color [10]–[12].

Thallospores and conidiospores are the two main types of conidia. The parent hyphae dissolve, releasing the thallospores that were produced by the transformation of the thallus' existing cells. They come in two different varieties Arthrosporous (also known as oidia) are produced when hyphae are split up from the base to the apex. Every cell produced in this way rounds off and splits to form a spore, which, under the appropriate circumstances, germinates to produce the mycelium. Chlamydospores, which are circular and expanded terminal or intercalary cells of a hypha, are generated in their place. Either one or many may be created. They continue to be alive and linked to the hyphae, which enables them to germinate when the conditions are ideal.

D. Sexual connection

This requires the fusion of two appropriate nuclei. Three distinct phases have been recognized based on nuclear behavior: Plasmogamy or the union of protoplasts to form two sexually compatible nuclei in a single cell, is the first stage. This process is referred to as plasmogamy.

E. Second phase

Karyogamy is the term for the process of joining two compatible nuclei to form a diploid nucleus. In the great majority of species, karyogamy proceeds plasmogamy; however, in higher fungi, the fusion is delayed and the nuclei stay close to one another without fusing. A pair of these nuclei is known as a dikaryon, and the phase they are in is known as the dikaryotic phase.

Phase 3: Meiosis: After nuclear fusion, a division takes place, resulting in a halving of the number of chromosomes. The gametes that are engaged in sexual fusion are referred to as plus (+) and minus (-) strains, and they might differ morphologically or physiologically. When the sex organs of the male and female are located on the same mycelium, the fungus is said to be monoecious or homothallic; when they are located on separate mycelia, it is said to be dioecious or heterothallic.

Sex organ development involves either the whole thallus (holocarpic) or only a piece of it (eucarpic). Fungi produce reproductive cells called gametes, and their sex organs are called gametangia, or gametangium. When the gametangia and gametes are morphologically similar, they are referred to as isogametangia and isogametes. Male and female gametangia and gametes that differ morphologically from one another are referred to as heterogametangia and heterogametes, respectively. In hetero-gametangium, the male and female gametangium are known as antheridium and oogonium, respectively. Male Antheridium gametes are referred to as antherozoids or sperms, while female gametes are referred to as eggs or ecospheres. Plasmogamy - There are many ways to combine the two compatible nuclei, utilizing any of the methods listed below:

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Vol 10, Issue 2S, February 2023

F. Planogamete copulation

If two naked gametes are motile and fuse, this kind of copulation is called a planogametic copulation. In Allomyces species, the fusing gametes are anisogamous, but in Synchytrium, they are isogamous. Comprehensive biochemical and genetic analyses reveal that even the isogametes are physically and chemically unique from one another. Nevertheless, heterogamous planogametic conjugation has been seen in Monoblepharis, where it has been shown that the male (antherozoid) gamete is motile while the female (oosphere) gamete is non-motile and carried in a female gametangium, the oogonium.

G. Interaction with the gametes

When both the male and female gametes are non-motile, the contact of male and female gametangia may also result in plastogamy. The male gametangium's nuclei—the male gamete is made up of nuclear material—transfer into the female when the two gametangia of different sexes come into close contact with one another. A pore or a short fertilization tube is created when two gametangia (Sphaerotheca spp.) come into contact, allowing the male gametangium's nuclei to move to the female one (Phytophthora spp.). In the latter case, the oogonium advances after the nuclei migrate, and the antheridium often degenerates. In certain instances, such as in Pyronema sp., the female gametangium's short- or long-term tubular growth of the trichogyne is what makes contact. Gametangial copulation is quite common in lower fungi. The oogonium, a female gametangium, contains fertilized oospheres, also known as oospores. The process is referred to as oogamy here (in all Oomycetes).

H. Gametangial copulation

The two gametangia totally fuse together during this phase. The first of two probable pathways for the contents of one gametangium to enter the other is via a pore that develops in the gametangial wall at the site of contact. The second technique includes the fusing of two gametangial cells by the disintegration of their walls, as seen in higher members of lesser fungi such as Mucorales and Entomophthorales. Yet, the contents of the smaller (male) gametangium flow into the bigger (female) gametangium in certain Chytrids (lower fungus).

I. Spermatization

Certain higher fungi, such as Ascomycetes and Basidiomycetes, produce spermatia, which are small, uninucleated male structures (sing. spermatium). Insects, wind, water, or other agents may transfer them to specialized hyphae called the receptive hyphae, which serves as reduced female gametangia. A pore forms at the point of contact when the nuclei (male) move from the spermatium to the receptive hyphae, resulting in a binucleate (dikaryotic).

J. Somatogamy

Several fungi have functioning gametangia in the form of vegetative cells, and no conventional sex organs grow. Lesser fungi don't do this, whereas Ascomycetes and Basidiomycetes members do it often. In lower fungi, Karyogamy often takes place just after plasmogamy and entails the fusion of two nuclei of opposite sexes. Nevertheless, this process is delayed in higher fungi where plasmogamy creates dikaryotic cells (the two nuclei of the opposite sex lying unfused). The dikaryon cell may sometimes divide into more dikaryons, each of which has a nucleus that duplicates the initial pair. Sometimes dikaryotic cells in hyphae form a distinctive tissue that ultimately transforms into a separate layer known as the hymenium. These dikaryotic cells undergo a process known as karyogamy during which they develop into specialized cells called asci in ascomycetes and basidia in basidiomycetes.

After meiosis-karyogamy, a reduction division is the last major stage of reproduction. The diploid nucleus undergoes meiosis during which the chromosomes do not split but instead separate into two complete sets. Each pair constitutes the chromosomal complement of a haploid daughter nucleus. As a consequence of this process, some chromosomes from each parent are incorporated into the nucleus of each daughter. The ensuing mitotic divisions increase the number of haploid nuclei within the zygote cell. When planogametes undergo isogamy or anisogamy, the resulting zygote is a dormant sporangium. Each zoospore produced by this latent sporangium encysts, germinates, and forms a germ tube. When an oospore is created as the resultant zygote, it either germinates directly to produce a germ tube or indirectly to produce a resting sporangium where zoospores are produced (Phytophthora spp). In other situations, a zygospore often produces a short germ tube with an apical sporangium known as a germ sporangium that includes aplanospores (Mucor spp.).

Similar to higher plants, there is often a cycle of haploid and diploid structures that correspond to gametophyte and sporophyte generations. In contrast to the predominantly haploid phase, the diploid phase in most fungi starts after the nuclei fuse (Karyogamy) and may only take up a small portion of the life cycle. Nonetheless, there could not be a definite alternation of generations, much like higher plants. It is difficult to examine them since they are so little. As no spindles nor metaphase plates are produced, somatic nuclei divide in a method that isn't entirely comparable to mitosis, according to electron microscopy. The meiotic divisions of fungi are typical and comparable to those of more developed members.

Karyogamy, which involves the fusing of two nuclei of opposing sexes, sometimes occurs just after plasmogamy. Nevertheless, in higher fungi, where plasmogamy produces dikaryotic cells, this process is postponed (the two nuclei of the opposite sex lying unfused). Sometimes the dikaryon cell may split into further dikaryons, each with a nucleus that is a

replica of the first pair. In hyphae, dikaryotic cells may sometimes create a unique tissue that develops into the hymenium, a distinct layer. After a process known as karyogamy, these dikaryotic cells become specialized cells known as asci in ascomycetes and basidia in basidiomycetes.

A reduction division is the last significant step of reproduction before meiosis-karyogamy. Meiosis, a process in which the chromosomes divide into two full sets rather than splitting, occurs in the diploid nucleus. A haploid daughter nucleus's chromosomal complement is made up of each pair. As a result of this procedure, each daughter's nucleus has some chromosomes from each parent. The zygote cell's haploid nuclei grow as a consequence of the subsequent mitotic divisions. The zygote produced by isogamy or anisogamy in planogametes is a dormant sporangium. This latent sporangium produces zoospores, each of which encysts, germinates, and forms a germ tube. The ensuing zygote, known as an oospore, either directly produces a germ tube or indirectly creates a resting sporangium where zoospores are formed (Phytophthora spp). (Albugo spp.). Under different circumstances, a zygospore often creates a brief germ tube with an apical sporangium called a germ sporangium that contains aplanospores (Mucor spp.).

III. CONCLUSION

Fungi are eukaryotic creatures that include yeasts, molds, and mushrooms. These creatures belong to the kingdom Fungi. The creatures found in the Kingdom of Fungi have cell walls and are ubiquitous. Among living organisms, they are classified as heterotrophs. In the life cycle of fungi haploid and diploid phases in most fungi that begins after the nuclei fuse and may only occupy a minor fraction of the life cycle, in contrast to the primarily haploid period. Fungi have typical meiotic divisions that are analogous to those of more evolved members. Fungi are most often used in the manufacturing of bread, beer, cheese, enzymes, and organic acids, as well as in food such as mushrooms. Fungi are often found in yeast, penicillium, and mushrooms

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A Brief Overview of the Characteristics of Fungi

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Abstract*— Fungi are eukaryotic creatures that are non-vascular, non-motile, and heterotrophic. They might be single-cell or filamentous. They proliferate using spores. Fungi display the alternation of generation phenomena. Certain fungi have the potential to lead to systemic, cutaneous, subcutaneous, autoimmune, or allergy disorders. Yeasts are tiny fungi made up of single cells that divide by budding. In this chapter, we discussed the characteristics of the fungi.

Keywords*— Imperfect Fungi, Multinucleated Fungi, Sexual Reproduction, Slime Molds, Trophic Phase.

I. INTRODUCTION

Fungus and plants have a similar thalli structure and spore-based reproduction, mycologists currently think that the majority of fungi descended from an original protozoan with flagellates. In his classification of fungi, Ainsworth divided them into two groups: the Myxomycota, which included plasmodia forms, and the Eumycota, which included non-plasmodial forms that were typically mycelial. Five further subdivisions of Eumycota were created, including the Ascomycotina (for ascomycetes) and the Basidiomycotina (for basidiomycetes). In a hierarchical classification, it is inappropriate to associate these fungi with the ascomycetes and basidiomycetes as they are the fungi that are still in a state of flux. For convenience's sake, the imperfect fungi were classed since the Deuteromycotina. While several systems of classification have been suggested from time to time by taxonomists, no stable or perfect system has yet been developed [1]–[3].

They are also occasionally referred to as acellular slime molds and go by the names true or plasmodial slime molds. These fungi have a free-living, mobile, acellular (coenocytic), multinucleate, saprobic plasmodium as their trophic phase. Inside a fructification, the spores proliferate in large groups with a persistent peridium. Each spore releases one to four flagellated swarm cells during germination. Binary fission is the method used for asexual reproduction. The fusion of zygotes results in plasmodia, which are the result of sexual reproduction.

A. Plasmodiophoromycetes

These organisms, sometimes referred to as end parasitic slime molds, have a naked, monocarpic plasmodial thallus that moves and feeds. Members are necessary parasites of higher plants, aquatic fungi, and algae. The plasmodium, which forms within the host cells, is the somatic phase. The zoospores are biflagellate, with two whiplash flagella of different sizes anteriorly inserted. Before infecting the host, these zoospores may merge (but remain nucleate), forming a cosmogenous plasmodium that gives rise to thick-walled cysts (resign spores). Karyogamy and meiosis are likely to occur before and after cyst development, respectively.

These fungi feature a single posterior whiplash flagellum on each of their motile cells. The blepharoplast, a part of the cell, is where the flagellum is connected. Sexual reproduction often occurs when motile exogamous or anisogamous gametes fuse, when a nonmotile female gamete and an otile male gamete fuse, or when rhizomycelia fuse, or when small and large thalli conjugate, culminating in the creation of a thick-walled resting body.

B. Oomycetes as a class

While some are terrestrial, they are generally aquatic, either free-living or parasitic on algae, water molds, tiny animals, and other types of aquatic life. The production of biflagellate zoospores with two forms of flagella—the shorter, tinsel-type flagellum directed forward, and the whiplash-type flagellum directed backward—is one characteristic of the Oomycetes. There are two ways that the flagella may be attached to zoospores: anteriorly or laterally. Certain species produce pear-shaped and reniform zoospores.

1. Advanced oogamous reproduction occurs
2. vegetative thallus is diploid and meiosis is gametangia rather than zygotic;
3. The life cycle is of the haplobiontic type.

This class is characterized by the presence of coenocytic hyphae, lack of motile cells, and gametangial copulation-based sexual reproduction, which produces zygospores. Typical non-motile sporangiospores used in asexual reproduction are sporangia [4]–[6].

C. Ascomycotina

Hemiascomycetes (hemi = half + portion) are the first class. The lack of an ascocarp, which leaves the asci bare and devoid of sterile cells, defines the class. The asci often have thin walls that rupture to release the ascospores. Cells may often stay joined to one another for a variety of times. These Ascomycotina are the most basic.

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Vol 10, Issue 2S, February 2023

D. Plectomycetes as a class

They are distinguished by the globose, evanescent asci that emerge from the ascogenous hyphae at various levels inside the closed fruiting body, the cleistothecium. Typically, the asci have eight seeds. The cleistothecium's wall may range in texture from loosely woven to distinct, with one to many layers of thickness. Most of the members are sexist. A handful, including a few on man, are parasitic on both plants and animals. This class of fungus has significant economic significance.

E. Pyrenomycetes as a class

They are classified as ascomycetes with unitunicate asci that are principally organized in a hymenial layer and ascocarps that are fully encircled by a periodical wall. The ostiole, an aperture, is present in ascocarps. The members may develop in a variety of environments. Others are fungal symbionts of lichens, while others are significant plant pathogens.

F. Discomycetes

These ascomycetous fungi produce fructifications known as apothecia (sing. apothecium; Gr. apotheke = storehouse that have an exposed hymenium. All the Discomycetes, with the exception of the Tuberales, expel their spores forcefully; the majority of them are cup-shaped or even mushroom-shaped.

G. Teliomycetes subdivision basidiomycotina

The rusts and the smuts are two significant groups of plant diseases that belong to this class. The development of a teliospore, a thick-walled resting spore in which karyogamy occurs, is the distinctive trait. The dolipore septum, a distinctive septum present in other Basidiomycetes, and a simple pore-like those of the Ascomycotina are lacking from teliomycetes.

H. Hymenomycetes

This is the biggest class within the Basidiomycotina subdivision. It contains the fungi known as coral fungus, jelly fungi, fairy clubs, bracket fungi, polypores, mushrooms, and toadstools. The production of basidia in a hymenium, the gymnocarpous or semiangiocarpous structure of the basidiocarp, and the explosive release of the basidiospores are the distinguishing characteristics. Conidia are generated in these imperfect fungi from aggregated or separated modified hyphae carried on the surface of substrates and are encased in extra fungal or host tissue.

I. Coelomocytes

Conidia are generated inside cavities bordered by either fungal tissue, host tissue, or a mix of the two in these imperfect fungi. They are mostly Ascomycotina asexual states, however it is possible that some of them still have a relationship to Basidiomycotina

II. DISCUSSION

A. Fungi's economic importance

Due to both their negative and positive impacts, fungi have significant economic significance. Many fungus wreak havoc on our important crops, timber plants, and a variety of food goods. Besides with attacking people, they also attack living animals. Yet, since the majority of species promote the decomposition of animal feces and plant and animal dead bodies, none of them are toxic to humans. They are also helpful in the creation of new-age medications and other practical items. There are a number of fungal species that are very important economically. Both good and bad things might come from them for humans.

Fungals' advantageous traits are edible fungi. Fungi provide us with food that is high in proteins. Protein makes up around 50% of dried yeasts. They are also a good source of vitamins and B-complex. In general, mushrooms belong to the Basidiomycetes phylum. Around 105 saprophytic mushrooms have fruiting bodies that may be eaten; these are valued for their flavor and nutritional content [7]–[9]. The majority of fungi that are edible belong to the families Basidiomycetes and Ascomycetes, such as:

Ascomycete fungi that are edible include the saddle fungi Helvella and Gyromitra.

1. Morchella and Verpa morels
2. Truffles - Tuber and Cyttaria species

Basidiomycete edible fungi include: Jew's ear fungus (Hirneola auriculajudae and Hirneola polytricha

B. Agaricus species of mushrooms

Boletus, Strobilomyces, and Fistulina are pore fungi. Clavatia mexima and Lycoperdon species, giant puffballs, Hydnum species, and teeth fungus (ii) Function of Fungi in Agriculture: Fungi and Nitrogen Fixation - Certain soil fungi are helpful to agriculture because non-symbiotic fungi like Rhodotorula and Saccharomyces also fix a tiny amount of atmospheric nitrogen.

Certain soil fungus help to preserve the soil's fertility. In acidic soils where bacterial activity is at its lowest, saprophytic fungi, in particular, cause the decay and decomposition of dead plant bodies and their wastes by consuming the complex organic compounds (cellulose and lignin) and secreting enzymes that break down the fatty, carbohydrate, and nitrogenous constituents into simpler compounds like carbon dioxide, water, ammonia, hydrogen sulfide, etc. The majority of them are released into the air, where they may once again be employed as the starting material for the synthesis of food. Some of these return to the soil to produce humus. Several fungi have the ability to bind soil, including Aspergillus, Cladosporium, Rhizopus, Penicillium, and others. Mucilaginous substances are secreted to do this. Several common fungi found in soil contribute to the fight against illnesses brought on by these fungi. In moist soils, you may find Trichoderma lignum and Gliocladium fimbriatum. They have a growth-inhibiting

impact on Pythium's mycelium. They work to control the fungi that cause the seedling damping off disease, which benefits crop growth. The soil contains several fungi that are predatory. The nematodes are captured and eliminated.

The function of fungi in industry: baking Baker's yeast, also known as Saccharomyces cerevisiae, is a common ingredient in baking. Alcoholic fermentation is the cornerstone of the baking business because it produces ethyl alcohol and carbon dioxide when yeasts ferment sugar solutions. Dry ice is made from collected, crystallized carbon dioxide. CO_2 is a useful product in the baking business. It does two things. it makes the dough rise and it makes the bread light. Alcohol production: Alcohol is another byproduct of the fermentation of sugar or malt solution. Hexose carbohydrates are turned into alcohol by the enzyme zymase found in yeast cells.

C. Acid production

Several fungi are useful in the industrial production of many organic acids, including Aspergillus niger in the production of citric and oxalic acid, A. gallomyces in the production of gallic acid, Penicillium purpurogenum in the production of gluconic acid, Mucor in the production of fumeric acid, and Rhizopus oryzae in the production of lactic acid.

Production of enzymes several fungi generates enzymes with industrial use, such as zymase from Saccharomyces, invertase from Alternaria, and amylase from Aspergillus. Making cheese: Penicillium camemberti and P. roquefortie are also utilized. These molds give the cheese a unique flavor [10]–[12].

The best sources of vitamin B complex are yeasts, while vitamin B12 and vitamin A are obtained from Rhodotorula gracilis and Eremothecium respectively. Gibberellins are plant hormones produced by the fungus Gibberella fujikoroi, which causes a disease of rice accompanied by abnormal elongation. Many horticulture crops are grown faster thanks to gibberellin.

D. Function of fungi

There are now about 700 fungus species that release antifungal and antibacterial compounds. Antibiotics are what we term these drugs. Sir Alexander Flemming derived the first antibiotic penicillin from Penicillium notatum, for which he was given the Nobel Prize in 1945. The following are some significant antibiotics and their sources: Several of the medications used to decrease cholesterol and blood pressure are also derived from certain fungus, such as lovastatin and mevastatin from monnascus ruber and penicillium citrinum, respectively.

Fungi in Biological Research - A biological assay is the use of microorganisms to gauge a drug's efficacy and identify and estimate a variety of substances in provided samples. Aspergillus niger, a fungus, is used to identify very small amounts of Zn, Ca, Pb, Mn, and other elements in provided samples. The material from neurospora is perfect for genetic and biochemical research. It is sometimes referred to as the "Drosophila of the Plant World" due to its adaptability for biological science investigations.

E. Plant illnesses

Fungi have a negative value since they are the primary source of several diseases that affect our crops, fruits, and other commercially valuable plants. These fungi infections have a terrible toll and result in enormous financial losses. The table below lists several significant plant diseases and the root causes of each.

III. CONCLUSION

Fungi are microorganisms that are eukaryotic in nature. fungus have ancient beginnings, with evidence suggesting they originally arose about one billion years ago, albeit the fossil record of fungus is limited. Fungal hyphae found in the tissues of the earliest plant fossils demonstrate that fungi are a very old group. Fungi may exist as yeasts, molds, or a mix of the two. Fungi may cause superficial, cutaneous, subcutaneous, systemic, or allergic illnesses. Yeasts are tiny fungi that reproduce by budding single cells. The majority of fungi may reproduce both asexually and sexually, allowing them to adjust to changing environmental conditions. Yeast multiplies asexually through budding, while other fungus generates spores that reproduce asexually.

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A Brief Investigation of Plant Pathology

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***Abstract*— Plant pathology is a branch of biology that focuses on understanding the origins of plant diseases, how they spread through populations and individual plants, and how to manage or prevent them. The bulk of molecular genetic alterations that are being suggested for domesticated crops is equivalent to those that have previously been accomplished using conventional techniques. Along with compositional changes in the seed or other plant components, they include resistance to pesticides, weed killers, drought, and salt.**

***Keywords*— Host Plant, Plant Diseases, Plant Illness, Plant Species, Plant Pathology**

I. INTRODUCTION

Plants may be genetically modified in a variety of ways. The three major groups we've divided them into are classical, cellular, and molecular. Traditional techniques include anther and ovule culture, undirected mutagenesis, embryo culture (rescue), and sexual hybridization. To create soma clonal diversity, cellular techniques such as cell fusion and tissue culture are used. Recombinant DNA and electroporation are two examples of procedures used in molecular biology that lead to the precise insertion of predetermined DNA sequences [1]–[3].

Plant pathology is the study of (1) the organisms and environmental factors that cause disease in plants, (2) the mechanisms by which these elements cause disease in plants, (3) the interactions between the agents that cause the disease and the diseased plant, and (4) the techniques for preventing disease, reducing the harm it causes, or controlling a disease either before it develops in a plant or after it has already done so.

The majority of biotic (alive) organisms are responsible for plant illnesses. Fungi, bacteria, phytoplasmas, viruses, viroids, nematodes, and parasitic higher plants are the main causes of plant illnesses. Noninfectious causes are the origin of abiotic illnesses. Although there are virtually no limits to the causes of disorders, the most prevalent ones are typically brought on by conditions like temperature extremes, moisture extremes, light extremes, nutrient extremes, poor soil (acidity or alkalinity, salt, texture), pesticide toxicity, air pollution, powerful winds, hail, and improper cultural practices. They also experience damage from insect assaults and competition from unwelcome plants (weeds). Nevertheless, research on plant pathology seldom includes plant damage brought on by humans, other animals, or insects [2]–[4].

A. The theory of plant disease

When a plant can perform its physiological tasks to the highest degree possible given its genetic makeup, it is said to be healthy or normal. These include typical cell division, differentiation, and development; soil absorption of water and minerals and their transportation throughout the plant; photosynthesis and the transportation of the products of photosynthesis throughout the plant; reproduction for survival and multiplication; and storage of food supplies for overwintering or reproduction. When a pathogen or other harmful environmental element prevents a plant's cells from doing one or more of these vital tasks, or when a plant part's capacity to perform one or more of these tasks is compromised, the plant becomes ill.

Pathogens or elements of the physical environment are the main causes of illness, however, the precise methods by which diseases are formed vary greatly depending on the causative agent and sometimes the plant. The plant's first response to the disease-causing substance at the affected spot is chemical in nature and initially undetectable. Nevertheless, the response quickly spreads, and histological changes happen that are visible under the microscope and represent the disease's symptoms. The disease-causing chemicals often weaken or kill the afflicted plants' affected cells and tissues. Plant growth is inhibited or the plant dies as a consequence of these cells and tissues' diminished or destroyed capacity to carry out their typical physiological duties. Defined as "a series of invisible and visible responses of plant cells and tissues to a pathogenic microorganism or environmental factor that result in adverse changes in the form, function, and integrity of the plant and may lead to partial impairment or death of the plant or its parts," disease in plants is thus defined as "abnormal changes in the form, function, and integrity of the plant [5]–[7].

When a plant is not developing as predicted, it is said to have a sickness or condition. Symptoms and indications are the two visual cues for detecting "sick" plants. Symptoms are the plant's visible defense mechanism against infection or an abiotic threat. For instance, plants that display leaf spots, chlorosis, necrosis, wilting, and stunting are displaying abnormality-related symptoms. Determining the source of plant issues requires careful consideration of the symptoms. Yet, there are several circumstances that keep symptoms from pinpointing the precise cause.

The same effect on the plant may be caused by a wide range of diseases and abiotic elements. For instance, a plant will wilt if anything prevents the flow of water through it.

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Vol 10, Issue 2S, February 2023

The fact that symptoms evolve is another aspect. As a result, accurate symptom descriptions need ongoing observation of the plant and tracking of the symptom development. Sometimes symptoms appear far from the infection site. For instance, when roots are harmed, signs of water and nutrient stress appear above ground. The degree of host vulnerability, the environment, and the pathogen's virulence (aggressiveness) will all affect the symptoms in different ways.

Symptoms include the visible appearance of a pathogen-created structure on the host plant. Examples include spores, fruiting bodies, bacterial slime, and fungal mycelium. Although symptoms are general, indications help to identify the causative agent in a more precise manner. The precise source of the symptom may sometimes become apparent. For instance, fungi that produce powdery mildew are responsible for the white powdery growth on plant surfaces. In other situations, indications will assist in reducing the list of likely causative factors. For instance, mycelium on the turf's surface indicates the presence of a fungal illness [8]–[10].

B. Triangle of illness

Three elements must interact for a disease episode to occur: the host, the infection, and the environment. The illness triangle refers to this connection. The host plant must be vulnerable to the pathogen for a disease to develop (disease organism). The plant must first be genetically susceptible, which means that any disease-causing organism present may affect the plant. In certain circumstances, the host's physiological condition must be just right for illness to manifest. For instance, some creatures exclusively harm young plants, while others prey on older or elderly plants, and yet others may harm a plant at any stage of development. Pathogens often take advantage of stressed plants. Plants that are healthy, vigorous, and not under stress are less prone to illness than ones that are. Only virulent pathogens, which are aggressive and capable of causing illness, may induce infection and subsequent disease. The majority of infections have a life cycle that includes periods of dormancy.

A pathogen cannot cause illness if it is dormant. While a triangle with equal sides is used to represent the illness triangle, the environment plays the most significant role in the interaction. The conditions must be favorable for the development of the illness. That is, the pathogen's growth and development must be favored by the temperature, moisture, nutrients, and wind. Some illnesses (most notably those brought on by viruses) need a vector (transmitting agent) to infect the body. The vector is an extra element of this interaction in certain situations. The degree of interaction between these three factors and the severity of the illness. For instance, the illness will be exceedingly severe if the host is very sensitive, the infection is highly virulent, and the environment is highly favorable. Time also has a role in illness severity; the longer the environment is conducive to disease development, the more severe the disease will be.

Disrupting a portion of the illness triangle is necessary for effective disease management. For management techniques in general, and especially for successful chemical control, an accurate identification of the causing agent is necessary. In addition to being ineffective against the disease agent, using the wrong chemical might cause new illness issues by destroying environment-beneficial microbes. There are several approaches to managing diseases. The most effective approach, however, relies on the coordinated use of all possible control techniques.

C. *Plant pathology history*

At the beginning of antiquity, man first learned about plant illnesses. The fact that blasting and mildew are mentioned in the Old Bible is proof of this. Before the Greek philosopher Theophrastus ever mentioned plant illnesses, our ancient religious literature provided knowledge about them. Some of the ancient Indian texts that describe illnesses and other plant enemies include the Rigveda, Atharvaveda (1500–500 B.C.), the Aroha Shashtra of Kautilya Sushruta Samhita (200–500 A.D.), Vishnu Puran (500 A.D.), Agnipuran (500–700 A.D.), and Vishnudharmottar (500– Classification of plant illnesses and the germ hypothesis of disease were covered in the Rigveda. The educated folks of the Vedic era were aware that microorganisms are what cause sickness. In ancient India, Surapal wrote a treatise called "Vraksha Ayurveda" that included knowledge of plant ailments. This is the Indian book that provided the first knowledge about plant diseases. He separated plant diseases into internal and exterior categories. The Bible made note of plant illnesses including rust, smut, downy mildew, powdery mildew, and blight. Theophrastus, a Greek philosopher who lived from 370 to 286 B.C., was the first to research and document tree, grain, and legume diseases. Theophrastus described his observations, fantasies, and experiences in his book "Enquiry into plants," although they were not founded on any studies. He had said that distinct plant species had unique illnesses that are autonomous or spontaneous, meaning that no outside sources were connected to the plant diseases. This is a brief history of many elements of plant pathology:

In an effort to placate the rust deity Robigo, the Romans observed the feast known as "Robigalia" in which reddish-colored dogs and calves were sacrificed. Around 470 B.C., Pliny used amurce of olives, a fungicide, for the first time to combat blight.

1. The Irish Potato Famine of 1844–1845, which was brought on by the Phytophthora infestans Late Blight fungus, hit Ireland and led to the development of modern plant pathology. From 1845 and 1850, the Famine claimed the lives of 1.5 million people and caused another 1.5 million to immigrate. Ireland's population fell from 8.5 million in 1840 to 4 million in 1900.

2. 1885-Bordeaux mixture: Downy Mildew of Grape was a significant issue in the French vineyards, but there were no recognized solutions. Burglars were a problem in the vineyards as well. They started spraying plants at the fields'

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Vol 10, Issue 2S, February 2023

boundaries with a solution of copper sulfate and lime. Also, it was noted that these plants retained their leaves all season long.

3. 1900 - Cronartium ribicola, which causes White Pine Blister Rust. On seedlings from European nurseries, the pathogen was introduced. White pines are sensitive to the disease, particularly young trees and plants from the genus Ribes (currants and gooseberries). While White Pine Blister Rust on Ribes plants may sometimes be a serious foliar disease, if allowed to develop from an infected branch into the trunk, it can be fatal to white pines. In 1912, this illness prompted the country's first quarantine.

Chestnut blight, caused by Cryphonectria (Endothia) parasitica, existed between 1904 and 1940. The disease that wiped out all of the mature chestnuts in eastern North America was introduced with chestnut seedlings from the Orient. Those who depended on the chestnut tree for their livelihood were decimated by the illness. The live root systems in the woods continue to produce occasional sprouts, but they were all finally destroyed by the blight.

1910 saw the discovery of the Xanthomonas axonopodis pv. Citri-caused citrus canker, which was eliminated in 1931. In Dade County, 400 miles distant, the pathogen was discovered in 1912. The disease extended to South Carolina in the north and all of the Gulf States. The citrus canker epidemic was eradicated after more than 20 years. Almost 3 million nursery trees and over 250,000 grove trees were burned down in 26 counties. Further outbreaks took place in 1986 and 1995.

Dutch elm disease first appeared in 1930, brought on by Ophiostoma ulmi. Most of the United States was destroyed by this disease, which decimated American elm trees planted along roadways and in malls. Globodera rostochiensis, sometimes known as the golden nematode, was first identified in 1941.

It led to the gradual deterioration and final death of potato plants. The spread was thought to be limited to the New York State counties of Nassau and Suffolk as of 1955. The Golden Nematode was able to reduce potato production by up to 70% after spending decades increasing their population levels.

Southern Corn Leaf Blight in 1970, brought on by Helminthosporium maydisAn epidemic was brought on by a shift in the genetics of seed corn, which was formerly thought to be a minor illness. Every state east of the Mississippi River and numerous states west of the Mississippi River reported cases of the illness in 1970. Damage caused losses of 50–100% in certain locations. Losses were on average 20–30% nationwide.

1995: Phytophthora ramorum, which causes Sudden Oak Death, was found in California. Tanoaks were observed to be decreasing in great numbers for no apparent reason. The causative culprit, also known as ramorum blight and ramorum dieback, required five years to isolate and identify. While the disease was first detected in tanoaks in the United States, it is now known to affect a wide variety of plant species.

1999 saw the onset of Southern Wilt/Brown Rot, which was brought on by Ralstonia solancearum Race 3 Biovar 2. Geraniums are susceptible to Southern Wilt, whereas potatoes are susceptible to Brown Rot. There have been a few instances of Ralstonia solanacearum Race 3 Biovar 2 on Geranium in recent years, but it seems to be limited to greenhouse crops and there is no indication that it has spread to potato, tomato, or eggplant.

1999- Plum Pox, often known as "Sharka," is a disease of stone fruits brought on by the Plum Pox Virus, a viral infection. In 1999, it was found for the first time in an orchard in Adams County, Pennsylvania.

Phakopsora pachyrhizi and Phakopsora meibomiae are two fungi that produce soybean rust, which first appeared in 2004. In November 2004, P. pachyrhizi reportedly arrived in the US on Hurricane Ivan's winds. Soon later, it was detected in 9 States. Early in 2005, it was discovered in Florida on soybean, and subsequent detections during that growing season stayed in the South

II. DISCUSSION

A. 1 Plant pathology's range

Plant pathology has a wider scope than human pathology and deals with several elements of plant diseases. The welfare of plants is particularly important to those who are directly involved in the development of plants, the production and sale of plant products, and those who are indirectly involved with each of us as consumers of plants and the many items made from them.

Plant pathology may benefit from the fundamental skills and knowledge of many different scientific disciplines, including botany, mycology, bacteriology, virology, nematology, genetics, biochemistry, horticulture, soil science, forestry, chemistry, physics, and meteorology. Advances in any one of these fields benefit plant pathology, and several advancements in other fields have been made in an effort to address psychopathological issues. Each plant pathologist must have a solid understanding of at least the fundamentals of the allied disciplines in order to execute their job effectively. Although while the discipline of plant pathology seeks to better understand the origins and progression of plant diseases, it also has a more pragmatic end in mind. To create defenses against all plant diseases is the goal. The objective is to preserve the product that is being destroyed by plant diseases and make it accessible to the producers who toil hard to create it as well as the millions of hungry and poorly clothed people in our globe, which is becoming more overpopulated.

Plant pathologists have recently started to focus on a few areas where notable advancements have been made, such as the chemical, molecular, and genetic interactions between the host and the pathogen, plant virology, the chemistry of fungitoxicity, disease forecasting, plant protection chemicals,

ISSN (Online) 2456 -1304
International Journal of Science, Engineering and Management (IJSEM)
Vol 10, Issue 2S, February 2023

breeding for disease resistance, etc. A growing population places more emphasis on the use of all available tools to fulfill the need for food, including greater agricultural area, enhanced farming techniques, higher fertilizer usage, improved crop types, increased irrigation, and crop protection.

B. Disease classification for plants

Many different types of illnesses harm plants because of their enormous variety. Each kind of plant is susceptible to at least 100 different plant diseases on average. Each kind of disease may have an impact on a single variety of plants to dozens, even hundreds, of plant species. Plant diseases may be divided into a few broad groups to make research on them easier. Also, it becomes crucial for the later diagnosis and management of any specific plant disease. The categorization of plant diseases may be based on a number of characteristics. Plant diseases are categorized based on: • The symptoms they produce (root rots, cankers, wilts, leaf spots, scabs, blights, anthracnoses, rusts, smuts)

1. The plant organ that is impacted (root diseases, stem diseases, foliage diseases, fruit diseases)
2. Affected plant varieties (field crops diseases, vegetable diseases, fruit tree diseases, forest diseases, turf diseases, diseases of ornamental plants)
3. How closely a plant disease is related to a plant:
4. An isolated area of the plant is affected by a localized illness.
5. A disease that affects the whole plant systemically.
6. Natural reproduction method and infection method:

The kind of pathogen that causes the sickness, however, is the criteria that is most often utilized. Diseases are divided into two categories based on the causes of each category.

1. Non-parasitic diseases: These have physiological or environmental causes, such as freezing injury brought on by low or high temperatures, unfavorable oxygen levels or soil moisture, mineral deficiency or excess, etc. Example: A potato's blackened heart was produced by a high temperature, Mineral deficiencies are to blame for Khaira disease in rice, red leaf in cotton, and bark necrosis in red delicious apples.

C. Parasitic disease

Parasitic micro- or microorganisms are the disease's causative agents since they need a host plant to thrive or complete their life cycle. Infected host plants are parasitized by a variety of fungi, bacteria, viruses, mycoplasma, algae, and animal parasites including nematodes and others. For instance, a bacterial blight of paddy, mycoplasma-caused club root of crucifer, virus-caused tobacco mosaic, fungi-caused ergot, smut, and rusts, nematode-caused wheat ear cockle, etc.

A parasite is a creature that feeds off of or inhabits another organism in order to survive. Parasitism is the association of a parasite with its host. Every kind of inter-specific interaction along a gradient of dependency would fall under a wide definition of parasitism. As a result, connections such as commensalism, mutualism, and symbiosis are different aspects of parasitic phenomena.

There are multiple points of equilibrium in the dynamic parasite-host-environment system. Since it is impossible to determine whether something is beneficial or harmful, the concepts of commensalism, mutualism, and symbiosis lose all of their meaning. Being a parasite is necessary for life. At the molecular level, parasitism led to the emergence of life, and intracellular parasitism sparked evolutionary processes that led to the diversification of species. Parasites are defined by Leuckart (1879) as organisms that find their habitat and food source in other organisms. All living things, whether plants or animals that are dependent on another organism for at least a portion of their existence are considered parasites, according to Brumpt (1913). Numerous parasites could be viewed as beneficial or even necessary to their hosts.

An organism that develops a close relationship with a plant and spreads or develops at the expense of the plant is called a plant parasite. In most cases, the parasite's removal of nutrients and water from the host plant reduces the efficiency of the plant's normal growth and is harmful to its continued growth and reproduction. Since the ability of the parasite to invade and establish itself in the host usually results in the development of a diseased condition in the host, parasitism is frequently intimately linked to pathogenicity. A parasite can coexist with a beneficial microorganism, such as the bacteria found in the root nodules of legume plants, and this coexistence is known as symbiosis. Just a small number of members of a few types of living creatures, including viruses, nematodes, and parasitic higher plants (all three of which belong to the plant kingdom), as well as fungi, bacteria, and parasitic higher plants, may parasitize plants.

These parasites must be able to infiltrate a host plant, feed on it, multiply there, and endure the circumstances that the host lives to be successful. Obligate parasites are those that can grow and reproduce solely on live hosts, such as viruses, nematodes, and those fungi that cause downy mildew, powdery mildew, and rust. Some parasites (the majority of fungi and bacteria) are referred to as non-obligate parasites since they may exist on either alive or dead hosts. Some non-obligate parasites spend the majority of their time or their entire life cycles as parasites, but under certain circumstances, they may grow saprophytically on dead organic matter (facultative saprophytes), whereas others spend the majority of their time and thrive on dead organic matter, but under certain conditions, they may attack living plants and turn parasitic (facultative parasites). While many illnesses produced by weakly parasitic pathogens are far more harmful to the plant than others than even those caused by obligate parasites, there is often no relationship between the level of parasitism of a pathogen and the severity of the disease it might cause.

Moreover, certain fungi, such as those that cause sooty molds, may spread disease by growing on a plant's surface and feeding on insect waste products rather than by

parasitizing the plant. Obligate parasites often target just a single kind of host, maybe because they have developed alongside their host and need certain nutrients that are only generated by these plants or made accessible to the pathogen only in these hosts.

Non-obligate parasites may target a broad variety of plants and plant sections of variable ages, presumably because they base their assault on non-specific poisons or enzymes that have an impact on components or functions that are widely distributed across the plants. Yet, certain non-obligate parasites will only cause illness in one or a small number of plant species. In any event, since only a few species out of thousands have been examined for their sensitivity to each disease, the number of plant species now known to be sensitive to a particular pathogen may be less than the actual number in nature. Moreover, a disease may be able to assault hosts who were formerly resistant to it due to genetic alterations.

III. CONCLUSION

The study of plant illnesses and problems is known as plant pathology. As a damaging divergence from the physiological systems' normal operation brought on by an infectious agent, the disease may be said to exist. If there are plant illnesses, the fungus, virus, bacteria, or parasitic flowering plant may be to blame. Plant pathology is the study of the biotic and abiotic factors that cause plants to fail to realize their genetic potential, as well as the development of therapies to protect plants, minimize crop losses, and increase food security.

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Evolution of Fungi in Plants Species

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***Abstract*— Some fungus, known as biotrophs, get their nutrition from a live host (plant or animal), whereas other fungi, known as saprotrophs, get their nutrients from dead plants or animals (saprophytes, saprobes). A fungus is a eukaryote that directly absorbs nutrients through its cell walls after externally digesting food. The majority of fungus reproduce by producing spores, and their bodies, known as thallus, are made of tiny tubular cells called hyphae. Since they are heterotrophs, fungi get their carbon and energy from other living things much as mammals do**

***Keywords*— Conidia Sporangia, Cell Wall, Fungi Kingdom, Host Parasitism, Germ Tube..**

I. INTRODUCTION

Fungi are classified as belonging to the advanced kingdom in Whittakar's five kingdom system (1969). Among the five kingdom two are advanced and three are primitive kingdoms). The three (Mastigomycotina, Zygomycotina, and Ascomycotina) were maintained as a class under the sub-division Fungi by Gwune-Vaughan and Barnes earlier in 1937. This is because fungi did not yet have the status of a kingdom at that time. Mastigomycotina, Zygomycotina, and Ascomycotina were all preserved within the section Eumycotina by Alexopoulos in 1962. Mastigomycotina was not recognized at that time because the fungi that make up this sub-division were investigated separately from those of Eucomycotina's Chytridiomycetes, Hyphochytridiomycetes, Oomycetes, and Plasmodiophoromycetes [1]–[3].

Whittaker's 1969 Five Kingdom System of Classification was followed by the categorization scheme developed by Ainsworth, Sparrow, and Susman (1973). Mastigomycotina, Zygomycotina, and Ascomycotina were given the status of distinct sub-divisions in his method of categorization. His categorization was based on the existence or lack of motile cells throughout the life cycle, as well as the processes of plasmogamy and the development of fertilized diploid structures.

A. Albugo Mastigomycotina

It's a division. Fungi that have been categorized in one of the divisions (such as Eumycota) of the kingdom fungi are included in Mastigomycotina. This fungi's primary characteristics are: The somatic structures of these organisms have defined cell walls (a few exceptions) This sub-division has been categorized into groups like Chytridiomycetes, Hyphochytridiomycetes, Oomycetes, etc. based on the kind of flagella, their quantity, and where they attach in the motile cells.

The four orders Saprolegniales, Leptomytales, Lagenidiales, and Peronosporales now make up the class Oomycetes, to which Albugo belongs. Albugo's role within the system is as follows: Mycoses Eumycota Mastigomycotina Asperonosporales Oomycetes Albuginaceae Albugo is the sole genus in the family, and the species it contains are responsible for a plant disease known as White Rust Disease.

B. Structure

The mycelium that makes up the thallus of Albugo is composed of well-developed, branching, intercellular, and coenocytic hyphae.

Hyphal cell walls are comprised of cellulose, multinucleate, and packed with vacuolated granular protoplasm. Nuclei are diploid. Since the mycelium is intercellular, it absorbs nutrients from host cells after passing through the tiny holes in their cell walls and growing inside of them as the haustorium, a globose or knob-like structure [4]–[6].

Albugo conceives and bears offspring via both asexual and sexual means. Conidia/sporangia are used by Albugo for asexual reproduction. The onset of asexual reproduction occurs after the hyphae have reached a specific level of development. At this point, the hyphae congregate or gather in specific locations underneath the host's epidermis and produce:

1. Club-shaped, thick-walled, and thin-tipped
2. at an angle to the host's epidermis
3. Conidiophores/sporangiophores are vertical formations that are closely packed.
4. They are arranged in dense layers or beds.

Conidia and sporangia are broken off from sporangiophores and conidiophores at their tips in a basipetal succession, or chain, after they reach a specific degree of development. A gelatinous disc known as a disjunctor cell separates two conidia or sporangia. Conidia and sporangia develop, detach, and become free in the area between conidiophores and sporangiophores under the host's epidermis. A pressure is formed towards the host's epidermis after the production of sporangiophores, conidiophores, and conidia in enormous numbers under the epidermis. As a consequence, the epidermis above the expanding sorus bulges and eventually bursts. Conidia and sporangia are

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International Journal of Science, Engineering and Management (IJSEM)
Vol 10, Issue 2S, February 2023

discharged once the epidermis bursts and produce a white crust on the surface of the host. When generated, conidia and sporangia have a globular shape. They later transform into cuboid or polyhedral shapes as a result of pressure during their creation. They have thin walls, are multinucleate, and may spread via the air, the water, or any other means. Several conidia and sporangia disappear.

Conidia/sporangia may germinate in two different ways:

1. When the temperature is high, directly
2. Indirect at chilly temperatures.
3. The asexual spores, known as conidia, directly germinate within the germ tube.
4. Reverse germination is caused by zoospores.

Here, the sporangia's asexual material separates into uninucleate components. Each of these components is converted into biflagellate, uninucleate kidney-shaped zoospores. Towards the end of the zoosporangium, a papilla forms. Sessile vesicles are generated from this papilla.

This vesicle contains zoospores that have escaped or expelled from the zoosporangium. They briefly move or swim within this vesicle before losing their flagella, encysting (changing their form), and germinating via a germ tube.

3. The oogamous sexual mechanism of reproduction produces an oospore, a resting spore, following plasmogamy, karyogamy, and meiosis. The development of antheridia and oogonia coincides with meiosis. All animals reproduce sexually, however the cytological aspects of fertilization most likely follow one of three patterns, as follows:

1. For instance, A. bliti, A. protulacae, and others have a big receptive papilla, a number of functional nuclei, and a tiny coenocentrum.
2. For instance, in a trapogonosis, all nuclei degenerate after migrating into the periplasm, with the exception of one male and one female nucleus. There is a big coenocentrum and a tiny papilla.
3. For instance, in A. candida, all other nuclei disintegrate before a pair of functional nuclei combine. Coenocentrum and papilla sizes fall somewhere in the middle of the other two categories.

The procedure for sexual reproduction using A. candida is as follows: When the host is mature or towards the conclusion of the host's growth season, gametangia (reproductive structures) are created. Hypertrophied or malformed host inflorescence serves as a manifestation of this. Antheridia and oogonia, the male and female, are gametangia. Both are multinucleate, one-celled entities that emerge close to one another [7]–[9].

Anthredium is a club-shaped structure that is farraginous, located to the side of oogonia, and is separated from the other hyphae by a septum. Oogonium is globose in form and terminal in location (occasionally intercalary). Moreover, a septum separates it from the other hyphae. Via mitotic division, the nuclei divide. The oogonium has an toxoplasma and periplasm when it is fully developed. Except for one, which is the sole functioning nucleus, all the nuclei migrate into the periplasm and slowly dissolve. The egg or oosphere is the only functioning nucleus in the ooplasm. A unique structure known as the fertilization tube aids in paragynous fertilization. The anthredium, which laterally attaches to the wall of the oogonium, is where the fertilization tube forms. At the connection site, a swelling known as the receptive papilla appears over the surface of the oogonium. The fertilization tube enters the oogonium via the wall of the receptive papilla and only one anthredial nucleus/male nucleus is released. Now that the male nucleus has fused with the egg or oosphere, the oospore is diploid. A short time after fertilization, the coenocentrum disappears.

Oospore structures have a globular form. It forms a thick, ornate wall that is known as an exospore. Endospores have a thin inner wall. Oospores are discharged once host tissue has broken down. The oospore moves into the next stage. The protoplast of the oospore splits into a large number of uninucleate sections after a period of rest, and under favorable circumstances, the nuclei begin mitotic activity. Each of these sections grows into a bifllagelate, reniform zoospore. Once the exterior thick exospores fracture, zoospores are released in a thin vesicle, which is the expansion of the thin endospore. After a while, the vesicle bursts, allowing the zoospores to swim for a while before losing their flagella, changing the shape of their bodies, encysting, and eventually germinating by creating a germ tube. As a result, a diploid mycelium forms.

C. Mucor Zygomycotina

Fungi belonging to the phylum Zygomycotina generate zygospores, which are thick-walled resting spores that grow within zygosporangiums created as a consequence of the full union of two gametangia. There are no flagellated cells. Habit and Habitat are the two classifications into which the subdivision has been separated.

Black mold is a frequent name for mucor. The majority of species are saprobic and may be found on products that contain simple carbohydrates, such as bread, jams, jellies, and other foods. Moreover, certain species are coprophillous, or dung-growing. Certain species may cause the organic materials in soil to decompose. Several of these human pathogens, such Mucor pusillus, cause zygomycosis. Alcohol is made with the help of M. javamicus [8].

D. Structure

Mycelium, which is composed of coenocytic (aseptate) branching hyphae, makes up the thallus. In order to absorb nutrients, hyphae shoot five branches into the substratum as they develop over it. These hyphae are absorptive. Moreover, these hypae have reproductive organs. Mucor does not contain stolons.

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Vol 10, Issue 2S, February 2023

II. DISCUSSION

A. The Development of Parasitism and Its Origin

Life itself is parasitic. Every creature from every species on earth has parasites. Certain species have used parasitism to proliferate since the dawn of existence. Actually, parasitism must have emerged early in the evolutionary process. All living things have a shared beginning in a common ancestor that lived a billion years ago according to their consistent biochemical makeup. In a planet that was still made of molecules, parasitism was the only thing that made life on Earth feasible. In reality, molecular parasitism caused life to emerge on Earth between 4.4 and 3.8 billion years ago, and modern life forms still include remnants of these old relationships in their genomes. These many linkages also led to later life form diversity and species radiation. These prehistoric occurrences mark the beginnings of a host-parasite mode of life, albeit at the molecular level. Transposable genomic elements provide a vivid example of molecular parasitism. Transposable elements are in fact acknowledged as molecular parasites by scientists.

Both prokayotes and eukaryotes have transposable elements. Transposition is the process by which a transposable element is inserted into a new genomic location in the host. These insertions may lead to chromosomal fusions, inversions, and deletions, which greatly increases genomic flexibility and promotes biodiversity with viruses and retroviruses, and McClintock first recognized them as "control elements" (1984). The genome fragments that make up the additional chromosomal transmissible genetic elements (viruses, plasmids, and bacteriophages), which rely on the host cell to reproduce, could not have existed before the cell. These substances may have originated the nuclear DNA and other cellular organelles. The transposable genetic elements and extra chromosomal genetic elements are remnants of early molecular parasites. Due to the promotion of genetic variety through their presence in the hosts' cell genomes, they were crucial in the development of living forms. Although many of the changes they brought about were unfavorable, some of them were beneficial to their hosts.

The eukaryotic cell is the outcome of a failed predation/parasitism event. Also, the parasitism that was originally the root cause of prokaryotic cells' formation is plainly seen in these cells. The whole cell is a chimera, a polyheterogenic condition resulting from a protracted history of parasite interactions, not just the nucleus. A considerable increase in the complexity of living things was made possible by the association of microbes that gave rise to mitochondria, chloroplasts, and other organelles, which improved their ability to fill new ecological niches. Also, the development of the cell presented parasites with potential new habitats.

B. Viral Diseases and Parasites

Both parasitic infections and parasitic illness are very different conditions that result from the same cause. A parasite is a prerequisite for the development of a parasitic illness but is not sufficient in itself. There is no guarantee that parasitism will harm or help the host. The end result of a specific parasite in a specific host from a specific population in a specific environment during a specific time period of both protagonists' co-evolution is parasitic illness.

In essence, it is a particular outcome of a parasite and host connection in a certain environment. It makes no difference whether a multicellular parasite or a molecular parasite is present. The parasite, the host, and the environment come together to create a system in which one of these components interacts with and impacts the others in such a manner that every change in one component has an impact on the other two. Systems may display order on their own. The parasite-host-environment system, which is subject to natural selection and/or the intrinsic characteristics of a system, responds to changes in each subsystem in a variety of ways, depending on the characteristics of the stimulus.

Any subsystem component may cause parasite illness in response to such a trigger. A unique response of a given individual host expresses indications and symptoms of a changed behavior of the whole system, i.e. sickness, and parasitic disease is not an imbalanced occurrence in the host-parasite-environment interaction but a normal reality.

Fundamentally, the history of species interactions is the history of evolution and biodiversity. A person who is separated from their surroundings may only be imagined as an abstraction. The primary forces that have shaped the structure and development of life were fostered by parasites. Zelmer (1998) suggested defining parasitism in terms of evolution. He puts all parasites within a common evolutionary framework, with the host immune response acting as a continuous and potent selecting force, before drawing a close. He challenges the idea that the change from commensalism to parasitism represents a permanent alteration to the nature of a particular symbiotic connection.

III. CONCLUSION

Food is produced by plants all throughout the globe. Along with all other living things, they are changing and living. Parasites are defined as organisms that damage humans either directly or indirectly. Depending on the reader's needs, there are several detailed categories into which plant diseases might be divided. They are often categorized according to the kind of infection that is responsible for the sickness. Plant pathology is the study of plant diseases, and it has a history that is as ancient as human history itself since humans have always relied on plant resources for their subsistence. Owing to this connection, man is very concerned about any damage that is done to economically significant plants. In order to better understand the pathogens and combat and control them, developments in the science of plant pathology and the study of the evolution of parasitism in plants have been made in response to severe crop losses and forest devastation caused by plant diseases

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Host-Pathogen Interaction-I: Pathogen Attack

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***Abstract*— Microorganisms are everywhere around us, even in the world of plants. During the growth season or for several years, the microorganisms continue to develop in the same surroundings as the plants and trees. These plants' surfaces are often in contact with nematodes, parasitic plants, bacteria, and fungi. To cling to plants, get past plant defenses, and inhabit plant tissues for growth, survival, and reproduction, plant pathogens have developed a variety of adaptations. They have at least momentarily evaded the fierce struggle from saprophytic organisms on plant surfaces and in the soil after they have been established within the plant**

***Keywords*— Cell Wall, Growth Regulators, Host Plant, Host-Pathogen, Mechanical Pressure.**

I. INTRODUCTION

A pathogen must thus be able to enter and pass through a plant, take nutrients from the plant, and destroy the plant's immune system in order to infect the plant. The majority of the time, pathogens carry out these functions by secreting chemicals that have an impact on certain organ systems or metabolic processes in their hosts. Yet, it seems that the mechanical stress that certain infections exert on the plant's cell walls helps, or in some instances perhaps causes, penetration and invasion [1]–[3].

1. The ways that various diseases adhere to surfaces
2. Penetration techniques using chemical and physical agents
3. Tissue colonization in the host

A. Illness process.

The following three steps generally correspond to the "infection process":

1. Stickiness
2. Infiltration
3. Colonization

It includes the development of an effective parasitic connection between a pathogen and a host, from the germination or proliferation of an infectious propagule in or on a prospective host. The characteristics of the pathogen, the host, and the external environment all have an impact on the infection process. The pathogen cannot infect the host and produce illness if any of these variables hinder any step of the infection process.

Although certain parasites (ectoparasites) colonize the exterior of the plant, diseases may also infiltrate the host plant by penetration, a natural opening (such as a stomatal hole), or a wound. The interruption of respiration, photosynthesis, nutrient transport, transpiration, and other elements of growth and development leads to the symptoms of the illnesses caused by these infections.

B. Adhesion

A spore must germinate and develop on the surface of the plant before it can infect a host tissue. Many fungi begin to germinate or begin forming germ tubes when they come into contact with their host or another solid substrate. These germ tubes may then develop into infection structures. Adhesion is also essential for diseases to successfully parasitize plants. Before penetration, fungal-substratum adhesion occurs on the surface of the plant host and serves several purposes.

Adhesion prevents pathogen propagules from being washed or blown away from a potentially favorable environment by water and/or wind. It is necessary for thigmotropism, thigmotropism via mechanical pressure, thigmotropism via mechanical pressure, thigmotropism via mechanical pressure, thigmotropism via mechanical pressure, thigmotropism via mechanical pressure, thigmotropism (which is required for contact stimulated germination).

Fimbriae are produced by several bacteria and have a function. For motile pathogens, navigating the host's surface is necessary before they can enter the host. Some diseases create specialized penetration structures, such as appressoria, while others make use of surface apertures that already exist on the plant, including wounds or stomatal pores. Plant viruses are often introduced into the plant and transferred by vectors like fungi or insects.

Inoculation refers to the first encounter between infectious parasite propagules and a prospective host plant. Several triggers are used by pathogens to find an appropriate entrance place. Many fungi employ topographical cues on the surface of the plant to direct them toward a potential stomatal location. Volatile substances that escape from the pore once the hypha reaches a stoma seem to act as a signal for the development of a specialized penetrating structure called the appressorium.

Plants release sugars, amino acids, and minerals at the leaf surface, which may serve as a general trigger for spore germination or as food for the pathogen. Without these components, certain harmful spores won't germinate.

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Temperature, moisture, light, aeration, the availability of nutrients, and pH all have an impact on pathogen growth. Whether contact is necessary may also depend on the environment. The prerequisites for a pathogen's survival and effective infection vary [4]–[6].

C. Penetration

While each species of pathogen often has a favored mechanism, pathogens typically use every available channel to infiltrate their host. By supplying certain stimuli, the host also contributes significantly to the pathogen's ability to penetrate. The hydrophobicity, hardness, chemical makeup, and topographical characteristics of the host plant may all act as stimulants for the germination, development, and differentiation of infection structures. The germination of plant pathogen propagules and the development of infection structures have both been linked to many chemical components of host plants. In particular, the wax on the plant's aerial portions is a rich source of several chemicals that may fulfill these functions. Many fungi pathogens get signals from plant surfaces due to their topologies. For instance, rust fungus often infects their hosts via stomata, and this topology causes infection structures to grow. Responding to other topological cues may help rust fungus that enters via stomata locate a stoma. For instance, P. graminis f. sp. tritici's germ tubes arrange themselves at a right angle to the leaf veins, which increases the likelihood that the tube will come into contact with a stoma because of the way the veins are distributed.

The pathogens use a variety of strategies to enter the host. In order to reach the host, fungal diseases often directly penetrate the surface of the plant. In order to get beyond the physical obstacles the plant's surface presents, this requires attachment to the plant surface, followed by the application of mechanical pressure and subsequently enzymatic destruction of the cuticle and cell wall. In order to combat plant defenses against them, many infections heavily rely on the numerous compounds they create, including poisons, growth regulators, and various polysaccharides.

D. Direct ingression

The simplest route for a disease to enter a plant is via a surface opening that already exists. This could be a wound or a natural aperture. When there is a coating of moisture on the leaf surface, pathogenic bacteria and nematodes often penetrate via stomatal holes. Without the development of any specialized structures, fungi are also capable of entering open stomata. Certain fungi enlarge the appressorium above the stomatal opening, and a small penetration hypha penetrates the air space within the leaf. From this vesicle, infection hyphae emerge and create haustoria in neighboring cells. Hydathodes, holes at the leaf edge that are continuous with the xylem, are also susceptible to pathogen invasion.

When the humidity is high, xylem fluid droplets (also known as guttation droplets) may appear at the leaf's surface, where they may be exposed to harmful bacteria. As the humidity drops, the bacteria then enter the plant when the droplet retreats back into the hydathode. Raised pores called lenticels enable gas exchange through the bark of woody plants. They also utilize less common apertures like nectaries, styles, and ectodesmata while excluding the majority of them. Many of the diseases that use wounds to enter the plant are unable to penetrate the plant surface without them, and entry via a wound does not need the production of specialized structures. The majority of plant viruses enter the host plant via wounds left by their insect vectors.

E. Pathogens' mechanical forces on host tissues

Although many plant infections may enter their hosts via wounds, natural openings, or vectors without needing the ability to break their cell walls, many fungal pathogens do so by the use of mechanical force, enzyme activity, or a combination of the two. As insects often transmit viruses straight through plant cells, they do not exert mechanical pressures. It is well known that many fungi exert mechanical pressure on the plant they are going to assault. The appressorium is a flattened, bulb-like structure that develops when fungus touches a plant surface and contact is made. This is caused by an increase in the diameter of the tip of the hypha or radical that is in contact with the host. By doing so, the pathogen is firmly fastened to the plant and the area of adhesion between the two organisms is increased. A little developing point known as the penetration peg emerges from the appressorium and penetrates the cuticle and cell wall.

By developing melanized appressoria that attach firmly to surfaces and inside which large turgor pressures are created, many fungi develop significant pressure on a constrained region. By initially securely securing the appressorium to the plant surface with proteinaceous glue, the pressure required for the hypha to enter the cell membrane is created. The appressorium's cell wall subsequently becomes melanin-impregnated, becoming waterproof and able to withstand the strong turgor pressure that develops within the appressorium. The wall is thinnest at the penetration pore, which is part of the appressorium that comes into touch with the cuticle. The pore herniates as a result of the rising turgor pressure, creating a penetration peg that exerts intense pressure on the host cell wall and cuticle[7]–[10].

II. DISCUSSION

The majority of pathogen activity in plants is chemical in nature, despite the fact that certain infections may employ mechanical force to enter plant tissues. Thus, pathogen-induced impacts on plants are nearly completely the outcome of biochemical interactions between chemicals generated by or present in the plant and those released by the pathogen. Although viruses do not directly manufacture chemicals, they do cause host cells to do so. The precise chemical that is produced may or may not be one that the infected host cell has previously produced. Enzymes,

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poisons, growth regulators, and polysaccharides are the primary classes of chemicals released by plant pathogens that seem to be directly or indirectly responsible for the development of disease (plugging substances). The role of these chemicals in pathogenicity varies widely, and their relative importance may change from one illness to another. In general, plant pathogenic enzymes disrupt the host cell's structural elements, break down inert food items within the cell, or directly influence the protoplast and its membranes, disrupting the cell's functional systems. The permeability of the protoplast's membrane and its activities seem to be interfered with by toxins, which also appear to act directly on its components. The capacity of cells to divide and expand may be increased or decreased by growth regulators, which act hormonally on the cells. Polysaccharides don't seem to be involved in other conditions than vascular disorders, where they passively obstruct water transfer in plants.

A. Enzymes

A series of genes are turned on and off by the pathogen in order to create cutinase, cellulase, pectinase, and protease, which attack the cuticle, cell wall, and middle lamella in the order that they are met during the destruction of the cuticle and wall.

Degradative enzymes are implicated in disease or virulence by a substantial body of data. Early research focused especially on pectic enzymes, which are likely to be important not only directly in the ingress and destruction of structural materials but also indirectly as a source of nutrients for the pathogen because the depolymerization of pectic substances to monomers or oligomers of a low degree of polymerization would be easily assimilable. Nevertheless, partial depolymerization may result in oligomers that serve as catalysts for inflammatory responses. Several enzymes, including lipases, cutinases, and proteases, have been studied more recently; in certain cases, this research has focused specifically on how well an organism can permeate its host. The fact that certain enzymes may harm cells is another thing to take into account.

B. Cutinases

The primary element of the cuticle is cutin. Wax is combined into the cuticle's top portion, whereas pectin and cellulose are mixed into the cuticle's bottom portion where it connects to the outside walls of epidermal cells. Cutinases degrade cutin molecules, releasing monomers and oligomers of the component fatty acid derivatives, such as Fusarium spp. and Botrytis cinerea, from the insoluble cutin polymer.

C. Pectinases

Pectin compounds are the primary building blocks of the middle lamella, the intercellular glue that secures the cells of plant tissues together. Pectinases, sometimes referred to as pectolytic enzymes, are a group of enzymes that break down pectic materials. Pectin methyl esterases, the first class of pectic enzymes, cut off tiny branches from pectin strands. Chain-splitting pectinases, also known as polygalacturonases, make up the second class of pectic enzymes. By including a water molecule and severing the bond between two galacturonan molecules, they were able to disrupt the pectic chain. The third class of pectic enzymes, known as pectin lyases, break the chain by removing a water molecule from the linkage, which results in the release of products containing an unsaturated double bond. Pathogens include, for instance, Didymella bryoniae and Ralstonia solanacearum.

D. Cellulases

A polysaccharide, cellulose is also made up of chains of glucose (1-4) D-glucan molecules. There are a lot of hydrogen bonds between the glucose chains. A number of cellulases and other enzymes carry out a sequence of enzymatic processes to create glucose. Cleaving cross-links between chains is how one cellulose, designated C1, targets native cellulose. Native cellulose is also attacked by a second cellulase (C2), which reduces it into shorter chains. The third set of cellulases (Cx) subsequently target them and breakdown them into the disaccharide cellobiose. Cellobiose is ultimately converted into glucose by the enzyme glucosidase. The majority of the cellulose degraded in nature is broken down by saprophytic fungus, primarily certain basidiomycete species, and to a lesser extent, saprophytic bacteria. Nevertheless, pathogen-secreted cellulolytic enzymes contribute to the softening and disintegration of cell wall components in live plant tissues.

Toxins are compounds produced by invasive microbes that directly affect the protoplast of a live host, severely harming or killing the plant's cells.

Such toxins may possibly harm host cells, adversely impair membrane permeability, deactivate or inhibit plant enzymes, and cause a lack of vital growth factors. They are also incredibly toxic, highly effective at low doses, and capable of harming host cells.

Certain poisons harm a wide variety of plant species from various families and operate as a broad protoplasmic poison. Others are perfectly safe for most plant species or variations yet hazardous to a small number of them. Many poisons are present in various forms with varying potencies. Host-specific Toxins may or may not exist.

Non-host-selective toxins, also known as non-host-specific toxins: Many toxic compounds produced by phytopathogenic bacteria have been shown to cause all or a portion of the disease state in plants other than the host plant, which is not typically attacked by the pathogen in nature.

(1) Tabtoxin is generated by Pseudomonas syringae pv tabaci, a bacterium that causes the tobacco wildfire disease, by pv tabaci strains that infect other hosts such beans and soybeans, and by other pathovars of P. syringae that infect oats, maize, and coffee.

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(2) The bacteria Pseudomonas syringae pv phaseolicola, which causes the halo blight of various legumes and beans, produces phaseolotoxin.

(3) The fungus Alternaria alternata produces a toxin called tentoxin that causes chlorosis and spots in a variety of plant types.

The fungus Cercospora, as well as a number of other fungi, generate cercosporin. Several agricultural plants are affected by destructive leaf spots and blight diseases brought on by it, including Cercospora leaf spots in zinnia and gray leaf spot in corn.

E. Host-specific or host-selective toxins

These are chemicals that a pathogenic microbe produces at physiological amounts that are poisonous solely to the hosts of that pathogen and exhibit little to no toxicity against non-susceptible plants.

(1) The fungus Cochliobolus victoriae produces the victorin or HV toxin. This fungus attacks vulnerable oat plants at the base and releases a poison that spreads to the leaves where it causes leaf blight and eventually kills the whole plant.

(2) The Cochliobolus heterostrophus race T, which is responsible for southern corn leaf blight, produces a toxin called T-toxin. Except for its capacity to manufacture the T toxin, Race T is identical to all other C. heterostrophus races.

(3) Race 1 of the Cochliobolus carbonum produces HC-toxin, which causes the disease northern leaf spot and ear rot in maize.

F. Growth regulators

A limited number of naturally occurring chemical groups known as "growth regulators" serve as hormones to control plant development. Auxins, gibberellins, and cytokinins are the most significant growth regulators, although other substances, such as ethylene and growth inhibitors, also play significant regulatory functions in the life of the plant. The same growth regulators or inhibitors of the same growth regulators that the plant produces may be generated in greater quantities by plant diseases.

Oftentimes, pathogens disrupt the hormonal balance of the plant and produce growth responses that are incompatible with the proper development of the plant. By stunting the plant, excessive root branching, stem deformity, leaf epinasty, premature defoliation, and/or bud development inhibition, pathogen growth regulators may upset the balance of plant hormones.

G. Auxins

Indole-3-acetic acid is a naturally occurring auxin in plants (IAA). It is necessary for cell extension and differentiation, and the permeability of the cell membrane is also impacted by IAA absorption. Many plants that have been infected by fungus, bacteria, viruses, nematodes, and mollicutes have elevated IAA levels, while other diseases, such the Exobasidium azalea that causes flower gall and the Ustilago maydis that causes maize smut, seem to diminish the auxin level of the host.

Gibberellins, a naturally occurring component of green plants, have pronounced growth-promoting properties. They encourage fruit development, blooming, stem and root elongation, and the quickening of dwarf kinds' elongation to normal proportions. The gibberellins generated by the pathogen seem to be the cause of the silly seedling illnesses of rice, which cause rice seedlings infected with the fungus Gibberella fujikuroi to develop quickly and become significantly higher than healthy plants.

Cytokinins are powerful growth factors required for cell growth and differentiation. They also prevent the breakdown of proteins and nucleic acids, which prevents senescence, and they have the ability to control the flow of amino acids and other nutrients through the point of high cytokinin concentration. In club root galls, smut and rust-infected bean leaves, cytokinin activity rises. It contributes to a number of bacterial galls of the sweet pea leafy gall disease produced by the bacterium Rhodococus fasciens.

H. Ethylene

This naturally occurring substance is produced by plants and has a number of impacts on them, including chlorosis, leaf abscission, epinasty, promotion of adventitious roots, and fruit ripening. Although no ethylene can be found in healthy fruits, in the fruit of bananas infected with Ralstonia solanacearum, the ethylene level rises proportionally with the (premature) yellowing of the fruits.

I. Polysaccharides

Nematodes, bacteria, fungi, and perhaps other pathogens continuously secrete varied quantities of mucilaginous substances that coat their bodies and serve as an interface between the microorganism's exterior and its surroundings. Slimy polysaccharides seem to have a significant role in plant disease, especially in wilt diseases brought on by pathogens that attack the plant's vascular system. Massive polysaccharide molecules that the pathogen releases in the xylem may be enough to mechanically obstruct vascular bundles and start withering.

J. Colonization

The creation and interpretation of signals by both parties are necessary for further processes to take place after a pathogen has come into contact with a prospective host plant or, in the case of soil-borne infections, a plant root. Pathogens in soil may be affected by substances released by the host root. Sessile propagule germination may be fostered or hindered, and motile phases can be attracted or repulsed. To guarantee that at least part of their propagules land on an appropriate host, airborne diseases often depend on vast populations of propagules. At this time, adherence is essential to prevent the propagule from washing off the plant, and it has been demonstrated that for at least one fungal pathogen, adhesion is a need for germination. After

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attachment, germination follows, and this process may be influenced by topological or chemical signals from the host. In certain cases, these signals result in the differentiation of infection structures. To exert any mechanical force, they must also be firmly anchored to the surface of the plant.

After the host has obtained access to the plant, the pathogen and host must form a parasitic connection in order for the infection to succeed. Pathogens may be divided into two categories: necrotrophs and biotrophs (those that infect live tissue) (those that kill cells before colonising them, by secreting toxins that diffuse ahead of the advancing pathogen). Due to the strategies these two categories of viruses employ to get nutrients from their hosts, they are also frequently referred to as "sneaks" and "thugs." Biotrophs often consume their food via haustoria, which invaginate but do not pierce the host plasma membrane and penetrate the host cell wall, very definitely with the aid of degradative enzymes.

There are no specialized penetrating structures produced by necrotrophs. Instead, they destroy the host cells by secreting poisons, then weaken the intermediate lamella and cell wall to enable their hyphae to enter the plant cells and through the cell walls. Necrotrophic toxins may be either host-specific or non-specific. Non-specific toxins are engaged in a wide variety of interactions between plants and bacteria or fungi, therefore they often do not reveal the host range of the pathogen that is creating them. Necrotrophic organisms often infect plants via wounds and produce severe and quick effects. The function of degradative enzymes in necrotrophs is apparent. They are necessary not only for plant tissue penetration and colonization but also for breaking down the tissues' high molecular weight components into digestible forms. This often leads to the mushy symptoms that give these illnesses their name when it comes to soft decaying organisms.

Hemibiotrophs are a kind of parasite that transition from being biotrophs to necrotrophs by using strategies from both groups of pathogens. Intercellular hyphae may produce haustoria in live mesophyll cells during hemibiotrophic infections, however when the lesion spreads under favored circumstances, those extensively parasitized cells in the inner, older section of the colony collapse and die.

Ectoparasites are pathogens that colonize the surface of plants and take nutrients from mesophyll or epidermal cells via haustoria. The only structures that enter the host cells are the haustoria. Some parasites enter the host's epidermal and mesophyll cells via haustoria that grow between the cuticle and the outer wall of the epidermal cells. Sub-cuticular infections are what they are known as. Pathogens may also establish colonies deeper inside the tissues of plants. These infections affect the mesophyll and parenchyma, and their interactions may be necrotrophic, hemibiotrophic, or biotrophic. A unique situation occurs when viruses colonize the host. Viruses travel from cell to cell through plasmodesmata, but they may also reproduce in locations that are far from the original cell. Long-distance viral migration via the phloem or xylem happens in the case of systemic infections and often calls for an intact capsid protein. While within the conducting tissues of the plant, the virus moves about and unloads much as solutes do, although the mechanics are yet unclear. Specialized biotrophic connections are formed between viruses, mildews, and rusts and their hosts. Downy mildew intercellular hyphae colonize host mesophyll cells and create haustoria. Unlike to necrotrophic diseases, the necrosis induced by the mildew is delayed and localized, and the infected cells finally perish. Infected cells may postpone senescence while sporulating under the influence of rust fungus. Vascular infections often result in wilting and discolouration because the diseased xylem arteries are physically blocked. While other infections may produce the same symptoms if they infect the vascular system in addition to other tissues, true vascular wilt pathogens only colonize the vascular tissue. There are a few viruses that are able to infect their host systemically. For instance, many viruses may travel to the majority of tissues in the plant, but not necessarily to all of them. By infiltrating the vascular tissue and spreading throughout the host, certain downy mildews may also systemically infect their host, leading to deformation as opposed to necrosis. Ultimately, certain infections may travel from cell to cell during cytokinesis and can complete their full life cycle within the cells of their host.

III. CONCLUSION

Considering that many diseases must get beyond the defenses of plant waxes, cutin, and suberin, as well as plant cell walls, before establishing a parasitic relationship with their hosts. Some soil-borne pathogens use chemical signals to find their hosts, and these signals are crucial for subsequent processes like propagule germination, chemotropism of germ tubes, and differentiation of infection structures, the latter of which is also influenced by the physical characteristics of the host. In many cases, adhesion is necessary for effective penetration, especially when it involves the application of mechanical force. Yet, many diseases also need the entrance of enzymes that break down the top layers of plants, including waxes, cutin, and suberin. After the pathogen has penetrated these surface layers, it must typically break through the cell wall, which calls for a variety of pectolytic enzymes, cellulases, xylanases, and enzymes that break down lignin. Other enzymes, such as proteases and membrane lytic enzymes, are sometimes assumed to play significant roles in pathogenicity or virulence. Necrotrophic pathogens feed on the byproducts of degradative enzymes working on host tissues, whereas the more subtle biotrophic pathogens feed via specialized structures called haustoria. Since they are immobile, viruses and viroids have a difficult time colonizing their hosts after they have been admitted. Long-distance spreading is accomplished by passive xylem or phloem movement.

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Host-Pathogen Interaction-II: Defense Mechanism

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Abstract*— Pathogen-host interactions are mediated in part by microbial proteins that are released and capable of exploiting host cells for survival. Several of these manipulations include but are not limited to, suppression of defense responses, changes in host vesicular trafficking, and gene expression manipulation. Understanding host-pathogen interactions is essential for developing effective treatments and preventative measures for infectious diseases. It is possible to understand how pathogens enter and multiply in their hosts by looking into and analyzing the various phases of infection.

Keywords*— Active Defense, Defense Mechanism, Host-Pathogen, Plant Defense, Signal Transduction.

I. INTRODUCTION

Signal transduction pathway in the plant defense system; Plant Defense Elicitors in Response to Pathogen Attack. Whether it be the host plant or the pathogen, adjustment is likely one of the most critical characteristics of a natural system that promotes its effective functioning and survival. The only biological mechanism capable of transforming solar energy (electromagnetic radiation) into chemical energy exists in green plants, which are autotrophs. They are constantly surrounded by a vast ecosystem of insects and microorganisms that are either directly or indirectly reliant on the producers. Even though it hurts the plants, these creatures in some ways use these natural resources. The biological system of plants resists this exploitation on all fronts and in all ways. The development of defensive mechanisms in plants is the result of co-evolution, which was compelled by co-existence with pathogens. Consequently, the plant system's inherent and universal defense against any "destructive act" has evolved. The heritable characteristic of plants that allows them to withstand an assault by parasites or diseases or their activities is their resistance to these organisms. Although coexisting with some of the most dangerous viruses, defensive mechanisms have allowed plants to survive [1]–[3].

1. Post-infectious or induced defense mechanisms;
2. Pre-existing or Pre-Infective defense mechanisms

A. Host reaction and pathogenesis

When the pathogen challenges the plants, they do respond with structural and chemical defensive mechanisms, according to the analysis of the majority of host-parasite interactions. When pathogen propagules come into contact with the host surface, plants immediately defend themselves using a variety of naturally occurring physical and chemical barriers to prevent penetration. If the penetration does happen, however, the host responds in a variety of ways that result in the formation of physical and chemical barriers. Consequently, it is possible to study plant defense systems concerning the chain of occurrences that result in a disease assault on them.

A.. An already-existing or early-stage defense mechanism

1. Barriers that be either physical or structural or that are biochemical

B. Post-infectious or induced defense system

1. Barriers that are physical or structural, biochemical, or that are triggered by signals
2. Existing or early-stage defense mechanism
3. Barriers, both physical and structural

The epidermal surface of plants serves as their first line of defense. A pathogen must overcome a number of surface characteristics of the plant in order to infiltrate the host. The pathogens penetrate the epidermis, cuticle, and cuticular wax to enter the plant host. A variety of natural holes that existed prior to the commencement of the pathogenesis may prevent penetration. If the infection penetrates, it will run across internal structural barriers that already exist. Pre-existing defensive structures and passive/static or anti-infection structures are other names for the exterior and internal structural barriers that exist prior to pathogen assault.

Cuticle and wax Plants' cuticles are made up of a wax layer, a cutinized layer, and a pectin layer that cover their epidermal cells. Fatty acids make up cutin. Waxes are a combination of long-chain aliphatic chemicals that stop water from remaining on plant surfaces, which is necessary for spore germination. Fatty acids normally cause the surfaces of leaves to become negatively charged. Airborne spores and propagules are repelled by this situation. Just a few pathogens are known to degrade cutin enzymatically [4]–[6].

Cherry leaves' cuticles can be penetrated by Monilinia fructicola, however Gingko biloba leaves cannot since the latter have more abundant cutin than the former. Cutinase synthesis is induced by particular antibodies and inhibitors against F. solani.

B. Epidermal layer

The epidermis is the first layer of the live host cells that the invading germs come into touch with. The polymers of cellulose, hemicelluloses, lignin, mineral components,

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polymerized organic compounds, suberin, etc. are responsible for the epidermis' toughness. Pythium debaryanum-resistant potato tubers have more fiber. Epidermal walls that have accumulated silicon are resistant to fungal assault. Citrus plants benefit from protection against Xanthomonas axonopodis pv. Citri when their epidermis is suberized. Certain types have been found to have a defensive mechanism that works because their stomata were only open at night after the infective propagules have stopped functioning and the fluid on the leaf surface has dried.

Hydathodes are pores that naturally occur on the margins of leaves and are used to expel extra water from the inside. They provide germs with simple access opportunities. The nectarthodes found in the inflorescence of many plants are similar to hydathodes. They produce sweet nectar, which acts as a barrier to species that cannot survive in this environment and cannot enter via nectaries. Pathogens are also prevented from entering by the leaf hairs on leaves and nectaries. Chickpeas have high hairlines on their leaves and pods, which makes them resistant to Ascpchyta rabei. The characteristics of groundnut cultivars that exhibit resistance to Cercospora leaf spots include a thick epidermis-cum cuticle, a compact palisade layer, few, smaller stomata, and a high frequency of trichomes on the abaxial side of the leaf. Unless the cork cells inside them are suberized, they have poor protection. Lenticels become more resistant to pathogen invasion after suberization and periderm development.

C. Biochemical barriers

Several compounds that plants release directly disrupt the pathogen's activity and lessen the impact of pathogenesis, avoiding or lessening infection. These substances and the resulting biochemical circumstances may affect the invader directly by secreting poisons or lytic enzymes, or indirectly by promoting hostile plant surface microorganisms. Constitutive antibiotics are such molecules that defend plants against infections that are already present, while wound antibiotics are those that are generated in reaction to wounds.

D. Antimicrobial chemicals released

During their regular growth and development, plants exude various gases and organic compounds from the epidermal surfaces of their leaves and roots, which are referred to as "leaf and root exudates." These exudates are a complex combination of materials that include sugars, amino acids, organic acids, enzymes, glycosides, and other compounds. These substances have a significant impact on the local environment, especially on the phyllosphere and rhizosphere's microflora and fauna. Although being excellent nutrients for bacteria and aiding in the germination and development of many saprophytes and parasites, these exudates also contain a significant amount of inhibitory compounds. These antimicrobial agents may directly damage the microorganisms or they may also encourage certain populations to take control of the environment and act as the pathogen's enemies.

The presence of inhibitors in plant cells Pre-existing toxic chemicals in the host cells serve as the foundation for resistance in many host-parasite interactions. These compounds develop in large quantities in the resistant variety, but in the susceptible variety, they may occur less often or not at all. Young tissues' resistance to parasitic fungi like Botrytis has been linked to a number of phenolic chemicals, tannins, and certain fatty acid-like molecules like di-enes that already present in high quantities in host cells. These substances are powerful inhibitors of a variety of hydrolytic enzymes. Other pre-formed substances with antifungal membranolytic action include saponins (glycosylated steroidal or triterpenoid compounds), tomatine in tomatoes, and avenacin in oats. The fungi that cause infections cannot infect the host because they lack the saponinases, the enzymes that break down the saponins. It has been noted that a number of pre-formed plant proteins may block pathogen proteinases or hydrolytic enzymes. Similar to this, many fungi are lysed and have their growth inhibited by lectins, proteins that attach to certain carbohydrates. Hydrolytic enzymes, such as glucanases and chitinases, are also present in varying levels on plant surface cells, where they may break down pathogen cell wall components.

E. Lack of plant recognizability factors

The exchange of information between the host and pathogens' cells marks the beginning of the infection process. If the surface cells of a plant's many species or variations lack certain recognition elements, the pathogen may not infect those plants. The pathogen may not cling to the host surface or develop infection-causing chemicals like enzymes or structures if it does not identify the plant as one of its hosts (appressoria, haustoria). These recognition molecules might take the form of different oligo-, poly-, or glycoproteins.

Lack of host receptors and toxin-receptor sites: In several host-parasite interactions, the pathogen creates host-specific toxins that cause symptoms and the progression of the illness. Toxin compounds are intended to bind to certain cell receptors or sensitive areas. Only plants with such delicate areas get diseases.

Crucial vitamins, minerals, and development elements: The majority of obligate parasites and many facultative saprophytes are host-specific, and some are so specialized that they can only grow and reproduce on specific strains of those plant species, which suggests that these pathogens can only obtain the vital nutrients and growth factors from their hosts. The other types and species are immediately rendered inappropriate hosts for such infections by the absence of these nutrients and stimuli [7]–[9].

II. DISCUSSION

1) During their lifespan, plants must contend with a large array of diseases (enemies) when stationary. They thus have a strategically planned pre-existing (structural and

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Vol 10, Issue 2S, February 2023

biochemical) defensive mechanism built into them by nature and the process of evolution. This system's true worth has not been thoroughly explored. It seems that plants can repel the majority of microorganisms as non-pathogens thanks to their innate defensive systems. But, it doesn't appear to be enough. The disease develops when a virus avoids timely evoking an active defense system in plant tissue or habits an active defensive response by secreting metabolic poisons. This happens when pre-existing defense mechanisms are unable to prevent the infection's penetration.

Induced Biochemical Defense Induced Physical or Structural Defense Both particular and non-specific defensive mechanisms may be activated or induced. Many biotic or abiotic elicitors are known to cause a number of structural alterations. These adaptable defensive systems stop the dissemination or further colonization of pathogens. Cellular defenses used in active defense in plants depend on built-in monitoring systems that are expressed by resistance genes. In order to identify the pathogen or component that pathogens translocate, the receptor proteins are placed strategically in the cell membrane. Genomics again controls a plant's capacity to develop an active defensive response. Even after an infection has been established in plant cells, the host defense system works to erect obstacles to prevent further tissue colonization. There are numerous levels at which this may be done.

A. Lignification

Cell walls that have been lignified act as an efficient barrier against hyphal penetration Also, they serve as an impermeable barrier to the free flow of nutrients, starving pathogens like those that cause potato or cucumber infections by Phytophtora infestans or Cladosporium cucumerium.

B. Suberization

In certain plants, as soon as the infection takes place in the cells, suberized cells surround the infected cells. This keeps them apart from healthy tissue. Along with the common scab of the potato and the root of the sweet potato, corky layer production is a component of the natural healing mechanism of plants.

C. Abscission layer formation

Plants naturally develop abscission layers as a method of dropping-off older leaves and ripe fruits. Many plants also slough off sick or invaded plant tissue or sections, along with pathogens, using this device as a defensive strategy Fruit tree leaves often have bullet holes in them.

D. Tyloses formation

The walls of xylem parenchyma cells often protrude by the route of pits to produce the tyloses in older xylem vessels of plants. The vessel is physically blocked by the size and quantity of tyloses. The tyloses are generated inductively far earlier than infection, preventing the propagation of the virus. It implies biochemical elicitors and tyloses inducing factor (TIF) migration up the stem as in Fusarium oxysporum f. sp. Batatas infection of sweet potatoes.

E. Gum deposition

The gums and vascular gels rapidly build up and cover the crevices between cells or within the cells that surround the infection thread and infective haustoria kills or starves infective propagules. Lignification, the creation of the Abscission layer, the C1, and C2 Cork layers, and lignification (d) Tyloses development (e) Infection threads sheathing

F. Resulting Biochemical Alterations

The final line of defense for the host plant is induced metabolic alterations. According to their genetic potential, a plant's or a particular plant tissue's reaction might range from sensitive to resistant. The following four characteristics serve as the foundation for the biochemical factor's part in host defense:

1. In the location where protection takes place, the chemical is linked to disease protection.
2. The chemical may be separated from the host and exhibit disease protection.
3. Protection is granted when an isolated chemical is administered to a suitable vulnerable host.
4. The kind of protection thusly created is similar to the organic components of a resilient plant.

G. Creation of toxic substances

A key element of plants' overall active defense strategy is the quick creation, appropriate modification, and/or accumulation of compounds that are poisonous to pathogens at effective quantities. Low amounts of comparable compounds or their slow synthesis have also been seen in sensitive host plants.

H. Phenolic compounds' function

The major hazardous chemicals created to suppress pathogens or their activities are phenolic compounds, namely chlorogenic acid, caffeic acid, and oxidation products of phloretin, hydroquinone, hydroquinones, and phytoalexins. Some of them are harmful compounds produced by phe, whilst others could be created from scratch or changed to take on more dangerous forms. The host cell already has the enzymes necessary for chemical processes (pre-existing).

I. *The function of phytoalexins*

The most typical reaction of plants to stress, whether caused by biotic (pathogens/insects) or abiotic (wounds), is the creation and accumulation of substrates that may impede the development and activities of the biotic factors or may aid in the healing process. In their research on the hypersensitive response of potatoes to avirulent P.infestans strains, Muller and Borger introduced the idea of phytoalexins. Antibiotics called phytoalexins are created during plant-pathogen interactions, in response to damage or other physiological stimuli, or both.

ISSN (Online) 2456 -1304
International Journal of Science, Engineering and Management (IJSEM)
Vol 10, Issue 2S, February 2023

J. The function of newly generated proteins

During infection, host cells undergo a range of structural and enzymatic protein modifications that play a significant part in their defensive mechanisms. The enzymes are necessary for a variety of synthetic pathways (either regular or modified) that produce chemicals relevant to resistance. In addition, enzymes that oxidize phenol play a critical role. These modifications may just affect the injection site or neighboring cells. Many bacterial and important pathogens have been shown to produce and activate Phenyl Ammonia Lyase (PAL) with increased frequency in resistance responses. PAL is essential for the production of phenols, phytoalexins, and lignin. The quantity and speed at which produced products are sent quickly to nearby healthy tissues to form effective defensive barriers determines how effective resistance is.

K. Toxins and enzymes are rendered inactive

It is generally known that infections' chemical weapons (toxins and enzymes) play a part in pathogenesis. As compared to specialized obligatory parasites, necrotrophs, and hemibiotrophs use more of these chemicals to inflict greater tissue harm. Proteins, tannins, and phenols function as enzyme inhibitors to help resistant plants defend themselves. Although not anti-fungal, phenolics render pathogens ineffective by blocking their enzymes. Catechol-tannin is reported to suppress Botrytis cinerea enzyme production in grape grapes that are still developing. It is well-recognized that toxins have a role in pathogenesis. Pathogen resistance will result from the host's toxin resistance. Detoxification or the absence of receptor sites for certain poisons may accomplish this.

L. The role of the altered biosynthetic pathway

The host tissue's post-infection metabolism changes (stress physiology) to deal with the pathogen's increasing activities. To create compounds relevant to defense, new enzymes (proteins) are created. The modified acetate route and the Shikimic acid pathway are used to create the majority of these chemicals. Always, respiration is enhanced in sick tissue, and a portion of glycolysis is replaced by the pentose pathway, which produces four-carbon molecules. It's likely that during the early stages of infection, the host cell's ability to regulate its genes is affected, and certain particular genes are turned on to produce the fresh materials needed for active defense.

M. Pathogens' active defense

Induction of structural or biochemical host resistance seems to be a trait shared by all plants. All kinds of pathogens have been documented to elicit active defensive responses (fungi, bacteria, viruses, and nematodes. Active defense mechanisms may result in host-pathogen interactions that are undesirable.

As a result, the host experiences a brief spike in cellular metabolic activity upon the introduction of the virus. Cells quickly perish as a result of stress brought on by increased metabolic activity and exhibit hypersensitive reactivity. In most sick systems, rapid cell death is associated with enhanced resistance. The metabolism of surrounding tissues also increases as the diseased tissues progress toward the necrotic phases, and phenolic and other chemicals accumulate. The synthetic molecules go from healthy to sick tissues throughout this process. Hypersensitive responses to typical phenols, phytoalexins, and other aberrant chemicals. The oxidized phenolic compounds may detoxify the poisons or render other pathogen weapons inactive. The nearby healthy tissues attempt to isolate the damaged sections by generating new tissues and eradicating the disease/pathogen when the spread of the pathogen is stopped. Pre-existing or induced host defense is a multi-component method where a number of variables combine to create the desired effect.

N. Elicitors

Elicitors are substances that, when added to a living thing, indicate the production or activation of another substance. One example of such a chemical is jasmonic acid, which in grapevine cell cultures promotes the manufacture of delta-viniferin. Chitosan is another example; it is used in agriculture as a natural biocontrol agent. Early reactions to the identification of a possible elicitor include fast ion fluxes, kinase cascade activation, and the production of active oxygen species (AOS). The activation of the hypersensitive response (HR), a limited type of programmed cell death (PCD) that restricts pathogen transmission, further strengthening of the cell walls, and development of antimicrobial chemicals such defense proteins and phytoalexins occur after these early steps. Jasmonic acid (JA), ethylene (ET), and salicylic acid are three signal molecules that combine to trigger many of the plant defensive responses (SA). The word "elicitor" was first used to substances that may cause the formation of phytoalexins, but it is now often applied to substances that stimulate any sort of plant defense. The stimulation of defensive reactions may eventually result in improved resistance.

Elicitors are different from hormones (compounds generated in one area of an organism to affect another area of that organism), which must be created inside the organism in which they are intended to elicit a reaction. Elicitors are also often not found in the organism naturally. Exogenous elicitors, which are chemicals derived from pathogens, are included in this definition of elicitors together with molecules produced by plants as a result of the pathogen's activity (endogenous elicitors). Elicitors are diverse families of molecules that include oligosaccharides, peptides, proteins, and lipids but do not have a common chemical structure. They separate elicitors from toxins, which may function only at greater concentrations and/or negatively influence the plant without active plant metabolism, by acting as signal molecules at low concentrations and giving information for the plant to start defense.

ISSN (Online) 2456 -1304
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Vol 10, Issue 2S, February 2023

The majority of elicitors seem to fit into one of two groups. Several of them, such as glucan and chitin fragments as well as bacterial flagellin and lipopolysaccharides, are constitutively present in the pathogen cell wall as structural elements (LPS). Although the function of certain elicitors is yet unknown, another class of elicitors, such as harpins, products of the avr genes, play an important role as virulence determinants. The primary elicitors for the plant response in certain plant-pathogen interactions may be generated as a result of the activity of plant cell wall-degrading enzymes. These enzymes also produce pectic fragments (oligogalacturonides, OGAs), which might function as endogenous elicitors. These enzymes are often crucial virulence factors and provide the invading pathogen with nutrition. The existence of a common elicitor theme is ruled out by the wide variety of elicitor chemicals, which shows that plants may identify a variety of structurally different molecules as signals for pathogen defenses. Early research on signal transduction pathways using elicitors found startling parallels between chemicals used by animals and plants to detect and transmit messages from intruders. These findings demonstrate the evolutionarily conserved forms of elicitors generated by defense-related signaling systems in several living kingdoms, which gave rise to the innate immune system.

Plants constantly protect themselves against fungi, bacteria, viruses, invertebrates, and other threats. They lack an immune system, but they do have built-in and programmable protective resistance. Resistance to plant diseases often relies on the capacity to recognize signals and activate them to start a reaction. Attacks by plant pathogens are detected by chemicals originating from plants or pathogens, which trigger a protective response.

While there are many different elicitors, there are generic models for cellular elicitor signaling that result in plant resistance. The first signaling activities that follow elicitor perception, such as modifications in plasma membrane protein activities, reversible protein phosphorylations, the creation of nitric oxide and active oxygen species, and changes in the quantities of free calcium in the cytosol and nucleus. These occurrences take place in the first minutes to a few hours after eliciting perception. Depending on the stimulus, one particular elicitor transduction route may employ a full or partial combination of these events, which may vary in strength. The connections between the signaling events enable signal transduction to be amplified and guarantee specificity to acquire the right plant defense responses. Only vulnerable plants are affected by the disease because they cannot identify the pathogen or react slowly enough. In this situation, plant-pathogen interactions are often compatible since the pathogen exhibits distinctive symptoms.

This interaction is incompatible because the resistant plant can quickly induce defense responses to stop the pathogen from developing when a putative pathogen manages to get past the host barriers and if the invader is recognized by the invaded plant. This is because the plant can resist both the development of symptoms and the reproduction of the pathogen. Signal transduction, in biology, is any procedure that a cell uses to change one kind of signal or stimulus into another. At the cellular level, signal transduction describes the transfer of signals.

Plant resistance (R) genes and pathogen avirulent (avr) genes are known to have a genetic role in controlling disease resistance in many plants (Flor 1947). Moreover, it has been proposed that R gene products serve as Avr protein receptors, either directly or indirectly (elicitor-receptor model). A signaling cascade that is responsible for activating the defensive response is started as a result of this chemical contact. Nevertheless, Avr protein binding has not yet been shown for the majority of compatible Avr-/R-protein pairings. Several elicitor binding proteins that might be a component of the recognition complex have been characterized as a consequence of biochemical research. A category of receptors most likely to be involved in pathogen sensing is transmembrane receptor-like protein kinases (RLKs). These serine/threonine kinases have been classified as resistance or R genes in some cases and as pathogen- or elicitor-induced in others.

Yet, activating resistance does not necessarily result from particular Avr products; rather, it sometimes happens as a result of broad elicitors. Elicitors contain substances from several chemical families of proteins, glycoproteins, glycans, lipids, and synthetic chemicals, as was covered in the paragraphs above. These are components of the pathogen, substances that it secretes, or substances that are released from the cell walls of the plant or the pathogen by hydrolytic enzymes from the pathogen or the plant. Early processes, such as protein phosphorylation or the activation of plasma membrane proteins, mobilize or produce various signaling molecules (such as free calcium, nitric oxide [NO], and active oxygen species [AOS]) that regulate many processes. These signaling molecules connect branch pathways that amplify and specify the physiological response through transcriptional and metabolic changes.

O. Transduction of signals

The next stage after perception is signal transduction. Internal signal transduction pathways are probably started by the perception of external signals via certain receptors. A signal is transferred through a series of intermediate molecules known as transcription factors before it is finally regulated by a final set of molecules known as protein phosphorylations as a result of the binding of ligands by a transmembrane receptor. This process is known as signal transduction. The two primary methods for signal transduction are: - a. Via G-Protein: G-proteins are made up of three subunits and, with serving as the primary regulator of specificity. The GTPase domain and the -helical domain are the two domains that make up the -subunit. Some areas of the

GTPase domain undergo conformational changes as a consequence of activation.

Using Mitogen-activated Protein Kinase (b) (MAPK) Cascades: In converting extracellular inputs into cellular and nuclear responses, MAPK cascades play a crucial role. Dual phosphorylation of threonine by the MAPK kinase (MAPKK), which is mediated by serine/threonine phosphorylation by a MAPKK kinase, activates MAPK (MAPKK). All MAPK pathways function by sequentially phosphorylating transcription factors and controlling gene expression.

P. Signal Reaction (Through Secondary Messengers)

Plant and pathogen interactions are unique, intricate, and dynamic. In response to the recognition, signals for the activation of numerous defenses start to be sent. The consequence of contact depends on how the organism is first sensed via the exchange of molecules through signaling cascades and altered gene expression. The first stage in producing a defensive signal response via a large secondary messenger system is recognition. The process of transmitting signals involves a large number of secondary molecules. Significant changes in gene expression are a result of signaling.

Agents of illness are pathogens. These contagious microorganisms, which include bacteria, nematodes, and fungi, feed on the plant and harm the tissues. Several defense mechanisms have been created by plants to deter or eliminate intruders. Plants have an unbroken, impermeable barrier made of bark and a waxy cuticle that serves as their first line of defense. Both protect plants against diseases. Mechanical harm to a plant's surface may undermine its defenses, opening the door for viruses to enter. The plant must switch to an alternative set of defensive mechanisms, such as toxins and enzymes if the initial line of protection is compromised. In the presence of pathogens, plants also contain a number of inducible defenses. Plants generate antimicrobial compounds, antimicrobial proteins, and antimicrobial enzymes that may combat infections in addition to secondary metabolites. To stop the pathogen from entering the plant, plants might shut their stomata.

III. CONCLUSION

Interactions between hosts and pathogens are critical to our knowledge of infectious illness, as well as its treatment and prevention. The methods by which pathogens enter and flourish in their hosts may be understood by investigating and analyzing the various phases of infection. Although some defensive responses take just a few minutes, others might take many hours. The capacity of plants to protect themselves against dangerous bacteria depends on their ability to identify possible diseases. A dizzying variety of substances, including various oligosaccharides, lipids, peptides, and proteins, make up microbial elicitors.

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Vol 10, Issue 2S, February 2023

Host-Pathogen Interaction-III: Pathogenesis and Disease Development

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***Abstract*— The process through which an infection results in illness is known as pathogenesis. Virus implantation at the point of entry, local replication, dissemination to target organs (disease sites), spread to sites of virus shedding into the environment, and so forth are some of the pathogenic processes of viral illness. In this chapter, we discussed the pathogenesis and the disease development in the plant.**

***Keywords*— Cell Wall, Host-Pathogen, Plant Tissue, Plant Cells, Secondary Metabolites**

I. INTRODUCTION

When viruses have attacked, unhealthy plants emit specific distress signs that may be seen. The stress of infection will cause a variety of symptoms in plants, including leaf spots, harmed fruit, wilting, and even death. In addition to the plant's external symptoms, its internal functions may also be harmed, which might cause the illness to manifest or the plant to abort. In this regard, there are often several interactions between the pathogen, the host, and the environment. In a given setting, whether or not illness progresses to destructive levels depends on how these interactions are balanced [1]–[3].

A. Symptom Development

In general, diseases entail a succession of symptoms that might be quite different. One of the most significant aspects of difficulties brought on by biotic agents is the development of symptoms. Primary and secondary symptoms may be caused by diseases. For instance, rotting tree roots may be a main symptom, although the tree being blown over by the wind may be a secondary symptom. When the disease progresses, secondary invaders may also mask the initial illness signs, resulting in symptoms that are dissimilar from those that emerged as a result of the first infection. The majority of plant pathogens are fungi, however insects, bacteria, nematodes, viruses, and phytoplasmas may also cause illness in plants. Abiotic variables such as temperature, light, chemical agents, and a lack of water or nutrients may also contribute to the development of disease-like symptoms.

Necrotrophs are parasites that release enzymes that cause host tissue to die so they may take resources from the cells and then dwell within the dead tissue. Pathogens may create little or widespread necrotic lesions. When widespread or spreading lesions progress until the whole organ or plant is dead, local necrotic lesions emerge as distinct necrotic regions. Deviation from the intricate balance of linked processes that occur in plants causes abnormal development and differentiation. In plants, parasites may change the hormonal balance, leading to an aberrant increase in cell size or quantity, leading to abnormal growth and differentiation, such as the development of galls. When water loss exceeds water intake, wilting happens. Either the roots' ability to absorb water and nutrients is hampered, the plant's ability to transmit water is hindered (for example, by an infection of the vascular tissue), or transpiration is no longer under the plant's control. The symptoms known as metaplastic are those that arise as tissues transform from one form to another. Proleptic symptoms are brought on by tissues developing sooner than normal. The most frequent causes of tissue discoloration are chlorosis and leaf mosaics, both of which might have a variety of underlying reasons. Leaves become yellow or chlorotic when something prevents the synthesis of chlorophyll. Mosaic, which manifests as alternating patches of light and dark green on the leaves, is a sign of several viral infections [4]–[6].

B. Necrosis, death, and destruction of host tissue

Necrosis is brought on by the death, or necrosis, of plant cells. The afflicted plant tissue often changes color from brown to black. Any portion of the plant, such as storage organs, green tissues, or woody tissues, might exhibit necrotic signs.

C. Organ necrosis in storage

When cells in storage organs die, the result is rot, which is a kind of breakdown or decay. Soft rots, also known as wet rots, are diseases where the pathogen weakens the host cell walls, causing the affected tissue to exude fluids. Due to colonization by secondary invaders, the organ sometimes turns pulpy or mushy and has an unpleasant odor. Many bacteria and fungi induce soft rots on a variety of fruits and vegetables. Examples of such frequently occurring pathogens that cause soft rots include species of the fungus Rhizopus and the bacterium Erwinia. Dry rot causes the storage organ to become hard and dry. Mummifications are caused by certain illnesses that cause a fast loss of water, causing the

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Vol 10, Issue 2S, February 2023

affected organs to become shriveled, wrinkled, and leathery. These dry rots are known as mummifications when they exhibit these signs.

D. Necrosis in green tissues

Depending on the kind of green tissue and the symptoms present, several terms are used to describe necrosis in green tissues.

1. Damping off: When soil-borne infections like the fungus Pythium attack the sensitive tissue of the roots and stem close to the soil line, it causes widespread necrosis and abrupt wilting and toppling over of seedlings. This fungus is known to induce damping off in a variety of seedlings, including those of tomato, brinjal, chili, mung beans, and other plants.
2. Spot: A well-defined patch of gray or brown necrotic tissue is referred to as a spot. Spots are perhaps the most well-known necrotic sign since they appear often on leaves and fruits.
3. Shot Hole: Occasionally the surrounding green tissue of a leaf spot can break and separate from the necrotic tissue inside, creating an empty gap. Shot holes are a common name for such a condition.
4. Flecks or Specks: These are tiny, insignificant dots that are sometimes referred to as flecks or specks.

1.1 Blotch

A symptom is referred to as a blotch when black mycelia of a fungal infection form on the surface of a necrotic patch, blotting the leaves, shoots, and stems as huge and irregular blotches.

1.2 Streaks and stripes

Both streaks and stripes are elongated, dead-cell-filled regions that may be seen in grasses. Although stripes reside in the laminar tissues between veins, streaks are seen along the stem and the veins.

1.3 Net necrosis

Net necrosis is a phenomenon that happens when potatoes grow under very dry circumstances. The vascular system at the potato's stem end starts to deteriorate, resulting in this dark discoloration. This condition is not dangerous. A symptom caused by an uneven arrangement of anastomoses between streaks or stripes is known as net necrosis.

1.4 Blights

Blights are characterized by the sudden death of the whole leaf, together with its veins, or of portions of the leaf. Flowers and stems might potentially get blights [7]–[9].

1.5 Scorches

1. Scorches mimic blights, but necrosis develops there in erratic patterns along leaf edges and between veins.
2. Fire is the abrupt drying, collapsing, and death of a whole leaf.
3. Pathogens that cause vascular wilt and root rot cause firing to happen.

1.6 Scald

The word "scald" refers to the blanching of the epidermal and surrounding tissues of fruits and, sometimes, leaves. Unopened buds or inflorescences that suddenly perish are referred to as blasts.

1.7 Shelling

Shelling is the extensive necrosis of fruits that resembles premature dropping.

1.8 Woody tissue necrosis

Woody tissue necrosis often results in a variety of die-back symptoms.

1.9 Dieback

The widespread necrosis of a shoot from its tip downwards is known as dieback.

1.10Canker

A canker is a limited necrosis of the bark and cortical tissue of stems and roots. Necrotic tissue in cankers is strongly constrained in the sunken lesions, often by a callus from neighboring healthy tissue.

1.11Gummosis:

Woody tissues that have a condition may discharge a variety of chemicals. The condition is known as gummosis when the discharge is gooey.

1. Rosiness: When the exudate is resinous, the condition is referred to as rosiness.
2. Bleeding: The exudate is referred to be bleeding if it is neither sticky nor resinous.

E. Improper Growth and Differentiation

Growth alterations in sick plants are linked to several illness symptoms. They might be brought on by either excessive growth brought on by hyperplasia and hypertrophy or decreased growth caused by hypoplasia and atrophy.

1.1Lowered growth

Hypoplasia

Hypoplasia is the inability of plants or plant organs to completely grow as a result of a lower cell production rate. Hypoplasia causes plants or plant components to be smaller than usual.

1.2 Atrophy

1. Atrophy is the shrinkage of generated plant cells. Stunted plants or sections of plants are another effects of this.
2. The inability of a plant or a plant component to reach its maximum size is known as dwarfism.
3. Resetting is a situation in which a plant's internode does not lengthen, causing the leaves to cluster together closely.

1.3Unreasonable Growth

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Vol 10, Issue 2S, February 2023

Hyperplasia: Hyperplasia is the swelling of plant tissue as a result of an uncontrollable rise in the number of plant cells generated. The size of plants or plant organs overdevelops as a consequence of hyperplasia.

1.4 Hypertrophy

1. Excessive growth brought on by individual cell expansion is known as hypertrophy. Moreover, this syndrome causes plants or plant organs to become too large.
2. The expansion of stems and roots as well as the enlargement of leaves and fruits are both possible outcomes of hyperplasia and hypertrophy.
3. Increasing the size of fruits and leaves: Several signs of leaf and fruit enlargement are often seen in sick plants, including leaf and fruit swelling.

1.5 Curling

Overgrowth on one side of an organ causes curling, which is the bending of the shoot or the rolling of the leaf. Such leaf deformities are often caused by viral infections because the lamina grows irregularly.

1.6Shoe-string effect

The symptom known as the Shoe-string effect results from a severe decrease in the leaf lamina.

1.7Savoring

1. Savoring is the puckering or crinkling of leaves brought on by varying rates of development in nearby tissue.
2. Scab: Scab development may be caused by excessive growth of the epidermal and underlying tissues of leaves, stems, fruits, and tubers. Raised, tough, and distinct lesions make up scabs. They often seem scabby because they are sunken and cracked.
3. Enlargement of stems and roots: Symptoms causing enlargement of stems and roots are termed differently based on their nature.
4. Blister Localized swellings or enlargement of epidermal cells due to excessive accumulation of water is termed intumescence, and the diagnostic symptom is the appearance of a blister.
5. Sarcody: A swelling known as sarcody is caused by an excessive buildup of food material in stems above a confined location.
6. Tumefaction (Galls, Clubs, and Knots): Tumefaction refers to localized swellings that affect whole organs. Tumefactions like galls, clubs, and knots are often seen.
7. Fasciculation: Fasciculation is the clustering of organs around a focal point and is caused by excessive adventitious organ growth. Examples of this include hairy roots and witch's broom.
8. Witch's broom: Due to the thick clustering of branches of woody plants, witch's broom is a mass proliferation that resembles a broom.
9. Hairy root: Excessive root growth is the cause of hairy roots.
10. Fasciation: The expanding or flattening of cylindrical organs, such as stems, is referred to as fasciation.
11. Proliferation: Proliferation is the continuous growth of any organ after it has reached a stage beyond which it ordinarily does not expand.
12. Callus: A callus is the tissue that grows outward in reaction to injury. The majority of cankers are reported to develop callus development.

1. 8Wilting

Wilting is caused by plant tissue losing its turgor, which causes plant components to fall to the ground. They are a frequent sign of illnesses when the host plant's vascular tissue is affected by the pathogen or the toxic byproducts it creates. Wilting results from the vascular pathogens' infection interfering with water transfer. Wilting brought on by the action of these pathogens cannot be treated by watering, in contrast to wilting caused by low soil moisture. Eventually, infected plants perish.

F. Metaplastic signs and symptoms

The symptoms known as metaplastic are those that arise as tissues transform from one form to another.

1. Phyllody: One of these signs is phyllody, which is the transformation of floral organs into structures resembling leaves.
2. Juvenillody: Juvenillody is the growth of young seedlings on established plants.
3. Rusting: Rusting is a surface-level browning of leaves, fruits, and tubers brought on by suberization.
4. Proleptic signs
5. Proleptic symptoms are brought on by tissues developing sooner than normal.
6. Prolepsis: Prolepsis occurs when a plant's bud develops into a shoot too soon.
7. Proleptic Abscission: Proleptic Abscission is the early production of layers of abscission.
8. Restoration: Restoration is the unexpected growth of previously simple organs.

G. Host tissue discoloration

One typical sign of plant illness is alterations in the color of plant tissue.

1. Yellowing: The most common cause of these color changes is the yellowing of normally green tissue, which occurs when chlorophyll is destroyed or fails to produce. A partial or total inhibition of leaf color may occur.
2. Albication: Abdications is the last stage of color suppression.
3. Chlorosis: A more widespread symptom of partial suppression, chlorosis.
4. Mosaic: Green tissue patches that alternate with chlorotic regions are referred to as a mosaic. Mosaic is a sign brought on by several infections. Mosaics are classified in a variety of ways depending on the degree and pattern of discolouration.

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Vol 10, Issue 2S, February 2023

5. Mottling: This term refers to irregular patches that have both distinct bright and dark regions.

6. Streaking: An additional different kind of decolonization involves staining. The development of extended chlorotic lines is known as streaking.

7. Ring Spots: Circular chlorosis masses with a green core are known as ring spots.

8. Vein clearing and vein banding: These are two more frequent color changes on leaves.

9. Chlorophyll may also grow in tissues that ordinarily lack it, a process known as virescence.

10. Consequently, the tissue that is white or colored often becomes green. This process is known as virescence.

11. Anthocyanescence: Anthocyanescence results from the overproduction of anthocyanin and gives off a purple tint. Flowers are another living thing that may change color. The tulips infected with the color break virus are one example.

H. Physiological infection-related changes

The host produces several defensive responses during phytopathogen interactions. The four main types of plant pathogens are oomycetes, bacteria, and fungi. As pathogens have developed a variety of invasion, feeding, and reproduction tactics, they have a variety of effects on plants. Necrotrophs, which destroy host cells before colonizing them, have minimal impact on plant physiology, while biotrophic pathogens integrate into and slightly alter several elements of host physiology, including respiration, photosynthesis, translocation, transpiration, growth, and development. Plants' respiration rate always rises after being infected by fungi, bacteria, or viruses. The greater rate of glucose catabolism raises the temperature of diseased leaves noticeably.

An oxidative burst, which is characterized by a rapid rise in oxygen consumption and the generation of reactive oxygen species such as hydrogen peroxide (H_2O_2) and the superoxide anion, is the first stage in the plant's reaction to infection (O_2). A variety of disease resistance and wound healing pathways include oxidative burst. The pentose phosphate pathway is employed by resistant plants to create defense-related compounds via an increase in respiration and glucose catabolism. The excess energy produced in sensitive plants is used by the expanding pathogen. In addition to inducing the various defensive responses as outlined in the preceding section, interactions with phytopathogens also influence the plant's main metabolism and secondary metabolism dependent on the induction of defense programs, which both impact the plant's ability to grow and develop. Studies on phytopathology also evaluate the physiological state of the affected tissues in connection to photosynthesis, assimilate partitioning, and source-sink control in relation to the progression of the infection

II. DISCUSSION

A. Primary metabolism changes

In the preceding unit, changes in plant metabolism were covered in depth. As a first line of defense, plants have been claimed to have produced cellulosic and papillae development, cell wall apposition, lignin deposition, and hydrolytic PR proteins. These cell walls' constituent parts have a primary metabolite origin. Ion fluxes, phosphorylation/dephosphorylation of proteins, and the synthesis of signaling molecules including salicylic acid, jasmonic acid, ethylene, and active oxygen species are all triggered in response to interaction with pathogens or non-pathogenic microorganisms or elicitors. As a result, genes are controlled and defensive mechanisms are triggered, such as cell wall strengthening, the accumulation of phytoalexins, and pathogenesis-related (PR) proteins. To successfully establish resistance in plants, secondary messengers like salicylic acid (SA), jasmonic acid, ethylene, and many others are created.

Impacts on Photosynthetic Processes: Pathogens also have a direct and indirect impact on photosynthesis. Necrotrophs reduce the rate of photosynthetic activity by killing cells and harming chloroplasts, whereas pathogens that induce defoliation deplete the plant of its photosynthetic tissue. Depending on the intensity of the infection, biotrophs have various effects on photosynthesis. A biotrophic infection site develops into a potent metabolic sink, altering the plant's normal pattern of nutrient translocation and resulting in a net input of resources into the infected leaves to meet the pathogen's nutritional needs. Incompatible relationships have been linked to a reduction in photosynthesis. To start respiration and other defense-related metabolic activities, the plants seem to stop photosynthesis and another assimilatory metabolism. Yet, research also demonstrates that the regulation of photosynthetic genes is not always present before a decline in photosynthetic performance. Accumulation of sugar: During plant-pathogen interactions, the down-regulation of photosynthesis and concurrently increased demand for assimilates often result in the conversion of source tissue into sink tissue. The rise in cell wall invertase activity is one sign that the infection has caused a sink condition in the infected leaves. Extracellular enzymes called cell wall invertases split sucrose in the apoplast into glucose and fructose. Hexose transporters carry the resultant hexoses into the cell. The export of assimilates from the tissue will be reduced as a consequence of the cleavage of extracellular sucrose. Many plant-pathogen interactions have been documented to result in increased cell wall invertase production and activity. Similar to this, less sucrose is exported from infected source leaves.

An initial pathogen infection sets off a sequence of quick alterations that cause photosynthesis to decrease and respiration, photorespiration, and invertase enzyme activity to rise. Most of the paths and processes that underlie these quick alterations are unknown. It has been shown that the

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Vol 10, Issue 2S, February 2023

electrophilic oxylipin 12-oxo- phytodienoic acid accumulates upon pathogen infection and reduces photosynthesis very soon after application, indicating that it may be responsible for the decline in photosynthesis following pathogen challenge. Increased invertase activity causes hexoses to be produced, which function as signaling molecules and suppress genes involved in photosynthesis. Again, the net rate of photosynthesis is decreased as a result of this down-regulation of photosynthetic genes. The disease inhibits plant development and further lowers the plant's photosynthetic efficiency by consuming, diverting, and retaining photosynthetic products.

The relationship between disease/resistance development and glucose metabolism is influenced by a number of variables. Initially, the plant's defense and general metabolism are impacted by its glucose level. Second, sugars serve as both signals and food for both the microbial and plant partners. As a result, changes in assimilate levels may affect the pathogen's ability to propagate and may control how the virus expresses its genes. Lastly, certain infections also have extracellular saccharolytic enzymes such as invertases, fructoexohydrolases, and levansucrases that, when produced, would allow the pathogen to change the concentrations of hexose and sucrose in the host tissue's apoplast. And this may affect a plant's metabolism in any way, whether directly or indirectly.

B. Secondary metabolism changes

Plants have developed several defensive mechanisms to deal with the variety of biotic and abiotic stress that they encounter in natural systems, where they confront a variety of antagonists. It is often difficult to link a change in a plant's physiology or metabolism to a single stressor since typically a complex range of different stressors influence the plant at the same time. It is commonly acknowledged that secondary metabolites play a part in how a plant interacts with its surroundings. For the synthesis, storage, and modification (hydroxylation, glycosylation, acetylation, etc.) of a wide variety of chemicals as well as for use in coping with abiotic and biotic challenges, the main metabolites resulting from photosynthesis are routed into several metabolite pathways. Due to their toxicity, plants produce a wide variety of secondary metabolites that play a significant role in defense against predators and microbial pathogens.

These compounds are also crucial for plant communication with other organisms but have little bearing on growth and developmental processes. Terpenes, phenolics, and N and S-containing chemicals are the three main categories of secondary metabolites. Diterpenes called gibberellins, a class of plant hormones, have a variety of negative effects on several plant defense mechanisms. A common linear basic furacoumarin called psoralin is used to treat fungus defense. Coniferyl, coumaryl, and sinapyl are three distinct alcohols that react concurrently and haphazardly to create free radicals (ROS), which are then oxidized by the common plant enzyme peroxidase to form lignin. Lignin is a highly branching polymer of phenylpropanoid groups. Lignifications are a common reaction to infection or injury and impede the development of infections. Phytoalexins, Thionins, Defensins, and Allinin are examples of secondary metabolites that include sulfur and have been associated, either directly or indirectly, with plant defense against microbial diseases. The production of phytoalexins, which seem to be a widespread method of resistance to pathogenic microorganisms in a variety of plants, occurs in response to bacterial, fungal, or other types of stress and helps restrict the spread of the invading pathogens by accumulating near the site of infection. Several of these alterations are connected to a quick apoptotic reaction, also known as the hypersensitive response, which kills one or two invading plant cells (HR). As they all have antifungal and/or antibacterial action, defensins and thionins are S-rich non-storage plant proteins that are generated and accumulated following microbial infection and similar conditions.

A plant that has higher levels of secondary metabolites may be more resilient. They are believed to be expensive to produce and hinder plant growth and reproduction. Defense metabolites may therefore be split between constitutive compounds, also known as prohibitins or phytoanticipins, and induced metabolites, also known as phytoalexins, produced in response to an infection requiring de novo enzyme production. Phytoanticipins are regarded as the first chemical barrier that prospective infections must get over because of their high energy and carbon consumption. In contrast, the creation of phytoalexins may take two or three days since, by definition, the enzyme system must be created first.

C. Additional physiological alterations resulting from infection

Infected plants' water relationships are impacted by pathogens. Before sporulation tears the cuticle, biotrophs have no impact on the transpiration rate; at that time, the plant wilts quickly. By destroying the root system, pathogens that affect the roots directly impact how well a plant can absorb water. This results in secondary symptoms including wilting and defoliation. By obstructing xylem vessels, vascular system pathogens also have an impact on water flow. Pathogen infection alters the source-sink patterns in the plant, which affects growth and development generally. Many diseases disrupt the balance of plant hormones by either releasing plant hormones directly or by inducing changes in the plant's hormone production or breakdown. This may result in several symptoms, including the growth of adventitious roots, gall development, and epinephrine release (the down-turning of petioles).

D. Factors influencing the development of illness

A plant community's susceptibility to illness depends on the characteristics of the host, the pathogen, and the environment. The host's vulnerability (for example, by stressing out the plant) and the activity of the pathogen may

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both be impacted by the environment (e.g. providing moisture for spore germination). The performance of the host and the pathogen may interact. By establishing a microclimate all around it, the plant may also alter its surroundings.

E. *Factors* that influence the onset of illness

Pathogen Factors

The key determinant that affects whether illness will arise or not is the existence or absence of a pathogen. In these plant ecosystems, significant disease outbreaks may result from the introduction of a pathogen to a region where it has never before been seen. The pathogenicity of the infection often determines how much illness develops. The word "pathogenicity" refers to the pathogen's virulence (ability to cause infection) and aggressiveness (infection vigor). The pathogen's capacity for multiplication, dispersion effectiveness, and fitness for survival all influence its pathogenicity.

The pathogen's capacity for adaptation is essential in deciding whether it can infect resistant hosts or endure changes in the environment. The genetic adaptability and reproductive effectiveness of the virus define its adaptability. The capacity of the virus to distribute quickly across great areas is essential for the spread of disease and the emergence of epidemics. For instance, the spores of cereal rusts may be transmitted across great distances in a matter of days, while soil-borne viruses have little potential for wide-scale dissemination. Moreover, a virus that is conveyed by seed must rely on outside spreading entities. A virus has to be able to live across seasons in order to spread illness from one season to the next. Although some infections colonize other plant species until the season of their main host returns, certain pathogens produce spores or sclerotia that may live in the soil for years. The quantity of infectious propagules accessible to infect plants is a critical element in determining the amount of illness that develops in addition to the pathogen itself. When the quantity of illness reaches very high levels and there are few accessible uninfected plants, the degree of disease tends to level off as the number of propagules grows. Environmental conditions have a significant impact on propagule survival and, therefore, the quantity of propagules that may spread disease.

Hosts factors

The occurrence of adequate hosts that are vulnerable to that specific pathogen is necessary for the disease to emerge in a plant ecosystem. An epidemic may happen if the majority of people are vulnerable to the local path types of a virus. Planting species or cultivars that are resistant to local diseases is the most effective strategy to reduce illness. The host plant's development stage and morphology may also have an impact on the incidence of disease. Although certain diseases are characteristic of seedlings, others are prevalent in adult plants. The microenvironment surrounding the plants, such as the humidity and sunshine levels beneath the canopy, may be influenced by the population's stage of development. A plant community's susceptibility to disease will depend on the population's composition and density.

The abundance of the primary host species and the percentage of non-host plants in the community will influence how quickly and how far the epidemic spreads. Since they are often thickly planted and there are no other species present, crop plants are more prone to the quick spread of disease. Massive epidemics may arise in dense, extensive plantations, especially if a novel disease is introduced to the region. Also, a host plant's overall condition prior to infection plays a crucial role in determining the success of a disease. Whereas biotrophs flourish on a healthy host plant, necrotrophs thrive on plants that aren't developing properly.

F. *Environmental elements*

Unless the environment is ideal, the presence of a pathogen against a specific plant usually does not result in serious disease. This encompasses both the terrestrial (edaphic) environment and the airborne environment. Human attempts of controlling disease usually involve manipulating the environment of the community in a certain way. For example, creating wheat cultivars that survive dry conditions helps farmers to sow the crop in places that are less suitable for diseases producing powdery mildew and leaf rust. Temperature, pollution, and moisture content all affect how diseases develop in the aerial environment.

Moisture is very critical to harmful bacteria and fungi. Raindrop splashes play an important role in the dispersal of some fungi and nearly all bacteria and a period of leaf wetness is necessary for the germination of most airborne spores. By using water for dispersal, propagules are dispersed at a time when they are likely to be able to germinate as well. Because the process of germination and infection takes time, the duration of leaf wetness also influences the success of the infection. The duration necessary for infection varies with temperature. Generally, a longer time of leaf wetness is required to develop an infection at lower temperatures, while germination and infection are often hastened in warmer settings.

Temperature also affects the incubation, or latent period (the time between infection and the appearance of disease symptoms), the generation time (the time between infection and sporulation), and the infectious period (the time during which the pathogen keeps producing propagules) (the time during which the pathogen keeps producing propagules). The disease cycle speeds up at higher temperatures, resulting in faster development of epidemics. The period of leaf wetness, combined with temperature information can be used to predict outbreaks of some diseases (infection periods) and be used to timely take up preventative treatments, such as spraying. A recently recognized aspect of the aerial environment that can influence disease in plants is air pollution. A high concentration of pollutants can affect

disease development and, in extreme cases, damage the plants directly by causing acid rain.

The edaphic (soil) environment affects soil-borne diseases, largely by determining the amount of moisture available to pathogens for germination, survival, and motility. Germination and infection success also rely on the temperature of the soil. The fertility and organic matter content of the soil can affect the development of disease. Plant defenses are weakened by nutrient deficiency, although some pathogens, such as rusts and powdery mildews, thrive on well-nourished plants. Other diseases thrive in soils that are specifically low in organic matter. The environment can affect both the susceptibility of the host and the activity of the pathogen. The pathogen can affect the host and the host can influence the pathogen in numerous ways. Similarly, the host can influence the environment such as by influencing the microclimate. The development of disease requires the interaction of a virulent pathogen and a susceptible plant host in an environment that favors the development of disease.

III. CONCLUSION

There are a number of changes induced by different pathogens which reveal the complexity and divergence of the symptoms produced by them. The symptoms that are produced are the result of the interference in the plant metabolic machinery either by the plant itself, in a defensive response to the disease, or induced by the pathogen. Certain metabolic signals such as hexoses are responsible for the regulation of carbohydrate and defense metabolism. The amount of disease that develops in a plant community is determined by the factors related to the host, the pathogen, and the environment. An understanding of these factors and their interactions with a particular disease in a particular locality allows the prediction of disease outbreaks and intervention to reduce the amount of disease

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Epiphytotic and Plant Disease Forecasting

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Abstract*— An epidemic occurs when a disease spreads to and adversely affects a significant number of people within a population across a sizable geographic region and in a sizable amount of time. Every rise of a disease in a population has been referred to as an epidemic. Epidemiology is the study of epidemics and the variables that affect them. Plant disease forecasting is the practice of predicting plant disease outbreaks in a certain region in advance so that effective management measures may be put in place to minimize losses. Forecasting plant illnesses requires a thorough understanding of the epidemiology of plant diseases, as well as how meteorological variables affect disease severity and appearance. It is possible to forecast plant illnesses by using information on the weather and epidemiology in connection to plant diseases

Keywords*— Disease Outbreaks, Epiphytotic study, Plant disease, Relative humidity, Viral Infections.

I. INTRODUCTION

Epiphytotic also known as epiphytology, is the study of disease outbreaks, including their causes, intensities, causes, and consequences. The emergence of epidemics involving certain host plants depends on several internal and external conditions. An epidemic or epiphytotic illness is one that periodically spreads across a large region in a very severe form, resulting in significant losses or total devastation. Something is always there in a place, but only sometimes takes on a severe form. This is due to the existence of favorable environmental conditions that encourage illness to spread quickly. For instance, late potato blight Puccinia graminis tritici powdery mildew and wheat stem rust. In one region, a certain illness is endemic, whereas, in another, it becomes epidemic. For instance, citrus canker is endemic in Asia but pandemic in the newly imported region [1]–[3].

A. Pandemic

A disease that causes mass fatalities and spreads across continents or subcontinents is referred to be a pandemic. The finest illustration of a pandemic illness is the black stem rust of wheat epidemic that occurred in India in 1947.

B. Sporadic

Sporadic illnesses are those that occur only infrequently and typically without geographic concentration. Tetanus, rabies, and plague are examples of sporadic illnesses. A disease is said to be sporadic if it spreads randomly across a small region or place. They are generally localized, such as the Fusarium wilt of cotton (Fusarium oxysporum var vasiinfectum).

C. Causes causing epiphytotic disease

Depending on the three basic variables that induce the illness, an epidemic may result in widespread and massive crop devastation quickly or may last for a long time:

D. Host factors that influence the spread of epidemics

The emergence of epidemics involving certain host plants depends on a number of internal and external conditions. The host plants that have vertical resistance do not enable a disease to get established in them, preventing the outbreak of an epidemic. a. Degrees of Genetic Resistance or Susceptibility of the Host: While horizontally resistant host plants will likely get infected, how quickly the illness and epidemic spread depends on the amount of resistance and the surrounding circumstances. The best substrate for the formation and growth of new infections is susceptible host plants that lack genes for disease resistance. Thus, vulnerable hosts facilitate the formation of disease epidemics in the presence of a virulent pathogen and a suitable environment [4]–[6].

E. Host plant genetic uniformity

There is a higher chance that a new pathogen race will emerge that can attack their genome and cause an epidemic when genetically uniform host plants are cultivated across a vast region. This is especially true when it comes to the genes linked to disease resistance. This phenomenon has been seen time and time again, for instance in the southern corn leaf blight and the Cochliobolus (Helminthosporium) blight on Victoria oats. Similar to the above, due to genetic homogeneity, vegetatively propagated crops often experience the greatest rates of epidemic development, self-pollinated crops experience intermediate rates, and cross-pollinated crops have the lowest rates.

F. Kind of crop

Diseases that affect annual crops, like corn, vegetables, rice, and cotton, as well as foliar, blossom, or fruit diseases that affect trees and vines, typically spread much more quickly (typically within a few weeks) than diseases that affect perennial woody crops, like fruit and forest trees, such as Tristeza in citrus, pear decline, Dutch elm disease, and chestnut blight. As plants become older, they become more

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susceptible to disease. The hosts (or their components) are only vulnerable during the adult stage in several plant-path.

G. Age of host plants

Ogen combinations, such as Pythium damping-off and root rots, downy mildew, peach leaf curl, systemic smuts, rusts, bacterial blights, and viral infections (adult resistance). Several diseases, including rusts and viral infections, make plant parts extremely resistant to infection while they are very young, more vulnerable as they develop, and then resistant once more before they have completely grown.

H. Pathogen factors that impact epidemic development

1.1 Degrees of virulence

More virulent pathogens that can quickly infect the host guarantee quicker creation of bigger volumes of inoculums and subsequently sickness. The amount of vaccine close to the hosts: the more pathogens there are the more propagules bacteria, fungal spores and sclerotia, nematode eggs, virus-infected plants, etc. that are present in or close to fields of host plants, the sooner and more inoculum that reaches the hosts and the greater the likelihood of an epidemic.

1.2 The pathogen's mode of reproduction

All pathogens have a large number of offspring, however, some of them have a greater number than others, such as the majority of fungi, bacteria, and viruses. Just a few worms, parasitic plants, and a few types of fungi reproduce in large numbers. The fact that certain diseases (the majority of fungi, bacteria, and viruses) have short reproductive cycles and may therefore create several generations in a single growing season is even more significant.

The majority of the rapid, catastrophic plant disease outbreaks in the globe are caused by these polycyclic pathogens, which often produce rusts, mildews, and leaf spots. Most nematodes and certain soil fungi, including Fusarium and Verticillium, typically have one to many (up to four) reproductive cycles every growing season. The capacity for these later infections to generate abrupt and extensive epidemics in a single season is limited by the amount of progeny and, particularly, the circumstances of dispersion. Certain diseases, like the smuts and some short-cycle rusts, have a one-year life cycle and can only result in one set of infections each year because they are monocyclic pathogens.

1.3 The pathogen's ecology

Several pathogens create their inoculums (spores and seeds, respectively) on the surface of the aerial sections of the host, including the majority of fungi and all parasitic higher plants. From there, spores and seeds may move easily across a broad variety of distances and result in debilitating epidemics. Within the plant, other pathogens such as vascular fungi and bacteria, mollicutes, viruses, and protozoa proliferate. Without the assistance of vectors, the propagation of the virus in this instance is very unlikely or impossible. As a result, these infections can only start epidemics when the vectors are numerous and active. Some pathogens, such as soil-borne fungi, bacteria, and nematodes, create their inoculum on diseased plant parts in the soil. Since the inoculum spreads slowly there, there is less risk of abrupt or widespread epidemics.

1.4 The pathogen's mode of transmission

Several plant pathogenic fungi release spores into the air, which may be carried by air breezes or strong winds across distances ranging from a few millimeters to several kilometers. These spores can cause rust, mildews, and leaf spots. The most pervasive epidemics are caused by these types of fungus. The second most significant category of infections comprises those whose inoculum is transmitted by airborne vectors, in terms of their capacity to produce abrupt and extensive epidemics. Aphids, whiteflies, and several other insects spread many of the viruses. Leafhoppers, planthoppers, or psyllids may spread mollicutes and fastidious bacteria. Certain bacteria, nematodes, and even some fungi, such as the cause of pine wilt disease Dutch elm disease, and bacterial wilt of cucurbits, are predominantly spread by beetles. Almost every year, severe but rather isolated epidemics within a field, a county, or a valley are caused by pathogens that are spread by wind-blown rain mainly fungus-producing diseases like anthracnoses and apple scab, and most bacteria. Pathogens are often spread among sensitive plants by being transported with seeds or other vegetative propagation organs (like tubers or bulbs), but the success of their subsequent spread to new plants determines whether they may produce epidemics.

I. Environmental factors that influence epidemic development

Moisture, temperature, and human actions in terms of customs and preventative measures are the environmental elements that have the most impact on the spread of epidemics of plant diseases.

1.1 Humidity

The majority of outbreaks of illnesses caused by a fungus (blights, downy mildew, leaf spots, rusts, and anthracnose), bacteria (leaf spots, blights, soft rots), and nematodes emerge when there is an abundance of extended or repeated high moisture, whether in the form of rain, dew, or high humidity. Moisture encourages new succulent and sensitive development in the host, but it also multiplies bacteria and fungus, increasing their sporulation. Moisture makes it easier for many fungi to release their spores and for bacteria to ooze onto the surface of the host. It also makes it possible for spores to germinate and for bacteria, nematodes, and zoospores to travel. High moisture levels enable all these occurrences to occur continuously and frequently, which causes epidemics.

1.2 Temperature

Since they lessen the plant's degree of horizontal resistance, temperatures that are higher or lower than what is

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Vol 10, Issue 2S, February 2023

ideal for the plant might occasionally favor epidemics. The vertical resistance of host plants may even be diminished or eliminated at certain temperatures. If the pathogen is still active, plants growing at such temperatures become "stressed" and susceptible to disease.

The quantity of fungi, bacteria, and nematodes that can survive a harsh winter is reduced by low temperatures. The number of viruses and mollicutes that can survive at high temperatures is decreased. Low temperatures also affect the proportion of vectors that survive the winter. During the growth season, low temperatures might limit the activity of vectors.

However, the most frequent impact of temperature on epidemics is on the pathogen during each of its lifecycle stages, including spore germination or egg hatching, host penetration, pathogen growth or reproduction, invasion of the host, and sporulation. When the temperature is favorable for each of these stages, a polycyclic pathogen can finish its infection cycle in a very short amount of time (usually in a few days).

As a consequence, throughout the growing season, polycyclic diseases establish several infection cycles. Because the amount of inoculum increases by a factor of 100 or more with each infection cycle and because some of the new inoculums are likely to spread to new plants, more infection cycles result in more plants becoming infected by more and more pathogens, which causes the emergence of a serious epidemic [7]–[9].

J. The Influence of cultural practices and Control Measures on Humans

1.1 Site Selection and Preparation

Low-lying, poorly drained, and generated fields tend to favor the emergence and spread of epidemics, particularly if they are next to other affected fields.

1.2 Propagative material selection

Using seeds, nursery stock, and other propagative materials that are contaminated with different diseases enhances the initial inoculum inside the crop and considerably encourages the spread of epidemics. Using propagative material that is either pathogen-free or treated may significantly lower the likelihood of epidemics.

1.3 Cultural practices

Herbicide application harm, continuous monoculture, huge areas planted to the same crop variety, heavy nitrogen fertilization, no-till culture, dense plantings, overhead irrigation, and inadequate sanitation all enhance the likelihood and severity of epidemics.

1.4 Disease prevention techniques

Chemical sprays, cultural norms (like cleanliness and rotation), biological controls (like using resistant kinds), and other prevention techniques lessen or completely prevent the chance of an outbreak. Yet, sometimes, certain restrictions, such as the use of a certain chemical or the planting of a specific variety, may result in the selection of virulent disease strains that are either resistant to the chemical or may attack the variety's resistance and hence cause epidemics.

The convenience and regularity of international travel have also enhanced the flow of seeds, tubers, nursery stock, and other agricultural products. Introduction of Novel Pathogens. These occurrences raise the likelihood of spreading infections to regions where hosts haven't had time to develop immunity to them. These infections often cause devastating outbreaks. Examples include citrus canker brought on by the bacteria Xanthomonas campestris Dutch elm disease, and chestnut blight.

1.5Plant Yield Loss

The percentage or proportion of plant area or fruit volume lost by a pathogen is often used to measure disease severity. Economic loss from illness is usually often a consequence of yield loss. Every time the crop's economic returns drop due to a lower yield, the expense of agricultural actions conducted to lessen crop damage, or both, there is an economic loss.

The economic threshold of the illness is the degree of disease, or the quantity of plant damage, at which control expenses just equal additional crop returns. The tolerance level (damage threshold) of a crop, which relies on the development stage of the crop at the time of the attack, crop management techniques, the environment, changes in pathogen virulence, and novel control techniques, affects the economic threshold of a crop-pathogen system.

1.6Epidemiology of epidemics

The disease-progress curve which depicts how an epidemic spread over time, provides information on an epidemic's patterns in terms of the quantity of lesions, the amount of sick tissue, or the number of affected plants. When a disease first manifests, the quantity of inoculum it contains, changes in the host's sensitivity over the growth period, recurring meteorological occurrences, and the success of cultural and control methods are all revealed by the point of origin and curve's shape. Disease-progress curves vary somewhat with place and time but are often recognizable for particular types of illnesses since they are influenced by weather, variation, etc.

The dispersion or disease-gradient curve describes the behavior of an epidemic in terms of changes in the number of lesions, the volume of diseased tissue, and the number of affected plants as it spreads across distance. Most disease-gradient curves are relatively similar, at least in the early stages of the epidemic, since the quantity of illness is often larger close to the source of inoculum, and declines with increasing distance from the source.

One may determine the epidemic rate of a disease, which is the rate of growth of the epidemic, using the data gathered at different time intervals and used to draw the illness-progress curve of a disease. The quantity of disease spread in the population of plants under study per unit of time (per day,

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Vol 10, Issue 2S, February 2023

week, or year) is known as the epidemic rate, abbreviated as r. Rate curves, which are distinct for each type of illness, are curves that provide patterns of epidemic rates.

II. DISCUSSION

A. Plant disease epidemic modeling

An epidemic is a dynamic process that starts on one or a few plants, becomes worse and spreads to a wider region before eventually dying out based on the kind, intensity, and length of environmental conditions that affect the host and pathogen. When all host plants are either killed by the virus, develop resistance to it as they become older, or are harvested, epidemics come to an end. In many circumstances, when the weather becomes dry or unexpectedly cold, epidemics slow down or halt. For phenomena, it is often studied their growth and predicted the size, course, and time of the attack in any given area using observations, measurements, mathematical formulae, and computers.

Plant pathologists have been creating models of a possible epidemic of the most prevalent and dangerous disease since the late 1960s in an attempt to better understand and anticipate the development of an epidemic. While building a model, consideration is given to all the elements and subelements of a particular plant disease for which there is information available for quantitative therapy, or treatment using mathematical formulae.

Plant pathologists use computers to create a number of programs that simulate epidemics of different plant diseases. In 1969, EPIDEM, one of the first computer simulation programs, was created by simulating each step of a pathogen's life cycle as a function of the environment. It was created to mimic an early blight outbreak of the fungus Alternaria solani that affects potatoes and tomatoes. The next year, computer simulators were created for the Cercospora blight of celery (CERCOS), the Mycosphaerella blight of chrysanthemums (MYCOS), the southern corn leaf blight caused by Cochliobolus (Helminthosporium) maydis (EPICORN), and the Venturia inadequacies apple scab Epidemic, a more versatile and all-encompassing plant disease simulator, was created mainly for stripe rust of wheat but is readily adaptable to other host-pathogen systems. Many plant diseases may now be simulated using computers.

Data defining the different epidemic subcomponents and control methods at specified times are provided to the computer in an epidemic simulation (such as at weekly intervals). The computer then continuously updates information on the illness's progress and severity throughout time, as well as the ultimate crop and any economic losses the disease is anticipated to produce under the particular parameters of the epidemic.

For plant pathology students and farmers to better grasp and comprehend the impact of each epidemic subcomponent on the overall extent of their crop loss, computer simulations of epidemics are a very valuable instructional tool. Yet, in genuine illness scenarios, computer models of epidemics are far more helpful. By estimating the impact on the ultimate crop loss, they act as instruments to assess the significance of the magnitude of each epidemic subcomponent at a certain stage in the epidemic. The simulation aims to draw attention to management strategies that are successful against these specific epidemic subcomponents by emphasizing the subcomponents that are most significant at a given moment. The computer assesses the epidemic in successive reviews, taking into account not only the disease's present state but also the efficiency of the implemented management strategies.

B. Disease forecasting in plants

Forecasts for diseases indicate potential outbreaks or increases in illness severity. It requires structured teamwork, time, effort, and financial investment. The forecasting services are used to advise farmers in a specific region that the weather is conducive to the development of illness in epidemic form and that control measures should be taken in due course to reduce the incidence of the disease.

It helps ensure that chemicals are applied promptly. Grapevine downy mildew forecasting programs were among the earliest spray warning systems developed for producers in France, Germany, and Italy in the 1920s. For the following plant diseases, disease forecasting techniques are available.

It is both intellectually fascinating and demonstrates the effectiveness of modeling or computer simulation of certain illnesses to be able to predict epidemics of plant disease. The actual control of crop disease, however, is where farmers may benefit from it. By predicting potential disease outbreaks or increases in severity, disease forecasting enables us to decide if, when, and where a certain treatment approach should be used. Growers must carefully assess the risks, expenses, and advantages of all of their options while treating crop diseases. They have to choose, for instance, whether or not to plant a certain crop on a given land.

A prognosis for plant diseases must take into consideration a number of aspects of the specific pathogen, host, and environment. In general, disease development may be anticipated by evaluating the quantity of beginning inoculum for the majority of monocyclic diseases (such as root rot of peas and Stewart's wilt of maize) and for a few polycyclic illnesses that may have a substantial amount of initial inoculum (such as apple scab). The simplest way to anticipate the progression of polycyclic diseases which have several infection cycles but few beginning inoculums, is to evaluate the frequency of the infection cycles. For illnesses like beet yellows, where there are many disease cycles and a big starting inoculum, both criteria must be considered in order to accurately anticipate disease outbreaks.

Before a relevant and accurate disease prognosis can be created, five key conditions must be met.

1. The illness must reduce output or quality to an economically relevant degree. For the purpose of creating a disease-controlling plan, damage assessment is crucial. For instance, estimates of the yearly yield loss brought on by

Erysiphe polygoni, a barley powdery mildew, in England and Wales have varied from 6 to 13%. Potato late blight, on the other hand, may result in a production loss of 28% if the disease reaches the 75% stage by mid-August. Diseases like apple scab and potato common scab cause significant financial loss to the producers by lowering the quality of the food and lowering the value of the produced crop.

2. Control methods must be affordable from a financial standpoint.

3. The timing of the initial infections and the disease's subsequent pace of progression must change with each season. Forecasting is not necessary if it doesn't.

4. The standards or model used to make a forecast must be founded on reliable investigative work done in the lab and in the field and evaluated over the years to verify its accuracy and applicability in all the locations where its usage is anticipated.

5. When a disease alert is issued, growers must have enough manpower and equipment to implement management measures. Short-term cautions or forecasts are less helpful than long-term ones.

C. Techniques for disease prediction

Based on the disease-weather association, forecasting systems for late blight of the potato and downy mildew of the vine have been implemented in several nations, including Great Britain, Germany, the U.S.A., Canada, and Russia. The ability to predict diseases needs field observations of the characteristics of the pathogen, the gathering of meteorological information, the diversity of crops, and specific studies and their linkages. The following techniques are often used in disease forecasting.

D. Predictions based on first inocula

The density and viability of primary inoculum are assessed in the air, soil, or plant material. By the use of various air trapping devices, the presence of live spores or propagules in the air may be measured (spore traps). The principal inoculums in the soil for diseases that are transmitted via the soil may be identified using the monoculture approach.

By using various seed testing techniques, it is possible to identify the presence of loose smut of wheat, ergot of pearl millet, and viral infections of potatoes in seed batches at random. Methods for evaluating seeds may be used to identify probable disease incidence and help establish if chemical seed treatment is necessary. The severity of the winter that came before, which has an impact on the size of the vector population during the growing season, determines the severity of many viral infections. Think about the sugar beet yellows virus.

E. Prediction based on current weather conditions

During the growing season and the winter growing season, weather conditions like as temperature, relative humidity, rainfall, light, wind velocity, etc., are measured. Also noted are the weather conditions above the crop and at the soil's surface.

It is very difficult to monitor meteorological parameters while a plant disease outbreak is in full swing. The challenges stem from the need for continuous observation of a number of variables, including temperature, relative humidity, leaf wetness, rain, wind, and cloudiness, at various points within the crop canopy or on plant surfaces in one or more fields. In the past, measurements were done using mechanical equipment that took rough or occasional measurements of key environmental variables and inconveniently recorded the results as ink traces on chart paper. However, since the 1970s, a number of electronic sensors types have been created that provide electrical outputs that are simple for computerized data loggers to capture. Such computerized sensors have significantly enhanced research on how the weather affects illness, and they have made it easier for people to adopt and apply predictive systems for disease management on farms.

To measure different meteorological parameters, a variety of conventional and battery-operated electrical equipment are utilized. Several kinds of thermometers, hygrothermographs, thermocouples, and particularly thermistors are used to measure temperatures (the latter are semiconductors whose electrical resistance changes considerably with temperature). A hygrothermograph, which relies on how human hair contracts and expands in response to changes in relative humidity, a ventilated psychrometer, which consists of a wet-and-dry thermometer or a wet-and-dry thermistor, or an electrode-bonding sulfonated polystyrene plate are all tools for measuring relative humidity whose resistance changes logarithmically with relative humidity. Leaf moisture is measured using string-type sensors, which tighten when wet or relax when dry and either leave an ink mark or complete or interrupt an electrical circuit in the process.

Electrical wetness sensors come in a variety of designs and may be attached to leaves or buried among them. Since dew or rain helps shut the circuit between two pairs of electrodes, they can detect and quantify the duration of rain or dew. The ancient instruments (rain funnels and tipping-bucket gauges for rain, cups and thermal anemometers for wind speed, vanes for wind direction, and pyranometers for irradiance) are still used to measure rain, wind, and cloudiness (irradiance). However, some of these gadgets have evolved into electronic monitoring.

The weather sensors are coupled to data-logging equipment in contemporary weather monitoring systems. The information may be sent to a printer or a cassette tape recorder, or it can be seen on a digital display. Data from the cassette may be transferred to a microcomputer. There, they may be seen, processed using a variety of programming languages, arranged into unique matrices for each meteorological variable, displayed, and studied. Depending on the disease model in use, precise meteorological data offers the most valuable foundation for predicting sporulation and infection and, as a result, offers the greatest warning to

timing disease control actions, including the administration of fungicides.

F. Making predictions using correlated data

The severity of the illnesses is associated with weather data gathered over a number of years. After a comparison of the data, the illness is forecasted. For diseases including Septoria leaf blotch of wheat, fire blight of apple, and barley powdery mildew, forecasting criteria have been presented. These criteria were produced by comparing disease observation with conventional meteorological data.

G. The use of computers to predict diseases

In certain developed nations, illness forecasting is done with the use of computers. This method provides the outcome promptly. In the USA, one such computer software for late blight on potatoes is called "Blitecast." In a computer simulation of an epidemic, the computer is provided information about the different epidemic subcomponents and control methods at certain times (like weekly intervals). The computer would then continuously report information on the illness's progression and severity, as well as the ultimate crop and any potential economic losses due to the sickness under the pandemic circumstances that the computer was given.

For plant pathology students and farmers to better grasp and comprehend the impact of each epidemic subcomponent on the ultimate amount of their crop loss, computer modeling of epidemics is very helpful. By predicting its impact on the overall crop loss, computer simulations of epidemics may be used as tools to assess the significance of the magnitude of each epidemic subcomponent at a certain moment in time

III. CONCLUSION

Expert systems are computer programs that aim to match or outperform the reasoning and problem-solving skills of a professional expert. The expertise of the experts who created an expert system has a direct correlation to its reliability. Every kind of data may be used by an expert system, which can also provide a solution to the issue. These expert systems are widely employed for diagnosis to determine the origin of a disease based on its symptoms and associated data. The expert system can advise growers of disease potentials based on the actual occurrence of infection periods and provides pesticide recommendations as well as its amount and timing of application. This is done by incorporating infection models of the significant diseases of a crop into the knowledge base of the computers

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Plant Disease Management – I: Physical, Chemical, Biological, and Cultural

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***Abstract*— The severe lack of food supplies in many nations and the recent fast population growth has highlighted the increased need to safeguard as much of the agricultural yields as possible by minimizing the losses brought on by infection and illness. Understanding the disease's causative organism, its evolutionary history, and the climatic factors that affect the interactions between hosts and parasites and enhance the likelihood of output loss is essential for controlling plant diseases.**

***Keywords*— Disease Management, Hot Water, Pathogen Plant Disease, Systemic Fungicides.**

I. INTRODUCTION

A. Different Forms of Control

The two basic categories of control strategies are (1) prevention and (2) immunization or disease resistance.

1. Protection of the host against infection, exposure to the pathogen, or environmental conditions that favor the development of illness is included in prophylaxis.

2. The enhancement of the host's resistance to infection and the onset of illness is implied by immunization or disease resistance. This technique is often used as a control measure to create host strains that are more resistant to one or more diseases via hybridization and/or selection.

3. Prophylaxis refers to a broad variety of preventative actions. Three subgroups of such control measure changes are being taken into consideration: (1) Exclusion, (2) Eradication, and (3) Direct Protection [1]–[4].

B. Removal of the Parasite

Excluding a parasite from a host refers to taking precautions to prevent the pathogen from getting close to where the host is developing or to lower its population to a level that is safe for the host. Regulations for quarantine, inspection, and certification are a few of these measures.

C. Quarantines

From time to time, several plant diseases from various parts of the globe have been brought into our nation. With the expansion of transportation infrastructure, the likelihood of the virus entering a new location has increased.

To prevent the spread of sick plant material or of the fungus, bacteria, or viruses that cause plant diseases, plant quarantine laws are vigorously enforced in a number of agriculturally advanced nations.

The "Destructive Insects and Pests Act" of India was approved by the legislature in 1914 and has since undergone many revisions. Inspection and Certification: Plants and their products are certified in a number of agriculturally advanced nations. The certificate must state that the live plants had a thorough inspection no later than 14 days previous to shipping and are in good health. Any shipment may be inspected, and it may also be treated or destroyed. Inspection and certification are necessary yet effective preventative steps to stop the spread of illnesses throughout the nation or from one region to another [3], [5], [6].

D. Removal of the Infestation

There are several techniques to eradicate the disease, including crop rotation, removing affected sections, eliminating alternative hosts, destroying natural hosts and weeds, and roguing. For instance, the systematic eradication of barberry bushes, the black rust's alternative host, has significantly decreased the severity of the black rust of wheat in the USA. On the other hand, roguing is the most effective way to reduce sugarcane smut.

Crop rotation: The vast majority of harmful parasitic fungi are unable to proliferate in the absence of the host plant. They may persist in the soil for a while, but if the right host plants aren't there, their population may decline and eventually go extinct. Even after the crop has been harvested, a parasite may still be present in the soil on unhealthy plant detritus. Many pathogenic organisms continue to flourish as long as host residue is still present to serve as a substrate for their saprophytic life.

Generally speaking, a 3 or 4-year length of rotation with non-host crops removes the source of inoculum. Getting Rid of Infectious Parts The primary centers of infection are eliminated by destroying infected plant portions in the field, which breaks the cycle. By removing the damaged plant sections, citrus canker caused by Xanthomonas citri can be successfully managed. An efficient defense against the spread of the illness is the destruction of afflicted treetops and the practice of general cleaning by burning all sick components.

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Vol 10, Issue 2S, February 2023

E. Removal of Alternative Hosts

The destruction of an alternative host is a potential method of control for certain of the damaging illnesses caused by long-cycled, heteroecious rust fungus. The American initiative to eradicate barberries was successful in containing wheat's black rust.

Elimination of Weeds and Wild Hosts: Several illnesses, especially viral infections, are carried by weeds and wild hosts. The removal of such wild hosts is an effective control strategy. In nature, the Hibiscus tetraphylus serves as a wild host for the yellow vein mosaic of bhindi, and systematic eradication of this host has been effective in eradicating the illness. The methodical eradication of maize from nearby fields, which serves as a collateral host for the continuation of the viral infection cycle, has also led to successful control of the mosaic virus in sugarcane.

By eliminating infection foci and halting the spread of the disease, the process of roguing entails removing infected plants from the fields as soon as possible. This becomes a common technique for controlling viral infections in plants. To stop the spread of viral illnesses, the virus-infected plants should be removed and killed as soon as possible. With these methods, the yellow mosaic of bhindi has been controlled.

F. Physical Techniques

Temperature (high or low), dry air, unfavorable light wavelengths, and various radiation kinds are the physical agents that are most often utilized to manage plant diseases. Certain crops may be protected from some illnesses by being grown in greenhouses made of glass or plastic, which act as physical barriers to pathogens. Similarly to this, covering row crops with plastic or net may shield the crop from contamination by preventing infections from vectors from getting to the plants.

Heat-based Soil Sterilization

By using the heat from live or aerated steam or hot water, the soil may be sterilized in greenhouses, seed beds, and cold frames. Either in specialized containers (soil sterilization), into which steam is provided under pressure, or on the benches of the greenhouse, into which steam is piped and is allowed to spread through the soil, the soil is sterilized using steam. Nematodes, certain oomycetes fungi, and other water molds are destroyed at temperatures about 500 C, but the majority of bacteria and fungi that cause plant disease, as well as some worms, snails, and centipedes, are often killed at temperatures between 60 and 70 OC. The majority of weeds, the remaining plant pathogenic bacteria, the majority of plant viruses in plant waste, and the majority of insects are all destroyed at around 82°C. At or around the boiling point, several plant viruses including the tobacco mosaic virus (TMV) and heat-tolerant weed seeds are destroyed (between 95 and 100o C). After the temperature in the coldest area of the soil has been maintained at 82° C or higher for at least 30 minutes—the temperature at which almost all plant pathogens in the soil are killed—the soil sterilization is often considered to be complete. It is also possible to sterilize soil using heat that is generated electrically as opposed to steam or hot water [7]–[10].

It is important to take precautions to avoid using excessively high or prolonged high temperatures when sterilizing soil because these circumstances eradicate all naturally occurring saprophytic microflora in the soil and cause the release of toxic amounts of some salts, like manganese, and the accumulation of toxic levels of ammonia (by killing the nitrifying bacteria before they kill the more heat-resistant ammonifying bacteria), which may harm or kill plants planted nearby.

G. Treatment of Propagative Organs with Hot Water

Some seeds, bulbs, and nursery stock are subjected to a hot-water treatment to eradicate any pathogens that may be living within the seed coats, bulb scales, etc., on the outside surfaces, or in wounds. In certain diseases, such as loose smut of cereals, where the fungus overwinters as mycelium within the seed where the chemicals cannot reach, seed treatment with hot water was the sole method of management for many years. Similar to this, hot water treatment of bulbs and nursery stock frees nematodes such as Ditylenchus dipsaci in the bulbs of different ornamentals and Radolpbolus similis in the rootstocks of citrus trees.

The method's success is predicated on the fact that dormant plant organs can endure temperatures greater than those at which their particular infections may persist for a certain amount of time. For various host-pathogen combinations, there are differences in the hot water temperature and treatment time. As a result, when bulbs treated for Ditylenchus dipsaci are held at 43 degrees Celsius for 3 hours, wheat seed in loose smut is heated to 52 degrees Celsius for 11 minutes.

H. Treatment of Storage Organs with Hot Air

Warm air treatment (curing) of storage organs eliminates excess moisture from their surfaces and speeds up wound healing, protecting them against infection by certain weak microorganisms. For instance, storing sweet potatoes between 28 and 32 degrees Celsius for two weeks promotes wound healing and guards against soft-rotting bacteria and Rhizopus infection. Moreover, hot-air curing of harvested tobacco leaves, maize ears, and other plant materials eliminates the majority of their moisture and guards them against assault by saprophytic fungi and bacteria. Similar to this, Xanthomonas campestris pv. translucens, which cause leaf streak and black chaff, is destroyed from barley seed by dry heat treatment at 72 degrees Celsius for 7 to 10 days with little seed germination loss.

I. Removing Certain Light Wavelengths to Regulate

Examples of plant pathogenic fungi that only sporulate when exposed to UV light are Alternaria and Botrytis (below 360nm). By covering or building the greenhouse with a specific UV-absorbing vinyl film that limits transmission of

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Vol 10, Issue 2S, February 2023

light wavelengths below 390 nm, it has proven feasible to manage illnesses on greenhouse crops brought on by various species of this fungus.

J. Drying Fruit and Storing Grains

All grains, legumes, and nuts have a wide range of fungi and bacteria that, in the presence of enough moisture, may lead to the degradation of these organs. However, if seeds and nuts are harvested when they are fully grown and then allowed to dry in the air or heated air until the moisture content is decreased enough (to around 12 percent moisture) before storage, such deterioration may be prevented. Following that, they are kept in ventilated conditions that prevent moisture accumulation to high levels (over 12 percent), which would trigger the activation of storage fungus. Fruits with flesh, such as peaches and strawberries, should be collected later in the day, after the dew has dried up, to prevent the fruit from developing fungal and bacterial deterioration from surface moisture while being stored.

If they are thoroughly dried before storage and the moisture level is maintained below a particular point while being stored, many fruits may also be kept dry for a long time and kept disease-free. As an example, grapes, dates, and figs may be dried in the sun or by being exposed to warm air to create raisins, prunes, dried dates, and dried figs, which are often resistant to fungus and bacteria as long as they are kept dry. If exposed to the sun or warm air currents long enough, even slices of fleshy fruits like apples, peaches, and apricots may be shielded against fungus and bacteria that cause illness and decomposition.

K. Disease prevention with cold storage

The most popular and efficient way of preventing postharvest infections in fleshy plant products is probably refrigeration. Even though pathogens that may be on or in plant tissues are not killed by low temperatures at or just above the freezing point, they do inhibit or significantly slow down their growth and activities. As a result, infections that already exist are less likely to spread and new infections are less likely to start. The majority of perishable produce should be chilled as soon as possible after harvest, transported in refrigerated trucks, and maintained under refrigeration until consumption. Succulent fruits and vegetables should always be refrigerated as soon as feasible. Routine refrigeration of these delectable fruits and vegetables may be preceded by a brief hydro cooling or air cooling of the items in order to swiftly remove any excess heat carried in them from the field to the store in order to stop the growth of any new or latent diseases. Infection spreads enormously from producers to consumers.

L. Radiation-based disease prevention

The capacity of several forms of electromagnetic radiation, including ultraviolet light, X and gamma rays, as well as particulate (as an alpha particle and beta particle), to reduce postharvest illnesses of fruits and vegetables by eliminating the microorganisms present on them has been investigated. In experimental studies using gamma rays to control postharvest infections of peaches and strawberries, some satisfactory results were obtained; however, the main drawback with this treatment is that the radiation dosage needed to kill the pathogen may also harm the plant tissues on which the pathogens exist. However, despite the USDA finding the technique of food treatment to be safe and fully permitted, certain demographic segments are vehemently opposed to it. Radiation therapy has not yet been used commercially to treat any plant diseases.

M. Chemical techniques

Pesticides made of chemicals are often applied to plant surfaces to prevent infection or to get rid of a disease that has already infected a plant. Nevertheless, certain chemical treatments try to completely eliminate or drastically reduce the inoculum before it comes into touch with the plant. These cover things like soil remediation, disinfecting warehouses, cleaning equipment, and controlling insect pathogen vectors.

N. Using chemicals to remediate the soil

The soil that will be used to grow vegetables, strawberries, decorative plants, trees, or other high-value crops like tobacco is commonly treated with chemicals to prevent nematodes, as well as weeds, bacteria, and sometimes soil-born fungi like Fusarium and Verticillium. In areas where irrigation is feasible, specific fungicides are given to the soil as dust, liquid drenches, or granules to prevent damping off of seedlings, blights, crown and root rots, and other diseases. While using sprinkler irrigation, the fungicides are sometimes added to the irrigation water. For treating soil, fungicides including metalaxyl, diazoben, pentachloronitrobenzene (PCNB), captan, and chloroneb are utilized. The latter two are mainly used to seeds as treatments. The majority of soil treatments try to suppress nematodes, and the substances used are volatile gases or generate volatile gases that permeate the whole soil. Although certain nematicides are volatile, others dissolve in soil water and spread throughout the soil.

O. Fumigation

The use of pesticides, sometimes referred to as fumigation, has shown to be the most effective way of managing nematodes and several other soilborne infections and pests in the fields. Several of them, including chloropicrin, methylbromide, dazomet, and sodium metam, either volatilize when applied to the soil or break down into gases there. These products are all-purpose pre plant fumigants that work well against a variety of soil microorganisms, including nematodes, many fungi, insects, specific bacteria, and weeds. Contact nematicides may be used before and after planting many crops that are resistant to these chemicals. They are effective against nematodes and insects and have minimal volatility.

ISSN (Online) 2456 -1304
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Vol 10, Issue 2S, February 2023

Nematicides are available as liquids under pressure, emulsifiable liquid concentrates, and granules for application as soil fumigants. These substances are distributed equally over the whole field (broadcast) or applied only to the rows that will be planted with the crop when they are applied to the soil (row treatment). In both situations, the fumigation is sprayed using delivery tubes that are installed on the rear of chisel-tooth injection shanks or disks that are mounted on tractors and typically extend 6 inches below the soil's surface. Nematicides may be incorporated into the soil using disk harrows or rototillers or instantaneously sealed in the soil by a smoothing and firming drag.

Nematicides that are very volatile are promptly wrapped in polyethylene sheeting and kept there for at least 48 hours. The most practical approach for fumigating tiny spaces is to inject the chemical using a hand applicator beneath a trap that has been set over the area. Before the chemicals are injected, the trap's borders are covered with earth. In all cases of preplans soil fumigation with phytotoxic nematicides several days to two weeks must pass from the time of treatment seeding or planting in the field to avoid plant injury. Application may also be made by placing small amounts of granules in holes or furrows six inches deep and six to twelve inches apart, which should immediately be covered with soil. Nevertheless, the efficacy of the fumigants depends on gaseous diffusion via the pores.

The size and continuity of soil pores, soil temperature (best range between 100 and 200C), soil moisture (best at about 80% of field capacity), type of soil (more material is needed for soil rich in colloidal or organic matter), and the chemical's own characteristics all affect how far the vapors travel. Low-volatility nematicides, like carbofuran, must be manually combined with the soil or wetted down with irrigation water or rainfall to sufficiently disperse into the soil.

In actuality, pre-plant soil fumigation with one of the nematicides applied just before planting is how chemical nematode control in the field is often achieved. These universal compounds are effective against all nematode species. The pricey broad-spectrum nematicides include chloropicrin, methyl bromide, and metamsodiam.

P. Direct chemical protection

The employment of chemical substances that are poisonous to the pathogens is one of the most well-known ways to manage plant diseases in the field, greenhouse, and sometimes in storage. These substances are either completely fatal to the pathogen or prevent it from germination, development, and replication. The substances go by the names fungicides, bactericides, nematicides, viricides, and herbicides depending on the kind of diseases they kill. Several substances are broad-spectrum pathogen-toxic insecticides. Fruit and vegetables each get roughly 25% of the total pesticides (mainly fungicides) used to treat plant diseases.

The majority of chemicals are used to treat diseases of plant leaves and other above-ground sections. Some are intended to decontaminate the soil, while others are used to decontaminate warehouses, cure wounds, and/or decontaminate and/or protect against infection seeds, tubers, and bulbs. With the use of different pieces of equipment, chemicals are administered directly to plants or the soil to manage plant diseases.

Sprays and Dusts for Plant Foliage: Chemicals used as sprays or dust on plant foliage are often used to combat fungal diseases and, to a lesser degree, bacterial illnesses. The majority of fungicides and bactericides are protectants and need to be on the plant's surface before the pathogen to avoid infections. Fungus spores are typically prevented from germinating by their presence, or by the substances that may prevent spore germination or destroy spores after germination. Bactericide exposure may prevent germs from multiplying or even killing them.

Several more recent fungicides operate as eradicates in this situation by directly attacking diseases that have already colonized the leaves, fruit, and stem (they kill the fungus inside the host or may suppress the sporulation of the fungus without killing it). Since they may be absorbed by certain leaf tissues and moved internally into the leaf region, some fungicides have a partly systemic effect. When administered intravenously, various bactericides, including streptomycin, tetracyclines, and some other antibiotics, can have a systemic effect. Several more recent systemic fungicides, such as metalaxyl and the sterol inhibitors triadimefon and fenarimol, are sufficiently efficient in post-infection treatments that crops may be saved with their usage.

When applied as sprays, fungicides, and bactericides are often more effective in leaving a protective residual layer on the surfaces of plants than when applied as dust. Dust and sprays don't adhere well when used in the rain. The active ingredient may be combined with other substances, such as lime, to lessen its phytotoxicity and make it safer for the plant. To help fungicides spread more widely and increase the contact area between the fungicide and the surface being sprayed, surfactants—compounds with low surface tension—are often added. The adhesion of the fungicide to the plant surface is improved by the addition of several substances with high sticking properties. By administering protectant or systemic fungicides to the foliage system in agricultural fields with sprinkler watering, some control of foliar disease by systematic fungicides may be achieved.

Because most pathogenic spores require a film of water on the leaf surface or at least atmospheric humidity near saturation before they can germinate, many fungicides and bactericides are protective in their action and may be at the plant surface before the pathogen arrives or at least before it has the time of germination entry and the establishment itself in the host. These factors may need chemical spraying of young, expanding leaves, twigs, and fruits more often than older tissues. Depending on the specific disease, the

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International Journal of Science, Engineering and Management (IJSEM)
Vol 10, Issue 2S, February 2023

frequency, and length of rains, the persistence or residual life of the fungicide, and the season of the year, the gap between sprays on mature tissue may range from 7 to 14 days or more.

Chemical Types: Many chemicals, including fumigants, soil treatments, sprays, dust paints, and pastes, have been created to date for crop protection.

Q. Inorganic Substances

1. Copper Compounds: Copper sulfate and calcium hydroxide combine to produce the Bordeaux combination (named after the Bordeaux area in France), which was used to treat grape downy mildew. It was the first aungicide created and the copper fungicide that was used the most commonly worldwide. It eliminates several bacterial and fungal cankers, downy mildew, leaf spot, and blight.

2. Inorganic sulfur compounds: Sulfur is perhaps the first known fungicide. In order to manage powdery mildew, specific rust, leaf blight, and fruit rots, it is applied as a dust, wettable powder, paste, or liquid.

3. Carbonate Compounds: Sodium bicarbonate, ammonium, potassium, and lithium bicarbonate salts, together with 1% superfine oil, have shown inhibitory and fungicidal properties versus powdery mildew fungi of roses.

4. Phosphate and phosphonate compounds: Spraying cucumber or grape plants with monopotassium phosphate or dipotassium phosphate solutions has had positive effects against the powdery mildew disease.

5. Film-forming substances: Substances like mineral oils and antitranspirant polymers, when applied to plant surfaces before the pathogen is injected, dramatically lessen the severity of infection. These gas-permeable, non-phytotoxic, film-forming polymers can withstand use for at least a week and are biodegradable.

R. Organic Substances:

1.1Use preventive fungicides in contact

Organic sulfur compounds (OSCs) One of the most significant, diverse, and frequently used classes of contemporary fungicides is the dithiocarbamate family. Thiram, Ferbam, Nabam, Maneb, and Zineb are a few of them. Since all of these substances are converted to the isothiocyanate radical (-N=C=S), which inactivates the sulfhydryl groups (-SH) in amino acids and enzymes inside pathogen cells and prevents their synthesis in host cells, they are all poisonous to fungus. Thiram is a substance that contains two molecules of dithiocarbamic acid and is mostly used to treat vegetable and flower seeds and bulbs.

Ferbam, a three-molecule compound that contains dithiocarbamic acid and reacts with one atom of iron, is used to treat ornamental and fruit tree leaf diseases. A wide-range fungicide called Maneb, which includes manganese, is used to prevent leaf and fruit diseases in various plants. For the safe treatment of leaf spots, blights, and fruit rots on vegetables, flowers, and fruit trees, use Zineb, a multifunctional foliar and soil fungicide.

Several substances feature aromatic benzene rings, which are poisonous to microbes and have been commercially produced as fungicides. The majority of them prevent the synthesis of substances with -NH2 and -SH groups.

The long-lasting soil fungicides pentachloronitrobenzene (PCNB) and terraclor are used to prevent soil-borne diseases of plants such as botrytis, sclerotinia, and rhizopus. A great wide-spectrum fungicide against various leaf spots, blights, downy mildew, rust, scab, and fruit rots is chlorothalonil (brand name Bravo). Biphenyl is used to safeguard stored fruits by impregnating transportation materials with it. This molecule volatilizes in storage.

Several of the finest fungicides, such as Captan, Iprodione, and Vinclozolin, are heterocyclic compounds. In fruit and vegetable crops, captan is used to suppress leaf spots, blights, and fruit rots. It also functions as a seed protector. A wide range leaf contact fungicide is iprodione (Rovral). It mostly has preventive and early curative effects and inhibits mycelial development and spore germination. Vinclozolin (Ornalin or Vorlan) is a contact and protection fungicide that is sprayed on ornamental plants like strawberries and lettuce.

1.2Systemic fungicides of organic compounds

Systemic fungicides are translocated inside the plant via the xylem after being absorbed by the leaves or roots. These fungi may build up near the leaf edge and typically travel upward in the transpiration stream. Almost every systemic fungicide is site-specific, blocking only one or maybe a few distinct processes in the metabolism of the fungus it is designed to suppress.

1.3 Acylalanines

Metalaxyl, which is the most popular and efficient against the oomycetes Pythium, Phytophthora, and downy mildews, is a class of amino acids. It is marketed as Ridomil and is intended for usage in the soil in conjunction with a wide range of fungicides applied to leaves.

1.4 Benzimidazoles

This class of fungicides includes vital systemic fungicides like Benomyl, Carbendazim, Thiabendazole, and Thiophene. Benomyl, marketed under the brand name Benlate, is a safe broad-spectrum fungicide that is effective against a variety of pathogens that cause powdery mildew of all crops and apple scabs.

1. The wide-spectrum fungicide thiabendazole (Mertect) kills a variety of defective fungi. It is often used as a post-harvest treatment to prevent citrus, apple, and banana storage rots.

2. Thiophnate (also known as Topsin) is effective against a variety of turf grass and vegetable-damaging root and foliar fungi.

3. •Oxathiins: This systemic fungicide was the first to be found. The activity of succinate dehydrogenase, an enzyme crucial for mitochondrial respiration, is inhibited by them

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Vol 10, Issue 2S, February 2023

when they are preferentially concentrated in the cells of this fungus.

Organophosphate fungicides are mostly fetal-Al, which is marketed under the name Aliette. It is very efficient against diseases of the stem, roots, and leaves. According to reports, this substance promotes the production of phytoalexins, which are defensive mechanisms against oomycetes.

1. Several substances, like Kitazin and Edifenphos, have been reported to be beneficial against rice blasts.

2. Pyrimidines: These compounds, such as diamethirimol (Milcurb) and ethrimol (Milstem), work well against powdery mildews on a variety of agricultural plants.

3. Triazoles: This class of fungicides contains a number of top-notch systemic medications, such as triadimefon (Bayleton), triadimenol (Baytan), butrizol (Indar), and difenoconazole (Score).

They have long-lasting preventive and curative efficacy against a wide range of foliar, root, and seedling diseases brought on by several ascomycetes, imperfect fungi, and basidiomycetes. They are used as foliar sprays, seed, and soil treatments.

Chloroneb is another top-notch systemic fungicide with a distinct chemical makeup that is utilized to treat cotton, soybean, and bean seeds. A fungicide for seed soil and grass that is effective against root and stem rots and damping off is ethanol (Truban). Imazalil (Fungaflor) works well against a variety of ascomycetes and poor fungi that cause powdery mildews. Dodine (Cyprex), which is used against apple scab and provides long-lasting protection as well as good eradication, is another example of a chemically varied molecule that is an outstanding protectant fungicide. A wide range of fungicide with suppressive or antifeeding actions on many insects is fentin hydroxide (Super Tin). Sometimes zinc is used to cleanse and preserve wood as zinc naphthenate.

1.5Antibiotics

These are the chemicals created by one microbe that is poisonous to another. These antibiotics are mostly poisonous to bacteria, mollicutes, and certain fungi and are derived from branching bacteria (Streptomyces) or some fungus (Penicillium). Just a few antibiotics, such as streptomycin, tetracyclines, and cycloheximide, are typically available to combat plant diseases.

Streptomyces griseus, an actinomycete, is the source of streptomycin. It works by attaching to bacterial ribosomes and stopping the production of proteins. It is used to combat a variety of oomycetous fungus and bacterial plant diseases. Tetracyclines have broad antibacterial and antimollicute activity. Magnaporthe grisea, a fungus that causes rice blast, is treated with blasticidin in Japan.

1.6Nematicides

Nematodes, as well as insects, fungi, and weed seeds, are targets of these broad-spectrum, volatile soil fumigants. Halogenated hydrocarbons, organophosphates, isothiocyanates, and carbamates make up the four major categories. Methyl bromide works better against nematodes, weed seeds, and dry wood termites above ground. Since it is soluble in lipids and interferes with membrane and nervous system function, it impacts living things.

Insecticides such as phorate (Thimet), disulfoton (Disyston), and fenamiphos are examples of organophosphates (Nemacur). They come in granular and liquid forms that are soluble in water. They don't work on soil fungus; they only work against nematodes. They cause the nematodes they affect to become paralyzed and eventually die because they block the enzyme cholinesterase, a nerve-transmitter.

1.7Isothiocyanates

These substances include Dazomt, Vorlex, and Metam Sodium (Vapam) (Mylone). They are injected, mixed in, then irrigated into the soil at least two weeks before planting. They are all successful in combating nematodes, soil insects, weeds, and soil fungi. Aldicarb (Temik), carbofuran (Furadan), and carbosulfan are examples of carbamates (Advantage). They are effective against certain leaf insects, soil insects, and nematodes. They paralyze and kill the nematodes and insects they impact by inhibiting the enzyme cholinesterase.

Chemicals' Mechanism of Action: Although the precise mechanism by which chemicals control plant diseases is still unknown, these chemicals act by preventing the pathogen from synthesizing specific cell-wall substances, acting as solvents, damaging the pathogen's cell membrane, forming complexes and inactivating enzymes, and generally precipitating the pathogens' proteins.

Virus and pathogen resistance when exposed repeatedly and when these compounds are used often, bacteria may develop resistance to the chemicals and medicines. Many plant diseases have also evolved fungicide-resistant versions of themselves. When preventative fungicides like Thiram, Maneb, or Captan were employed, no resistant pathogen strains were seen. This is likely because these fungicides interfere with a number of the pathogen's essential processes and induce excessive gene modifications. The discovery of naturally occurring Penicillium strains resistant to diphenyl, Tilletia strains resistant to hexachlorobenzene, and Rhizoctonia strains resistant to PCNB in the 1960s marked the beginning of resistance to the same fungicides, all of which had a benzene ring.

After just two years of chemical usage, fungicide-resistant germs have in some instances emerged and spread widely. Many significant fungus pathogens are known to have developed strains resistant to one or more systemic fungicides today, including Alternaria, Botrytis, Colletotrichum, Fusarium, Verticillium, Aspergillus, Penicillium, Phytophthora, Pythium, and Ustilago. This is because systemic fungicides have a narrow field of action and only affect one or possibly two steps in a genetically controlled event in the fungus. As a result, a resistant population can quickly emerge either through a single

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Vol 10, Issue 2S, February 2023

mutation or through the selection of resistant individuals in a population.

The two most frequent methods by which infections detoxify chemicals by altering their structure or by attaching them to components of cells are (1) lower permeability of the pathogen cell membranes to the chemical and (2) detoxification of the chemical. (6) compensating for the effect of inhibition by producing more of the inhibited product; (3) decreased conversion to the real toxic compound; (4) decreased affinity at the reactive site in the cell; (5) bypassing a blocked reaction through a change in metabolism, and (6) decreased affinity at the reactive site in the cell (e.g an enzyme). The use of effective systemic or nonsystemic fungicides that lose their efficacy due to the emergence of new resistant strains may continue, and the resistant strains can still be effectively managed by altering the fungicide's application techniques. This may be done by mixing different systemic fungicides, spraying systemic and protectant fungicides alternately, or spraying systemic fungicides for half of the season and protectant fungicides for the other half. While the protectant or nonspecific chemical lessens the likelihood or survival of any strains of the pathogen that may develop resistance to the systemic or specific action chemical, the systemic or specific action chemical still exerts the majority of its influence in each of these schedules in terms of containing the disease.

The nematicides in particular are exceedingly hazardous, even though most chemicals used to manage plant diseases are significantly less toxic than most insecticides. Moreover, some are genetically harmful, leading to morphologic and physiological problems in test animals. This is why each chemical's licensing, registration, and usage are subject to a variety of limitations.

The Environmental Protection Agency (EPA) and the Food and Drug Administration (FDA) in the United States both maintain a tight eye on the registration, manufacture, and usage of pesticides. Just one new chemical out of every 10,000 created by the pesticide industry is thought to be an effective pesticide.

Once a chemical is allowed for use on a particular crop, two key limitations on its usage must be followed: (1) the number of days that must pass before harvesting a crop following the use of a certain chemical; and (2) the maximum quantity of the chemical that may be used per application. If one of these limits is not followed, it is possible that crops, particularly fruits, and vegetables, will be harvested with more of the chemical present than is permitted, necessitating the destruction of the crop. The food products entering the U.S. markets are either free of any pesticides or contain minimal residues within the legal limits owing to all required and voluntary safeguards surrounding the use of pesticides. Less than 1% of the samples that were examined had residues that exceeded the limitations.

1.8Disinfestation of warehouse

After carefully cleaning the storage rooms and removing and burning the garbage, stored items may be safeguarded from getting contaminated by pathogens still present in the warehouse from past years. Bleach, a copper sulfate solution (1 pound in 5 gallons of water), or any other sanitizer is used to wash the wall and floor. Chloropricin, often known as tear gas, may be used to efficiently fumigate warehouses that can be closed hermetically and where the relative humidity can be maintained at close to 100% when the temperature is between 250 and 300 C. In every situation, the fumigants must be left at least 24 hours to work before the warehouse doors are opened for aeration.

S. Biological Methods

A common occurrence in nature is biological control of pathogens, which is defined as "the whole or partial eradication of the pathogen population by other species." Garrett (1965) defined a pathogen-caused illness as "any state or practice whereby the survival or activity of a pathogen is decreased via the action of any other living thing other than the man himself, with the consequence that there is the reduction in the incidence of the disease." For instance, in some diseases, the pathogen cannot spread to certain areas because the soil (known as suppressive soil) contains microorganisms that are antagonistic to the pathogen or because the plant is attacked by the pathogen has already been naturally vaccinated with antagonistic microorganisms before or after the pathogen attack. When hypovirulence and cross-protection are present, the antagonistic microorganisms may sometimes be avirulent variants of the same pathogen that kill or prevent the growth of the pathogen. In certain instances, even taller plants decrease the quantity of inoculum by trapping pathogens that are readily accessible (trap plants) or by dispersing pathogen-toxic chemicals into the soil. Agriculturalists have stepped up their attempts to exploit these inherent biological conflicts and create biological control methods that may be employed successfully against a variety of plant diseases. It is anticipated that biological antagonists will play a significant role in the prevention of many more illnesses.

1.1 Damaging soils

Many soilborne pathogens, including Pythium species (which causes damping-off), Heterodera avenae (the oat cyst nematode), Phytophthora cinnamomi (which causes take-all of wheat), Fusarium oxysporum (which causes vascular wilts), and Gaeumannomyces graminis (which causes root rots of many fruit and forest trees) develop well and cause severe diseases The ways by which soils inhibit certain infections may be dependent on the pathogen and may include biotic and/or abiotic variables. They function largely because such soils contain one or more microorganisms that are hostile to the disease. Such antagonists arise as a result of food competition, direct parasitization of the pathogen, the creation of antibiotics, and the development of lytic enzymes

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Vol 10, Issue 2S, February 2023

that prevent the pathogen from reaching sufficiently large populations to cause serious illness.

The most frequent pathogen and disease suppression has been demonstrated to be caused by fungus such as Trichoderma, Penicillium, and Sporidesmium, or by bacteria of the families Pseudomonas, Bacillus, and Streptomyces. A number of antagonistic microorganisms have been reported to proliferate in suppressive soils. By adding microorganisms hostile to the pathogen, suppressive soil may minimize the quantity of illness when added to conducive soil. For instance, potato tubers that have been grown in soil that has been modified with a strain of the scab-causing bacteria Streptomyces scabies are mostly devoid of the potato scab.

After many years of severe illness, persistent cultivation (monoculture) of the same crop in favorable soil finally results in a decrease in disease via an increase in the population of microorganisms that are hostile to the pathogen. For instance, ongoing wheat or cucumber cultivation reduces the amount of wheat that is consumed and cucumber damping-off caused by Rhizoctonia. Similar to how persistent cropping of the crimson sweet variety of watermelon permits the growth of antagonistic Fusarium species linked to those causing Fusarium wilt of watermelon, Fusarium wilt is minimized rather than enhanced as a consequence. It is possible to demonstrate that the suppressiveness is caused by hostile microorganisms by pasteurizing the soil at 600C for 30 minutes, which fully removes the suppressiveness.

Opposing microorganisms pathogens found in the soil many fungi that are often not harmful to plants penetrate and parasitize (mycoparasitism) or lyse (mycolysis) the mycelium and dormant spores or sclerotia of a number of phytopathogenic soil fungus, including Pythium, Phytophthora, Rhizoctonia, and Sclerotinia. The dormant spores of some plant pathogenic fungi are infected by a number of non-plant pathogenic fungi, such as certain oomycetes, chytridiomycetes, and hyphomycetes, as well as some pseudomonad and actinomycetous bacteria. Trichoderma harzianum, one of the most prevalent mycoparasitic fungi, has been shown to parasitize the mycelia of Rhizoctonia and Sclerotium, to inhibit the growth of numerous other fungi, including Pythium, Phytophthora, and Fusarium, and to lessen the diseases brought on by the majority of these pathogens.

Many of the above-mentioned antagonistic microorganisms are found in agricultural soils naturally and, independent of human activity, exert some level of biological control on one or more plant diseases. However, human beings have been trying to increase the effectiveness of antagonists by either introducing new and larger populations of antagonists in fields where they lacking in them and/or by adding soil amendments that serve as nutrients or otherwise stimulate the growth of the antagonistic microorganisms and increase their inhibitory activity against the pathogen. Sadly, although both methods work well in the lab and their greenhouse, none has had much success in the field. When new microbes are introduced to a field's soil, they cannot compete with the microflora already there and also cannot survive for very long. As a result, they have very little chance of ever controlling illness.

1.2Control using plant traps

If a few rows of rye, corn, or other tall plants are put surround a field of beans, peppers, or squash many of the approaching aphids carrying viruses who ideally target the beans, peppers, and squash will first pause and feed on the peripheral higher rows of rye or corn. Since most of the aphid-carrying viruses are non-persistent in the aphid many of the aphids lose the bean, pepper, or squash infecting viruses by the time they travel onto these crops. In this method, trap crops minimize the quantity of inoculum that reaches a target crop. Trap plants are also employed against nematodes in a different method.

Certain plants that are not genuinely vulnerable to certain sedentary plant-parasitic nematodes release exudates that promote eggs of these nematodes to hatch. The juveniles enter this plant but are unable to grow into adults and finally, they perish. Those plants are sometimes termed trap crops. By utilizing trap crop in a crop rotation scheme, the farmer may lower the nematode population in the soil for example Crotalaria plant capture the juveniles of the root-knot nematodes two or with water or via soil (the other) (the other).

1.3Control of insect vector vectors

When the infection is introduced or spread by an insect vector management of the insect vector is as essential as and oftentimes simpler than the control of the pathogen itself. The use of insecticides for the control of insect carriers of fungal spores and bacteria has been pretty effective and is a suggested practice in the management of various insect-carried diseases

II. CONCLUSION

Seven categories of pathogenic agents are documented on economically valuable plants. They include bacteria, fungi, viruses, nematodes, insects, parasitic flowering plants, and a diverse category that includes mineral deficits and excesses and adverse climatic circumstances. Various control strategies, physical, chemical biological, and cultural procedures or combinations of such methods are available to control the plant disease. The efficacy of the various management strategies relies on the pest density at the time of application. Biological agents for example will have maximal impact when the pest is numerous while insecticides and environmental controls are not affected by density. The effect of any one control method is determined by the net increase in the output of the crops. Any planning approach must take all the qualities viz. biological and abiotic elements into consideration and well-organized and properly-timed assault on the overall pathogenic population.

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Plant Disease Management-II: Biotechnology and Breeding

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***Abstract*— For many years, agricultural development has benefited greatly from gene transfer across plant species. It has always been essential to evolve, assess, and choose the ideal mix of alleles for plant development, whether the product of natural selection or the work of plant breeders. From non-cultivated plants, beneficial features have been introduced to agricultural varieties, including resistance to diseases, insects, and pests. The introduction, fusion, and expression of foreign genes in the recipient host plant comprise the entire process of genetic transformation. Transgenic plants are those that have extra, foreign genes from other genetic sources that are stably integrated and expressed. Transgenic plants are created by the combined use of DNA technologies, gene transfer procedures, and tissue culture techniques**

***Keywords*— Foreign Genes, Disease Resistance, Insect Resistance, Plant Breeding, Transgenic Plants.**

I. INTRODUCTION

The ability to introduce and express a variety of foreign genes in plants was initially noted in tobacco using vectors and the Agrobacterium-mediated method. The list of plant species that can be changed using vector-mediated (Agrobacterium) and vectors approaches has been expanding over time, and at this time, the number of species in at least 35 families that can be transformed has increased to more than 120.

A. Biotechnology in pest control

The goal of the use of genetic engineering in agricultural agriculture is to create transgenic plants that are resistant to pathogens, insects, herbicides, and post-harvest degradation. It entails the creation, isolation, modification, and use of compounds derived from biosynthesis. It is the use of genetically modified organisms in the production of crops or animals, including the creation of insect suppressive chemicals, in pest control.

B. Adaptation to biotic stress

Crops may now be genetically modified for increased resistance to insects and viruses, and this technology is quickly approaching commercialization. These developments serve as the foundation for a chemical-free and practical strategy for controlling pests and diseases. The following categories have been used to describe biotic stress resistance [1][2][3].

1. Resistance to insects
2. Virus defense
3. Resistance to disease
4. Bug Resistance

The utilization of insect control protein genes from Bacillus thuringiensis has advanced the creation of insect resistance in transgenic plants. The first insect-resistant crops were tobacco and tomatoes. The amount of insect resistance may now be increased in plants by introducing insect-resistant transgenes, whether they come from bacteria, plants, or other sources. Crops now include over 40 distinct genes that provide resistance to insects. The Bt gene from Bacillus thuringiensis, the ipt (isopentyl transferase) gene from Agrobacterium tumefaciens, the cholesterol oxidase gene from Streptomyces, and the Pht gene from Photorhabdus luminescens have all been shown to provide insect resistance to plants. Resistant genes from higher plants may be divided into two categories: lectins, such as the snowdrop lectin, and proteinase and amylase inhibitors (GNA, pea lectin, jacalin, rice lectin, etc.). Animal-derived resistance genes include tobacco hornworm and serine proteinase inhibitors from mammals (Manduca sexta).

An insect control protein is produced by the entomocidal bacteria Bacillus thuringiensis. The Bt toxin is produced by Bt genes, which vary in their range of insecticidal action. The majority of this toxin is effective against Lepidopteran larvae, although part of it targets dipteran and coleopteran insects specifically. The toxicity of this toxin is due to a sizable protein that builds up inside the bacteria during sporulation as crystal protein (delta-endotoxin) and transforms into an active form upon infection by a susceptible insect by impairing ion transport across the brush borders/membranes of susceptible insect. The Bt toxin is not toxic to people, animals, or helpful insects. This gene is a single dominant gene that segregates [4].

A wide variety of genes that code for delta endotoxin may be found in bt strains. The first insecticidal protein-encoding genes were cloned and sequenced, and the results were reported in 1981. Presently, more than 100 crystal protein gene sequences with unique activity spectra have been disclosed.

Bt delta - endotoxins have been delivered to plants in both their full-length and truncated versions, providing plants with

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International Journal of Science, Engineering and Management (IJSEM)
Vol 10, Issue 2S, February 2023

observable resistance to the pests Heliothis virescens and Helicoverpa zea in tomatoes, M. sexta in tobacco, and Heliothis virescens and Helicoverpa zea in potatoes. The first plants could synthesize the complete protoxin, but since the gene was so weakly expressed, there was minimal delta-endotoxin generated, which offered little to no insect resistance. Ultimately, further research led to the improvement of cry gene expression in plants. The first generation of insecticidal plants has been made available for purchase [5].

Additional resistance genes derived from microorganisms: The Streptomyces culture filtrate included the cholesterol oxidase (CO) protein, which exhibited acute toxicity to boll weevil larvae. Tobacco has been genetically modified using this gene. An important enzyme in the cytokinin biosynthesis process is encoded by the isopentenyl transferase (ipt) gene from the bacterium Agrobacterium tumefaciens. The tobacco hornworm (M. sexta) and peach potato aphid's ability to consume leaves has decreased as a consequence of the wound-inducible promoter's expression of ipt in tobacco and tomato (Myzus persicae).

There are several initiatives aimed at identifying non-Bt toxin genes with insecticidal action. A variety of non-Bt insecticidal proteins obstruct the insect's ability to eat. There are now two main categories of genes from plants that are exploited to provide agricultural plants with insect resistance. by halting the development and growth of insects.

Anti-proteinase drugs: Plants are known to possess peptides that function as protease inhibitors since 1938. Serine, cysteine, aspartic, and metalloproteinases are the various proteinases. They facilitate the release of amino acids from ingested protein, supplying the nutrition necessary for insects to grow and develop normally. By interfering with the insect's digestive enzymes, proteinase inhibitors deplete the insect of nutrition. Here are two examples of proteinase inhibitor genes:

The Cowpea Trypsin Inhibitor (CpTI) gene: Cowpea (Vigna unguiculata) contains CpT I, which is the most potent inhibitor yet to be discovered. The antimetabolite chemicals produced by this inhibitor gene provide defense against the main storage pest Bruchid beetle (Callosobruchus maculatus). This gene is not toxic to mammals; however, it is damaging to several Lepidopteran insects, including Heliothis virescens, Manduca sexta, Coleopteran insects, Callosobruchus, Anthonomus grandis, Orthopteran insects, Locusta migratoria.

Amylase inhibitor: Three a-amylase inhibitor genes have been expressed in tobacco, but the gene for the -amylase inhibitor (aAl-Pv) isolated from adzuki bean has received the most attention (Phaseolus vulgaris). It is effective against Callosobruchus chinensis and Zabrotes subfasciatus. This protein that inhibits amylase prevents larvae from eating in the midgut. The gut enzyme called -amylase that the larvae release breaks down the starch. The weevil may be starved to death by introducing a protein that prevents the digestive enzyme in insect guts, -amylase [6].

Another huge class of proteins that may be utilized to create insect resistance via genetic engineering is the lectins. These glycoproteins come from plants. Snowdrop (Galanthus nivalis) lectin GNA, recently discovered, has an action against aphids. This protein's gene has been effectively employed in genetic engineering experiments and expressed in a variety of species, such as tomato, oilseed rape, and potato. The results of laboratory experiments using transgenic potatoes revealed that GNA significantly decreased fertility but did not increase mortality. The ability of this protein to inhibit piercing and sucking insects is a significant trait. One drawback of the protein is that it only functions well when consumed in large amounts, or when insects are subjected to microgram levels in diet incorporation bioassays. Many lectin-encoding genes (including rice lectin, jacalin, and wheat germ agglutinin) have been expressed in transgenic plants.

The tobacco hornworm and serine proteinase inhibitors from mammals are the main sources of these resistance genes (Manduca sexta). Bovine pancreatic trypsin inhibitor (BPTI), antitrypsin, and spleen inhibitor (SI) have been identified as promising insect resistance proteins and have been transferred to a variety of plants based on in vitro screening of inhibition of proteolysis midgut extracts of a range of lepidopteran larvae.

C. Resistant to Virus

The relatively modest genomic size of plant viruses has contributed to the success of the development of molecular approaches for the management of viral infections. Molecular technology may be used in a variety of ways to incorporate existing resistance characteristics or develop brand-new ones in plant viral systems. The goal is to pinpoint the viral genes or gene products that, if present at the incorrect time or in the wrong quantity, will interfere with the infection process's regular operations and delay the onset of illness

II. DISCUSSION

The capacity of one virus to stop or reduce the impact of a second challenge virus is known as coat-protein-mediated cross-protection. When a mild viral strain is introduced to a susceptible crop strain, the susceptible strain becomes resistant to more severe virus strains. First shown by Powell-Abel et al. in 1986, transgenic tobacco expressing the coat protein of the tobacco mosaic virus (TMV) exhibited resistance like that shown in viral-mediated cross-protection. When produced in transgenic plants, a variety of coat protein genes from various virus families have been discovered to provide resistance. In many systems, the reduction of viral multiplication at the site of infection is associated with coat protein-mediated resistance. This resistance manifests as a decrease in the number of infection sites on inoculation

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International Journal of Science, Engineering and Management (IJSEM)
Vol 10, Issue 2S, February 2023

leaves, indicating the disruption of an early stage in the viral life cycle. The TMV coat protein of the protective virus may prevent the RNA of the challenge virus from becoming uncoated, resulting in TMV cross-protection [7][8].

The majority of the system for coat-protein-mediated resistance has been applied in a variety of crops, including rice, maize, alfalfa, melons, tomatoes, potatoes, tobacco, and potatoes. The tomato spotted Wilt virus is an example of a significant negative strain virus (TSWV). Here, the nucleocapsid (N) protein and genomic RNA are closely bonded. This protein aids in the viral RNA wrapping process and controls the transcription-to-replication transition throughout the infection cycle.

Resistance mediated by nonstructural proteins: A variety of viruses encode nonstructural proteins required for viral replication. When produced in transgenic plants, a number of these nonstructural "replicate" proteins have been reported to provide very high levels of resistance to viral infection. Transgenic tobacco was used by Golemboski et al. (1990) to produce the 54 kDa TMV open reading frame (ORF), which served as the first proof of this phenomenon. To combat the potato virus X and the pea early browning virus (PEBV), transgenic tobacco has been created (PVX). By expressing the replicase gene, Pinto et al. (1999) created transgenic rice plants that were resistant to the rice yellow mosaic virus. Transgenic tobacco and other crops have been used for testing the prevention of viral infection by blocking viral movement via the production of faulty viral movement proteins. Resistance that is a sense- and antisense-mediated: The transgenic production of sense- and antisense-mediated viral RNA segments has recently been studied as a pathogen-derived technique for controlling plant viruses. The idea behind this approach is to combine complementary RNA sequences expressed by the plant with viral RNA. Incorrect RNA-RNA base pairing might make it difficult for the viral RNA to be accessible for gene expression or replication. The earliest stages are necessary for the formation of viral infection might be blocked using these antisense and sense constructs. It has been shown that tobacco that expresses RNA that is complementary to the coat protein provides antisense protection [4].

Protection for satellite RNA Satellite RNAs is a group of short (about 300 nucleotides), single-stranded RNA molecules that need a helper virus for virion packaging and replication in order to infect another host. Although unconnected to the viral genome, satellite RNA relies on viruses for both replication and transmission. Many viruses have been linked to these satellite RNA types. It has been shown that a variety of satellite RNAs control the symptoms and replication of their helper viruses. Depending on the linked satellite RNA, changes in symptom development may vary from severe necrosis to almost total symptom reduction.

It may be possible to employ satellite RNAs to lessen the severity of the sickness caused by the helper virus. It is used to provide resistance while creating transgenic crops. Tobacco, pepper, tomato, and cucumber plants were effectively shielded against a virulent strain of CMV and production losses were decreased by the intentional inoculation of a mild strain of CMV (cucumber mosaic virus) with a symptom-attenuating satellite RNA. When exposed to a virulent strain of CMV, 121 transgenic tomato plants expressing an attenuating CMV satellite RNA produced 50% more fruit than control plants, according to Tien and Gusui (1991). This approach is only effective in viral systems that include attenuating satellite RNAs.

Resistance addressed by the pathogen: virucidal proteins Many plant species have been shown to contain a group of polypeptides known as ribosome-inactivating proteins (RIPs), or antiviral proteins, the most well-known source of which being pokeweed (Phytolacca americana). There are three different pokeweed antiviral proteins (PAPs). Due to their capacity to change ribosomal RNA and hence obstruct polypeptide translation, they have ribosome-inhibiting activity. PAP obtained from Phytolacca was used by Lodge et al. (1993) to create transgenic tobacco and potato plants that were immune to PVX, PVY, and CMV. The pokeweed antiviral protein-expressing transgenic tobacco was discovered to be TMV-resistant.

Resistance mediated by ribozymes: In essence, ribozymes are RNA-based RNA restriction enzymes with the ability to catalytically cleave RNA molecules at certain places. Given that the bulk of agriculturally significant plant viruses contain RNA genomes, the ability to guide ribozyme cleavage presents a potentially helpful technique to manage plant viral infections. Hence, viral replication and disease progression might be prevented by the transgenic production of ribozymes that are designed to break viral RNAs.

There are several varieties of ribozymes, each with a unique sequence and structure. A ribozyme's capacity to provide resistance to viral infection in vivo in a protoplast system was examined by Edington and Nelson in 1992. Findings showed that a TMV replicase ORF-targeted ribozyme was efficient in lowering viral accumulation in protoplasts by up to 90% in the first day after infection.

A. Resistant to disease

Several anti-microbial protein-coding plant defense response genes have now been cloned. In response to an infection or exposure to microbial elicitor macromolecules, the majority of these are transcriptionally activated. Hydrolytic enzymes, such as chitinase, 1-3-D glucanase, and other pathogenesis-related (PR) proteins, ribosome-inactivating proteins (RIPs), antifungal proteins (AFPs), biosynthetic enzymes for the production of anti-microbial phytoalexins, wall-bound phenolics, osmosis, thionins, lectins, etc., and hydrogen peroxide

Protein Linked to Pathogenesis: These proteins have a low molecular weight and are found in high concentrations in infected plant tissues. Tobacco PR-1, PR-2 (1-3 glucanase), PR-3 (chitinases), PR-4 (even-like), PR-5 (thaumatin like and osmotic), etc. are significant kinds of PR proteins. In order to

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Vol 10, Issue 2S, February 2023

create crop resistance to infections, hydrolytic enzymes' capacity to dissolve chitin and glucan in the cell walls of fungal pathogens has been used. Plant chitinase genes have been extracted and described in various ways. A bacterial chitinase gene from soil bacteria (Serratia marcescens) was first reported in tobacco, where it was successfully integrated and expressed in leaves. In transgenic plants of tobacco and Brassica napus, a basic chitinase gene of the bean has been produced constitutively at high levels under the strong CaMV 35S constitutive promoter control. The plants were significantly protected by this expression against the pathogen Rhizoctonia solani's post-emergent damping down. The protection in the case of Brassica napus was delayed rather than total inhibition.

B. Antimicrobial Protein

Plants and other organisms may have antimicrobial proteins that, although they may not necessarily be connected to naturally occurring defensive responses, do demonstrate resistance to infections. These are cysteine-rich proteins called ribosome-inactivating proteins (RIPs). When transplanted to tobacco, the barley-thionin gene demonstrated resistance to Pseudomonas syringae, P tabaci and P. syringae.

Lysozymes, iron-sequestering glycoproteins, and lytic peptides are antibacterial proteins that are not derived from plants. Small proteins called lytic peptides, which have an amphipathic helical shape, cause holes to develop in bacterial membranes (e.g. cecropin, attacin). Cecropins and attacins have been expressed in transgenic tobacco, potato, and apple plants (Mourgues et al., 1998). Transferring a cecropin gene cassette to tobacco and rice resulted in resistance to P syringae and bacterial infections [9].

Potatoes with the BacteriophageT4 lysozyme gene showed resistance to Erwinia carotovora subsp. Atroseptia. The insertion of a human lysozyme gene is a successful strategy for safeguarding crops against bacterial and fungal diseases. H202 is an active oxygen species (AOS) that has a defensive mechanism. It was discovered that transgenic potatoes carrying a fungal gene for glucose oxidase that produces H202 had high amounts of H202 and improved resistance to both bacterial and fungal diseases. The fungal endo 1,4-D polygalacturonases, which contributed to the breakdown of the plant cell wall and are likely necessary for successful colonization, provide a distinct strategy. Polygalacturonases inhibiting proteins, or PGIPs, are unique inhibitors of these endopolygalacturonases that are found in all dicotyledons studied so far but do not affect the plant's endogenous pectinases.

Many bacterial or fungal plant pathogen poisons now have recognized molecular targets. Resistance has been successfully engineered using toxin-inactivating enzymes. Phaseolotoxin, a tripeptide toxin produced by the bacterial halo blight pathogen of beans Pseudomonas phaseolicola, is what creates the chlorotic halos. Phaseolotoxin prevents ornithine transcarbamylase from working (OC). The gene encoding this enzyme has been cloned and introduced to tobacco, where it has been shown that its expression prevents the symptoms induced by administration of the toxin, and bacteria that possess a phaseolotoxin-insensitive OC has been chosen. A class of low-molecular-weight toxins called algicides is produced by the systemic xylem-invading pathogen Xanthomonas albilineans. These toxins preferentially obstruct prokaryote DNA replication and are responsible for the typical symptoms of chlorosis by obstructing chloroplast formation. Phytoalexins are low molecular weight secondary metabolites with antibacterial activity that are produced by the plant in response to an infection and help plants fight illness. These stored phytoalexins (in specific cells or organelles in a dormant state) are mobilized after infection, and genes for biosynthetic pathways are triggered, starting the manufacture of further phytoalexins. One of the most prevalent phytoalexins produced by various species is resveratrol.

The development of map-based cloning and gene-tagging techniques has largely contributed to the recent uptick in various efforts to uncover disease resistance and avirulence genes. Transposon tagging has been used to clone the HM1 gene from maize, which provides resistance to Cochliobolus carbonum. This gene produces the HC-toxin reductase, which renders the fungus' HC toxin inactive. Cloned-resistant genes include the tobacco N gene, Arabidopsis Rps2 and RPM1, Pto, Cf9, Cf2, and Cf4 from tomatoes. A variety of avirulence genes, including Avr9 and Avr4 from Cladosposium fulvum and NIP1 from Rhynchosporium secalis, have also been cloned.

One method established in tomato plants using the Pto resistance gene that confers resistance against Pseudomonas syringae pv tomato is the introduction of the resistance (R) gene from a plant variety resistant to a given disease into susceptible cultivars. The rice Xa21 gene gives resistance to around 30 different strains of the bacteria Xanthomonas oryzae pv oryzae, which causes leaf blight in rice, and Pseudomonas syringae pv tabaci, which expresses avr Pto in tobacco plants [10].

C. Selecting Disease-Resistant Types in Breeding

Early in the 20th century, scientists realized the importance of resistance in preventing plant disease. The ability to create resistant varieties was made feasible and desired by breakthroughs in the genetics field as well as the benefits of planting a resistant variety rather than a susceptible one. Sir R. Biffen, who discovered a single recessive gene for resistance to wheat yellow rust, is credited with developing scientific breeding for disease resistance. The disease resistance (R) genes were then bred into almost every crop, often by introgression from suitable wild cousins.

Nowadays, the practice of developing resistant cultivars as one component of larger plant breeding programs is increasingly widespread and extensive. Its value and significance in the production of food and fiber are crucial. The selection and breeding of plant lineages that naturally

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Vol 10, Issue 2S, February 2023

developed in one or more geographic locations over millions of years produced the cultivated agricultural plants of today. Plants have progressively evolved from their prehistoric origins to the agricultural plants we know today, giving rise to many genetically distinct varieties of these plants. In the place of origin or in the regions where the plant naturally spreads, many of these species still live in the wild.

With the advent of agriculture, certain wild plants in each region have been chosen and domesticated, giving rise to a large number of cultivated lines or varieties. The best prolific of these types were maintained year after year in each location, and those that withstood the diseases and the local climate were still grown. The weak and vulnerable were wiped out by nature and viruses, and among the survivors, farmers chose the finest producers. Several main and minor sets of resistance genes were present in the surviving types. In this way, agricultural plants continued to be chosen wherever they were produced, with individuals in each region individually choosing cultivars that were suited to the environment there and resistant to its illnesses. As a result, several kinds of each agricultural plant were grown all over the globe, and because of their own genetic diversity, these crops were regionally adapted while remaining genetically diverse overall, making them resistant to unexpected outbreaks of a single disease across a wide area.

Over 100 distinct types of fungi, bacteria, mollicutes, viruses, and nematodes harm each species of plant. A single plant often faces hundreds of thousands of attacks from one kind or many distinct pathogens. Even while some plants could sustain some degree of harm, many manage to withstand all of these assaults and continue to develop healthily in order to give respectable harvests. As new plant cultivars or breeds are created, they need to be propagated and maintained. Although some plants reproduce asexually, others do so via seeds. For the integrity of the plant breeding outcomes, seed-propagated cultivars need strict control over the seed supply and manufacturing processes. To avoid seed mingling after harvest or cross-contamination with related plants, isolation is required. Plants are typically isolated by being planted far apart, however, in other crops, plants are caged or confined in greenhouses. When plants were initially domesticated, disease-resistance breeding started. Breeding is a continuous process because pathogen populations are constantly under pressure from selection for increased virulence, new pathogens emerge, evolving cultivation techniques, changing climatic conditions, and plant breeding for other traits can reduce resistance and/or strengthen pathogens. An approved plant line that is resistant to one disease may not be resistant to others.

Typical components of a plant breeding program to develop plant resistance include: Identifying plants, particularly wild strains that often display improved resistance, that may be less appealing in other aspects yet have a beneficial disease resistance feature. Combining two desirables, but disease-prone, varieties to create one that is resistant to both diseases. Development of breeding prospects in an environment that promotes illness, maybe with pathogen injection. To address heterogeneity within a single pathogen species, attention must be directed to the particular pathogen isolates. Choose disease-resistant people who also possess other desired features including yield and quality as well as other disease-resistance traits.

If resistance is effective over several years of broad use while pathogen populations change, it is said to be durable and long-lasting. In order to conserve extremely desirable plant kinds, crops like potatoes, apples, bananas, and sugarcane are often produced vegetatively since outcrossing substantially undermines the desired features in these species. Crops that are grown vegetatively may be among the greatest candidates for resistance enhancement using the biotechnology technique of plant transformation to control disease resistance genes.

The goal of the first generation of genetic engineering in crop agriculture was to create transgenic plants that expressed foreign genes that conferred resistance to pathogens, insects, and illnesses, among other things. The method of transferring foreign genes using agrobacterium has been expanding steadily. An insect-killing bacteria called Bacillus thuringiensis creates the Bt toxin, a protein that is effective against lepidopteran larvae. It is possible to integrate or develop novel viral resistance utilizing molecular technology in a variety of plants, for example, coat protein-mediated cross-protection. A variety of plant defense-sensitive genes expressing anti-microbial proteins has been cloned whose products may include hydrolytic enzymes, ribosome-inactivating proteins, antifungal proteins, etc.

Sir Biffen, who discovered a single recessive gene for resistance to wheat yellow rust, is credited with developing scientific breeding for disease resistance. The disease resistance (R) genes were then bred into almost every crop, often by introgression from suitable wild cousins. Nowadays, the practice of developing resistant cultivars as one component of larger plant breeding programs is increasingly widespread and extensive. Its value and significance in the production of food and fiber are crucial. The selection and breeding of plant lineages that naturally developed in one or more geographic locations over millions of years produced the cultivated agricultural plants of today. Breeding efforts are ongoing because pathogen populations are constantly under pressure from selection for increased virulence, new pathogens emerge, evolving cultivation techniques, changing climatic conditions, and plant breeding for other traits all have the potential to reduce resistance and/or strengthen pathogens.

III. CONCLUSION

Both agricultural output and biotechnology research to manage plant diseases have increased in tandem with rising global population needs. Complex plant pathogens, such as

fungi, bacteria, viruses, and nematodes, may cause disease, and managing it calls for the use of transgenic technology, biochemistry, and genetics approaches. The advancement of rDNA technology, gene transfer, and tissue culture methods has made it possible to provide fresh approaches to venerable issues.

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Understanding of Molecular Plant Pathology

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***Abstract*— A chemical generated by the other organism causes the host-pathogen interaction genes in one organism to express themselves. For instance, it seems that the presence of monomers or oligomers of host cell wall macromolecules, which are substrates for these enzymes, induces the genes for cell wall-degrading enzymes in the pathogen. Similarly, the expression of certain signal chemicals activated by inducer molecules generated by the pathogen triggers the creation of genes for host defensive mechanisms, such as phytoalexin production.**

***Keywords*— Host Plant, Pathogen Races, Plant Species, Plant Diseases, Resistance Genes.**

I. INTRODUCTION

Every organism's genetic material is linearly encoded in DNA in the order of the four nucleotides (A, adenine; C, cytosine; G, guanine; and T, thymine). A specific amino acid is coded for by each triplet of nearby bases. A gene is a segment of DNA that typically consists of 100 to 500 contiguous triplets or more that code for one protein or, rarely, one RNA molecule.

In eukaryotes, non-coding DNA segments known as introns often obstruct the coding section of a gene. One of a gene's DNA strands is utilized as a template to create an RNA strand when the gene is activated. Some genes only produce a single RNA, which is either a ribosomal RNA or a transfer RNA (tRNA) (rRNA). Yet, the transcriptional byproduct of the majority of genes is messenger RNA (mRNA). The mRNA is then joined to ribosomes, which, with the aid of tRNAs, translate the strand's base sequence into a particular sequence of amino acids that folds into a certain shape and produces a particular protein. Proteins are encoded by several genes. While most of the proteins function as enzymes, others are necessary for cell membrane construction. The structure, size, and color of cells and organisms, as well as the types of chemical compounds that the cell produces and the regulation of all cellular and organismal processes, are all characteristics of proteins [1]–[3].

Not all of the genes in a cell are expressed constantly; instead, some genes are activated or inactive depending on the length of extra DNA strands known as promoters, enhancers, silencers, or terminators. Moreover, they serve as cues for the synthesis of RNAs and proteins, which in turn operate as either promoters or enhancers of gene expression or repressors or terminators of gene expression.

A. Genes and illness

Many plants, including tomatoes, apples, and wheat, get the disease as a consequence of pathogen infection. Often, the pathogen is unique to that single host plant. For instance, the fusarium oxysporum sp. lycopersici that causes tomato wilt solely affects tomatoes and has no impact whatsoever on apples. The existence of one or more genes for pathogenicity, specificity, and virulence against the particular host in the pathogen is what makes it possible for illness to develop in a host.

A pathogen's virulence gene or genes are often unique to one or a small number of closely related plant species that serve as its hosts. Moreover, only that particular kind of plant and potentially a few closely related types of plants have the genes and gene combinations that render a plant vulnerable (host)to a certain disease. All plants also have naturally occurred and artificial defenses that provide resistance to the majority of diseases. Non-host resistance refers to a disease that is virulent on one kind of plant but is unable to attack another type of plant.

Few diseases may attack a wide variety—sometimes hundreds—of host plants. These necrotrophic pathogens can do this either because they have many different virulence genes or because they somehow have virulence genes that are less plant-specific than those of the more often specialized pathogens. Yet, it seems that only a tiny subset of pathogens, often fewer than a hundred for most plants, may infect each species of the plant [4]–[6].

Why aren't all plants attacked by their diseases, and why don't the infections typically kill the plants that are attacked? The answer is complicated, but in general, it occurs because plants have gained one or typically many genes for resistance that shield them from infection or serious illness in addition to the genes that make them vulnerable to a pathogen via evolution or systematic breeding. When a novel gene for pathogen resistance emerges or is inserted into a plant, the plant develops resistance to all or the majority of the pathogen's previously existing individuals. Such pathogens have one, and often several, virulence genes; but, if they lack the extra new virulence gene needed to counteract the impact of the plant's new resistance gene, they cannot infect the plant and the plant stays resistant. Hence, even a single novel gene for pathogen resistance may prevent plants carrying the gene from contracting the disease for at least a few months and potentially even years from the majority of pre-existing races of the pathogen.

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International Journal of Science, Engineering and Management (IJSEM)
Vol 10, Issue 2S, February 2023

B. Mechanism for variation

In host plants and pathogens that typically reproduce sexually, such as the majority of fungi, higher plants, and nematodes, diversity in the progeny is predominantly introduced by segregation and recombination of genes during the meiotic division of the zygote. Because of sexual recombination, bacteria, and even viruses display variances. Heteroploidy and certain parasexual mechanisms provide variety in many fungi. Pathogens and plants both experience mutation and recombination, two sources of diversity.

C. Modification

mutation is a sudden alteration in an organism's genetic makeup that is passed on hereditarily to the organism's offspring. Changes in the DNA's base sequence, such as base substitutions, additions, or deletions of single or multiple base pairs, are known as mutations. Further alterations may result from the numerous copies of certain DNA segments, the insertion or deletion of a transposable element, or moveable DNA segment, into the coding or regulatory sequence of a gene, and the inversion of a DNA segment.

All living things experience spontaneous mutations in the natural world. Single-celled species like viruses, bacteria, and fungi with haploid mycelium may all express mutations right away. In diploid or dikaryotic organisms, most mutations are recessive and might go unnoticed until they are brought together in a homozygous situation.

D. Stages of pathogen variation

A species of pathogen, like Puccinia graminis, the culprit behind cereal stem rot, is made up of the complete population of that specific organism on the planet, which may be a fungal disease. This population shares certain morphological and other phenotypic traits. Nevertheless, certain members of this species solely attack wheat, barley, or oats. These members form groupings known as varieties or special forms (formae specialis), including P. graminis f. sp. tritici, P. graminis hordei, and P. graminis avenae. Each group of these people makes up a race. Even within each unique form, some individuals target certain host plant kinds but not others, others attack a different set of host plant varieties, and so on. For instance, there are over 200 different varieties of Puccinia graminis tritici (race 1, race 15, race 59, and so on). On rare occasions, a race's progeny may attack a new variety or will severely afflict one that it had previously barely infected. This person is referred to as a variation. A biotype is made up of identical people that the variation produces asexually. Each race is made up of one or more biotypes.

As the pathogen's host range changes, the development of new pathogen biotypes may be rather dramatic. If the variation has lost the capacity to infect a commonly grown plant variety, it simply loses the ability to support itself and perishes without ever letting itself be known to humans. Yet, if the variant pathogen changes such that it may infect a plant variety that has been bred because of its tolerance to the

Being the sole person capable of surviving on this plant variety, regardless of parental race or strain, the variant individual quickly spawns enormous populations that spread and eradicate the previously resistant variety. This is how a plant variety's resistance is said to be "broken down," and the change in the pathogen, not the host plant, is to blame.

E. Plant resistance types

True, cultivar-specific, or gene-for-gene resistance occurs when a plant has R genes that are directed against the avirulence genes of a pathogen, while gene-for-gene resistance occurs when a plant escapes or tolerates infection by a pathogen. Plants can also be resistant to certain pathogens because they belong to taxonomic groups that are outside the range of those pathogens' hosts (nonhost resistance), have R genes that are directed against those pathogens (apparent resistance)

Each kind of plant is a host to a limited, distinctive group of diseases that account for a very tiny part of all known plant infections. Each kind of plant is a nonhost to the great majority of known plant diseases, however, in another sense. Nonhosts are entirely immune to the diseases that affect other plants, often even in the most virulent environments (nonhost resistance). Yet, the same plant species that are nonhosts to most infections are vulnerable to some degree to their pathogens.

The varying types and numbers of resistance genes that may exist in each variety account for the difference in plant varieties' sensitivity to the disease. Depending on how crucial the processes they regulate are, a resistance gene's impacts might range from significant to little. A variety that is very vulnerable to a particular pathogen isolate lacks efficient genes for resistance to that isolate. Yet, the same variety may or may not be vulnerable to a different pathogen isolate isolated from sick plants of a different variety. It's probable that the variety also has several resistance genes, each tailored to a distinct pathogen strain.

F. Real Resistance

True resistance is defined as disease resistance that is genetically regulated by the presence of one, a few, or many resistance genes in the plant. True resistance occurs when the host and the pathogen are more or less incompatible, either as a result of a lack of chemical recognition between the host and the pathogen or as a result of the host plant's ability to fight the pathogen using a variety of defense mechanisms that are either already present or are activated in response to the pathogen's infection. True resistance comes in two flavors: horizontal and vertical.

G. Horizontal Resistance

Any disease that affects a plant may be overcome by a certain amount of resistance, which is present in all plants but may not always be at the same level. Non-specific, broad, quantitative, adult-plant, field, enduring, and most often horizontal resistance are all terms used to describe this kind

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Vol 10, Issue 2S, February 2023

of resistance. This resistance is also known as polygenic or multigene resistance since it is regulated by several genes (dozens or hundreds) [7]–[9].

As they are all rather inefficient against the virus on their own, these genes may only have a little impact on the overall horizontal resistance (minor gene resistance). The many different physiological processes in plants that supply the raw materials and building blocks for the defense mechanism of the plant are controlled by the multiple genes involved in horizontal resistance. While horizontal resistance does not prevent the transmission of the illness or the emergence of epidemics in the field, it does slow down the growth of individual infection loci on a plant. The inheritance of this resistance is quantitative.

H. Vertical resistance

Although many plants kinds are vulnerable to other races of the same disease, they are extremely resistant to certain of those races. In other words, a variety may look very resistant to one pathogen race and sensitive to another race under a range of environmental circumstances, depending on the race of the pathogen that infected it. Such resistance clearly distinguishes between distinct pathogen races since it is only effective against certain pathogen races and ineffective against others. Strong, significant, special, qualitative, or differential resistance are other names for this kind of resistance, although vertical resistance is the one that is most often used.

Vertical resistance is usually regulated by one or a small number of genes (monogenic or oligogenic resistance). These genes, also known as R genes, play a significant role in the development of resistance because they regulate an important phase in the host plant's detection of the pathogen. The host and pathogen seem incompatible in the presence of vertical resistance. The host may react in a hypersensitive manner, may seem immune, or may inhibit the spread of the virus.

To prevent epidemics from spreading, vertical resistance either restricts the initial inoculum or the rate of infection-related reproduction. One resistant gene may be able to confer total resistance. Several resistance genes (R1R2, R1R3, R1R2R3) should be combined or pyramided in the same plant to create a plant that is resistant to all pathogen races to which each of the genes gives resistance. For instance, wheat possesses 20 to 40 genes for resistance to the Puccinia recondite leaf rust fungus. Any pathogen races that have the matching gene for avirulence are resistant to the plant when it has a resistance gene, such as R2, which renders the plant resistant to all pathogen races. When the pathogen infects plants that lack the specific gene for resistance, this particular pathogen race and its avirulence gene (A2) are discovered (R2).

Yet, for several plant diseases, the genetic material found in the cytoplasm of the cell regulates resistance. Cytoplasmic resistance is another name for this kind of resistance. The two most well-known instances of cytoplasmic resistance are in corn, wherein the absence of a gene in the mitochondrial normal cytoplasm of different types of corn that encodes a receptor for the host-specific toxin produced by each pathogen confers resistance to two leaf blights, the southern corn leaf blight caused by Bipolaris (Helminthosporium) maydis and the yellow leaf blight caused by Phyllosticta maydis. All maize lines containing Texas male-sterile cytoplasm are vulnerable to these diseases because this gene is present in the mitochondria of Texas male-sterile cytoplasm.

Limited or widespread plant disease outbreaks affect a variety of agricultural plants practically every year in any location. Yet, some extremely vulnerable plants or types of these crops may be free from illness or symptoms and hence look resistant under particular settings or situations. Plants that are known to be sensitive to disease can seem to be resistant to it because of disease tolerance or escape.

When the three elements required for disease (susceptible host, virulent pathogen, and favorable environment) do not coincide and interact at the right moment or for a long enough period, disease escape occurs in genetically susceptible plants. Because their seeds germinate more quickly or because their seedlings harden sooner than others and before the temperature becomes ideal for the pathogen to attack them, plants may be able to avoid illness from soil-borne infections. Because they are only susceptible to a pathogen at a certain growth stage (young leaves, stems, or fruits; during blossoming or fruiting; during maturity and early senescence), some plants are immune to disease if the pathogen is absent or dormant at that specific time. As a result, these plants avoid becoming infected.

Many times, plants escape disease because they are mixed in with other plant species that are resistant to the disease, which reduces the amount of inoculum that gets to them compared to if they were in monocultural plantations; because their surface hairs and wax repel water and pathogens suspended in it; because their growth habit is too upright or otherwise unfavorable for pathogen attachment and germination; or because their natural openings, like stomata, are resistant to the disease.

In practically every site, a variety of environmental conditions are critical in the development of plant diseases. For instance, most infections are geographically distributed according to temperature, and plants that grow outside of that temperature range are disease-free from such pathogens. Yet, plant disease escapes most often occurs at temperatures that support plant growth considerably more than pathogen development. Temperatures outside of specified ranges prevent fungi from sporulating, as well as spore germination and infection, and raise the risk of disease escape. Insect vectors and diseases are less mobile due to the low temperature, which helps more plants resist illness.

I. Disease tolerance

The capacity of plants to produce a healthy crop while being affected by a pathogen is known as disease tolerance. Tolerance results from specific, inherited traits of the host

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Vol 10, Issue 2S, February 2023

plant that permit the pathogen to grow and multiply in the host while the host manages to produce a good crop, either by lacking receptor sites for the pathogen's irritant excretions or by inactivating or compensating for those excretions. Plants that are tolerant to the disease are often sensitive to it, but they seldom die from it and typically suffer minimal harm.

The interaction of at least two organisms, the host plant and the pathogen, results in infectious plant diseases. The DNA, which is arranged into multiple segments that make up the genes, is the genetic material that controls the characteristics of each of these two animals. It is well established that the host response, or how susceptible or resistant the host is to certain infections, is a hereditary trait. This information has been used in the development and distribution of cultivars resistant to the pathogens responsible for certain illnesses rather successfully. The diseases come in a variety of races, and each race differs from the others in that it may infect certain types of plant species but not others.

A variety is vulnerable to one race but resistant to the other when it is infected with two well-selected races of a disease. In contrast, when two well-selected varieties of a host plant are inoculated with the same race of a disease, one variety becomes vulnerable while the other becomes resistant to the same pathogen. This demonstrates unequivocally that in the first instance, one race has a genetic trait that allows it to attack the plant, whereas the other race does not, and that in the second instance, one variety has a genetic trait that allows it to defend itself against the pathogen, remaining resistant, whereas the other variety does not. It is once again noted that one pathogen race can infect a particular group of varieties; another race can infect another group of varieties, including some that can and some that cannot be infected by the previous races; and so on when several varieties are inoculated separately with one of several races of the pathogen.

Studies on the inheritance of resistance vs susceptibility in plants demonstrate that resistance is controlled by a single gene, and susceptibility results when that gene is absent. Research on the inheritance of avirulence vs virulence in pathogens demonstrates that avirulence is controlled by a single gene, while virulence is enabled by its absence. The R genes in the plant are particular to the avr genes in the pathogen, according to studies of their interactions. As a result, varieties with specific resistance genes respond differently to distinct pathogen races and their genes for avirulence. These types' offspring respond to the same diseases in precisely the same way that their parent plants did, demonstrating that a pathogen's susceptibility to infection or resistance is a trait that is genetically regulated (inherited). Similar to how the parent infections affected each variety, the offspring of each pathogen likewise has the same impact on each variety, showing that the disease's virulence or avirulence is similarly genetically regulated (inherited).

The genetic makeup of the host and the pathogen determines whether any host-pathogen combination will get infected (susceptibility) or not (resistance) under optimum environmental circumstances. Similar to how different pathogens have different numbers of genes affecting virulence or avirulence, different plants have different numbers of genes determining resistance or susceptibility.

The idea of "gene for gene" In nature, host plants and the diseases that infect them coexist, proving that the two have been developing simultaneously. The resilience of the host and variations in the infections' virulence seems to be continuously balancing each other out. In this, virulence and resistance are maintained in a dynamic balance, allowing the pathogen and host to coexist peacefully for extended periods. The gene-for-gene principle, which states that for every gene in the pathogen that imparts virulence, there is a matching gene in the host that confers resistance to the host and vice versa, explains the progressive development of virulence and resistance. The gene-for-gene theory was first shown in the instance of flax and flax rust, but it has since been demonstrated to work in a wide variety of rusts and smuts, powdery mildews, apple scab, late blight of potato, and other fungi-caused diseases.

Genes for susceptibility that lack resistance are often recessive in the host, while genes for resistance are typically dominant (R). The genes for avirulence (inability to infect) are often dominant in the pathogen, while the genes for virulence are recessive. Each gene in the host can only be recognized by the gene that serves as its counterpart in the pathogen, and vice versa. Only the AR interaction, in which the host possesses a specific gene for resistance that identifies the matching particular gene for avirulence of the pathogen, is incompatible (resistant) among the four potential gene pairings. Since the host lacks genes for resistance in the Ar combination, the virus may infect it by using its other virulence genes to assault it. Since the pathogen lacks the gene for avirulence that is uniquely identified by this particular gene for resistance, infection occurs in aR even though the host has a gene for resistance. As a result, no defensive mechanisms (resistance) are triggered. In the ar interaction, infection occurs as a consequence of the pathogen attacking the plant because it lacks resistance and is thus vulnerable since it is a pathogen.

In pathogen-plant interactions, pathogens produce a variety of substances that are necessary for the pathogen to infect and harm its host, including some plant cell wall-degrading enzymes (such as cutinases), some toxins (such as victorin and HC-toxin), hormones (such as indoleacetic acid and cytokinin), polysaccharides, proteinases, siderophores, melanin, etc. These elements serve as pathogenicity elements in certain circumstances. The same substances are beneficial but not necessary for the onset and progression of illness in different plant-pathogen systems. These substances are regarded as virulence factors in certain situations.

Pathogens create an infinite number of known virulence factors. Almost all molecules and structures are amylases,

lipases, signaling molecules like homoserine lactone exopolysaccharides, flagella, hormones, poisons, and many more enzymes that break down cell walls. These substances or structures might be found on the pathogen's surface or relocated to the pathogen's extracellular environment, and they could have a range of effects on the infection's ability to spread throughout the plant.

R gene: The bulk of the time, plants remain disease-resistant despite being exposed to many diverse plant diseases because they are not hosts to the great majority of infections (nonhost resistance). Depending on the type and quantity of resistance genes present in the plant, the current environmental conditions, and other factors, some varieties of a plant that is a host (susceptible to a given pathogen) may be susceptible, or more susceptible, to the pathogen, while others may be resistant, or more resistant, to the pathogen. Yet, several defensive response (resistance) genes are active even when a plant is attacked and infected by a pathogen. As a consequence, the plant often succeeds in preventing the pathogen from spreading into a smaller or bigger area, lesion, canker, etc. via defensive substances and structures that prevent the disease from spreading further. Yet, in certain instances, unique resistance (R) genes that allow the plant to continue to be resistant to infections carrying the appropriate avirulence (avr) genes are present in plant types that make them resistant to particular pathogen races.

The maize Hm1 gene, the first R gene, was discovered, extracted, and sequenced in 1992. A molecular description of its function followed. The Hml R gene confers resistance to race 1 of the fungus Cochliobolus carbonum, which infects susceptible maize cultivars with the leaf spot disease. More than a dozen plant R genes were extracted from plants, sequenced, transferred, and expressed in additional, sensitive plants after the Hm1 gene was discovered.

II. CONCLUSION

As a consequence of infection by the pathogen, which is often unique for each kind of host plant, many plants develop diseases. A pathogen's virulence gene or genes are often unique to one or a small group of closely related plant species that serve as its hosts. Few viruses can infect a wide variety of host plants. The two potential strategies to cause variation in both the host and the pathogen are mutation and recombination. These potential processes might cause diseases to undergo several phases of variation, leading to the development of diverse species, varieties, biotypes, races, and pathovars. Different types and amounts of resistance genes explain why various plant varieties vary in their sensitivity to the disease.

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Fungal Diseases I: Classification and General

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Abstract*— Plant diseases are significant because they harm plants and plant-based products. The kind and magnitude of losses brought on by plant diseases vary depending on the plant, the pathogen, the location, the environment, the management approach, etc. Before the identification of microbes as the primary cause, many writers classified illnesses based more on the effects they had on plants than on their underlying causes. Around 1850, however, the causes of the illnesses rather than their effects were used to categorize them. Some of them are based on the host, such as cereal or potato illnesses, or the symptoms, such as root rot or powdery mildew, etc. Based on their etiology, illnesses may be categorized most effectively. Several facets of fungi illnesses are explored in this section.

Keywords*— Fungal Diseases, Host Tissue, Invasive Fungal, Life Cycle, Powdery Mildews.

I. INTRODUCTION

A. Fungal classification

Four classifications have been established for fungi: Phyco, Asco, Basidio, and Deuteromycetes. Several employees have embraced and adopted this. The latter three classes in these categories have had their ideas mostly held steady, while the first class, Phycomycetes, has recently undergone dramatic modifications. Based on their reproductive features, Oomycetes and Zygomycetes were first used to categorize Phycomycetes into two sub-classes. Eventually, it was claimed that this group was not natural. Sparrow classified the Phycomycetes older class into six divisions in 1958 and assigned class rankings to each group [1]–[3].

Slime molds were formerly classified as Mycetozoa and maintained in the animal kingdom, although now most botanists believe they are connected to fungi. Myxomycetes should be classified as a separate division called the Myxomycophyta because they differ from other fungi so noticeably (multinucleate, free-living, naked plasmodium, zoospores with two heterokont, whiplash type of flagella, asexual reproduction by sporangia, and non-motile spores, for example).

Also, the Commission on International Rules of Botanical Nomenclature's suggestions have been implemented in the name-endings of fungal groupings. It states that the names of the categories of fungus should end in mycota, the subcategories in mycotina, the classes in mycetes and mycetidae, the orders in ales and the families in aceae, whereas the terms genus and species have no set ends.

The formation of motile cells (zoospores or planogametes), each with a single posterior whiplash flagellum, is the only distinguishing trait. The following traits may also be found in other fungi: (1) the thallus' coenocytic structure, which can take the form of a multinucleate globose or oval structure, an elongated simple hypha, or a fully developed mycelium; and (2) the transformation of the dormant spore or zygote into a dormant sporangium

B. The symptoms of fungi diseases

The collection of symptoms a plant with a disease exhibit is known as its symptomatology. A specific pathogenic fungus on the host plant produces a specific set of symptoms. Certain symptoms brought on by a specific fungus may be utilized to diagnose the disease. These are some examples of the many signs that fungus may cause:

C. Damping off and seedling blights

The phrase "damping-off" refers to several plant diseases that are transmitted via the soil, such as crown, soil line, or subterranean rots. With germinating seeds and seedlings, damping off and seedling blight occur. The virus spreads through the soil and has an impact on crop establishment at first [4]–[7].

There are two different forms of damping off symptoms: (a) Pre-emergence damping off when the rotting of sprouting seeds begins before they emerge from the soil. Seeds that are in the process of germinating may get infected as soon as moisture enters the seed coat or a little later when the radicle starts to stretch. Infected seeds die right away under the soil's surface. When germination is sluggish, pre-emergence damping off is more frequent in cold, wet soils. Due to reduced viability, bare spots in regular rows of seedlings may be noticed in field regions where such infections have occurred.

Seedling blight is another name for post-emergence damping off. The seedlings perish or wilt as soon as they break through the earth. The cotyledons may emerge from the soil only to wither and die, while seedlings that seem healthy may unexpectedly topple over. Succulent stems have a water-soaked, necrotic, and sunken zone at ground level, and seedlings fall to the ground. For woody seedlings, wilting and upright growth is followed by root degradation.

This kind of damping off is typical in greenhouses or outside in warm, humid conditions, particularly in places

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International Journal of Science, Engineering and Management (IJSEM)
Vol 10, Issue 2S, February 2023

where seedlings are overcrowded. The most frequent causes of damping off of seedlings are fungi found in the top layers of soil. Examples include Rhizoctonia solani and Pythium debaryanum. Yet, this may also be caused by other organisms including Fusarium, Botrytis, and Phytophthora.

D. Root rot and foot rot

In this case, the root system rots (decays or disintegrates) gradually, which causes the foot (basal region of the stem) to also rot. As a result, plants' aerial portions are deprived of water and nutrients, which causes a variety of symptoms, including stunted growth, yellowing and dropping leaves, and finally, the plant collapsing and dying. The pace of foot and root rotting as well as the plant's capacity to grow new roots from undamaged regions both have a major role in how quickly these symptoms arise on the plant. This is also dependent on the plant's capacity to endure water stress brought on by root loss.

There are two different sorts of rots: hard, dry decay and soft, squashy ones. For instance, Thielaviopsis basicola causes black root rot in tobacco, peas, and tomatoes. Rhizoctonia crocorum and its teleomorph Helicobasidium purpureum cause violet root rot in sugarbeet, clover, and carrots, among other plants. Armillaria causes root rot in plantation crops like tea and cocoa. Aphanomyces (Saprolegniales) cause pea rot.

E. Wilts

Wilt occurs when a plant's degraded root system is unable to absorb enough water to make up for the water lost via transpiration, causing the plant to lose its freshness or to become flaccid. The lower petioles bend downward, creating an obtuse angle between the stem and the petiole, which is known as epinasty, as the first sign On the lower leaves, vein clearing and yellowing also take place. These leaves ultimately perish after becoming increasingly chlorotic over time. The plant dies as a result of similar symptoms appearing on the higher leaves. Fusarium lycopersici on tomato and Fusarium oxysporum on cotton are the two most prevalent and significant fungi that produce wilt.

Wilt is also a symptom of two Verticillium species. One, known as facultative wilt, is moderate; the other, known as "propagative wilt," destroys crops. Fusarium and Verticillium, in contrast to the other wilts, enter their hosts via the roots, develop in the cortical cells without significantly affecting the cortical tissue, then reach the capillaries and settle, obstructing them. This causes vascular browning, wilting, and epinasty yellowing. Some of these alterations in the host plant might be attributed to changes in the host plant's metabolism, which include ethylene synthesis, an increase in IAA levels, and enzyme activity. Combinations of vascular blockage, toxin and chemical production, and elevated enzyme activity may all be signs of disease.

F. Delicate mildews

Downy gray color patches on the underside of leaves or stems carrying sporangiophores are the first signs of downy mildew development. The Peronosporales subclass of the Mastigomycotina contains the causative agent. Except for Phytophthora, all downy mildew-producing fungi are members of the Peronosporaceae family. The vegetative mycelia (nonseptate) grow in the intercellular spaces of the host tissue (leaf) and take up nutrients by simple, sac-like, or forked intracellular haustoria. At the terminals of the ultimate branches, the sporangiophores that are generated in groups emerge through the stomata and bear sporangia. The illness is known as downy mildews because of these clusters of sporangiophores and sporangia, which have a grey color and sporangia that resemble dewdrops [8]–[10].

Either zoosporangium create germ tubes and start an infection, or sporangia germinate and produce biflagellate zoospores that infect the host. These organisms enter the host tissue and are obligatory parasites. Sporangiophores are not always able to identify downy mildews from other types. One such illness is the common in India downy mildew of the millet Pennisetum typhoidum, which is brought on by Sclerospora graminicola. The glumes and stamens of the flower head acquire leaf-like structures as a result of the fungus that infects the inflorescence, replacing the close spike with grains that would have formed a loose, green structure. The green ear head is what is referred to as this. It initially forms sporangiophores on the leaves before causing lengthy chlorotic streaks that separate the leaves into threadlike structures. The latter stage, sometimes known as leaf shred, contains the fungus' oospores. Pseudoperonospora humuli, the source of hops' downy mildew, also causes infections that result in enlarged basal shoots on infected rootstocks.

G. Powdery mildews

Similar to downy mildews, powdery mildews may be identified by the hyphae, conidia, and conidiophores they produce on the surface of their hosts. The host seems to be covered with talcum powder as a result of this. Moreover, powdery mildews are members of the Ascomycotina's solitary family Erysiphaceae, which is in the order Erysiphales. Powdery mildews are saprophytic growth-free obligate parasites. Before the white mycelium is visible, dwarfing and stunting are the first symptoms, often accompanied by a minor reddening and curling of the leaves. The flower bud becomes distorted, similar to how the powdery mildews of roses affect them, as a result of excessive respiration and nutrition depletion.

White mycelial tufts made of hyphae bearing erect conidiophores with colorless conidia in chains or singly make up the vegetative phase. The host is covered in masses of white mycelia, conidiophores, and turgid, dewdrop-like conidia, giving the fungus its name, powdery mildews.

ISSN (Online) 2456 -1304
International Journal of Science, Engineering and Management (IJSEM)
Vol 10, Issue 2S, February 2023

When powdery mildew spores germinate on the surface of the host, the germ tube doesn't enter the tissue, instead leaving a surface covered in a tangle of hyphae. The hyphal cells create haustoria, which enters the host cell epidermis by thin tubes and takes on the shape of a pear or a round once inside. These thin tubes of Erysipha graminis branch many times, increasing the absorbing surface.

(Rusting the orange-brown (uredo) spore masses that many of these fungi develop on their hosts in pustules are what give rust its name. Members of the Basidiomycotina order Uredinales are responsible for rust infections. Rusts are obligatory parasites that prey on certain ferns, angiosperms, and gymnosperms. As with downy mildews, the intercellular mycelium that parasitizes the host sends intracellular haustoria.

Many rusts are heterogeneous, finishing their life cycle on two distinct plant species. Yet, some spores only develop on a single host plant because they are monoecious (or autogenous). The rusts mostly exhibit physiological specialization. Some various strains and races exist within the same species.

The five kinds of spores seen in rusts with a full life cycle range in number from 0 to 4. 0. Spermagonium: Also known as pycnidia, they resemble the pycnidia of Sphaeropsidales. They are often located on the leaf's top side. Pycnospores with just one cell, called spermatia, are expelled in a delicious nectar-like liquid. They are created from homokaryotic hyphae and serve as fertilization agents.

H. Aeciospores (also known as aecidiospores)

They are formed on the underside of the same leaf. They are one-celled binucleates and are generated in a chain in a sorus that resembles a cup. The aecidium has a peridium (wall which opens at or beyond the surface of the host). These aeciospores form mycelium from which other spore types, but never aeciospores, grow and germinate. There are five main morphological kinds of aecia in rust fungus. In the absence of any distinct features, each of these may serve as the foundation for a "form genus":

I. Aecidium

In a brief cup-shaped structure surrounded by a layer of cells known as the peridium, the aeciospores are formed in chains. This is the classic cluster cup that is seen in many Puccinia species.

J. Roestelia

The peridium is long, well-developed, and often more horn-like, much like the peridermium. At maturity, it usually splits longitudinally. This phrase refers to aecia produced by the Gymnosporangium genus.

K. *Iridium*

Often referred to as summer spores or red rust spores, they are one-celled, binucleate spores. This develops from the mycelium that aeciospores create. On germination, uredia are produced by uredospores. As a result, they are referred to as recurring shapes. Uredospores are transient and aid in spreading the parasite's presence throughout the host. Just a few species, including Puccinia vexans, can produce thick-walled uredospores (amphispores) that can withstand harsh environments.

L. Telium

These spores are often referred to as winter spores or black rust spores. The majority of rusts have thick-walled teliospores that are binucleate and resting or winter spores. Certain rusts need overwintering in order for teliospores to germinate.

For example, Uromyces, a one-celled, stalked rust, Puccinia, a two-celled, stalked rust, Phragmidium, a several-celled, stalked rust, Melampsora, a one-celled sessile rust, and Cronartium, a one-celled rust are some of the more common rust genera. Telia is joined to create a telefilm column.

Four. Basidiospores Teliospores that germinate produce a basidium in which the two nuclei fuse, go through meiosis, and basidiospores are then produced. Uninucleate basidiospores are these.

Rust spores are classified as macrocyclic if they include all spore types 0–4 or if the spermagonia are absent. Demicyclic individuals have both aecia and uredia or both of these conditions plus spermagonia, whereas microcyclic individuals have either telia alone or both conditions plus spermagonia.

Each spore type of certain rusts may infect the same host while they are all present on the same host. Some species are referred to be autecious, such as Trochodium. Heteroecism organisms, such as Puccinia graminis tritici, rotate between two unrelated hosts, both of which are required for the completion of the life cycle.

M. Schmutz

The sooty, black spore masses that the illness produces are what give it its name. They are brought on by fungus from the Basidiomycetous fungal suborder Ustilaginales. The dikaryotic mycelium's vegetative cells roll up into chlamydospores with thin walls. They may be generated single, as in the cases of Ustilago and Sphacelotheca, or in groupings known as spore balls, as in the case of Georgefischeria. These smut spores might have smooth walls or other types of sculptures. These spores have one cell and divide into two.

On germination, the smut spores produce a germ tube with restricted development known as promycelium. Everyone goes through this time. Many groupings of genera have distinct later phases of development. Cells alone or the binucleate or dikaryotic mycelium created when sporidia fuse are both capable of starting an infection. Smut fungi are parasitic, heterothallic, and have binucleate mycelium. As compared to rusts, only a few are obligatory parasites.

ISSN (Online) 2456 -1304
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Vol 10, Issue 2S, February 2023

Although mycelium is present throughout the vegetative sections, sporulation only happens in the inflorescence.

N. Blight

The word "blight" is often used to refer to illnesses brought on by a range of species, including insects. All of them exhibit abrupt and severe leaf injury. The death of the host tissue is the main symptom. Example: Late blight of potatoes and tomatoes brought on by the Oomycete Phytophthora infestans of the order Peronosporales. In damp conditions, big, dark-green water-soaked patches initially form on lower leaves after flowering. The spot's center shrinks and turns dry, dark brown to black as it gets bigger. A downy, whitish growth appears at the edges of these lesions on the lower leaf surfaces when it is moist. This is made up of sporangiophores with sympodially branching ends that carry sporangia.

The stem and petioles get similar lesions. When tops are blighted, a distinctive, pungent odor is present. The zoospores that are washed into the soil from leaves and stems infect tubers. On tubers on its top side, tiny skin discolorations are ranging from brown to purple. They sink into despair. Rotting during storage is mostly caused by bacterial infiltration via these blighted patches. As oospores, the fungus survives the winter. Yet, this is a seed-borne pathogen as well.

O. Anthracnose

From the Greek word's anthrax, which means coal, and noses, which means sickness, the phrase anthracnose is formed. The phrase means "like coal." Two different illnesses are referred to as anthracnose: A classic necrotic area or lesion of dead tissue characterizes one, whereas hyperplastic signs like a raised perimeter surrounding a sunken core characterize the other.

Sphaceloma ampelinum, an imperfect fungus belonging to the Melanconiales and the asexual stage of the ascomycete Elsinoe ampelina, is the pathogen of the grape anthracnose disease. A bird's eye spot with an elevated border is the main symptom. This term was later used to a blackberry disease brought on by an Elsinoe species, as well as a Phaseolus bean disease brought on by Colletotrichum lindemuthianum. When Sphaceloma, Colletotrichum, and Gloesporium conidial stages create a disease, it is referred to as anthracnose.

The major argument against using the name "scab" is that it refers to both elevated hyperplastic symptoms and lesions, which is why the term "Anthracnose" is often used instead. Acervuli, which are erumpent-shaped aggregates of conidiophores, bear the conidia. Hyaline one-celled conidia are ovoid to rectangular in shape.

***P.* Leaf spots**

The primary symptom of leaf spot diseases is just a spot of variable size and form. Leaf spot diseases cause a small region of necrosis. They often have a brown center, sometimes a white core, and a darker edge. They are brought on by bacteria, fungus, viruses, or even insects. Several fungi may create leaf spots, but Ascomycotina and Deuteromycotina are home to the bulk of them. Members of the Moniliales family are responsible for the leaf markings within the imperfect fungus group.

A kind of Cercospora with 400 or more species is one that is mostly recognized by its host. Cercospora species are responsible for several economically significant leaf spot diseases. Example: The "Tikka disease" of groundnuts is caused by two species of Cercospora: Cercospora arachidicola and Cercospora personata, which in their ideal stages are known as Mycosphaerella arachidicola and Mycosphaerella brekelyii, respectively. Mycelium is both inside and outside, as well as between and among cells. Both types of fungus may directly penetrate the host or enter via the stomata.

Leaf patches on tomatoes and potatoes are caused by Alternaria solani. To differentiate it from the late blight on potatoes brought on by P. infestans, this is referred to as early blight. Alternaria spot is referred to by another illness term, target spot. In the leaf lesions, they create concentric circles. Infected tomato and potato leaves drop before their time, lowering production. In cabbage and cauliflower, Alternaria brassicae and A. brassicola are problematic because they generate black leaf patches.

On Gramineae, Drechslera (Helminthosporium) creates several significant leaf blotches. The fungus first enters the coleoptile, where it spreads through it to the inner surface before infecting the seedling and finally entering the leaf via the leaf base. Barley leaves have a stripe due to H. gramineum. Several employees said that after invading the seedling, the fungus spreads throughout the tissue like a bunt or loose smut of wheat. Yet, N J G. Smith (1929) discovered that mycelium that had been sprayed externally had infected each leaf.

The development of lesions is so severe in vulnerable cultivars that the leaves dry up before the plants reach maturity. Broken heads or litter grains are the consequence of lesions below the ear head. Crop leftovers include substantial amounts of mycelia and conidia.

Q. Curl a leaf

In leaves, puckering and curling are caused by a rise in cells on each side of the midrib, stimulation of the development of palisade cells, and a lesser number of cells of spongy parenchyma. The leaf curl is a name for this. One of the most outstanding illnesses of this kind affects peaches and is brought on by the fungus Taphrina deformans, which is a member of the Ascomycotina order Taphrinales. As soon as the leaves appear, symptoms start to appear.

The whole blade of the leaf or just a portion of it thickens and coils. The chlorophyll quickly evaporates, and the damaged parts start to take on red or purple hues. Eventually, the sporulation of the fungus causes this to seem to be covered with a gray bloom. Leaves fall off too soon. This awakens dormant buds, causing them to sprout new leaves.

ISSN (Online) 2456 -1304
International Journal of Science, Engineering and Management (IJSEM)
Vol 10, Issue 2S, February 2023

They are often not diseased. Frequent leaf losses over many seasons have a negative impact on the tree's strength and ability to produce fruit. Young fruits and blossoms are also affected and fall. Even while these warty outgrowths are not as well-developed as they are on leaves, some of these infected fruits will mature with noticeable warty outgrowths that have reddish hues.

On the surface of the leaf, Taphrina's asci may be observed in portions with clarity. Exoascus, the former genus name, refers to the exposed layer it creates on the surface of the host. In an ascus, there are initially eight ascospores, which bud and produce several blastospores. Leaf Galls or Blisters Exobasidium is the culprit here (these are hyperplastic abnormalities, which have a definite form). Rusts are responsible for other leaf galls. The host cell is invaded by the intercellular mycelium with branching haustoria.

As the asci of Taphrina, basidia, which contain the 2–8 basidiospores, extend above the epidermal layers. Grey or dark-brown cluster-like spots may be seen in the infected area. Blister blight or fire blight, which is often brought on by Exobasidium vexans, occurs when these blisters grow confluent and the whole plant looks to have been burned.

R. Witches' broom

Other species of Taphrina, such as Taphrina cerasi on cherries, produce witches' broom in addition to T. deformans, which causes peach leaf curl. A thick mass of twigs that resembles a broom is produced when the fungus encourages the host's development of shoots. Insects or mites, viruses, and parasitic plants all induce these deformities on a variety of hosts. Witches' broom is brought on by Georgefischeria riveae in Rivea hypocraterijormis. Theobroma cocoa's witches' broom is brought on by Marasmius perniciosus.

S. Club root

Club root illness is caused by the root system's abnormal development. The most significant one is Plasmodiophora brassicae, a member of the Plasmodiophorales family of the Myxomycotina, which causes the club root or finger and toe disease of crucifers. The defining sign of infected roots is club-like swellings. These swollen areas have a marbling or mottled look, which sets them apart from the Agrobacterium-caused apple crown gall.

The shoot system displays symptoms as a result of the roots' obstruction with the flow of water and nutrients. In the final stages of the illness, growth is slowed and the foliage begins to yellow and wilt.

T. Cankers

One of the worst ailments is the apple canker brought on by Nectria galligena. Here, only wounds allow the fungus to penetrate. There won't be any canker if the cut is shallow since the fungus is only present in the cortex. For a canker to develop, the wound has to reach the wood. It will destroy a little quantity of cambium. The fungus enters the xylem via the medullary rays and develops through the pits as it moves up and down the vessels. The host responds to the fungus's invasion. Tyloses and gum development both impede its motion. A wound callus limits its ability to travel laterally.

U. Scab

Streptomyces scabis is the culprit behind the common scab that affects potatoes. Spongospora subterranea is the culprit behind potato scabs that are powdery or corky Apple scab is brought on by Venturia inaequalis. On leaves, lesions show themselves as regions of lighter color on the top surfaces. They lack the typical shine. As the lesions grow, they change from being velvety to becoming olive, brown, or even black. Eventually, they stop being velvety and start to resemble a dry corky scab. On the fruit, similar lesions may be seen. As the healthy portions grow bigger, growth is inhibited in the damaged region and fissures show up around the lesion.

V. disease recognition

There are several methods for diagnosing plant disease based on signs, hosts, spore shape, etc. based on the symptoms Plasmodiophora brassicae, a member of the Plasmodiophorales family of the Myxomycotina, is the organism that causes club root or finger and toe disease in crucifers. The defining sign of infected roots is club-like swellings. These swollen areas have a marbling or mottled look, which sets them apart from the Agrobacterium-caused apple crown gall.

On the basis of symptoms, even distinct species of the same genus may be distinguished. As an example, Cercospora personata creates more circular necrotic lesions on both surfaces, which take on a dark brown hue, and has no halo surrounding newly formed spots. Cercospora arachidicola produces irregular, round, often confluent, and bigger leaf spots. There has always been a round, brilliant yellow halo that melds with the leaf's green color. On the bottom surface, halo details are less noticeable.

The primary characteristics of smuts that distinguish the various species of smut fungi are the shape of smut spores or chlamydospores. Like in the case of George Fischeria, some are entirely composed of fertile spores, while others, like Urocystis, may include sterile components that encase viable spores.

The kind and location of the sori in smut illness can aid in identifying the condition. For instance, in certain cases, such as in Ustilago and Tilletia, the sori are solely covered by host tissue. Others, including Sphacelotheca and Sorosporium, also grow a peridium of fungal tissue above the budding spores.

Several groupings of genera have diverse smut spore germination and development processes. For instance, when Ustilago avenae, U. tritici, causes loose smut of oats and wheat, the chlamydospores germinate to produce septate promycelium. Through budding, each of these cells produces sporidia, which are tiny hyaline cells with thin walls and no

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Vol 10, Issue 2S, February 2023

nuclei. A mycelium that may infect the host tissue is created when the two sporidia of opposing strains unite.

No sporidia are generated in loose smut of barley (caused by Ustilago nuda). The promycelia grow into mycelia, and the branches of these mycelia eventually join together to form a dikaryotic mycelium. The promycelium is aseptate and 8 filiform septate sporidia grow terminally in wheat bunt brought on by Tilletia caries. The sporidia fuse their nearby cells, which subsequently infect wheat.

Only when a certain host is present do some fungal species cause illness. The physiological specialty behind this may be. For instance, the fungi that cause black stem rust Several physiological races of Puccinia graminis exist; although they have a similar physical structure, these races may vary in their ability to cause illness in various hosts. Similar physiological races are seen in powdery and downy mildews, rusts, and smuts.

On the basis of fruit bodies, the Deuteromycotina, a diverse collection of organisms, may be divided into three major groups:

(1) Melanconiales include acervuli that bear conidiophores and conidia.

(2) In Sphaeropsidales, conidiophores and conidia develop inside pycnidia.

(3) even though conidiophores are grouped in several Moniliales genera, there are no distinct fruit bodies.

Anthracnose is a disease caused by members of the first order of fungi, the Melanconiales. Sphaeropsidales are responsible for cankers and rots (fruits). Members of the Moniliales are responsible for the leaf spots.

W. Preventative measures

To design control strategies, scientists must know the signs, causes, and mechanisms of a certain illness. For each illness, a different set of variables, including the kind of pathogen, the host, the interaction between the host and the pathogen, and many more, are taken into consideration while developing control methods. As it is more important to conserve plant populations than individual plants, populations are often managed as a whole. Individual plants, such as particular trees or ornamentals, are seldom handled differently.

X. Regulatory techniques

This technique primarily aims to keep a virus away from a host or a specific region. This is accomplished by inhibiting the spread of disease by prohibiting the importation of plants and seeds.

The circumstances under which certain crops may be cultivated and transferred across various states and nations are governed by federal and state legislation. These limitations are put into place by quarantines, plant inspections in fields or warehouses, or the removal of certain host plants. To produce seeds, plants are sometimes cultivated on a global scale. This is carried out in places that are pathogen-free or where diseases are kept away by adverse environmental factors, such as a lack of vectors or low rainfall, or relative humidity. This is referred to as evasion or avoidance.

Y. Inspections and quarantines

A novel infection may trigger a more devastating epidemic than one brought on by an already present disease in a region where it was previously absent. The reason for this is that the plants that were growing there were unable to choose resistance genes that were particular to the newly imported disease. It's also possible that there aren't enough organisms that can fight against or outcompete these infections. This allows the infection to thrive and replicate unrestrained in enormous quantities of tissue that is sensitive. One example is the introduction of grape downy mildew to Europe

II. DISCUSSION

Plant quarantine is not completely foolproof, however, since diseases may persist even after treatment on seeds or propagative organs in the form of resistant spores, for example. Plant quarantine stations take precautions such as growing plants for specific amounts of time under observation before releasing them, repeating ELISA serological tests on seed lots, using DNA probes and PCR to amplify specific pathogen DNA sequences, and inspecting imported nursery stock on the growers' premises, among other measures.

A. Crop certification

Some states have mandatory or optional inspection programs. Growers who want to produce and market disease-free plants voluntarily submit them to these organizations for inspection and indexing. After receiving a certificate of disease-free plant material, growers may then market and sell disease-free seeds or propagules.

B. Crop Isolation

This involves moving cultivation to a new, uncultivated location in order to treat Fusarium wilt of banana (also known as Panama disease), which is brought on by Fusarium oxysporum f. cubense. Some of the ways to stop the spread of illness include using healthy seeds, planting either early or late, choosing the right locations, keeping the right space between plant rows, planting in soil that drains properly, etc. Using pathogen-free materials in order to produce disease-free crops, it is necessary to use disease-free plant propagation materials, such as seeds, tubers, bulbs, etc. These disease-free propagules may be produced by growing plants in an environment that is (I) pathogen-free, (II) unsuitable for the development of pathogens, or (III) unsuitable for the pathogen's vector.

Spraying dodecyl alcohol on leaves will remove pathogens from their surfaces and enable gases like oxygen and carbon dioxide to flow through, but not water. It guards against

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Vol 10, Issue 2S, February 2023

illnesses caused by powdery mildews in plants including cucumber, tomato, beet, wheat, and rice.

C. Cultural approaches

This includes the management of disease through the cultural manipulation of plants and is accomplished through pathogen elimination, plant resistance enhancement, the creation of unfavorable conditions for pathogen development, and the production of propagules free of pathogens through tissue culture, sanitation, crop rotation, etc.

D. Removal of the diseased host

Notwithstanding quarantine, an epiphytotic (epidemic) occurs if a disease is introduced to a specific region. To stop the spread of the infection, any hosts that are afflicted or thought to harbor it should be destroyed. Many kinds of diseases may overwinter in tubers that are left behind in the field in various crops, such as potatoes. In the spring, they create contaminated plants that enable pathogens to emerge above ground, where they may then spread. Such stray plants need to be removed. While crops are not being planted, such as when tomatoes are, volunteer plants develop in warmer climates. Since this is a crop-free season, these volunteer plants get infected by various viruses and act as reservoirs for disease-causing inoculum when plants are farmed throughout the season.

To complete their whole life cycle, certain diseases need two different hosts, like Puccinia graminis triticii black stem. Wheat and the barberry plant are necessary for the life cycle of wheat rust. In these situations, eliminating the wild host or a host that is less significant economically will end the pathogen's life cycle.

E. Crop rotation

Planting crops different than these for three to four years in the soil might sometimes minimize soil-borne diseases that affect one or a few types of plants. When a pathogen exclusively lives on a host or as a saprophyte on the remnants of that specific host, this is feasible in the case of soil invaders. Crop rotation is unsuccessful when it is a soil habitant, that is when it develops long-lived spores that slumber for 5 to 6 years. Yet, under these circumstances, crop rotation may lower the number of diseases like Verticillium in the soil. A field may be tilled and not planted for about a year. This lowers the number of infections in locations that experience harsh summers.

F. Sanitation

By burying contaminated plants, you may encourage the inoculum on infected plant portions to decompose underground. Pathogens are kept out of healthy plants or plant parts by covering leaves with home or garden plants, cutting sick branches, removing infected blossoms or fruits, etc. Burning these diseased components is necessary. Infection may be decreased by washing hands before touching particular plants, such as tomatoes, disinfecting blades used to cut plant propagation components, washing dirt off agricultural equipment before moving it from one field to another, cleaning the walls and floor of storage buildings, etc.

To stop spores existing on the seed surface from germinating, seeds or other propagative materials should be adequately aerated before storage. Plants should be adequately spaced apart in both fields and greenhouses to avoid the development of very humid conditions that might lead to disease invasions like Botrytis and Peronospora tabacina. Pythium and other diseases are avoided via soil drainage.

It is important to choose fertilizers and soil amendments that will alter the pH of the soil and prevent the growth of pathogens. By flooding and then drying, pathogens like Fusarium and Sclerotinia sclerotiorum, among others, may be decreased. Composted tree bark is used in nurseries to cut down on soil-borne diseases.

Soils that suppress the growth

In certain types of soil, referred to as favorable soils, certain pathogenic fungus thrives and produce illnesses. On favorable soils, the wilt fungus Fusarium, the wheat 'take all' fungus Gaeumannomyces graminis, the root rot fungus Phytophthora cinnamomi, Pythium, the damping off fungus, etc., produce severe illness. However, in suppressive soils, the pathogen is diminished, leading to a mild infection, as a result of the antagonistic activity of soil microorganisms that generate antibiotics or lytic enzymes. Examples include the reduction of pathogens by Penicillium, Trichoderma, Sporidesmium, and other organisms including Pseudomonas, Bacillus, Streptomyces, etc. Pathogens will also undergo mycolysis when their inoculum is reduced by antagonistic organisms, such as Trichoderma harzianum, which lyses the phytopathogenic microbes Rhizoctonia, Sclerotium, and numerous others. Verticillium and Botrytis are similarly lysed by Pichia gulliermondii and Talaromyces jlavus, respectively. Pathogen populations in soil are also decreased through competition for food, direct toxic effects, and indirect toxic effects caused by volatile chemicals like ethylene generated by the antagonist's metabolic processes.

G. Heat treatment

In greenhouses, soil used for seed beds is sterilized using hot water or live steam. Oomycetes and water molds are destroyed at 50°C, whereas other phytopathogenic fungi and bacteria are destroyed at 60–72°C and at 95–100°C, respectively. Most soil pathogens may be eliminated by heating the soil to 82°C for 30 minutes. Nevertheless, the temperature and duration vary depending on the pathogen, for example, 52°C for 11 minutes for loose smut of wheat.

By removing particular light wavelengths: Only when they are exposed to light in the UV spectrum can spores of Alternaria, Botrytis, Stemphylum, and other organisms sporulate (below 360 nm). Covering greenhouses with specialized UV-absorbing vinyl film that filters out light with

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Vol 10, Issue 2S, February 2023

a wavelength below 390 nm may stop this from happening. In addition to these, post-harvest illnesses may be controlled by chilling fleshy plant products, drying stored grains and fruits until the moisture content is decreased to 12%, UV, X-ray, gamma radiation, particulate radiation such as particles, etc.

H. Chemical techniques

Chemical fungicides are applied to a plant either to prevent infection or to lessen the impact of an existing infection. The management of insects through soil treatment, (fumigation) disinfection of glass buildings and warehouses, cleanliness of handling equipment, and soil treatment are some of the methods used to avoid infection. The soil is chemically treated before planting. These fungicides are sprinkled, sprayed as liquid drenches, or applied as granules to the soil. They are primarily designed to lessen issues like crown and root rots, damping off, and seedling blight.

Up to this point, hundreds of chemicals have been developed for crop protection as systemic, sprays, dusts, paints, and pastes. The inorganic ones are some of the most significant. Fungicide is used with the water when irrigation is used, particularly sprinkle irrigation. The fungicides that are utilized include metalaxyl, diazoben, pentachloronitrobenze (PCNB), captan, and chlorine.

I. Compounds that are organic-based

Spraying cucumbers and grapes with solutions of either monopotassium phosphate (KH2PO4) or dipotassium phosphate helps reduce powdery mildew illnesses (PMD) (K2HPO4). Before plants get infected, film-forming substances such as antitranspirant polymers, mineral oils, surfactants, etc. are applied to their surfaces to stop infections from occurring. The majority of these polymers are biodegradable, permeable to several gases, non-toxic to plants, and they survive weather for at least a week.

J. Copper-based compounds

Bordeaux concoction: This disease was created and used to treat grape Downy mildew (DMD) in Bordeaux, a region of France. The globe still uses this fungicide the most often. It results from the reaction between CuS04 and CaOH (hydrated lime). It eliminates several bacterial and fungal leaf blights, cankers, anthracnoses, and mildews. When used in chilly, rainy conditions, it might, however, burn foliage or rust fruits like apples. The element that is harmful to fungi and sometimes to plants is copper, while lime largely serves as a "safety" measure.

Compounds of inorganic sulfur: element Very likely the first known fungicide was sulfur. They are used to combat Powdery mildews, specific rusts, leaf blights, and fruit rots as dust, wettable powder, paste, or liquid. In hot, dry conditions (over 30°C), it may harm plants, particularly S-sensitive species like tomatoes, melons, and grapes.

K. Carbonate substances

It was shown that sodium bicarbonate, bicarbonate salts of ammonium, potassium, and lithium, together with 1% superfine oil, were efficient against powdery mildews of roses, cucumber pathogens, black spot fungi, southern blight fungi, Sclerotium rolfsii, and grey mold fungi.

L. Sulfur organic compounds

The flexible and often used fungicides nowadays are dithiocarbamates. Examples include thiram, ferbam, nabam, maneb, zineb, and mancozeb, which are dithiocarbamic acid derivatives. Dithiocarbamates may be converted into the isothiocyanate radical (-N = C = S), which is the fundamental reason why they are harmful to fungus. The sulfhydryl groups (-SH) in amino acids and enzymes inside pathogen cells are rendered inactive by this radical, which limits the synthesis and activity of these substances. Thiram is created by joining two dithiocarbamic acid molecules. This is often used to treat vegetable seeds and bulbs as well as grasses and flowers. This is also used in the treatment of several leaf diseases, such as rust which affect lawns.

The ethylenebisdithiocarbamate derivatives, which include maneb and zineb, are another class of dithiocarbamic acid derivatives with various molecular structures. Manganese is present in maneb. A versatile foliar and soil fungicide is Zineb. Some of the antibiotics used to manage plant infections include streptomycin, tetracycline, and cycloheximide.

M. Biological management

Gliocladium virens, a kind of microorganism marketed under the brand name Gliogard, is used to treat ornamental and bedding plant seedling illnesses. To manage a number of soil-borne phytopathogenic fungus, Trichoderma harzianum is offered under the trade name F-stop. For the prevention of wood degradation, trichoderma harzianum/trichoderma polysporum

III. CONCLUSION

A specific pathogenic fungus on the host plant produces a specific set of symptoms. With germinating seeds and seedlings, damping off and seedling blight occur. The virus spreads through the soil and has an impact on crop establishment at first. When a plant has root rot or foot rot, the root system gradually rots, which causes the foot of the plant to likewise become rotten. Wilt occurs when a plant's degraded root system is unable to absorb enough water to make up for the water lost via transpiration, causing the plant to lose its freshness or become flaccid. Although powdery mildews give the host the appearance of being powdered with talcum powder, downy mildew grows as downy gray color patches on the bottom side of the leaves or stems carrying sporangiophores. On the host surface, rust disease causes orange-brown rusty spots.

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Vol 10, Issue 2S, February 2023

Fungal Diseases - II: Plant Diseases Caused by Fungi

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Abstract*— The majority of parasitic fungi infect plants with illness. They are in charge of damaging billions of rupees' worth of crops. If they are not monitored and regulated, they might cause a disaster. Phytophthora infestans were to blame for the devastating Irish potato famine that occurred between 1945 and 1949 and claimed almost one million lives. Similar to this, Perenospora tabacina infection caused tobacco yields in North America and the Middle East to drop by almost 60% in 1962. In England, Ceratocystis ulmi infestation caused the death of almost 5 million elm trees between 1967 and 1977. Smuts, rusts, mildews, blights, rots, and wilts are frequent plant fungal diseases that affect many plants with significant economic value. This chapter discusses significant fungal illnesses.

***Keywords*— Covered Smut, Fungal Diseases, Leaf Sheaths, Plant Diseases, Seed Treatment..**

I. INTRODUCTION

The disease affects many types of grass, including wheat. The illness was discovered for the first time in Australia in 1868, and ever since then, reports of it have come from every region of the globe that grows wheat, including Japan, South East Asian nations, India, Pakistan, Middle Eastern nations, Europe, South Africa, and the United States. Almost all significant regions of the globe where wheat is grown are affected by the disease [1]–[3].

Butler from Layallpur in West Punjab was the first individual to report this sickness to authorities in India (Butler, 1918). The illness is said to have traveled from Australia to India (Bedi, 1957). According to Bedi (1957), the prevalence of illness is quite high (up to 75%) in various areas of Punjab, Haryana, and Himachal Pradesh. In India, Punjab, Haryana, Madhya Pradesh, Himachal Pradesh, and Rajasthan are now reporting cases of the illness. In Rajasthan, the illness resulted in losses of 39% to 78% in the late 1970s.

The illness is not extremely harmful until it is quite prevalent, but it may have major effects on the export of grain or wheat-based goods. The smut may linger in soil for a very long time, and given the right circumstances, it can grow to dangerous proportions. The disease's most notable consequence is reduced yield caused by the afflicted plants' total loss of production.

A. Symptoms

The disease targets the leaves, culms, and stems. All portions of the shoots exhibit symptoms, although leaf and leaf sheaths are often harmed. From the late seedling stage until crop maturity, the infection is visible, and typically every plant branch is affected. The leaves start to droop (flag), then wither, with the look of herbicide harm similar to that caused by hormones. These leaves will soon drop, and the plant as a whole will die. Twisted and drooping leaves have stripes that are made of black powder. The heading may be avoided, resulting in culms that typically do not bear any grains. In the event that grains develop, they shrivel. Plants that are affected have severe stunting. The ears often fail to emerge and excessive tillering is prevalent [2], [4], [5].

The infection often spreads throughout the body and affects all tillers. Sometimes, the problem simply affects a single tiller. Plants exhibit lengthy, dark-gray to-black streaks, somewhat enlarged bands running perpendicular to the veins of the older leaves, on the leaf blades, and leaf sheaths at or near heading. These streaks include smut sori, which are visible as oily lesions in the mesophyll tissue under the epidermis. While young, spores usually appear in leaves as long, thin blisters between the veins that are covered by the epidermis; once they rupture, the spores are revealed, causing the leaf to split into ribbons. Moreover, grass rachis, glumes, and rhizomes may have linear sori.

The black teliospores are finally exposed by the erupting sori, which subsequently gives the leaves a ragged look. The teliospores are then spread, giving the plants the impression of being coated in soot. The disease may be identified in the very early stages of plant growth at the seedling stage by a distinctive twisting and bending of the coleoptile, which is followed by the appearance of bleached spots on the coleoptile.

The pathogen responsible for the disease flag smut is Urocystis agropyri (Preuss) A.A. Fisch. Waldh. 1867 (synonym U. tritici), which belongs to the order Urocystales and subclass Ustilaginomycetes. Flag smut is caused by the bacterium Urocystis agropyri on the leaves of Poaceae plants. It seems to have a broad host range and a global distribution as a grass pathogen. Nevertheless, some experts do not classify the pathogen seen on wheat, known as U. tritici, as U. agropyri. According to Rossman et al. (2006), U. agropyri poses a "Threat to Key Crop Plants," and imports of wheat and wheat straw are prohibited into North America. Tuburcinia agropyri is the biosynonym for the fungus.

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Vol 10, Issue 2S, February 2023

Little spore balls (diameter 18–52) are produced by the fungus. Dark brown to black powdery spore ball mass. Spore balls are comprised of 1–5, generally 1–3, teliospores and are subspherical to oblong in shape, measuring 18–38 x 35–40 m. A layer of smaller, sterile peripheral cells surrounds the spore ball. The teliospores are globose to subglobose, smooth-walled, reddish-brown, and 8–18 in diameter. The peripheral sterile cells are thin-walled, sub-spherical to oblong, hyaline to yellowish, and 3–12 m in diameter. In situ teliospore germination results in the formation of a brief hypha (promycelium) with three to four basidiospores (sporidia) close to the tip. Sporidia are 12–15 x 3 in diameter, aseptate or 1-2 septate, and cylindrical. The infection thread is created when the sporidia germinate while still adhering to the promycelium. Several fungal strains target other grasses, but the strain (s) that damage wheat is unique to that crop. It is challenging for the fungus's fresh spores to germinate. Germination benefits from preliminary drying. The pH range of 5.1–5.7 and temperature range of 18–24 °C are said to be favorable for spore germination. The spore balls travel in the wind. The teliospores that are expelled from the leaves may either be carried by the wind and contaminate the grain of healthy plants or they can fall to the soil and remain there for a very long time. Teliospores may last up to 4 years on stored seed or in the soil. They begin to grow in the soil when it is between 40- and 86-degrees Fahrenheit. Around 64° to 77° F, germination is at its best [6]–[8].

B. Barley smut with cover

Covered Smut of Barley is abundantly available everywhere. It is widespread across India's barley-growing regions, particularly in the country's north. The vulnerable host species suffer severe harm as a result of the illness. Several monocot species including Agropyron and Elymus have been found to be affected by the fungus.

C. Symptoms

Before ear emergence, there are no disease signs in the covered smut of barley. Unless in extreme situations, this condition is difficult to detect. The awns of smutted heads quickly shrivel after blooming, and the heads seem stunted. In extreme situations, plant dwarfing and peduncle compaction have been seen. The afflicted ear may emerge at around the same time as the healthy ears, although it will often be shorter and held within the sheath for a longer period before emerging, or it may never emerge at all.

With the exception of the grains seeming to be coated with a thin, white, or grey membrane, the ears look normal at the time of ear emergence. The spore mass of sori in spikelets has a dark brownish color and is first covered by a membrane derived from the host tissue (covered smut). When this is cut apart, it is seen that the translucent membrane is holding masses of dark brown smut spores in place in lieu of the kernels that were formerly present in the heads of afflicted plants.

The distinguishing feature of barley-covered smut is a persistent membrane that covers the smut sorus until the plant is fully grown. The membrane may be broken rather readily, and when the spores begin to spread, the symptoms start to resemble those of loose smut. Several times, complete masses of spores show up in harvested grain.

During harvest, the regular grain becomes contaminated by the thousands of black spores that are present in each smutted head. As the grains are threshed, the smut sori are mostly broken, and the spores then mix with and adhere to the healthy seeds. Long strokes in nodal tissue or leaf blades might sometimes be the first sign of smut sori. In maturity, smutted heads are particularly noticeable. Compared to healthy plants, infected ones are often smaller. Ustilago hordei Langerheim is the pathogen. There are several physiological races in the species. The pathogen's species is crop-specific and mostly affects oats and barley. The fungus, an obligatory parasite, targets barley that has been grown.

D. Pathogen distribution over time

The smut spores, also known as teliospores, are smooth, light olive brown, globose to subglobose, and measure 3.6–7.2 (more often 4.5) in diameter. The bulk of the teliospores is dark. It has a smooth epispore. As the spores germinate, they release a four-celled promycelium that gives birth to sporidia close to the septa and apex. Uninucleate, ovate to oblong, and capable of budging, new secondary sporidia may be produced, particularly when nutrients are present. Inter-sporadical anastomoses and hyphal anastomoses, via which the nucleus of one sporidia enters into the other, are both necessary for the achievement of dikaryophase. Infection threads from the dikaryotic sporidia's germination turn into the highly branching mycelium in the host tissue.

E. Health cycle

When contaminated grains are physically broken and dispersed among healthy grains during harvest and other seed-handling procedures, covered smut infection penetrates via outwardly seed-borne smut spores. Smut spores that have been covered may live for up to three years and are transported on the exterior of the seed.

On the seeds of barley or in the soil, teliospores may overwinter. During threshing, smutted heads are broken and crushed. When sufficient moisture is present, they begin to sprout at the same time as barley seeds. At 25–30 °C, teliospores germinate in 16 hours, at 20 °C, they do so in 24 hours, and at 5–10 °C, they do so in 3 days. A four-celled basidium with four ovate to oblong basidiospores is produced when the teliospore germinates. The emitted pheromones cause conjugation tubes to develop and fuse when sporidia of opposing mating types are near together, as they would be after teliospore germination. The contagious dikaryotic mycelium forms later.

The extremely immature seedling becomes first infected by sporidia. The coleoptile becomes infected during the first eight days of seed germination. The spores spread throughout

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International Journal of Science, Engineering and Management (IJSEM)
Vol 10, Issue 2S, February 2023

the seed coat when the infected seed starts to sprout and then enter the seedling's shoot right before emergence. Just beneath the plant's growth point, the mycelium penetrates the host tissue and subsequently expands between the plant cells. The mycelium stays in situ inside the meristem while the plant develops until flower development, at which point it enters the ovary tissues and creates the fungal mass in lieu of a seed. The cells of the hyphae create spores, which take the place of the kernel. Consequently, instead of regular grain, black spore masses are formed in the skull after the fungus has infected the head's tissues. A permanent membrane protects the teliospores, which are discharged during harvest.

After emergence, plants develop resistance to covered smut infection; as a result, if an uninfected plant has emerged, it cannot get the infection. Hence, no infection occurs after the host's main shoot has emerged above the soil's surface.

Infection is encouraged by high soil moisture across a broad temperature range. Temperatures between 14 and 25 °C (20 to 24 °C is ideal) and high soil humidity levels are conducive to infection [9], [10].

II. DISCUSSION

A. Control Techniques

Control over culture: After emergence, plants develop resistance to covered smut infection; as a result, if an uninfected plant has emerged, it cannot get the infection. The spread of illness may be minimized by using disease-free seeds. Since the illness is seed-borne and external, By treating seeds with systemic and protectant fungicides, an efficient and cost-effective control may be accomplished. Good control may be achieved with seed treatments. The most often suggested fungicide was Agrosan GN, an organomercurial, sprayed at a rate of 2.5g/Kg seed.

B. Brutal paddy

The term "rotten neck" of rice is another name for the illness "Blast of Rice or Paddy." At least 80 nations where rice is grown are affected by this illness, which is widespread globally. In places that get a lot of moisture and humidity, the condition worsens. The illness mostly affects the leaves, but it also affects the leaf sheath, rachis, joints of the culm, and even the glume. During the post-transplant period, there is a severe leaf infection that completely destroys the foliage. Earheads arise at the neck infection stage when they are partially or completely chaffed. The ear has a propensity for breaking and detaching. The pathogen is thought to have caused up to 75% of the damage to the rice harvest in India. Due to significant rice crop loss, several nations have experienced severe epidemics repeatedly.

C. Symptoms

A rice plant's leaf, collar, node, neck, sections of the panicle, and sometimes the leaf sheath are all susceptible to it. Rice may develop blast at any stage of development. Nevertheless, as plants age and build up adult plant resistance to the disease, the incidence of leaf blast tends to decline. The symptom occurs on the rachis, glumes, leaf sheaths, and even the leaves themselves. White to gray-green lesions or patches with dark green edges are the primary symptoms. Older leaf lesions have oval or spindle-shaped cores that are pale to grey with a reddish-brownish or necrotic border. The most prevalent and diagnostic signs are diamond-shaped lesions that are broad in the middle and pointed in either direction. Older lesions often take on a pale brown hue with necrotic edges on cultivars that are vulnerable. Lesions often stay tiny (1-2 mm) and brown to dark brown in hue on resistant cultivars.

On foliage, it initially mm-wide azure specks that may grow noticeably to several centimeters in length on younger leaves. With big lesions, the outside rim is dark brown in color and has the impression of being drenched in water. The middle portion becomes light green or dull greenish green. Later on, the centers of the dots become grey or straw-colored. On leaf sheaths, similar dots may be seen. The whole leaf may be killed by lesions that become larger and combine.

On the rachis of the mature inflorescence, brown to black dots appear. Similar dots may also appear in the ears. On culms, the most distinctive symptoms manifest. The neck (stem) gets shriveled and coated in a grey, fluffy mycelium. The ear disintegrates and collapses as a result of necrosis of neck tissues. The disease's current stage results in the most harm.

The rice blast fungus often infects necks at the node, which results in a condition known as rotten neck or neck blast. Necks are part of the stem that rises above the leaves and supports the seed head or panicle. The inability of the seeds to fill (a condition known as blanking) or the collapse of the panicle as if it were rotting are two particularly devastating effects of infection of the necks. When pedicels contract an infection, a condition known as blanking, seeds are not generated. Brown Spot lesions and blast lesions are often mistaken for one other. Brown spot lesions tend to be more spherical, brown in color, and have a yellow halo around the lesion, while leaf blast lesions are often elongated and pointed at either end.

D. Pathogen

Due to the fact that it develops sexual spores (ascospores) in asci, the fungus Magnaporthe oryzae is categorized as an ascomycete and belongs to the recently established family Magnaporthaceae. The perithecia, which are specialized structures, are where the asci are found. The fungus M. oryzae has septate mycelium, and its spores and mycelium both contain haploid nuclei.

Pyricularia grisea has septate, mainly uninucleate branching hyphae in its mycelium. Conidia, the spores, are generated in large quantities on lesions on specialized stalks, or conidiophores. Single or fasciculate conidiophores, which are straightforward and seldom branching, emerge from the mycelium. They are septate, thin, denticulate, grey in color,

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Vol 10, Issue 2S, February 2023

and exhibit sympodial growth. At their apex, they produce conidia. At the tips of conidiophores, conidia are formed individually, one at a time in succession. The conidia are multinucleate, narrowly pyrifomed (pear-shaped) to obclavate, and have three cells when mature. Conidia have two septa. The conidium's cells are uninucleate. Many germ tubes are produced by each conidium during germination. Sclerotia may also develop.

In susceptible cultivars, the fungus sporulates in the core of the lesions under ideal circumstances. Conidiophores and spores collectively may give the lesions a dusty gray look. Spores are generated on diseased leaves, collars, panicles, and seeds as well as on conidiophores that extend beyond lesion surfaces.

According to reports, the fungus produces Pyricularin, a toxin that, at low concentrations, stimulates plant development but is hazardous to plants at greater concentrations. Moreover, it generates pectolytic enzymes that help tear down the walls of the host cell. This fungus has been documented in over thirty different physiologic races in India.

Plants are more susceptible to infection when nitrogenous manures are added to the soil. Disease resistance is often seen in varieties with high silicon content in the leaves. Regarding the severity of the damage, environmental conditions, in particular temperature and moisture, are significant. They have a variety of effects on both the occurrence and transmission of illness. Conidia cannot be generated below 88% relative humidity, and large-scale conidia production requires at least 90% saturation.

Subramanian (1967) and Suryanarayanan have looked at how high temperatures and humidity affect the occurrence of illness (1967). The best conditions for infection are a nighttime temperature of 20°C, followed by a daytime temperature of 30°C, with 14 hours of light and 10 hours of darkness. Forecasting the illness has made use of information on meteorological conditions related to it.

In Russia, the Covered Smut of Sorghum was originally recognized in 1890. Nowadays, the disease is visible on sorghum and Sudan grass throughout the former USSR. It coexists with the production of sorghum and is found in Africa, Asia, Australia, Central, North, and South America. In the Indian states of Tamil Nadu, Andhra Pradesh, Andhra Pradesh, Uttar Pradesh, Madhya Pradesh, and Maharashtra, it is one of the most dangerous crop diseases. In certain places, up to 25% of the plants have been discovered to be impacted, and the estimated worth of the lost grain is several million pounds sterling (Butler, 1918). Around 6 to 10% less grain is produced as a result of this illness.

E. Symptoms

The disease's infection slows down the growth and development of the afflicted plants. The earheads must fall out before this condition may be diagnosed. After the ejection of inflorescences, when smut sori begin to form in place of the flower components, is when sorghum becomes infected with covered smut. The inflorescences' ovaries are often completely afflicted, but sometimes some of them are left untouched and normal caryopses develop. The impacted ovaries change into conical, porcelain-white sori, or spore sacs, which contain a black powder made up of millions of the fungus' chlamydospores. Smut sori, therefore, takes the place of individual grains. In an ear, most of the grains are transformed into sori. The sori are a grey, oval, or cylindrical sac that is 5–15 mm long and 3-5 mm wide. They are coated in a strong, white membrane called the peridium, which often remains intact up until threshing. Except for a thin, sometimes curved central column of hard tissue, the columella, which is hollowed into depressions at the surface, the interior of the sorus is entirely filled with the spore powder. Black spore mass fills these depressions. The columella is made up of parenchyma that is crossed by fibro-vascular bundles and is made up of the host tissues. The columella may sometimes have branches at the apex. During harvest, the peridium collapses, releasing teliospores and contaminating the grain. A diseased panicle does not exhibit hypertrophy, and the size and form of the glume are unaltered.

F. Pathogen

The cause of coated sorghum stalks is the fungus Sphacelotheca sorghi (Link) Clint. The fungus has many names that are synonyms, including Cintractia sorghi-vulgaris Clinton, Endothlaspis sorghi Sorokin, Sphacelotheca sorokiniana Ciferri, and Tilletia sorghi.

Only once earheads appear can the condition be diagnosed. In lieu of healthy grains, the damaged earheads create spore sacs. The species' spores are smooth-walled, 5–9 m (often 6 m) in diameter, round to briefly oval, and dark brown in mass but olive brown singly. They often form loose balls that, when submerged in water, separate into individual spores. Current research on S. sorghi-caused grain smut has shown differences in the kinds of sori, varietal reactivity, and cultural traits of monosporic isolates collected from various locations (Ranganathaiah and Govindu, 1970).

The severity of the illness is influenced by the environment. Kulkarni (1922) came to the conclusion that temperature has a significant impact on the infection and spread of the illness based on germination experiments. About 25°C is the ideal temperature for the growth of this smut. Maximum infection is encouraged by medium to low soil moisture along with medium to low soil moisture. All farmed sorghum species, as well as S. halepense and S. sudanense, are affected by the smut.

G. Control Techniques

Control over culture: Only at the seedling stage can infection, which is mostly seed-borne, occur. According to Butler (1918), there is field data that indicates previous crop spores don't linger in the soil. Thus, the disease may be realistically managed with the aid of seed disinfection. Pre-sowing seed treatment and the creation of resistant

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Vol 10, Issue 2S, February 2023

hybrids and cultivars are protective strategies. The disease may be prevented by using disease-free seeds, rotating crops, collecting smutted ear heads in fabric bags, and burying them in the ground.

H. Sorghum loose smut

It is dispersed over North, Central, and South America as well as Asia, Africa, and Europe. Compared to grain smut, it is less frequent. It occurs in the Indian states of Madhya Pradesh, Karnataka, Maharashtra, Tamil Nadu, and Andhra Pradesh. Due to this smut's impact on both plant development and the output of both grain and fodder, both may be diminished.

I. Symptoms

Before the ears appear, the damaged plants may be identified. They have weaker stalks, noticeable tillering, and are roughly a foot shorter than healthy plants. Compared to healthy ears, the ears emerge more early and are less compact. The glumes are enlarged (2.5 mm in length), and the gearhead seems more floppy than normal. All of the spikelets are diseased, and in addition to the spikelets' vital organs, sores may also be carried on glumes and pedicels. The flower bracts often get longer and more numerous. The altered pistil and stamens may be present in the sorus. Even after the spores have been released, the columella remains. The variety of the host affects the sorus' size

Flag smut mostly affects wheat and several grass species in regions of the globe where wheat is grown. The wheat-growing provinces of Punjab, Haryana, Madhya Pradesh, and Rajasthan in India suffer significant devastation as a result. All components of the shoot exhibit symptoms, although the leaf and leaf sheath are more severely impacted and exhibit flagging. The disease's causative agent is Urocystis agropyri (Preuss) A. A. Fisch. Walsh, which belongs to the order Urocystales and subclass Ustilaginomycetes. Teliospores, which remain viable in the soil for years, are the means by which the illness is transmitted. Effective control strategies include seed treatment with systemic fungicides and cultural control.

In locations where barley is grown, the Covered Smut of Barley may be seen everywhere. Before the appearance of the ear, the host exhibits no illness symptoms. The disease's defining hallmark is the appearance of a thin, white, or grey membrane covering the grains in affected ears. Sori appear as a cohesive blackish brown smut spore mass in spikelets. Stillage hordei (Pers.) Langerheim, a member of the subclass Teliomycetes. The pathogen is Basidiomycotina. Globus-shaped or subglobose are teliospores. The disease is transmitted via seed handling and harvesting processes. Once teliospores germinate, sporidia are formed, which cause the first infection. The best strategy for cultural control is to plant pathogen-free seeds. Systemic fungicides used in seed treatment provide great outcomes.

In nations where rice is grown, the condition known as a blast of rice, paddy, or rotting neck of rice is widespread and worse in humid regions. The illness mostly affects leaves, although it may also affect leaf sheaths, culm joints, and even gums. White to gray-green lesions or patches with dark green edges are the primary symptoms. Older leaf lesions have oval or spindle-shaped cores that are pale to gray with a reddish-brownish or necrotic border. The fungus Magnaporthe oryzae, of the subgroup Ascomycotina, class Discomycetes, which is responsible for the blast, has an asexual conidial stage known as Pyricularia oryzae Cavar (Subdivision Deuteromycotina, class Hyphomycetes). Fungi rely on secondary hosts to live. Conidia contribute to the disease's secondary dissemination. Effective control techniques include field cleanliness and seed treatment with Agrosan GN.

Four different varieties of smut of Jowar (sorghum) may arise depending on the pathogen and symptoms: Grain smut (Kernel smut/Covered smut/Short smut), Loose smut, Head smut, and long smut. Sorghum becomes coated in smut due to the fungus Sphacelotheca sorghi, which results in the production of smut sori rather than floral components. The impacted ovaries change into porcelain white sori, which are conical spore sacs containing a black powder made up of millions of chlamydespores from the fungus. Compared to healthy plants, they are smaller. The ovaries and floral bracts are where the spores are generated. A thin membrane that covers the sorus breaks extremely quickly, revealing the spores even before the head emerges from the sheath. The pathogen Sphacelotheca reiliana (Kuhn) Clinton is in charge of sorghum's heat smut. An enormous sorus is formed out of the whole inflorescence. The pathogen Tolyposporium ehrenbergii (Kuhn) Pat is in charge of the lengthy smut of sorghum. Often, only a tiny part of the dispersed florets on a head are affected by this illness. Sanitation practices and chemical treatments may be employed to control the smut of Jowar's sickness.

Colletotrichum falcatum, an imperfect fungus that causes red rot of sugarcane, is a devastating disease that affects sugarcane in tropical and subtropical regions of the globe. The most vulnerable parts of the plant to this disease are the stems and midrib regions of the leaves. The inside of the canes has entirely decayed, and a gooey, dark crimson substance seeps from the cells and fills the intercellular gaps. The cell walls of these organisms absorb the soluble pigment found in this slime, giving the rot its distinctive red look. The pathogen generates aseptate, one-celled, sickle-shaped conidia and is sett borne. Cultural practices and the adoption of resistant cultivars may be used to manage the illness.

Due to uredia, the autoecious rust known as flax rust disease is noticeable in the field because the affected sections have a vivid orange color. Telia, which are reddish brown in hue, later occur. Melampsora lini Lev. or Melampsora lini-usitatissimi Kuprev, belonging to the sub-division Basidiomycotina, class teliomycetes, is the pathogen that causes the sickness. The rust thrives on linseed and other hosts at high elevations in the uredial or telial stage, when the

uredospores may be carried by the wind to lowlands. The best control methods include using resistant cultivars and using sanitary care.

III. CONCLUSION

Spindle-shaped multicellular conidia, which are olive in color, germinate and cause infection. When budding maize, the disease known as maize seedling blight emerges. Brown patches on the roots, culms, and coleoptile are symptoms. Shortly after emerging, shoots become brown and wither. Imperfect fungus that impedes soil growth The illness is brought on by Fusarium verticillioides and Microdochium nivale, formerly known as Fusarium nivale. The spores that cause illness are dispersed by wind, water, cultivation, and contaminated seed. The disease may be controlled by removing infected crops, using resistant types, and treating grain with fungicides.

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Bacterial Diseases-I: Classification and General

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Abstract— Single-celled, tiny creatures make up bacteria. These are some of the planet's oldest known living forms. Bacteria come in hundreds of distinct varieties and may be found worldwide in any kind of habitat. They are found in the deep layers of the earth's crust, the sea, and the soil. Even in radioactive waste, some microorganisms have reportedly been found to survive. Many bacteria may be found living on and in the skin, airways, mouth, digestive, reproductive, and urinary systems of both humans and animals without causing any damage. These microbes are referred to as resident flora or the microbiome. Our local flora contains at least as many bacteria as there are cells in the human body. Several types of resident flora are beneficial to humans, such as those that aid in digestion or stop the spread of more harmful bacteria.

Keywords— Bacterial disease, Bacteria Taxonomy, Bargery's Manual, Bacterial Nomenclature, Systematic bacteriology..

I. INTRODUCTION

All prokaryotes have the same chemical components (DNA, RNA, and protein), although some of them have completely different structures and functions from the majority. A hierarchical system of categorization (families, orders, etc.) has proven impossible without knowledge of their origins. Bergey's Manual of Determinative Bacteriology, published in 1923, is a comprehensive book on bacterial taxonomy. Concerning the makeup of taxa higher than genus (families, orders, tribes), the classification has been significantly altered in its subsequent editions. The eighth edition, which was released in 1974, had a more logical approach, but because of future changes in bacterial taxonomy based on the DNA's nature and the chemical makeup of the cell and the cell wall, this edition is likewise not very useful. There won't be any further editions of this guidebook published after this one. Instead, work has begun on a number of volumes titled "Bergey's Handbook of Systematic Bacteriology." Pseudomonas, Xanthomonas, Agrobacterium, Erwinia, and MLOs are only a few of the phytopathogenic bacteria found in the first volume (Krieg and Holt, 1984). The second Volume contains information on coryneform bacteria (Sneath, 1986) [1]–[3].

A. Classification

All prokaryotes have the same chemical components (DNA, RNA, and protein), although some of them have completely different structures and functions from the majority. A hierarchical system of categorization (families, orders, etc.) has proven impossible without knowledge of their ancestry. Bergey's Manual of Determinative Bacteriology, published in 1923, is a comprehensive book on bacterial taxonomy. With regard to the makeup of taxa higher than the genus (families, orders, tribes), the classification has been significantly altering in its subsequent editions. The eighth edition, which was released in 1974, had a more logical approach, but because of future changes in bacterial taxonomy based on the DNA's nature and the chemical makeup of the cell and the cell wall, this edition is likewise not very useful. There won't be any further editions of this guidebook published after this one. Instead, work has begun on several volumes titled "Bergey's Handbook of Systematic Bacteriology." Pseudomonas, Xanthmonas, Agrobacterium, Erwinia, and MLOs are only a few of the phytopathogenic bacteria found in the first volume (Krieg and Holt, 1984) [4]–[6].

The prokaryotes were split into 19 groups (parts) in the eighth edition of Bergey's Manual, of which 18 parts are in the division Scotobacteria, which includes real bacteria and mycoplasmas. Three courses make up these 18 components. The grouping is summarized here, listing just the components that have plant pathogenic bacteria.

The key characteristics of plant pathogenic prokaryotes are outlined in the table below. It will be evident that Gram-negative bacteria make up the majority of the significant plant pathogenic genera. Streptomyces and the coryneform bacteria Clavibacter and Curtobacterium are the only Gram-positive bacteria. Rarely are the gram-positive bacteria Bacillus and Clostridium plant harmful. The majority of phytopathogens flagellate. All organisms are rod-shaped except mycoplasmas.

All bacteria, whether harmful or not, are saprophytes and may be cultivated on synthetic media. The microorganisms that cause plant diseases are all rod-shaped. The majority of bacteria that cause phytopathology are flagellated. Just two of the six genera, Corynebacterium and Streptomyces, are Gram-positive, the others being Gram-negative.

B. Nomenclature

As a biological system's fundamental unit of classification is a species, a novel bacterial isolate must be recognized at this level using a set of generally accepted standards, reducing the need to heavily rely on appearance alone. The International Code of Bacterial Nomenclature includes the criterion. A thorough and contemporary description that

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Vol 10, Issue 2S, February 2023

satisfies these requirements includes extensive pathogenicity and host range tests with thorough descriptions of symptoms as well as morphology, including flagellation, Gram's stain reaction, cultural, biochemical, and physiological characters, serology, phage, and bacteriocin typing, DNA base composition (the G + C content), DNA-DNA or rRNA-DNA homology, and DNA base composition. Cell and cell wall chemical analyses are today's key instruments for identifying and categorizing things. Every time a new bacterium is claimed, its description must be published in the International Journal of Systematic Bacteriology, and its type culture must be deposited with a type culture repository that is recognized globally [7]–[9].

II. DISCUSSION

A. Approved bacterial nomenclature names

The establishment of new species had been based on the "new host-new species" notion, which had led to a proliferation of names given to bacteria that were essentially the same despite the presence of stringent criteria for bacterial naming. The method suffers from a lack of sufficient contemporary descriptions, bacterial comparison with potentially related species, and a lack of appropriate host range research. Certain bacterial species may cause various symptoms on various hosts or variations of the same bacterium because various symptoms on the same host have been classified as separate species by various researchers.

The International Committee on Systematic Bacteriology (ICSB) made some actions to clear up the aforementioned misconception. In 1976, a revision to the International Code on Bacterial Nomenclature was made. According to this code, all names (classes, orders, tribes, families, genera, and species) published before January 1, 1980, and included in the Approved Lists of Bacterial Names (Skerman, et al., 1980), should be considered as having been properly published for the first time on that day. The names that were deemed valid before January 1, 1980, but were not on the Approved Lists will no longer be used in bacterial nomenclature and may be used for other taxa that may be presented in the future. While this choice greatly contributed to the reduction of uncertainty, it presented several issues for plant pathologists. Moreover, several modifications to the authorized names were allowed in other studies that were published shortly after. The signs and symptoms of bacterial diseases

The bacterial invasion causes very quick and widespread necrosis of the damaged plant portions, giving the surface a burnt look. The main consequence is tissue softening owing to the middle lamella's breakdown by enzymes, and tissue disintegration is preceded by a change in color. The necrosis of tissue around the substomatal gap causes necrotic regions to form on the lamina surface when the particular bacteria invades leaves via stomata. The spots often continue to develop slowly, and the dead tissues seem to be wet. Hyperplasia and hypertrophy of the invaded tissues are side effects of invasion in several bacterial infections. Tumors grow in the impacted areas as a consequence. Rhizobium association causes the production of root nodules in leguminous plants; however, since the relationship is not antagonistic, the plants are unaffected. The most well-known and in-depth researched illness in this category is crown gall disease, which is brought on by Agrobacterium tumefacient. Leaves, twigs, and fruits develop cankers or warty outgrowths. They are the outcome of tissue necrosis and the unharmed tissue's response, which is the production of cork cells. This ailment mainly affects one area.

Vascular disorders: In certain bacterial leaf spots, the infection enters the bloodstream and causes the leaf's circulatory system and spread throughout the body. In other cases, the plant's usual wilt is caused by an invasion from seeds or subterranean portions that is concentrated in the vascular tissues and blocks the arteries, and produces toxins. Tomato, potato, brinjal, cucurbit, maize, and bean bacterial wilt are among the examples.

B. Techniques of bacterial pathogen identification

The range and host specificity of the numerous phytopathogenic bacteria species allows for differentiation. In addition, they are distinguished based on their cultural, physiological, and biochemical characteristics. The main work on bacterial taxonomy, Bergey's Manual of Determinative Bacteriology, was published in 1923 but could only be used for identification. The majority of bacterial diseases can be quickly grouped into the appropriate genus, however, it might be challenging to distinguish between different species, subspecies, etc. The morphological variations of eukaryotes (plants, fungi, etc.) are such that it is simple to compare two individuals and tell them apart from one another. On the other hand, prokaryotes within a genus cannot be distinguished from one another based only on morphology due to their striking similarity. Additionally, while it is simple to compare individuals in eukaryotes (such as a single plant, thallus, or one of its parts), this is challenging in prokaryotes because comparisons must typically be made between colonies or masses of cells, where the presence of contaminants or variants cannot be ruled out.

Verification of the Pathogen For identifying and categorizing bacterial isolates into pathovars, methods including DNA analysis, PCR (polymerase chain reaction), fatty acid profiles, and serology are helpful. For instance, different pathovars and variations of the bacterium X. axonopodis induce varied kinds of citrus canker disease. Due to the commonality of symptoms, these forms are distinguished from one another using a combination of factors, including host range, cultural and physiological traits, bacteriophage sensitivity, serology, DNA-DNA homology, and PCR (polymerase chain reaction) examination of genomic DNA. The later tests show that these variants are distinctive genetically.

ISSN (Online) 2456 -1304
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Vol 10, Issue 2S, February 2023

C. Control of Culture

Rotation of crops One method of preventing the bacterium's soil-borne inoculum is by proper crop rotation. In soils where the disease is known to be present, susceptible types shouldn't be planted. For instance, a three-year rotation using maize, soybeans, and redtop grass helps prevent the brown rot of potatoes (Agrostis alba). It's also advised to age the seed for two years before planting. Growing plants from different plant families together has been used to control bacterial populations in soil and prevent the spread of bacterial disease from root to root. In several nations, intercrops of bean, maize, cowpea, and sugarcane have been utilized to prevent potato brown rot. Usage of seed free of infections Always buy seed from a place or field that is free of illness.

D. Sanitation

To lessen the soil-borne inoculum, sick plant detritus should be removed and destroyed. It's also crucial to destroy any potential collateral or other hosts. No sick plant debris or crop refuge should be left in the field after harvest. Always remove and burn any plant residue that has been infected. To prevent the entry of diseased material into the nursery stock, crop cleanliness is required. For instance, the introduction of pathogenic A. tumefaciens strains may be prevented by carefully examining nursery plants for signs of crown gall. If plants with black legs are found, they should be dug up and burned. As a seed, only approved nursery stock should be utilized. In sugarcane rot Spread is slowed down by regularly removing and burning the damaged branches.

E. Deep plowing

On the plains, deep plowing the field after harvest helps expose the soil to the summer heat of May through June. Several instances When exposed to 43° C consistently for four days or more, infected soil becomes bacterium-free. For instance, Ralstonia solanacearum, which cannot resist desiccation, has much lower soil populations in areas that are regularly plowed.

After harvest, deep plowing buryes the diseased stalks, decreasing the bacterium's capacity to survive in the soil. In certain nations, the primary crop is planted after pre-sowing irrigation to help the leftover seeds germinate, followed by plowing. The incidence of illness is decreased by crop rotation, late planting, early thinning, adequate tillage, and early watering.

Controlling moisture: High soil moisture accumulations brought on by either a high water table or a lot of rain may sometimes encourage the development of diseases like bacterial wilt. Below a soil moisture level of 50%, infection is decreased. It is best to prevent the passage of any water, including irrigation or rainwater, from infected to healthy crops.

F. Chemical regulation

Generally speaking, plant bacterial infections are highly challenging to manage due to a lack of efficient chemicals. The usage of copper, which has the potential to be phytotoxic, is the most efficient option.

G. Soil treatment

Chemical management of many bacterial infections has been ineffective because the pathogen persists in a variety of soil types. Due to their high cost, using harmful compounds like Sulphur, chloropicrin, etc., or applying very high doses of urea is not advised. In rare circumstances, bleaching powder application to the soil has been advised. The bleaching powder (chlorine) treatment prevents the bacteria's respiratory enzymes from working. In certain circumstances, adding potash to the soil may assist to lower the incidence of illness.

H. Seed Treatment

Seed treatment helps get rid of seed-borne inoculum. Delinting the seed with strong sulfuric acid destroys the external inoculum on the seed. For 10-15 minutes, seeds are submerged in acid, properly washed by suspending them in water to remove the acid, dried, and treated with organo-mercurial chemicals like Agrosan GN, Ceresan, etc. The internally transmitted inoculum from seeds is not destroyed by this treatment. One of the controls might be the eradication of infection in seeds by soaking them in an Agrimycin solution. In certain illnesses, the seed-borne inoculum may be eliminated by simply soaking the seed in water for 12 hours, followed by exposure to hot water at 53° C.

The pathogen was successfully removed from the seed using Du-Ter and Captan dissolved in dichloromethane as well as Blitox, Terramycin, and Benlate dissolved in acetone. The use of antibiotics is possible, but they are pricey. The internal seed-borne inoculum is eliminated when seeds are treated with antibiotics like streptomycin. In comparison to antibiotics, the systemic fungicides Vitavax and Plantvax are more effective.

The exterior and interior inoculum of the seed is destroyed by hot water treatment at 56° C for 10 minutes without impacting seed viability. Some scientists have also suggested using antibiotics as a potential therapy for blackleg illness. Antibiotics have been tested to prevent crown gall disease, including Vancomycin, Aureomycin, Streptomycin, and Terramycin.

To treat the potato blackleg disease, chopped tubers may be dipped in mercuric chloride solution, organo-mercurial compounds like Agallol, Aretan, or Emisan, or in a stable bleaching powder solution.

I. Foliar Spray

Foliar spray aids in preventing the disease's subsequent spread. Agrimycin sprays were suggested as a supplementary spread prevention measure. Giving 5 sprays of Agrimycin

and copper oxychloride at 12-day intervals might lessen the severity of bacterial blight in the field and boost yields.

J. Use of genetic engineering

In order to increase potato resistance to bacterial wilt and other bacterial illnesses, genetic engineering and technology are being utilized to introduce lysozyme, cecropsins, and other effective antibacterial proteins obtained from insects. Nevertheless, the likelihood of success in the near term is minimal. Moreover, efforts are being made to use biocontrol chemicals to combat bacterial wilt. The agents are virulent strains of Ralstonia solanacearum and hostile rhizobacteria. The antagonists' induction of resistance and precolonization of the rhizosphere may be the mechanism at play.

K. Biological management

The first effective creation of a biological control agent was sparked by A. tumefaciens. By separating non-pathogenic strains of Agrobacterium radiobacter from disease locations and evaluating their capacity to outcompete pathogenic strains in mixed inoculations, Australian scientist Allen Kerr made the discovery of the biocontrol system. Several non-pathogenic strains assisted in lowering infection, but A. radiobacter strain K84 in particular prevented illness entirely when applied to wound sites in a 1:1 ratio with A. tumefaciens cells.

treatment with the non-pathogenic biocontrol bacterium as a preventative measure for seeds or transplants Agrobacterium radiobacter is an efficient and reasonably priced tool for controlling the growth of crown gall in industrial settings. The strain that is sold internationally is this one. It is sold commercially on agar plates or on a peat substrate, and it is applied by soaking seeds, seedlings, or cuttings in a suspension of the bacterial cells in water before planting. Due to strain K84 of A. radiobacter's synthesis of the antibiotic agrocin 84, application of this antagonist by soaking seeds or dipping transplants may inhibit infection by most strains of A. tumefaciens. A. radiobacter biological control is used at a high population level to guard any wound sites from pathogenic invasion since it is only effective as a preventive measure rather than a cure for infections.

III. CONCLUSION

Whittaker's five kingdom categorization places all prokaryotes under the heading of Monera. Bergey's Manual of Determinative Bacteriology, published in 1923, is a comprehensive book on bacterial taxonomy. The categorization of bacteria was updated in the latter version. The International Code of Bacterial Nomenclature includes the phytopathogenic bacteria nomenclature requirements. The criteria also include extensive pathogenicity and host range tests with thorough descriptions of symptoms, morphology, including flagellation, Gram's stain reaction, cultural, biochemical, and physiological characters, serology, phage and bacteriocin typing, DNA base composition, DNA-DNA or rRNA-DNA homology, and serological tests..

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Vol 10, Issue 2S, February 2023

Bacterial Diseases-II: Plant Diseases Caused by Bacteria

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***Abstract*— Burrill was the first to identify the pathogenic potential of bacteria in 1878. He determined that a bacterium is responsible for apple fire blight. More than 180 illnesses are thought to be caused by bacteria today. Certain symptoms, such as galls, canker, leaf discoloration, blight, dwarfing, rot, and wilting, among others, are caused by bacterial plant infection. These symptoms result in significant crop losses in the food industry and, in certain circumstances, a decline in the quality of the fruits and vegetables**

***Keywords*— Bacteria disease, Plant Diseases, Soil Moisture, Seed tubers, Vascular bundles.**

I. INTRODUCTION

A. Brown potato rot

In tropical and subtropical areas as well as in certain mild temperate sections of the globe where temperature and moisture conditions are favorable for its growth, the bacterial brown rot and wilt disease of potatoes are widespread. It is the most severe bacterial disease of the potato in India, causing a reduction in tuber yield of 10% to 70%. The illness is devastating in West Bengal, the plateau area, and the mid-hills. The disease constantly threatens potato farming in West Bengal, Madhya Pradesh, Karnataka, and Maharashtra. The bacteria is known to attack castor, ginger, groundnut, papaya, cabbage, radish, banana, and a vast variety of other plant species in addition to solanaceous crops including chili, potato, tomato, and eggplant [1]–[3].

By directly destroying plants in the field and causing tubers to rot in storage, the disease harms the crop. The losses alter as cropping systems change. For instance, the yield of potatoes is lost every year in the Kumaon Hills of northern India by between 37 and 55 percent, compared to up to 40% in Maharashtra and up to 75% in certain areas of Karnataka. The disease's recognizable signs, which include stunting, yellowing of the lower leaves, abrupt wilting, and ultimately collapse of the whole plant, may manifest at any stage. In young, succulent plants, the disease may be severe and manifest itself as fast leaf withering and stem collapse. At first, just one stem may get wilted. The sickness has several symptoms. Stunting and yellowing of lower leaves are uncommon occurrences in India.

Vascular bundle browning may or may not be present. A fortnight after the beginning of the monsoon, many wilted plants in the hills where bacterial wilt often manifests in July display stem rot at the soil level. This symptom might be mistaken for the potato blackleg disease brought on by Erwinia carotovora. Bacterial streaming from diseased plant material may be utilized to quickly identify R. solanacearum in the field and separate bacterial wilt from vascular wilts brought on by fungal pathogens.

The xylem in the vascular bundles has become brown, which is referred to as brown rot. Because of browning, diseased vascular bundles may appear striped on stems. The bacterium's synthesis of pigment is what causes this browning. Due to the brown ring that develops in the tuber as a result of the vascular bundles' discoloration, the illness is also known as "ring sickness." The diseased tubers' skin often has a discolored appearance. A sticky exudate may develop at the eyes or where the stolon is linked to the tuber in seriously damaged tubers, and the eye buds may become a greyish-brown color. When the diseased stems or tubers are sliced crosswise and pressed, a vascular ring-shaped, greyish-white bacterial slime emerges. Infected tubers that are left in the ground will eventually develop into a slimy mass encircled by a thin layer of outer tissue. Other isolates induce bacterial wilt and rot of tubers but do not create a brown color. Such circumstances give the parenchyma and vascular bundles a wet appearance [4]–[6].

B. Pathogen

Ralston solanacearum Yabuuchi et al., previously known as Pseudomonas solanacearum Smith, are members of the order Burkholderiales and family Ralstoniaceae and are responsible for potato bacterial wilt. Worldwide, tropical, subtropical, and certain temperate climates all have the pathogen Ralstonia solanacearum.

C. Illness cycle

One possible source of primary inoculum is soil. The pathogen may persist between crop seasons in soil, seed tubers, and on other host plants, whether they are farmed or wild. Even in the first crops on recently cleared soil, the disease has been detected. While some studies claim that the bacteria cannot live in soil for merely one year, it has been shown that it can survive in cultivated soil for a duration of more than two and a half years. It has been observed that naturally contaminated soil placed in plastic bags at 4° C may

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Vol 10, Issue 2S, February 2023

survive for up to 673 days. In sterile and natural soil, the bacteria may live for more than 250 days, according to Rangaswami and Thirunavakarasu (1964). The bacteria are more likely to survive in well-drained soils with strong water retention capacity, moderate to high soil temperature, and low to moderate soil pH. Ralstonia solanacearum infestation is typically strongest in the top 30 cm of the profile in most soils, although minor populations have been found as deep as 65–75 cm.

The bacteria may persist in populations on the roots of plants that are not its hosts. Even non-host plants like wheat, sorghum, and maize may harbor small populations of bacteria in their root systems. The potato crop is grown in the hills of northern India from March to September. Farmers often leave the tubers with brown rot in the field after harvest. Desiccation is avoided because of the chilly, humid weather that persists from September to March, and there is also minimal activity by antagonists or secondary invaders. Hence, under such circumstances, the pathogen may live in plant waste. The bacteria may survive on potato crops produced all year round in the Nilgiri Hills. Nevertheless, because of the very hot and dry summer that comes after the primary potato-producing season in the plains of India, it has been questioned whether the infection can survive in damaged plant debris.

In vascular tissues (active infection), on the tuber surface, and in lenticels, potato tubers contain the bacteria. In the last 20 years, infection by lenticel has emerged as the most prominent and crucial means of tuber transmission. No symptoms appear in the tubers and the bacteria is undetected in lenticels infection. Only when the tubers are incubated at high temperatures can it manifest itself. If infected or contaminated (or latently infected) tubers are kept for seed at reasonable temperatures, tuber transmission of the disease is conceivable. Active infection-carrying tubers readily decay at high temperatures and cannot be utilized for seed. The majority of them do not germinate even when planted because of soil rot. Increased numbers of lenticel-infected tubers result from delayed tuber harvesting. Infected and surface-contaminated (latent infection) potato seed tubers seem to be the sole source of primary inoculum in the plains of India, where soil survival of the bacteria is uncertain [7]–[9].

Stolons spread the infection to potato tubers. The bacteria may enter the host via wounds on the stem and through stomata, although it often infects tomatoes through damaged roots. If they assault the host before it comes into touch with the bacteria, root-knot nematodes help in penetration. Moreover, some gall-forming insects, cutworms, white grubs, and parasitic fungi that invade roots may cause root damage that allows the wilt bacteria to enter the plant. Cutting tubers with knives during the planting process without taking care contributes to the contamination of healthy tubers. After penetration, the pathogen climbs through the vessels of the host plant and quickly colonizes. The incubation time varies depending on the host species, habitat, and plant age.

The relationship between hosts and parasites as well as their ability to survive in soil are both greatly influenced by temperature. At 37° C, disease development occurred most quickly. High soil moisture and temperatures between 30- and 35-degrees Celsius favor the illness. Race 1 of the bacterium requires a somewhat high-temperature range of 28°–30° C for the development of wilt. Lower temperatures may cause infection, but no symptoms appear. As a result, there is a very high likelihood of latent infection at lower temperatures.

The disease is favored by high soil moisture. At the beginning of the rains in mid-July, the sickness begins to manifest itself. Also, it has been noted that the bacterial population in soil peaks in July and August, when both soil moisture and temperature are at their greatest. Wilt is less common when soil moisture falls to 8–10% of its water-holding capacity and when the highest and lowest temperatures are respectively 20° and 15° C.

The pathogen may develop in a broad pH range. pH should be between 6.2 and 6.6, and at most 7.4. Nevertheless, strains may alter this. Both acidic and alkaline soil types are affected by the illness. It is severe in Madhya Pradesh's alkaline soils (pH 7.0 to 8.0) and the Nilgiris' acidic soils (pH 3.6 to 5.0). If the soil's clay concentration rises, the bacterium's growth is inhibited. In contrast to chemical fertilizers, organic matter fosters development. In older plants, the severity of the illness is lessened.

II. DISCUSSION

A. Crop rotation

A good crop rotation program is one approach to prevent the bacterium's soil-borne inoculum. It had been discovered that a three-year rotation of maize, soybeans, and redtop grass (Agrostis alba) provided the crop with a significant amount of protection. For the control of the illness, crop rotations in India consisting of potato-finger millet potato and potato-wheat-potato are advised. In addition to these, it has been discovered that the combinations of potato-sorghum-potato, potato-maize-potato, potato-wheat-sun hemp green manure, and wheat-green manure-potato are efficient in reducing disease incidence to below 3%.

The bacterium's root-to-root transmission and soil populations have both been reduced by the use of intercropping. In several nations, intercropping with sugarcane, beans, maize, and cowpeas has been practiced. Utilize infection-free seed: Seed tubers must always come from a place or area free of illness. After making a 5 mm deep incision, the tubers taken from a healthy crop in an endemic region should be treated with 0.02% Streptomycin for 30 minutes. It is not advisable to allow irrigation or rainwater to flow from infected to healthy land.

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Vol 10, Issue 2S, February 2023

1. Sanitation: No infected or decaying tubers or crop refuge should be left on the field after harvest. Always remove and burn any plant residue that has been infected.

2. Plowing: The field should be plowed after harvest to expose the soil to the plains' May–June summer heat. Ralstonia solanacearum cannot tolerate desiccation, therefore farms with frequent plowing have much lower soil populations of this plant.

Moisture management Bacterial wilt is often more likely to occur when there are large soil moisture accumulations due to either a high-water table or significant rainfall. The bacteria can survive best in moist, well-drained soils, but soil desiccation and floods are detrimental to life. Below a 50% soil moisture level, no infection is acquired. Thus, it is not advisable to allow irrigation or rainwater to flow from contaminated fields to healthy plots. When exposed to 43° C consistently for four days or more, infected soil becomes bacterium-free.

B. Variety resistant

Solanum tuberosum types vary in their sensitivity to brown rot, however, as of yet, neither bacterial wilt nor brown rot resistance has been discovered in the commercial potato varieties grown in India. Indian strains of the bacteria are very virulent, and in Indian circumstances, alien cultivars that were previously resistant to it become susceptible. It was discovered that a wild potato clone (S. microdontum) has significant levels of resistance to races I and 3 as well as biotypes II, III, and IV. S. tuberosum x S. microdontum culture BRB/A-24 was discovered to be disease-resistant. S. phureja clones that exhibit disease resistance are being employed in hybridization projects. The challenge in creating resistant types is that the resistance discovered so far is racial. Hence, a race/biotype that is resistant to it is not also resistant to other races/biotypes.

C. Chemical regulation

Chemical management of the illness has not been viable since it is a systemic vascular wilt and the pathogen persists in many kinds of soil. Due to their high cost, using harmful compounds like sulfur, chloropicrin, etc., or applying very high doses of urea is not advised. It has also been advised to use stable bleaching powder in furrows at planting time (12 kg/ha).

D. Using genetic engineering

To increase potato resistance to bacterial wilt and other bacterial illnesses, genetic engineering and technology are being utilized to introduce lysozyme, cecropsins, and other effective antibacterial proteins obtained from insects. Nevertheless, the likelihood of success in the near term is minimal. Moreover, efforts are being made to use biocontrol chemicals to combat bacterial wilt. The agents are virulent strains of Ralstonia solanacearum and hostile rhizobacteria. The antagonists' induction of resistance and recolonizations of the rhizosphere may be the mechanism at play.

E. Disease of rice

Since 1881, Japan has been aware of the bacterial leaf blight (BLB) of rice as an endemic illness. Moreover, China, Taiwan, Korea, Thailand, Vietnam, Philippines, Indonesia, Malaysia, Bangladesh, and Australia are reported to experience it. Based on the bacterium's isolation and toxicity, Srinivasan, et al. (1959) made the first Indian record from Maharashtra, where it had been believed to be pervasive and destructive since 1951. Yet, their descriptions of the symptoms are consistent with the bacterial leaf streak, which differs from leaf blight in terms of both the causative agent and the symptoms. Indian authors Bhaskar et al. 1960 seem to be the first to report the usual signs of bacterial leaf blight. Until 1963, the illness was thought to be exclusive to Maharashtra. However, in the Shahabad area of Bihar, a severe blight that had previously been ascribed to a nutritional issue was later determined to be a bacterial blight (Srivastava and Rao, 1963). Since then, the illness has also been documented in various regions of north India. In the Tarai area of Uttar Pradesh, where the weather is often favorable for its emergence and spread, the disease causes significant damage.

The illness is classic vascular wilt, with leaf blight merely being a minor phase brought on by secondary infections. Damage occurs when leaves become partially or completely blighted, or when damaged tillers completely wilt, leaving empty grains. Crops may entirely dry out during the wilt or "Kresek" period prior to seed development. If the assault happens late, the yield loss may not even be noticeable. The damage in India has been estimated to range from 6 to 60%. (Srivastava and Rao 1966).

F. Symptoms

Rice leaf blight caused by bacteria has two stages: (a) blight and (b) "Kresek," or wilting. The disease's symptoms are greatly influenced by the infection stage and the local climate. The disease's leaf blight stage is its most obvious symptom. Linear, yellow to straw-colored lesions with wavy borders, often on both leaf edges but sometimes on just one, define this disease phase. These stripes often extend downward from the tip of the animal. The leaf tip then begins to twist, and the marginal blight spreads quickly longitudinally and across to cover significant portions of the leaf. Infected seedling leaves curl up and become a grayish green color. Lesions often appear as water-soaked to yellow-orange stripes on leaf blades, leaf tips, or on leaf portions that have been damaged manually on older plants. The edge of the lesions is wavelike, and they advance toward the leaf base. The tillers or the whole culm may be killed if the blighting spreads to the leaf sheath and culms.

On the surface of the leaf, in dry weather, are opaque, turbid droplets of bacterial slime that dry into yellowish beads. Rains carry these drips down to the ground. While the symptoms are not well characterized, the glumes of seeds

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Vol 10, Issue 2S, February 2023

also get affected. Usually starting four to six weeks after trans-planting, the disease's blight phase manifests.

The bacteria may persist in different ways from season to season. The rhizosphere of the grass hosts is where the pathogen reproduces. Leersia oryzoides and L. oryzoides var. japonica are the main sources of primary inoculums in Japan, according to Goto et al. (1953). Many similar grass hosts have also been found in India. They include Leptocorsia acuta, Leersia hexandra, Cyperus rotundus (motha grass), and C. defformis. Trimurthy and Devadath (l981a) claim that the bacteria may survive on the leaves of Paspalum scrobiculatum, Leersia hexandra, Panicum repens, and Cyperus rotundus for 130–140, 120–130, 100–110, and 50–60 days, respectively, without causing signs of blight.

Some Japanese and Indian workers have noted the persistence of the disease in contaminated rice straw left in the field as well as in the stubbles. This means of survival is questioned in India, however. Volunteer rice seedlings propagate the disease in low-lying fields in double-cropped regions, such as south India. Even though soil type affects bacterial survival, the bacterium only lives a brief time in soil.

Hence, the main inoculum may be provided by diseased wild rice growing in ponds. The principal inoculum is also provided by irrigation water that has been tainted with the bacteria and is being circulated from field to field. For the illness to start, rice leaves must come into contact with infected water. The pathogen and its phage (virus) are more resistant to the environment in field water that has been sterilized than in water that has not been. Phage population analysis can predict when the illness will start, but not how severe it will be.

The main source of primary inoculum is also seed from contaminated crops. The bacteria survive the longest at a very low temperature (4° C) in naturally infected leaves and artificially injected seeds. So, it seems that the bacteria can survive in nature for only brief periods of time at high temperatures. X. campestris may be present in 54% of seeds and survive for 120–180 days, according to Trimurthy and Devadath (1984). While the bacteria can be isolated from soil near seeds, showing that the main inoculum passes from seeds via soil, it is possible that such seeds may not generate infected plants.

Bacterial cells spread through wind-borne raindrop splashes, irrigation water, or rainwater from infected fields, contact between sick and healthy leaves, and stomata cause secondary dissemination through wounds and stomata. The grasshopper and the leafhopper may manually spread the bacteria on their bodies. The bacteria cannot thrive within the body of the insect. Upon entrance, the bacteria multiplies in the host parenchyma's intercellular gaps before being discharged once again via stomata. The bacteria create phytotoxic organic acids such as succinic acid, fumaric acid, isovaleric acid, phenylacetic acid, and 3-methylthiopropionic acid, all of which have been demonstrated to be toxic to cut rice shoots (Sreeramulu, et al., 1987).

Poorly drained fields near rivers, lakes, and hilly basins, an abundance of rainfall and humidity, floods, and typhoons, as well as Japan's hot summers with little sunlight and mild autumns, all contribute to the development of illness. In India, Uttar Pradesh is said to be the region most prone to disease development when there is cloud cover, rain, or excessive humidity (Pavgi, et al., 1964). Epidemics may be caused by moderate volumes of equally distributed rain throughout the growing season. Temperatures over 25° C favor the disease's growth. At temperatures lower than 20° C, symptoms never manifest. The size of lesions is longer at a mean temperature range of 21.3° to 32.7°C (Premlatha Dath, et al., 1979). Strong winds, rain, and temperatures between 20 and 26 degrees Celsius all contribute to the illness spreading quickly in the field. According to Srinivasan and Singh (1983), severe Kresek development happens when there is a combination of maximum temperatures between 30 and 35 degrees Celsius, minimum temperatures between 24 and 26 degrees Celsius, uniformly high humidity between 64 and 84 percent relative humidity, brief sunny days, and heavy, evenly distributed rainfall.

Strong winds and persistent downpours often cause it, which makes it easy for the disease-causing bacteria to spread via oozing droplets on lesions of afflicted plants. Workers have also said that water logging promotes the illness spread by allowing leaves to come into touch with floating germs. When a crop ages, disease incidence rises. Even in somewhat resistant types, the severity of the disease is increased by heavy nitrogen treatment, poorly drained soil, and shade. The increasing nitrogen content of leaves is not what causes the condition to worsen. It may be because specific metabolites released by the bacteria facilitate invasion (Pandey and Iswaran, 1982). The illness is made worse by microbial fertilizers such as Azotobacter sp. and Pseudomonas sp. In conditions of strong nitrogen fertilization, bacterial blight in sensitive rice types may be severe.

G. Soft vegetable rot

Throughout the majority of Europe, the USA, and Canada, various species of Erwinia cause bacterial soft rot in crops, including potatoes. It is a typical illness of travel and storage. These bacteria in potatoes not only induce soft rot of the tubers but also black leg and wilt of the field plants. Hingorani and Addy (1953) conducted a thorough investigation of the illness in India and determined the characteristics of the causing organism with particular attention to the organism's qualities.

H. Symptoms

On the field, the illness sometimes manifests. The plant begins to wilt and eventually dies after becoming a light green or yellow color. The distinctive brown-black or jet-black color of the stem at the soil level is a distinguishing feature of the characteristic "blackleg" in potatoes. The old

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Vol 10, Issue 2S, February 2023

seed tuber is generally where this discoloration begins. Cortical tissues might dry up and rot. The plants may grow to a normal height, although they often stay small and stunted. The branches and leaves exhibit a propensity to grow upwards rather than spread naturally. The foliage quickly wilts after becoming pale green or yellow with a faint metallic shine. There may also be leaf curling comparable to that brought on by the potato leaf curl virus. Young seedlings emerging from sick seed tubers may sometimes die before or shortly after emergence. The rot may eventually spread over the whole tuber or it may be mostly contained to the inner peri medullary (or parenchymal), which is the tissue within the vascular ring, as the condition worsens.

They transport the bacteria to the storage godowns when infection occurs after tubers have grown. The presence of blackleg bacteria on the surface of tubers in an uncontrolled potato storage environment may lead to significant deterioration. When tubers are stored in storage under wet circumstances, decomposition sets in and the tubers become a mushy rotted pulpy mess that is only held together by the corky epidermis that is not attacked by the parasite. This process may happen partially or completely, slowly or quickly. A tuber with visible rot is sliced open, revealing a colorless putrified mass that becomes pink-red when exposed to air and quickly turns brownish-red to brown-black with a watery mass of bacterial slime and a sulfurous odor.

I. Pathogen

Erwinia carotovora subsp. carotovora (Jones) Bergey, et al. and Erwinia carotovora subsp. atroseptica (van Hall) Dye are the bacterial species responsible for potato black leg and soft rot. Although the latter is said to be the primary cause of potato black leg in temperate countries, the former is thought to be the disease's primary cause in India. A synonym of Erwinia carotovora subsp. carotovora is Erwinia aroideae (Townsend) Bergey, et al., which was previously identified as a separate species connected to soft rot. Pectobacterium carotovorum var. carotovorum and P. carotovorum var. atrosepticum are alternate names for this species.

III. DISCUSSION

Tropical and subtropical parts of the globe are prone to the bacterial brown rot of potatoes. By directly destroying plants in the field and causing tubers to rot in storage, the disease harms the crop. The disease's recognizable signs, which include stunting, yellowing of the lower leaves, abrupt wilting, and ultimately collapse of the whole plant, may manifest at any stage. Stems may look striped as a result of the browning of the xylem in the vascular bundles. Due to the brown ring that develops in the tuber as a result of the vascular bundles' discoloration, the illness is also known as "ring sickness." The gram-negative motile rod Ralstonia solanacearum (Smith) is responsible for potato bacterial wilt. Bacteria are soil-borne and have a wide variety of hosts. Primary inoculum comes from the soil because seed tubers are where pathogens thrive. The disease is favored by high soil moisture. Culture may limit the illness through crop rotation, the use of seeds free of contamination, hygienic practices, and moisture management. Technology, genetic engineering, and resistant types are also used.

There are two stages to bacterial leaf blight on rice: (a) blight, and (b) "Kresek" or wilting signs. The illness is a classic case of vascular wilt, with leaf blight merely being a moderate phase brought on by secondary infections. Leaf blight symptoms include linear, yellow to straw-colored streaks with wavy borders that often appear on both leaf edges but seldom only one. Damage occurs when leaves become partially or completely blighted, or when damaged tillers completely wilt, leaving empty grains. Crops may entirely dry out during the wilt or "Kresek" period prior to seed development. a rod-shaped, G-negative univallate bacteria Oryzae-specific Xanthomonas campestris (Ishiyama) The pathogen is the dye. The main source of primary inoculum may include various grass types and sick wild rice growing in ponds. Stomata and wounds both contribute to secondary dissemination. The disease may be controlled by streptomycin-treated seeds, foliar sprays with Agrimycin, hot water treatments, and seed treatments.

Several species of Erwinia are responsible for the bacterial soft rot of vegetables. Infected plants become light green or yellow, quickly wilt, and eventually die. The distinctive brown-black or jet-black color of the stem at the soil level is a distinguishing feature of the characteristic "blackleg" in potatoes. The whole tuber may deteriorate or rot as the condition worsens. Potato black leg and soft rot in India are caused by the bacterial species Erwinia carotovora subsp. carotovora (Jones) Bergey, et al. The bacterium is motile by peritrichus flagella, gram-negative, facultative anaerobe, and rod-shaped. Seed tubers that have been contaminated are one source of the first inoculum. Tubers get infected as a result of injuries, sunburn, insect bites, and nematode punctures. Cleanliness, dipping cut tubers in mercury chloride or other organomercury compounds, and other practices may assist to lower the prevalence of sickness. Bleaching powder applied to the soil has been proven to be a more effective control.

The huge tumor-like swellings (galls) that often develop above the plant's crown, just above soil level, give rise to the term "crown gall disease." While young, the galls are soft, spherical, white, or flesh-colored, and often resemble the callus tissue that develops after injury. When tumors age, their form becomes fairly erratic and they darken to a brown or black color. The damaged plants may develop chlorotic leaves and become stunted. Crown gall disease is brought on by the bacterium Agrobacterium tumefaciens, which affects a variety of dicotyledonous plants, particularly those in the rose family. A. tumefaciens is a rod-shaped, Gram-negative, non-sporing, mobile bacteria. The bacteria enter the plant via wounds close to the soil border. Crop cleanliness and the application of antibiotics like Vancomycin, Aureomycin, Streptomycin, and Terramycin are effective

disease-controlling strategies. Biocontrol has been proposed as the preventative application of the non-pathogenic microbe Agrobacterium radiobacter to seeds or transplants.

According to the plant portion affected, the angular leaf spot disease has four separate phases: angular leaf spot (leaf infection), black arm (stem infection), boll rot (boll infection), and seedling blight (seedling infection). The first sign of the condition is the appearance of tiny, wet patches on the underside of the cotyledons. The cotyledons' shape is distorted by these water-soaked spots, which grow in diameter, change color from brown to black, and create uneven patches. This causes the spots to dry out and wither. An angular leaf spot, which starts as dark-green, wet patches, is a sign of the second stage of the leaf infection. These patches grow larger, have sharp edges, get encircled by tiny leaf veinlets, and change color from brown to black. On each side of the vein, black lesions may sometimes be seen. This condition is known as Black vein or vein blight. Black lesions have the potential to girdle the petiole or primary branches, breaking them. This stage is referred to as the blackarm. Water-soaked lesions that form on the surface of the boll are indicative of the boll rot stage. The cause of cotton's angular leaf spot disease is the bacterium Xanthomonas campestris pv. malvacearum (Smith) Dye. The bacterium is rod-shaped, does not generate endospores, is enclosed, is gram-negative, and is mobile thanks to a single polar flagellum. The principal inoculum comes from the contaminated seeds that are latent in the field and that sprout throughout the crop season before the main crop. On the soil's surface, infected cotton bolls, leaves, and twigs are also a significant source of the bacterium's spread. Effective control strategies include sanitization, seed treatment with organomercurial chemicals, and antibiotics

IV. CONCLUSION

Red-striped sugarcane disease initially manifests as lengthy, water-soaked streaks that quickly become chlorotic and have dark red stripes running through them. More damaged than the tip is the bottom part of the leaf. Top rot symptoms manifest when new shoots are harmed. The developing apex of the shoot has several dark-red stripes that seem to be wet and decaying. The disease spreads downward, destroying the leaves and their terminal buds. The cause of the illness is Pseudomonas rubrilineans. The bacterium is rod-shaped, nonendospore-forming, motile, and has one to three polar flagella. The bacteria are Gram-negative and facultatively anaerobic. Using setts from afflicted plants as a source of initial inoculum in fresh fields is another benefit. In addition to these, the bacteria can also live on sorghum, pearl millet, maize, finger millet, various species of Saccharum, and a number of grasses. The infection spreads via stomata and wounds. Spread is slowed down by regularly removing and burning the damaged branches. The most effective way to prevent this illness is to use resistant cultivars.

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Viral Disease- I: Classification and General

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***Abstract*— Due to their unique chemical makeup and form of parasitism, viruses are more harmful than fungi and bacteria and are far more difficult to manage. The word "virus" was originally used by Beijerinck in 1898. Long ago, slimy liquid poison, venom, or contagious material was referred to as a "virus." More detailed ideas about viruses started to develop as our understanding of the nature of viral particles increased. a virus is a collection of one or more template molecules that are typically covered in a protective coat or coats of protein or lipoprotein and that can only plan its reproduction inside compatible host cells**

***Keywords*— Plant Viruses, Mosaic Viruses, Viral Disease, Viral Infection, Vein Binding**

I. INTRODUCTION

According to Bos (1983), a virus is an infectious agent that often causes illness, is invisible to the naked eye (submicroscopic), is tiny enough to get past a bacterial filter, lacks its own metabolism, and relies on a live host cell for growth. Viruses are required parasitic pathogens with diameters smaller than 200 millimeters (m), according to Bawden (1964). These are potentially harmful submicroscopic infectious organisms that exclusively reproduce intracellularly [1]–[3].

Viruses are now regarded as living organisms, and the following definition of a virus is generally accepted: With just one kind of nucleic acid (DNA or RNA), viruses can only replicate in the form of nucleic acid and are unable to expand or undergo binary fission. They are purely intracellular and potentially pathogenic creatures with an infectious phase. Under a coat of one or more kinds of proteins, often with an additional coat (envelope) and other components, viruses are little bundles containing the host-alien genetic material of one type (RNA or DNA), either in one strand or in a few segments encased together or separately. According to the current understanding of plant viruses, viruses are naturally occurring nucleo-proteins that behave as living things in vivo and as chemicals or molecules in vitro.

A. Viral disease symptomatology

Plant viral infections show a range of symptoms.

1. Mosaic: Mosaic is one of the most typical symptoms. Mosaic spots, which are white or yellow and originate from a viral infection, emerge on the surface of the leaves. A mosaic of yellow and green is created when different levels of chlorosis are interspersed with the leaf's natural green color. The yellows kind of symptom is used to describe a consistent loss in chlorophyll.

2. Vein clearing and vein banding: These symptoms show up in leaves that have a systemic infection. Vein cleaning takes place before mottle, mosaic, or chlorosis of the tissue inside or next to the veins. Vein banding in that area is characterized by wider bands of green tissue that are caused by chlorosis or necrosis in the interveinal parenchyma.

3. Ring spots: These symptoms include different forms of necrosis and chlorosis and manifest as isolated areas. These are known as chlorotic ring spots and may be circular. Necrosis may show up as rings alternating with typical green in necrotic ring patches. Any sort of spot's core may ultimately become necrotic. As in the tobacco ring spot.

4. Necrosis: Necrosis may manifest in several ways in both the yellow and mosaic disorders. The most severe impact is the death of cells, tissues, or the whole plant. Necrosis may appear on tissues devoid of chlorophyll, including roots, hypocotyls, and tissues that do contain chlorophyll.

5. Wilt: When a plant is infected with a certain virus, the outer whorls of the leaves droop and become yellow. Also becoming light yellow are the inner whorls. The leaflets quickly start to dry up and become brown from their tips. The leaves quickly start to fall. The size of the leaves shrinks and becomes stunted. Moreover, root development is drastically decreased [4], [5].

6. Astonishing: It may cause the size of the leaves, flowers, and fruits to decrease, and it may impact all plant components. As with the bean yellow mosaic virus, the petioles and internodes are shortened. Depending on when the infection occurs in the plan's growth stage, the degree of stunting differs. There are instances when some plant sections may be more stunted.

7. Modifications to the shape of the leaf: The development of the leaf lamina is often irregular in mosaic disease. Curled, brittle, and puckering leaves develop (prominences and depressions). The leaf may roll upwards and inward, as in potato leaf roll, or the lamina may be severely shortened, creating the appearance of a fern leaf, as in TMV or CMV on tomatoes.

8. Outgrowths: Viral infections often include abnormal growth. Infected plant leaves often develop foliar outgrowths and vein swellings on the underside similar to tobacco leaf curl disease. In the stems and roots of sweet clover infected with wound tumor virus, tumors or swellings develop.

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International Journal of Science, Engineering and Management (IJSEM)
Vol 10, Issue 2S, February 2023

9. Floral breakings: Variegation in flower color is often caused by viral infections. As with tulip breaking, this is referred to as the breaking of flower color. Turnip mosaic virus in Wall flowers causes similar symptoms.

10. Fruit abnormalities: Many symptoms, like mottling on cucumber and papaya caused by mosaic-type viruses and star crack in apples and plums caused by the plum pox virus, may appear on fruits when specific viral infections occur.

B. Internal Symptoms

The virus-affected plants exhibit several cytological and histological abnormalities. Although visible in tissues, the histological abnormalities are solely cytological. Vascular tissues are impacted by several viruses. Endocellular cordons, which are lignified strands, are present in the xylem components of a grapevine that has been infected with the grapevine fan leaf virus. Tyloses occur when viruses cause yellowing. In the phloem sieve plates, callose is deposited when the phloem cells degenerate or die. Certain organelles are impacted by one virus. They might change the mitochondria and assemble them to create inclusion bodies. They could also cause the creation of marginal vesicles in the chloroplasts. The inclusion bodies might be amorphous and crystalline. Pinwheels and "cat-o-nine tails" are the shapes of the amorphous formations. These bodies show up in infections caused by the potato virus group's flexuous rod-shaped viruses [6]–[9].

C. The spread of viruses

The following list includes the several ways that plant viruses are spread:

1. Seed Transmission: Viruses may be outwardly seed-borne, as in tomato, cucumber, etc., or internally seed-borne, as in barley, cowpea, bean (bean mosaic), etc., in the testa, endosperm, and/or embryo. Viruses that are internally seed-carried are more potent than those that are outwardly seed borne.

2. Grafting: Grafting between live cells of virus-infected and virus-free plants is a very simple method of viral transmission because viruses are closely linked to the living cells of the host. Grafting becomes a natural way of viral transmission in fruit and decorative trees where grafting is the usual mode of multiplication.

3. Transmission via Vegetative Propagation: Perennial plants' vegetative organs often serve as a breeding ground for viruses (fruit trees). All of the vegetative portions utilized to propagate such plants also get the virus when they are infected. As a result, nursery stock, bulbs, tubers (such as potato leaves), and roots that are contaminated with viruses are easily spread from one location to another. As a result, the typical reservoirs for many viruses that persist are perennials that have been infected.

4. Phanerogam transmission via parasitic: While parasitizing virus-infected host plants, a species of Cuscuta transmits haustoria into the host tissue, where they are infected by the virus. The virus may spread to other plants by newly produced penetrating) haustoria when the same virus-infected species of Cuscuta extends its stem to parasitize them.

5. Spread via Insect: Insects carry the majority of viruses. The insects that transmit viruses either have teeth designed for biting or stylets designed for piercing and sucking. The typical insect vectors are sucking insects. Nevertheless, thrips, plant bugs, leafhoppers, white flies, aphids, and coccids are the main insect vectors.

Certain viruses may be mechanically transmitted on an insect's mouthparts, where they can stay infectious for only a few minutes or a few hours. These viruses are referred to as non-persistent ones. They are often quickly shed by the vector after a brief feeding session. If the feeding phase lasts for many hours, the non-persistent viruses are usually transferred to the first plant and seldom to the second. Once again, certain vectors may wait a while after feeding on the infected plant before transmitting the viruses to a healthy plant. Some viruses are tenacious. The development of infective power is delayed and infectivity is retained by persistent viruses for an extended length of time. In this scenario, the insect likely ingests the virus, which is then transferred via the body into the saliva and ultimately used to infect the next host plant. The latent period, sometimes referred to as the period of incubation, is the delay in the development of infective power and varies widely amongst viruses. The vectors' bodies may potentially support the growth of these viruses. For a long time, all plants instead get the persistent viruses rather than only the first two or three.

6. Transmission Via Mechanical Methods: This method of transmission involves the intentional or natural transfer of sap from a virus-infected plant to a healthy one. Although infection via "natural openings," such as stomata, is rather uncommon, mechanical transmission often entails damage to the host tissue for the virus's simple passage from host to host. Viruses spread mechanically and are often concentrated in large numbers within the plant. Certain viruses may be transferred from a sick plant to a healthy plant by wind-induced contact between the leaves. The methods used in cultivation and the movement of animals may contribute to the transmission of viruses. Rub the juice of a sick plant over the leaves of a healthy tobacco plant to quickly spread the tobacco mosaic virus. During this mechanism, epidermal or hair cells are sufficiently injured to cause infection.

7. Soil Transmission: Hosts are infected by soil-borne viruses via their root systems. Typically, these viruses don't stay in the soil for more than a few months at most. Yet, the soil texture has a significant impact on the survivability of the soil-borne viruses. Soil-borne viruses are stored permanently in the roots of infected perennial hosts.

8. Mite transmission: Eriophyid mites spread a number of viruses. The virus that causes the Ribes illness is transmitted by the big-bud mite, Phytopus ribis. As mites cannot fly, they must move from plant to plant by crawling or, more frequently, by being carried by the wind.

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Vol 10, Issue 2S, February 2023

9. Transmission by Nematodes: Many viruses are transmitted by nematodes from the genera Xiphi-nema, Longidorus, and Trichodorus. Plants with broad root systems may become systemically infected, which might make the roots accessible to nematodes feeding far away from the initial site of infection. The nematodes pick up virus while feeding on the epidermal cells close to the root tip.

10. Transmission by Fungi: Olpidium and Synchytrium, which infect plants, are the carriers of a number of viruses, including those that cause big-vein diseases of lettuce and tobacco necrosis. As the zoospores of the fungus form in the virus-infected host, they carry the virus inside. As compared to other methods, viral transmission via pollen grains is rare. Bean mosaic virus is a typical example

II. DISCUSSION

Control Techniques

Several of the techniques listed below may be used to manage common plant diseases. The majority of plant virus control still relies on hygienic and preventative measures. While the majority of plant viruses are not seed-borne, it is nevertheless preferable to choose seeds from places, fields, or plants that are disease-free. Planting material carries the majority of viruses that affect crops that are reproduced vegetatively. In these situations, effort should be made to choose planting material from healthy plants. Nevertheless, this approach will fail if secondary infection through insect vectors is frequent and there are no signs evident on the plant.

This technique is used to choose potato tubers free of viruses for mass reproduction. They are given to gardeners after enough seed tubers have been generated in this manner. Preventing the spread of plant viral illnesses while the crop is growing is made possible in part by taking this vital precaution. Insecticides should be applied correctly by spray or soil to stop insect vectors from infecting healthy or sick plants or to restrict their population growth. It is also advised to utilize repellant mulches, obstacles, and trap crops to draw and kill insects. This strategy involves a voluntary agreement among all the producers in a region to eradicate all of the disease's host plants for a certain amount of time. Fresh planting is begun using disease-free seeds and plants at the conclusion of this time. The roguing technique works well for treating viral illnesses. Regular removal of all sick plants significantly slows the spread of illness and the early inoculums of pathogens. It is generally known that weeds may harbor some viruses. Such weeds must be removed in order to control illness. The land and its surroundings should be kept clear of these weeds by taking all reasonable precautions. The most effective approach to controlling plant diseases is by the production of resistant varieties, however, very few viral infections have been managed in this way. Wild plant species may sometimes be resilient to various viruses and illnesses.

These sources from wild species may be exploited to breed resistance in domesticated plants. This technique is employed when a disease spreads by cuttings, bulbs, or grafts. Cuttings of sugarcane have been treated for Sereh disease by submerging them in water at a temperature of 52° C for 30 minutes. Cuttings have also been treated at 53–54 °C to reduce sugarcane mosaic. A 20-minute immersion of setts in water that is 52°C eliminates the sugarcane chlorotic streak virus. Several viral infections of fruit plants have shown similar outcomes. Even though cross-protection has been shown in many plant diseases, particularly viral diseases, the technique has not been highly effective for field-scale disease control

III. CONCLUSION

Johnson devised a technique for classifying and identifying plant viruses in 1927. The creation of a committee to look into viral taxonomy at the World Congress of Microbiology held in Moscow in 1966 satiated the necessity for a reliable categorization system for plant viruses. The adjective 'virulent,' which is often used to describe anything particularly dangerous, venomous, or malignant, still has the original meaning of the word "virus." Neither can viruses be seen nor can they be developed on synthetic medium. The signs that are shown resemble those of dietary deficits. Yet, although inanimate objects are not contagious, viruses are always contagious. As a result, no pathogen can be acquired in artificial culture conditions, and because the sickness is contagious, it may be a viral disease. Plant viral infections show a range of symptoms

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A Brief Introduction of The Evolution of Food Safety

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***Abstract*— Anybody who consumes food is affected by the issue of food safety. Whether a person consciously considers food safety before eating a meal, a variety of other people farmers, scientists, corporate presidents, federal government officials, and sanitarians have done the same. The issues that persons who deal with food face are introduced in a general way in this chapter.**

***Keywordss*— Herbal Tea, Food Additives, Food Drug, Food Safety, Foodborne Disease.**

I. INTRODUCTION

the numerous chemicals, microbiological, and physical risks to the food supply after defining safe food and foodborne disease. The risks are presented in this order: The most significant foodborne pathogens are included in a table along with the foods they affect and the symptoms of foodborne sickness [1]–[3].

The variables that affect foodborne disease are then discussed, including:

1. Demographics
2. Consumer wants and lifestyles
3. Economics of food production
4. Adaptive and new pathogens

The focus of the history of food safety is on scientific advancements from the 1600s to the present. The chapter concludes with a look at the methods of food preservation that humans have used for millennia to make food safer. These methods span from the oldest forms of drying to more recent high-tech ones like food irradiation and more recent lower-tech ones like the use of natural antimicrobials.

A. Safe food terms

Safe and healthful food includes a wide range of different ideas. From a nutritional perspective, eating is what provides individuals with the nutrients they require and aids in preventing chronic long-term illness, hence encouraging health well into old age. From the perspective of food safety, it is food that is free of microbiological pathogens, such as bacteria and viruses that may cause disease, in addition to being free of toxins, pesticides, and chemical and physical pollutants. Food safety is the focus of this book; nutritionists should be the ones to address diet and nutritional aspects of food.

While the food supply in the United States is among the safest in the world, there are still several risks to its security. Some of these dangers have existed for a very long time, while others are more recent and are the consequence of altered lifestyles, altered industrial techniques, or even the development of microbes themselves. Producers, businesses, the government, and consumers all have responsibilities for ensuring food safety.

This book places a lot of emphasis on microbial foodborne disease, a common but sometimes ignored ailment that affects almost everyone at some point. It is brought on by consuming food that has been exposed to pathogens like bacteria, viruses, or parasites. A pathogen, a food carrier, circumstances that enable the pathogen to live, reproduce, or create a toxin, and a susceptible human who consumes enough of the pathogen or its toxin to cause sickness are requirements for the occurrence of foodborne illness. The flu-like symptoms, such as nausea, vomiting, diarrhea, stomach discomfort, fever, and headache, are often present as well. Even while they may not identify it as such and instead attribute it to the "stomach flu" or "24-hour bug," the majority of individuals have suffered foodborne disease. The majority of the time, symptoms go away after a few days, but in rare circumstances, longer-lasting complications including joint inflammation or renal failure may occur. In the worst circumstances, foodborne sickness results in death. Around 5,000 People die each year as a result of consuming contaminated food.

A foodborne disease might manifest itself anywhere between an hour and many days, or even weeks, after consuming the infected meal, making it difficult to link it to a specific dish. While tracking a foodborne disease outbreak, epidemiologists may need to speak with dozens of individuals and ask them to recollect their diets during the previous week. People sometimes have trouble recalling every meal they had, much less a week ago. The fact that one individual could consume the infected food and not get sick while someone else in a higher-risk group further complicates the situation. The cause of 81 percent of foodborne diseases is still unknown.

B. Food dangers

Specialists categorize dangers as chemical, microbiological, or physical when describing difficulties

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Vol 10, Issue 2S, February 2023

with food safety. They have long believed that naturally occurring toxins are the second most harmful kind of hazard, behind those of microbiological origin. Yet, because pesticides and additives have received a lot of public attention, some individuals could pay more attention to those risks than others. Yet, as more reports of individuals becoming sick from bacterial contamination surface, the general public is becoming more aware of the significance of microbiological dangers.

Microbial risks can cause mortality; however, they are uncommon compared to deaths from ingesting pesticide residues or food additives. Water may get contaminated by microbes since it is food. Certain diseases are more waterborne than foodborne, including Cryptosporidium parvum. Although the topic of waterborne risks produced by pollution, such as heavy metals, or diseases that travel via organs other than the digestive system is covered in this chapter, it is beyond the purview of this book.

C. Chemical risks

Toxic chemicals from industrial processes that can enter the food chain directly during processing or indirectly through plants and animals include cleaning residues, naturally occurring toxins, food additives, allergens, and agricultural chemicals such as pesticides, herbicides, rodenticides, insecticides, fertilizers, and antibiotics and other animal drugs. The United States Department of Agriculture regulates antibiotics and animal medications, the Environmental Protection Agency regulates chemicals used on farms, and the Food and Drug Administration regulates additives and residual chemicals in processed foods.

D. Food supplements

Food additives have been used since prehistoric times. Salt for preserving meats and fish, herbs and spices for flavoring food, sugar for preserving fruits, and vinegar for preserving vegetables are a few examples of these early additives. More than 3,000 food additives are now used by manufacturers. Any ingredient that is directly or indirectly added to a food during manufacture, processing, storage, or packaging is a standard definition of a food additive. Many purposes are served by food additives:

Preservatives to preserve food and stop it from spoiling. This is significant since, in today's society, food is seldom consumed at the location or at the time of production. Mold-inhibiting calcium propionate is often added to bread goods for this reason. Nutrients that help meals keep or boost their nutritional value. To avoid goitre, a disorder brought on by an iodine deficit, the majority of salt includes iodine. Processing aids to preserve product texture include moisture retention, lump prevention, and stability addition. Silicon dioxide is added to foods that are powdered, like cocoa, to avoid clumping when water is added. Flavors to improve or alter a food's flavour or scent. They consist of sugars, herbs, natural and artificial flavours, flavour enhancers, and spices.

Foods may seem appetising thanks to colour. The majority of the hues we associate with food come from added colorings, such as caramel in cola beverages to turn them brown and annatto in margarine to turn it yellow. Both manufactured and naturally occurring elements are used to make food additives. Scientists may now produce in the lab a variety of additives that formerly came from natural sources, resulting in a bigger and more affordable supply. The majority of the 140–150 pounds of additives that Americans eat each year come from ingredients including sugar, corn sweeteners, salt, pepper, vegetable colours, yeast, and baking soda. Without the inconvenience of cultivating our own food or going to the store every day, food additives enable us to enjoy healthy, nutritious, and delicious meals all year long. Food additives are necessary to produce convenience foods.

Before any food additives are introduced, the FDA must first authorise them. The USDA endorses the use of additives in meat and poultry products. Manufacturers must demonstrate that an addition works as planned and won't damage people at the anticipated amount of intake before they may use it. The FDA's stringent clearance procedure does not apply to two categories of additives: those that have received previous sanctioning and those that are widely accepted as safe. Before the 1958 Food Additives Amendment to the Food, Drug and Cosmetic Act, prior sanctioned substances had previously received FDA approval. Experts consider GRAS chemicals, such as salt, sugar, spices, and vitamins, to be safe since they have been used widely in the past with no known negative effects. If there is scientific proof that an additive is safe, the FDA may additionally designate it as GRAS. Once new information becomes available, FDA and USDA continue to monitor previously sanctioned and GRAS chemicals to make sure they are indeed safe. To further analyse any complaints about particular foods, food and colour additives, or vitamin and mineral supplements, FDA also runs the Adverse Reaction Monitoring System.

Certain portions of the population are susceptible to particular chemicals, despite the fact that the vast majority of additives are safe for everyone. Sulfites are one example of this; in certain persons, they might result in hives, nausea, shortness of breath, or shock. As they were used in salad bars to keep lettuce and other food appearing fresh, sulfites were prohibited from being used on fresh fruits and vegetables starting in 1986. If sulfites are added, they must be disclosed on product labels. Several people believed that chemicals may cause childhood hyperactivity in the 1970s, but research done since then have revealed no connection.

E. Dietary allergens

Up to 6% of children and 2% of adults have a food allergy, which is an immune system reaction to a specific dietary item, often a protein. Hives, swelling, itching, vomiting, diarrhoea, cramping, and trouble breathing might come from the immune system misinterpreting a chemical component of food as hazardous and releasing histamines and other

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Vol 10, Issue 2S, February 2023

chemicals to resist it. Anaphylaxis, which may cause fatalities, can be brought on by severe responses. 90% of all food allergies are caused by eight foods: egg, wheat, peanuts, milk, soy, tree nuts, fish, and shellfish. Avoiding that meal totally is the only method to avoid an allergic response.

Due to the similarity of their symptoms, food allergies and intolerance are often mistaken. An unfavourable response to a meal known as food intolerance does not involve the immune system. Food intolerances include, for instance, a lactose intolerance. A lactose intolerance prevents a person from producing the enzyme necessary to break down a kind of sugar found in milk. Eating dairy products results in stomach discomfort, bloating, and gas without triggering an immunological response. If someone really has a milk allergy, the best approach to prevent milk allergy symptoms is to completely avoid all dairy products. For those with lactose intolerance, specialised drops or pills that aid in milk sugar digestion are available, enabling them to ingest dairy products.

Consumers need to know precisely what is in their food in order to avoid allergens. The Food, Drug and Cosmetic Act mandates that food labels provide a comprehensive list of all components. Due to incorrect food labeling, many food items are recalled, such as ice cream with a label that omits peanuts or processed meals that do not include soy products as an ingredient. Common food allergies might sometimes appear in surprising locations in restaurant fare, such as in Asian noodles made with peanut butter or meatballs made with egg products.

Officials at several schools have banned peanut goods because of recent incidents in which pupils had allergic reactions to peanuts. This is a challenging undertaking since, in addition to the famous peanut butter and jelly sandwich, any snacks or sweets that include peanuts would also be prohibited. Foods offered at schools may be subject to regulation, but it is very difficult to manage food that children bring from home. The key to preventing food allergy attacks is teaching kids who have food allergies to carefully read food ingredient labels and refuse items if they do not know what the components are.

F. Animals and medicines: hormones, antibiotics, and medications

Drugs are often used to prevent and cure animal diseases, while hormones are frequently used to help cattle develop faster and more effectively. Animal medications are administered to 80% or more of the cattle and poultry in the United States during their lives. This comprises topical antiseptics, bactericides, and fungicides for the treatment of wounds and infections of the skin or hooves, as well as hormones and compounds that function like hormones to promote growth, antiparasitic medications, and antibiotics. Animal medications used improperly may leave residues in the organs and tissues that are used for human consumption. The FDA Center for Veterinary Medicine must approve a novel animal medicine on the basis of quality, safety, and efficacy before it may be commercialized in the US. Animal medication producers must demonstrate both the safety of the medicine for the animal and the safety of the food products obtained from the treated animals when the drug is intended for use in food-producing animals. The FDA establishes tolerances to ensure that the medicine won't have any negative effects on those who eat the food product. Together, the FDA and USDA monitor the use of animal medications, spot any inappropriate usage, and take appropriate enforcement action as needed.

The administration of medications to animals used as food raises two concerns. The first is drug residues seen in meat or milk from animals that have received animal medication. In sufficient quantities, some of these residues may be hazardous, carcinogenic, or allergic to people. The Use of Medicines in Food Animals: Advantages and Hazards, a 1999 assessment by the National Research Council, states that FDA programs that keep an eye on drug residues in animals are successful in shielding consumers from this risk. The health danger provided by drug residues is negligible since relatively few illicit drug residues have been found in meat, milk, or eggs.

The second issue, antibiotic medication residues in farm animals, is seen by many experts in food safety as being more serious. Farm animal antibiotics have two objectives. Initially, they are used in the same manner as in humans to prevent and cure illnesses. The second justification for giving antibiotics to farm animals is to stimulate growth and feed efficiency, which increases the amount of meat or milk produced with a given amount of feed. Given at levels lower than those needed to treat an illness, this is known as a subtherapeutic dose. Antibiotics are used sub therapeutically to suppress gut bacteria that prevent animals from absorbing nutrition. The prevention of infections also makes animals healthier and enables them to employ resources for development and production rather than fighting illnesses. One of the reasons why American food is so plentiful and reasonably priced is antibiotic usage.

Antibiotics used to destroy bacteria will eventually develop resistance. This is because most bacteria that antibiotics target do not always be completely killed. Always, a few will live and pass on their resistance to bacterial generations to come and, sometimes, to unrelated bacteria. The bacterial strain's genetic makeup eventually varies enough that the medication loses its effectiveness. Both infections that infect humans, like TB, and those that infect animals do this. Overuse of antibiotics is the most frequent factor in antibiotic resistance. There are two prominent exceptions to this rule, Campylobacter and Salmonella. Most bacterial illnesses that affect animals cannot be transmitted to humans. These two bacteria have already developed resistance to various medications, notably the fluoroquinolones that were formerly effective against them.

There is some evidence that the rise of fluoroquinolone-resistant Campylobacter and Salmonella in

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humans is related to the use of fluoroquinolone medicines in chickens and other food-producing animals. If diseases in farm animals develop resistance to antibiotics, there is a chance that, if those germs are transferred to people, they will also develop drug resistance. According to the NRC research, there is a connection between the use of antibiotics in food animals, the development of antibiotic-resistant bacteria in those animals, and the transmission of these infections to people. The paper continues, however, by stating that the likelihood of this occurring is very low and that there is insufficient evidence to establish whether the likelihood is increasing or decreasing. Alternatives to antibiotic usage for preserving animal health and production should be developed, the report's authors suggest. The FDA, USDA, and the Centers for Disease Control and Prevention collaborated to create the National Antimicrobial Resistance Monitoring System in January 1996, and it aims to collect more information on antibiotic resistance to explain the possible hazards.

G. Biologically based toxins

In addition to naturally occurring poisons, the food supply also includes manmade substances like pesticides. Scientists know relatively little about the toxicity and presence of these natural poisons in foods, compared to manmade compounds. We consume at least 10,000 times more of them than manufactured chemicals, making them a larger danger. Every meal has a complex blend of chemical ingredients, some of which are good for you like vitamins and minerals but also some of which are bad. If consumed in large enough doses, even vitamins and minerals may be harmful. A required vitamin like vitamin A, for instance, may be hazardous at doses as low as 15 times the RDA. To combat insects, microbes, grazing animals, and other possible threats, plants and animals evolved poisonous compounds.

The potato, one of the most popular meals in America, contains solanine, a very poisonous compound. The peel and the eyes of the potato have higher concentrations of this naturally occurring toxin than the flesh itself. Solanine doesn't make people sick in the levels that are typically consumed, but certain potato peels and eyeballs may contain enough solanine to make people sick and even die. The potato is protected by solanine, a natural pesticide, against the Colorado beetle, the leaf hopper, and other pests that attack potatoes. In another case, herbal teas are seeing a resurgence in popularity in the US. These teas are seen by consumers as a natural means of enhancing their health or healing illnesses.

Herbal tea compounds, however, have the potential to be fatal and have already been known to do so. Herbal teas are drunk at far greater rates than they were previously since they are marketed as the cure for a variety of chronic illnesses. This might have natural, but detrimental, adverse effects. The advantages and risks of herbal treatments are passed down from generation to generation in countries where their usage is deeply ingrained in tradition. The safety of just a small number of the plants used in natural herbal teas has been investigated or evaluated. Ephedra, sometimes referred to as Ma Huang, is one of them and is a prominent constituent in herbal teas touted as weight-loss aids. Ephedra is a substance similar to amphetamine that has the potential to have strong stimulant effects on the neurological system and heart. The Food and Drug Administration has received reports of more than 800 adverse occurrences linked to the use of ephedrine-containing products. They include high blood pressure episodes, irregular heartbeats, sleeplessness, anxiety, trembling, and headaches, as well as seizures, heart attacks, strokes, and fatalities. For those who avoid pharmaceutical medications, some people may not think twice about drinking herbal teas, even though some of them may have highly potent drug-like responses and negative physiological repercussions [4]–[6].

II. DISCUSSION

Products made from seafood may include naturally occurring marine toxins that pose specific food safety risks. Molluscan shellfish, which include oysters, clams, scallops, and mussels, are capable of absorbing toxins from the algae they consume, leading to paralytic, neurotoxic, amnesic, or diarrhoeic shellfish poisoning. The most dangerous of them is PSP, which may cause symptoms including tingling, burning, or numbness in the tongue or throat, paralysis, respiratory failure, and in extreme circumstances, death. Everywhere in the world during the warmer months, algae that generate these poisons may be found. Authorities from the state keep an eye on the harvest waters and stop shellfishing there if algae are found. The easiest way to manage these poisons is for people to only eat shellfish from waters that have been deemed safe since they are not destroyed by heat and cannot be seen physically [7]–[9].

By consuming smaller fish that have ingested toxin-forming algae, tropical and subtropical reef fish including grouper, barracuda, snappers, jacks, and king mackerel may collect ciguatera toxin. Humans who use ciguatera may have headaches, nausea, vomiting, or diarrhea. Scombroid poisoning, a form of foodborne sickness brought on by consuming marine fish species that have started to decay, has been linked to tuna, mahi mahi, bluefish, and mackerel. This happens when histidine, an amino acid, converts to histamine, often as a consequence of insufficient refrigeration. The signs and symptoms of scombroid include a rash, burning or peppery mouth and throat sensations, nausea, headaches, disorientation, and tongue swelling. Fugu, or puffer fish, is a highly regarded and perilous delicacy in Japan. The fish's internal organs build up tetrodotoxin, an exceedingly lethal chemical. Since incorrectly cooked fugu causes paralysis, respiratory failure, convulsions, and cardiac arrhythmia within 20 minutes, only highly trained and licensed chefs are permitted to prepare fugu fish. Death happens often.

Molds and mushrooms are examples of fungi, which also create poisons that are harmful to people. Mycotoxins are

poisons that molds create; the main mycotoxin-producing mold species include Aspergillus, Fusarium, and Claviceps species. Molds often develop on wet cereal grains including rye, wheat, maize, rice, barley, and oats or oilseeds, and as they go through their life cycle, they expel mycotoxins. As the majority of these mycotoxins are heat-resistant, cooking does not lessen their danger. The only approach to avoid intoxication is to keep the product clean throughout production processes including harvesting, drying, storing, and processing.

Several historical occurrences have been connected to a specific mold, Claviceps purpurea. Ergotism is a condition brought on by eating rye and other cereal grains infected with Claviceps purpurea. This illness, which has often affected up to 40,000 people simultaneously, was first noted in the Rhine Valley in 857 and has subsequently been reported on multiple occasions. Ergot contamination is especially prone to occur in the rye. Conditions for producing or storing grain that is cold and wet can aid in the production of ergot.

Lysergic acid diethylamide, along with many other ergot derivatives, is derived from ergot and is a hallucinogen. Ergotism may cause a variety of symptoms, including abnormalities of the central nervous system including muscular spasms, disorientation, delusions, convulsive fits, hallucinations, visions, a feeling of being in the air, and psychosis. Additional typical symptoms include prickly sensations in the limbs, acute feelings of heat and cold, and an increase in hunger in between fits. The Salem, Massachusetts, witch trials of 1692, according to Linnda Caporael and Mary K. Matossian, may have been caused by ergot poisoning. They connect the higher consumption of rye bread that could have been ergot-contaminated to the weather, agricultural, and economic situations in the years 1691 and 1692. Suspiciously similar to the signs of ergotism are the symptoms shown by persons who are suspected of being bewitched. Peter the Great's men and their horses ate rye infected with ergot, which caused hundreds to either die or go insane, forcing Peter to abandon his preparations to assault the Ottoman Empire in 1722.

The liver is the body's very effective system for eliminating numerous synthetic and natural toxins. Little amounts of various toxins may be safely excreted by the liver, allowing people to eat otherwise dangerous chemicals. Nonetheless, the body's defenses may be rapidly overwhelmed by huge doses of poisons and chemicals. While we often perceive naturally occurring molecules as relatively benign, several of them are really among the most poisonous poisons ever discovered.

Pesticides work to eliminate, control, or prevent pests. Any creature, including bacteria, viruses, rodents, worms, fungi, insects, or weeds, that harms plants, animals, or food is considered a pest. Herbicides, insecticides, fungicides, rodenticides, and disinfectants are all included under the umbrella word "pesticide," which is quite inclusive. Agriculture accounts for three-quarters of pesticide usage, although it is also used post-harvest, during transportation, and during storage to prevent the development of mold or bug infestation. Even though we may not consider home cleaners, pet flea collars, lawn and garden supplies, and insect repellents to be pesticides, they are. To safeguard our houses, pets, and the food we consume, almost 350 pesticides are utilized [10]–[12].

III. CONCLUSION

Food safety refers to the circumstances and techniques that keep food fresh and avoid contamination and food-borne diseases. To preserve consumer rights, there should be no such situation that might create major health difficulties. To safeguard customers and screen for food adulteration, a broad range of scientific approaches have been developed. A good diet not only promotes adequate physical fitness and lower susceptibility to illness but it has also been shown to promote brain development and scholastic accomplishment.

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Factors That Contribute to Foodborne Illness

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***Abstract*— A recall and destruction of more than a million pounds of meat. One youngster died after drinking fresh juice, while others were ill. 400,000 people in Milwaukee are ill with diarrhoea and vomiting. Salmonellosis affects 35% of nursing home patients, and four people die away. Raspberries have been linked to intermittent foodborne disease over the last three years. People becoming ill from food is a common topic in the news these days. In this chapter, we discussed the factors that contribute to the foodborne illness.**

***Keywordss*— Demographics, Food Consumer, Food Value, Food Safety, Foodborne Disease.**

I. INTRODUCTION

These days, both electronically and via the news media, news spreads quickly. Events and stories that were previously isolated now reach millions of people in a matter of hours. Diagnostic methods are continually being improved, allowing for the identification of illnesses, both foodborne and not, that were previously of unknown origin. Public health professionals, however, feel that the risk of foodborne disease has grown over the last 20 years, even after taking these data into account. How food is produced and consumed is changing as a result of changes in demography, consumer lifestyles and needs, and food production and economics. The microbial world is also developing. The variables affecting foodborne disease and food safety issues in the United States are discussed in the next few pages [1]–[3].

A. Demographics

As the U.S. population ages and the number of persons with compromised immune systems rises, a greater percentage of the population is at considerable risk of contracting a foodborne disease. Individuals' susceptibility to foodborne microorganisms varies. Hence, even if two individuals consume the exact same meal in the same quantity, one may become sick while the other does not. Infants, young children, the elderly, pregnant women, those using certain drugs, and people with illnesses like AIDS, cancer, and diabetes that compromise their immune systems are among those who are more likely to get very sick. This category includes 25% of Americans, and the proportion of this vulnerable demographic is expanding. Demographers anticipate that by 2025, the percentage of individuals over 60 in developed nations like the United States would increase from the current 17 percent to 25 percent. Due to the weakened immune system that comes with ageing, as well as the use of antibiotics and other medications, nursing home patients are more vulnerable to foodborne disease. This gives microorganisms an opportunity to establish a foothold. Compared to the general population, residents in nursing homes are more likely to die from foodborne diseases. According to a recent report, children under the age of five and elderly 55 and above accounted for 89% of fatalities with diarrhoea being the primary cause.

Although anybody may become sick from eating contaminated food, how sick they get and how long it takes them to get sick depends on a variety of factors. Age, the quantity of pollution ingested, and the person's health state are the three factors that matter most. The body has a variety of mechanisms in place to protect itself against dangerous microorganisms. Due to the fact that many bacteria cannot live in an acidic environment, the stomach's gastric fluids are one of the body's first lines of defence against foodborne pathogens. In comparison to older, healthy individuals and very young newborns, gastric juice production is decreased or becomes less acidic. By preventing pathogenic bacteria from populating the stomach, the normal bacteria found in the gastrointestinal tract provide another barrier to guard against foodborne disease. Antibiotics may thereby increase a person's vulnerability to foodborne disease since they eradicate all germs, regardless of whether they are beneficial or harmful. Pathogenic bacteria may more readily penetrate and cause sickness when the defensive bacteria that are typically found in the gastrointestinal system are absent. Last but not least, the human immune system, which is not completely developed at birth, gradually achieves maturity throughout puberty and then gradually starts to deteriorate after around 50 years of age.

B. Demand and consumer lifestyles

In the United States, life is moving more quickly. As we don't have enough time to make meals at home, we often eat on the go. This implies that by the time you consume your food, whether it is a meal from a restaurant or a quick supper, it may have been moved, cooked, chilled, stored, moved again, reheated, and handled by a number of people. It is possible for dangerous bacteria to survive and thrive throughout each stage of processing, which may eventually result in foodborne illnesses.

In 1998, two out of every three individuals ate their primary meal out from home at least once every week. Over the age of eight, consumers typically ate out at least four times a week. Every time you dine at a restaurant, you are

putting your faith in the staff there to properly manage your food. Every dollar spent on food in the United States goes towards food purchased from supermarkets, eateries, or institutions, accounting for 50 cents.

The probability of becoming sick rises when you include the abuse that goes place after a customer buys food and brings it home. Home-cooked food is the source of around 20% of reported incidents of foodborne disease. Specialists think that this figure is really considerably higher since most individuals fail to disclose illnesses brought on by home-cooked meals. Americans are making fewer meals at home, which also implies that parents are teaching their children less about cooking yet giving them more responsibility for doing so. Compared to earlier generations, young chefs now get less instruction in the art of cooking. This will have serious effects on food safety going forward. 86 percent of respondents in a poll on consumer food safety behaviours and understanding understood they should wash their hands before handling food, but just 66 percent said they really did so.

Just 67% of respondents said they cleaned or replaced their cutting boards after chopping raw meat or poultry. More senior individuals than younger ones engaged in safe practises. In an Australian study, there were significant discrepancies between what individuals claimed to do and what they really performed when researchers observed participants making meals while asking them questions about their kitchen practises and food safety. About half of those who claimed to wash their hands after handling raw meat really did not, and those who did often used water without soap. Just 19% of the homes that said they had soap in the kitchen really did.

Customers are expecting more and more items that are natural, fresh, and contain less preservatives. Modern all-natural and fresh goods are more perishable because they lack the usual preservatives and processing methods that stop bacteria development. Food preservation techniques, namely canning, freezing, and pasteurisation, not only increase food shelf life but also stop germs from growing, making food safer. For instance, there have been multiple outbreaks of foodborne illness linked to fresh apple cider. An E. coli O157:H7 epidemic that resulted in a child's death was linked to raw, unpasteurized apple juice produced by a business that prided itself on the naturalness of its ingredients. Only pasteurised apple juice is now used by this firm to make its goods. Although pasteurisation will destroy hazardous germs, proponents of fresh juice contend that it dilutes the flavour. The FDA updated its food labelling guidelines to warn customers about the danger presented by fresh, unprocessed juices. Fruit and vegetable juice products must include a label warning that indicates they have not been treated to prevent, minimise, or eradicate any potentially harmful bacteria.

People are adding fresh fruits and vegetables more often in their diet as their importance in a healthful diet has come to light. Americans consumed fresh food at a rate of 27% more in 1993 than they did in 1973. Along with this rise in consumption, there have been more occurrences of foodborne diseases linked to fresh vegetables. The frequency of outbreaks with known causes in which vegetables served as the food carrier has increased during the last 20 years. Also, since we desire produce all year round, we must import it to satisfy our needs.

The majority of vegetables in the United States only grow during certain seasons, yet our stores no longer provide this seasonal variety. A few examples of year-round foods are corn, berries, lettuce, peaches, and tomatoes, or at least for considerably longer than their growing season. More than 2,400 persons were affected by Cyclospora cayetanensis between 1996 and 1998 in 20 states and Canada. Raspberries brought from Guatemala were this people's sole shared food item. Basil and mesclun lettuce cultivated in the US has been linked to smaller Cyclospora outbreaks. Despite the fact that there are tests to detect Cyclospora in stool samples, there are currently no reliable methods to do so in foods. Public health professionals' recommendations to the general population are complicated by their inability to screen for the organism in food samples.

C. Production of food and economics

Foodborne disease outbreaks in the past were often minor and local. Local occasions like weddings, church meals, and other gatherings where many people shared the same food might be linked to illness. Most of the victims knew one another and lived in the same neighbourhood. Today, that image has altered for a number of reasons.

Food production has changed significantly since simply a few decades ago. Traditionally, food was harvested, made, and supplied locally. In comparison to earlier times, food production is today more concentrated and widespread. Mass quantities of goods produced in a single processing facility are transported throughout the nation and sometimes beyond. A processing error will not only be felt locally but also nationally. This is exactly what occurred in 1994 with Schwan's ice cream. According to research published in the New England Journal of Medicine, ice cream manufactured on certain dates at a Minnesota ice cream manufacturing factory caused an estimated 224,000 illnesses nationwide due to Salmonella enteritidis. Bulk ice cream ingredients were delivered to the factory by tanker truck from a number of vendors. The contamination of the ice cream premix during transit in tanker trailers that had previously transported unpasteurized liquid eggs, a known source of Salmonella enteritidis, was found to be the most probable cause of the epidemic. Processing plant recalls are becoming more widespread. Due to the presence of E. coli 0157:H7, Hudson Foods recalled 25 million pounds of ground beef in 1997 from their large Nebraska factory. This is a scale that was unheard of only a generation ago.

Even how farmers rear their animals might lead to a rise in food safety issues. Animals are often packed closely together,

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International Journal of Science, Engineering and Management (IJSEM)
Vol 10, Issue 2S, February 2023

which raises their stress levels and impairs their immune systems. Also, this overcrowding makes it easier for diseases to pass from one animal to another. A sick animal used to be quite separated from the rest of the flock or herd and wouldn't spread disease to others. Yet when animals come into touch, sickness may spread very fast.

Animals that we eat have a variety of diseases that may infect people via food. It is challenging to tell which animals are harbouring diseases and which are not since the pathogens do not make the animals sick. E. coli O157:H7-infected cattle exhibit the same levels of health as uninfected cattle. On how these animals get the diseases and how they spread them, nothing is known. The study of what animals eat and drink, and how that eventually affects people, is being added to the field of food safety research [4]–[6].

II. DISCUSSION

In the last 50 years, scientists have discovered four new foodborne diseases. Five times as many people are on the list today. Three of the four pathogens—Campylobacter jejuni, Listeria monocytogenes, and E. coli O157:H7—that the Centers for Disease Control and Prevention believe to be the most significant in causing foodborne disease were not even known to science twenty years ago. The origins of Cyclospora cayetanensis, which first surfaced in 1979, are still unclear. As laboratory methods advance, it is conceivable that scientists may find novel foodborne infections [7]–[9].

Pathogens are live things that are continually changing. Scientists are learning that certain germs persist in areas that were formerly assumed to be safe as they improve their capacity to track outbreaks. For instance, E. coli O157:H7, which was formerly known as "hamburger sickness" due to its association with undercooked ground beef, has been found in a variety of foods, including salami, apple cider, raw milk, and lettuce. Moreover, it may persist in conditions with a lower pH than formerly assumed, which causes outbreaks in foods high in acid, such as lami and apple cider. It is now known that Listeria monocytogenes and Yersinia enterocolitica may thrive and grow at low temperatures.

Recently, certain foods that were formerly thought to be safe have been linked to foodborne outbreaks. Years ago, experts thought Salmo- nella enteritidis was not a problem since the interior of an egg was thought to be sterile. Nevertheless, in 1989 it was revealed that hens with Salmonella infections may transmit this sickness to their eggs, resulting in the bacterium being present within the raw egg, making it dangerous to consume raw or undercooked eggs. Due to their awareness of this problem, experts in food safety now suggest using liquid pasteurised eggs or completely cooking eggs. This implies that raw egg-containing products including icings, egg beverages, ice cream, cookie dough, sauces, and salad dressings may have the bacterium. A private firm has created a method to pasteurise entire eggs still in the shell, making these raw items safe to consume once again.

One of the biggest epidemics in the United States was caused by the water supply rather than food. In April 1993, watery diarrhoea struck an estimated 403,000 persons in Milwaukee, Wisconsin. In the end, it was determined that the perpetrator was the one-celled parasite Cryptosporidium parvum, which was first known to infect people in 1976. Although cryptosporidiosis in healthy individuals only causes watery diarrhoea that lasts seven to fourteen days, in immunocompromised individuals it may cause severe chronic diarrhoea and even cause death. 4,400 persons were hospitalised during this epidemic. While previously discovered in surface water, it was not anticipated that treated water from a municipal water source meeting state and federal regulations for acceptable water quality would include Cryptosporidium. Increased testing for the parasite as a result of increasing awareness has shown, unsurprisingly, higher prevalence. In addition to outbreaks in drinking water, Cryptosporidium is linked to wave pools at amusement parks and swimming pools. Since Cryptosporidium is so resistant to chlorine and other chemical disinfectants, this is especially significant. This is a brand-new parasite with brand-new resistance skills that are emerging in brand-new habitats [10]–[12].

III. CONCLUSION

Foodborne illness will remain a serious worry for the foreseeable future, despite some significant national accomplishments in decreasing the levels of particular pathogens in foods as a consequence of improved farming methods, food processing laws, and so on. Bacteria have changed throughout time to resist efforts to eradicate them. Nowadays, certain microorganisms are evolving a resistance to popular antimicrobials. It is believed that using these antibiotics on animals may be the cause of the resistance. Foodborne microorganisms exhibit the same flexibility. Particularly in Europe, Salmonella typhimurium DT104 is often found in farm and wild animals and is resistant to several popular medicines. Parallel increases in the number of cases of this kind of Salmonella that is drug-resistant have been observed..

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Vol 10, Issue 2S, February 2023

History Of Food Safety and the Role of Food Preservation in Food Safety

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Abstract— Historical records reveal almost little regarding foodborne disease or food safety. The association between germs and illness was not fully understood by scientists until the late eighteenth century. Food spoilage was acknowledged, but the causes and likelihood of food-borne illness were not understood. Maybe the lack of food safety from historical accounts suggests that it was formerly less of an issue than other issues.

Keywordss— Food Safety, Foodborne Disease, Koch's Postulates, Non-Thermal Food Preservation.

I. INTRODUCTION

Even the first food laws were designed more to stop economic fraud than to make food safer. So, there isn't truly a history of food safety, but a number of discoveries, technologies, and regulations have contributed to the current understanding and state of things in the field. Many innovations that have improved food safety are covered in the section on food preservation in Chapter 1; the history of food regulations is extensively covered in Chapter 4; and further information on the history of food safety is included in Chapter 3's timeline [1]–[3].

Techniques for preserving food, including drying, smoking, freezing, marinating, salting, and pickling, date back thousands of years. It is unknown whether these methods were used just to preserve food for later use, to enhance taste, or for other purposes. Yet they also contributed to the safety of food. Even cooking may be seen as a traditional way to make food safer. Consuming sour rice, rotting fish or meat, food that has been left out too long, or food that has been undercooked is not advised, according to the Chinese Confucian Analects of 500 BCE. Uncooked food was detested by the Chinese because they believed that "anything boiled or cooked cannot be toxic." One of the first instructions on food safety was released in China. It's probable that drinking tea became popular because it needed hot water, which would be safer than using contaminated unheated water. Although they may not have known the reasons or ways to prevent foodborne illness, other ancient societies undoubtedly encountered it and offered suggestions for prevention.

Early scientists debated the nature of illness and microorganisms, which laid the groundwork for subsequent findings. A significant portion of the current understanding of the microorganisms that cause foodborne disease is based on scientific advancements made over the course of more than three centuries. Insects and animals were thought to emerge spontaneously from dirt, vegetation, or other animal species, according to Aristotle and his Greek philosopher/scientist forebears. Italian physician and poet Francisco Redi set out to refute this hypothesis in 1668. He disagreed with the conventional thinking of the time and thought that maggots didn't develop on their own in flesh. He filled eight flasks with meat, four of them were sealed while the other four were left exposed to the air.

The sealed flasks prevented flies from landing on the meat, preventing maggot growth. The obvious conclusion was that flies produced eggs that were too tiny to be seen, not that maggots spontaneously generated. Yet doubters remained unconvinced despite this. In 1768, Italian scientist Lazzaro Spallanzani refuted the hypothesis of spontaneous genesis. Redi's findings disproved the theory that insects evolved spontaneously, although experts continued to hold this belief. Spallanzani used long-boiling times to destroy any germs that could have been in the solution, on the flask's walls, or in the air within the flask. These solutions would often proliferate microbes. To stop any fresh spores or microbes from entering, he next sealed the flasks. No matter how long he left them standing, no germs developed. There was no spontaneous generation since no brand-new bacteria arose.

The idea that cleanliness is important and that unsanitary conditions can contribute to disease was born out of the discovery of bacteria in the late nineteenth century, the increased understanding of bacteria's role in disease, and the realization that there is a connection between human diseases and animal diseases. Ignaz Semmelweiss, a Hungarian physician, pondered in 1847 why, on average, women who gave birth at home did not experience fever during labor but those who gave birth in hospitals often did. He came to the conclusion that physicians were spreading sickness to the ladies because they moved directly from the surgery room to birthing moms. In those days, physicians didn't wash their hands; instead, they wiped them on aprons that had already been contaminated with bodily fluids.

Before entering the maternity wards, Semmelweiss had the physicians wash their hands with soap and water before

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rinsing them in a solution of lime chloride. Death rates decreased from 10% to 1.5% before rising once again once the tests were stopped. After that, he had physicians wash their hands before attending to patients. Regrettably, his work's legitimacy was not appreciated at the time. His coworkers laughed at his notion because they couldn't accept the idea that sickness might spread via their own hands. Instead, they blamed the fatalities on a phenomenon brought on by the pregnant women's "combustible" nature.

The mockery of Semmelweiss's beliefs and personal insults, according to historians, contributed to his final dejection. He was sent to a mental hospital, where he later passed away from blood poisoning. Even 150 years later, poor personal cleanliness is still one of the leading contributors to foodborne disease. Dr. John Snow illustrated in 1848 how cholera spread across London in a famous instance of epidemiologic detective work. He observed that those who drew their water from one well were more likely to fall sick than those who drew their water from a different well. He convinced municipal authorities to take away the pump handle from that specific well, forcing locals to use a different well to get water. The amount of cholera cases quickly decreased.

Louis Pasteur's research on fermentation and pasteurization in the 1860s and 1870s helped to clarify the relationship between microbes, illness, and deterioration. By publishing a three-volume dissertation on bacteria in 1872, German scientist Ferdinand Julius Cohn basically created the field of bacteriology. In addition to being the first to describe bacterial spores, he was the first to try to categorize bacteria into genera and species. Yet in order to do experiments and conduct research, this new science of bacteriology required microorganisms. It took Robert Koch until the 1880s to master the method for cultivating isolated bacterial strains in a lab. He initially grew the bacteria on flat glass slides. Julius Richard Petri, his assistant, recommended utilizing Petri dishes, which are shallow glass plates with covers. Koch also imposed stringent requirements for demonstrating that a certain germ causes a particular illness. Koch's Postulates are presently the name given to them. Scientists can identify germs that cause a variety of illnesses, including foodborne illnesses, using these criteria. The discovery that bacteria may reproduce sexually by Joshua Lederberg and Edward Lawrie Tatum in 1947 created a whole new area of study known as bacterial genetics.

The identification of microbes that cause foodborne sickness progressed slowly, despite the fact that Anthony van Leeuwenhoek, a Dutch scientist and microscope innovator, had improved the microscope to the point that tiny microscopic creatures could be seen for the first time as early as 1673. Trichinella spiralis was initially characterized by James Paget and Richard Owen in 1835. Friedrich Albrecht von Zenker and Rudolph Virchow, two German pathologists, were the first to describe the clinical signs and symptoms of trichinosis in 1860. Trichinella spiralis is a parasite of trichinosis, however, this link was not discovered until much later. Escherichia coli's non-pathogenic variant was identified in 1855. Later, it developed into a crucial tool for biotechnology research. William Taylor, an Englishman, demonstrated in 1857 how typhoid illness may spread via milk. Daniel Salmon, a USDA veterinarian, first identified a bacterium that, when consumed in tainted food, caused gastroenteritis and fever in 1885.

Salmonellae were finally given to the bacterium. In 1888, German scientist August Gärtner was the first to identify Bacillus enteritidis from a food poisoning case. When a cow with diarrhea was killed for meat, 57 persons who consumed the meat were sick as a consequence. The bacteria that cause botulism, Clostridium botulinum, was initially discovered by Belgian bacteriologist Emilie Pierre-Mare van Ermengem in 1895. The incident included a salty, raw ham that was served at a wake in Belgium. 23 individuals fell sick, and 3 of them passed away. Van Ermengem recovered C. botulinum from the victim's intestine as well as the ham. He showed how the organism develops in an atmosphere devoid of oxygen and how it creates the poison that causes the disease.

M.A. Barber proved that Staphylococcus aureus causes food poisoning through an enthusiastic use of the scientific process. During each of his three trips to a farm in the Philippines in 1914, he became sick. Barber brought two bottles of cream home, let them set out for five hours, and drank part of it. He then felt unwell with the identical symptoms he had on the farm two hours later. Barber suspected the cream originated from a cow with an udder infection. He removed a bacterium from the milk, put it in a milk container without any other bacteria, waited a time, and then persuaded two helpless volunteers to consume the milk. They all had the same symptoms of illness. The first time Clostridium perfringens was identified as a cause of foodborne disease was in 1945. Several of the most common foodborne pathogens today—Campylobacter jejuni, Yersinia enterocolitica, Escherichia coli O157:H7, and Vibrio cholera—were not discovered until the years between 1975 and 1985.

Throughout the beginning of time, humans have looked for methods to make food more wholesome and last longer. Foods will naturally include the environmental microbes that are prevalent everywhere and will develop and reproduce if no preservation method is used. By creating an environment that is unfavorable for them, preservation tries to either eliminate or prevent the development of hazardous bacteria in food. The drying of grains and subsequent storage in airtight silos are the oldest examples of food preservation that have been documented. To protect against hunger in the event that the Nile River flooded, the grain could be held in storage for a number of years. As early as 6000 BCE, people in different regions of the globe invented methods for drying and smoking food. Water is necessary for microorganisms to carry out their metabolic functions. Several commonly used preservation methods, including drying, smoking, and

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Vol 10, Issue 2S, February 2023

salting, aim to lower a product's accessible water content. Foods that have been frozen or made more acidic by fermentation or pickling also stop the development of microorganisms. Romans valued salting so highly that they paid their warriors with "salarium," or salt. This is where the word "salary" came from today.

In order to keep food safe for soldiers in the field, large-scale military deployments necessitated the development of increasingly sophisticated food preservation techniques. Napoleon decided to offer a reward for a better food preservation technique after realizing that armies do, in fact, move on their stomachs. Nicolas Appert, a French candy manufacturer, came up with a method for filling bottles with food, sealing them, and then heating them in boiling water for hours. In 1810, when Appert published his approach, he was ignorant of germs. Louis Pasteur and other researchers worked for another 50 years before they could explain how germs and food spoilage are related. The method for canning food is basically what Appert created. Over

The underlying principle of applying high heat hasn't changed despite several advancements in canning technology throughout the years produced by food experts. A can of beef from Captain Parry's 1824 voyage to the Northwest Passage that was opened 114 years later, in 1938, was still totally safe and delicious as proof of the longevity of canned goods.

The refrigerator, which is found in the majority of American households, is a gadget that is very helpful for keeping food safe. Despite the fact that refrigeration was invented in the early 1800s, house refrigerators were not widely accessible until the 1930s. At chilled temperatures, the majority of harmful bacteria either do not grow at all or develop extremely slowly. Yet, germs that ruin food—those that make it taste or smell bad—can develop in the refrigerator. While they make food of undesirable quality, spoilage microorganisms do not make people sick. The presence of spoilage microorganisms serves a useful function by preventing the consumption of potentially dangerous food. It took until the 1950s for freezing to completely develop, even in polar areas. By delaying the flow of molecules and putting germs into a latent state, freezing keeps food safe. As freezing prevents the development of the germs that lead to food deterioration and foodborne illness, frozen food is theoretically safe indefinitely. Freezing preserves food for long periods of time. Yet, the quality of frozen food swiftly deteriorates over time. For instance, when air touches food, dry, grayish-brown, leathery patches develop on the surface. Although a turkey maintained in the freezer for ten years may be dried down to nothing more than skin and bones, it would still be completely safe. One can only speculate about the caliber of the meal William Buckland, dean of Westminster, England, presented his unprepared dinner guests in 1799 when he allegedly fed them flesh from a freshly found frozen mammoth that was 100,000 years old.

Pasteurization is a well-known and widely-accepted way of securing food. Pasteurization is the process of heating food to a temperature for a certain amount of time in order to kill germs that might cause illness and/or food deterioration. The temperature determines how long the product has to be heated; higher temperatures need less time. In contrast to sterilization, certain spoilage microorganisms continue to exist. Louis Pasteur, the man who invented pasteurization, gave it its name. In the US, milk is the most popular pasteurized food item. Prior to milk being regularly pasteurized, it was a common source of TB, brucellosis, typhoid fever, diphtheria, and scarlet fever. It took thirty years for pasteurized milk in the United States to become widely accepted after its introduction in the 1880s. The only pasteurized food item sold in grocery shops is milk. Many well-publicized outbreaks of foodborne illness in the middle of the 1990s were linked to unpasteurized juice. Nowadays, pasteurization is used to preserve 98 percent of all juices in the US. Another item that has profited from pasteurization is eggs. Although it is believed that only one in 20,000 eggs are contaminated with Salmonella enteritidis, with an annual production rate of about 60 billion eggs, there are still close to three million infected eggs. The law requires that liquid, frozen, and dry egg products—eggs that have been separated from their shells for use in processed foods—be pasteurized. The most recent product to be pasteurized is eggs with their shells intact. To ensure that the nature of the egg is preserved, shell eggs are pasteurized using a combined water bath and hot air treatment for prolonged periods of time at relatively low temperatures.

Ultrahigh-temperature pasteurization is a more recent kind of pasteurization. The number of germs destroyed by a heat-based technique, such as pasteurization, depends on the temperature and the length of time the food is exposed to that temperature. For instance, cooking at a lower temperature necessitates keeping the meal there for a longer period. The meal can only be held at that temperature for a limited period when employing extremely high heat. UHT pasteurization utilizes this idea by applying a very high temperature for a very little period. This results in an almost sanitary product that has a longer shelf life and doesn't significantly alter the food's color, taste, or texture. Several nations process milk with UHT, allowing customers to buy cartons of milk that don't need refrigerated.

Drying, salting, smoking, and other methods of heat-based preservation, as well as pasteurization and canning, significantly affect the nutritional composition of the food. These procedures cause food's texture, color, taste, and nutritional value to decline. Consumers of today need food that looks natural, fresh, and as recently selected or butchered as feasible. People demand convenience while yet opposing the addition of preservatives and other chemicals to their meals. But, few Americans are prepared to buy fresh produce or meats every day. Several innovative methods are now in use or being developed to attempt to satisfy this desire for food with fresher, more organic attributes. The term "cold

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Vol 10, Issue 2S, February 2023

pasteurization" refers to several techniques that use electricity instead of heat to pasteurize food. These methods include high-intensity pulsed electric fields, irradiation, and ohmic heating.

Ohmic heating is one of the oldest uses of electricity to cook food. During this procedure, the food is continuously fed via an electric current that produces heat. Early in the 20th century, ohmic heating experiments were conducted. Foods with particles and thick liquids may both benefit from this processing technique. Another developing nonthermal approach is high-intensity pulsed electric fields. PEF, in contrast to ohmic heating, does not raise the temperature of the meal. PEF involves damaging bacterial cell membranes by introducing a brief burst of high voltage to food sandwiched between two electrodes. Potential applications for this procedure include juices, cream soups, milk products, and egg products—all of which undergo unfavorable modifications when heated.

Similar to canning, food irradiation is a process that was developed to make food safe for the military. The US Army started experimenting with irradiating fresh meals for deployed soldiers after World War Two. All radiation is energy in the form of waves that travel across space undetected. The kind of energy in a wave depends on its length. The energy of the wave rises as the wavelength decreases. Given that microwaves have a relatively long wavelength, their lower energy is sufficient to move molecules and generate heat via friction, but not sufficient to structurally alter the atoms inside the molecules. Ionizing radiation has a shorter wavelength than non-ionizing radiation, which gives it greater energy. This energy is sufficient to modify atoms by removing electrons from them to create ions, but it is insufficient to break atoms and turn exposed objects radioactive. Foods that have been irradiated are subjected to very powerful, brief invisible waves.

Irradiation has a variety of uses depending on the dosage. Modest dosages prevent insects and parasites from infesting food and postpone the ripening and sprouting of fresh fruits and vegetables. By destroying the genetic makeup of bacteria, medium dosages lengthen the shelf life of food and decrease spoiling as well as harmful germs. High dosages sterilize meat, poultry, shellfish, and prepared meals as well as disinfect certain food components, such as spices. In 1972, NASA started irradiating food for astronauts because, without access to medical treatment, a foodborne infection in space may be fatal. Similarly, to this, several hospitals feed their most vulnerable patients with irradiated food.

The FDA approves the procedure since irradiation is regulated in the United States as a food additive. Each new meal is given individual approval with a certain dose level. Upon FDA clearance, regulations are made. The rules for irradiating meat and poultry products are created by the USDA. In the United States, irradiation of eggs received the most recent approval in 2000. Irradiation of ready-to-eat beef and poultry products is now petitioned for approval. The radura and the phrases "processed with radiation" or "treated by irradiation" must be visible on irradiated food products. Food irradiation is now permitted in 40 nations, although it hasn't gained much traction in the United States.

High startup costs and concerns regarding customer acceptability of the procedure are the major causes of this. Many people believed that irradiation meant that the food would be radioactive when the technique was new. Consumers have learned that this is not the case as they have gotten more knowledgeable. Irradiation opponents claim that irradiating food causes chemical changes in the food. The technology's proponents respond that cooking food causes the same chemical changes. There is a need for irradiation goods as a result of recent outbreaks of E. coli O157:H7, Listeria, and other bacteria. Compared to meals that are heated to preserve them, foods that have been exposed to radiation keep their texture, color, and flavor better [4]–[6].

II. DISCUSSION

Another non-thermal food preservation technique involves evenly applying high pressure across a food product. This extends the shelf life of food by inactivating bacteria, spores, and undesirable enzymes. In this technology, Japan is at the forefront. Consumer demand has sparked a resurgence in interest in commercializing the procedure, even though this approach was first investigated towards the end of the nineteenth century. In contrast to normally cooked jams, jams created using high-pressure processing maintain the flavor and color of fresh fruit. Yogurt, salad dressings, and citrus juices are presently processed under high pressure. It might be utilized to make less processed meat and fish products, convenience meals with lengthy shelf life and fresh, natural colors, and higher-quality frozen foods. This method's primary flaw is how expensive it is to put into practice. The consumer's willingness to spend more for more natural food will determine how much will be used in the future [7]–[9].

In the process of "modified atmosphere packaging," oxygen is taken out of a food container and replaced with other gases, often carbon dioxide and/or nitrogen. Another kind of MAP is vacuum packing, which involves the removal of oxygen but not the addition of any other gases. Foods degrade and spoil as a result of oxygen's action as a spoiler in the environment. Hence, limiting or removing oxygen from packaging increases the product's shelf life.

The customers' preferred convenience food items are these. Nonetheless, there are potential risks associated with MAP products in terms of food safety. The aromas that would often alert customers that a meal is ruined are absent in MAP goods because oxygen deprivation inhibits the majority of spoilage microorganisms. Certain harmful bacteria, most notably C. botulinum, can thrive without oxygen. These bacteria may flourish if they are not competing with rotting bacteria for food and water. Manufacturers battle this by reducing the amount of water that is accessible in a meal, adding salt, maintaining a low temperature, and adding other gases like

carbon dioxide, which lowers pH. Customers need to realize that in order to keep these items safe, the appropriate temperatures must be maintained.

The primary component of sunlight that bacteria are destroyed by is ultraviolet radiation. Scientists are killing harmful germs using UV light. The technique is mostly used to eliminate pathogens in water systems. It is safer, more cost-effective, and less harmful to the environment than chlorination, and it doesn't alter the flavor of water as chlorination does. This method has the drawback of just acting on the surface since it doesn't permeate substances very deeply. High amounts cause items to develop off smells and aromas, whereas modest quantities may help meals last longer without losing quality. It is used in ice cream manufacturing facilities, meat and vegetable processing facilities, dairy plants, and facilities that sterilize packaging materials.

Natural antimicrobials are being used for food preservation as customers have grown more wary of chemicals and preservatives. This idea proposes a softer, more natural substitute for food safety. Natural antimicrobials by themselves are unable to fight bacteria due to their inherent gentler nature. However, when combined with other food preservation techniques, they may increase food safety without the use of conventional chemical preservatives like sorbate or benzoate, which consumers no longer see as natural and healthful. Many antibacterial chemicals may be found in nature. Those utilized in food preparation come from either microbes or plants. Yeasts, bacteria, and mold have long been inhibited by the use of spices and herbs. Yet, the essential oils, organic acids, and phenols that are included in spices and herbs make them more potent than they are on their own. Instead of employing the whole spice or plant, scientists are attempting to use these active ingredients [10]–[12].

III. CONCLUSION

Microorganisms create substances as part of their life cycle that have an impact on the development of other microbes nearby. Several of these substances prevent microbial development in order to provide the generating organism with a competitive advantage. The most significant of these natural antimicrobials are lactic acid bacteria. From ancient times, lactic acid bacteria have been utilized in the fermentation of foods like cheeses and sausages. The advantage of being controlled as widely recognized as safe compounds is another benefit of many natural antimicrobials.

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A Brief Overview of The Issues in Food Safety

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Abstract— The dispute around one specific product, bovine somatotropin, is discussed in this chapter along with the controversy surrounding genetic engineering as it relates to agricultural and food goods. Food irradiation is also investigated since it still sparks discussion, although less often than in the past. The discussion of pesticides and water quality is centred on food safety rather than environmental concerns. Lastly, the chapter discusses food safety problems in restaurants since dining out has become such a significant part of our life.

Keywordss— Food Allergies, Food Safety, Food Issue, Foodborne Disease, Food Biotechnology..

I. INTRODUCTION

Several terminologies, including food biotechnology, frankenfoods, agricultural genetic engineering, genetically modified organisms, transgenic, and genetic engineering, have been used to describe genetic engineering methods used to produce agricultural goods, both plant and animal. It is the subject for the new century, whatever name it goes by. Simply put, genetic engineering involves changing an organism's genetic makeup. The discussion is anything from straightforward. Customers, scholars, and governments from all over the globe have strong feelings about it. A naive perspective would hold that although businesses, academic institutions linked with and supported by industry, and the American government promote genetic engineering, grassroots consumer groups, organic farmers, religious organisations, and Europeans reject it. The American consumer is caught in the middle, seduced by the promise of affordable food costs and enhanced foods, terrified by new technology, manipulated by the media, and perplexed by contradicting scientific studies. Both sides of the debate may offer a large number of well-known specialists who back their positions with research [1]–[3].

The contentious techniques of contemporary food biotechnology rely on the insertion of genes from one species into another in an effort to convey a desired trait. Deoxyribonucleic acid, the molecule that contains a cell's genetic information, is transferred from one microbe, plant, or animal to another by the use of a process known as recombinant DNA. In contrast to conventional plant breeding techniques, this enables the development of plants with traits from other plants or even animals. In 1998, the United States produced 25% of maize, 38% of soybeans, 45% of cotton, and 42% of canola that had undergone genetic modification.

A. Regulation

Most novel foods, novel food additives, and animal feed are governed by the Food and Drug Administration. The FDA decides whether genetically modified food is safe to consume. The Center for Food Safety and Applied Nutrition and the Center for Veterinary Medicine are both in charge of FDA's biotechnology regulations. The FDA decided in 1992 that biotech-produced foods will be subject to the same assessment and approval procedures as other new food items. Federal rules assess the final product rather than the manufacturing process. As with other novel foods, the FDA assesses new food biotechnology products for their individual safety, allergenicity, and toxicity in accordance with the Federal Food, Drug, and Cosmetic Act.

One of the first food biotechnology products to be subject to FDA regulation was Calgene's FlavrSavr tomato. Very trace levels of a protein not typically seen in tomatoes were created by an antibiotic marker employed in the genetic engineering of the tomato. Given that it was a material unique to tomatoes, the FDA treated this novel protein as a food additive and regulated it accordingly. The FDA wants to tighten its pre-market examination of genetically altered foods in part as a result of the substantial public feedback received during public outreach sessions in 1999.

Foods created using biotechnology must be labelled accordingly under current U.S. labelling rules if a recognised food allergy has been added, the food's nutritional value has changed, or the product's composition has been significantly modified. Products that include any of the eight most common food allergens—milk, eggs, wheat, fish, shellfish, tree nuts, peanuts, and soy—must be labelled in order to safeguard customers who have food allergies. All new food items, biotech goods, and conventional products are examined by the FDA for the existence of these allergies.

The Animal and Plant Health Inspection Service is the U.S. Department of Agriculture's main biotechnology agency. The field testing of agricultural biotechnology crops is governed by APHIS. The safety of growing genetically modified plants is determined by APHIS. Biotechnology plants that manufacture pesticides to defend themselves against insects and other pests are within the authority of the Environmental Protection Agency, the federal agency that oversees pesticides. EPA evaluates the environmental safety of genetically modified plants. As it kills pests, Bacillus

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thuringiensis is classified as a pesticide and was certified for use by the EPA in 1996.

B. The evidence vs. food biotech

Genetic engineering, as defined by opponents of food biotechnology, is the alteration or disruption of the genetic blueprints of living things. According to them, customers are now being used as test subjects in a sizable genetic experiment and it is fundamentally unpredictable, risky, and riddled with ambiguities. They cite the FDA's utilisation of the findings of industry-sponsored research rather than its own investigations to determine the safety of GE foods as an example of weak government regulation. The argument put out by opponents is that the state of knowledge at the moment makes it difficult to foresee the long-term consequences of unleashing new species into the ecosystem. These novel organisms have the capacity to interact, procreate, and pass on newly acquired traits to unanticipated species. These new species, whether they be bacteria, viruses, plants, or animals, once they are out, cannot be controlled. There are several instances of how people have changed ecosystems with unforeseen and unfortunate outcomes. Scientists that are opposed to the new technology assert that because private firms already pay more than half of university research departments, providing findings that these businesses don't like is unlikely to lead to more financing. Human health, environmental, and economic risks are the three categories into which opponents categorise the dangers of genetically altered products.

C. Health risks to humans

The majority of food allergies are brought on by certain proteins in food. Some proteins may trigger abrupt death in certain persons because they are so sensitive to them. Food allergies may affect up to 6% of children and 2% of adults; if a foreign protein that causes these allergies were spliced into a meal, the implications might be disastrous. New proteins are produced as a consequence of gene transfers in genetic engineering. Opponents contend that it is impossible to tell if the proteins created by these genes will induce allergic responses since the majority of the genes added to food items originate from sources that have never been a part of the human diet. It is likely that many individuals may consume meals to which they would respond if a protein were added to food where it doesn't ordinarily occur. They assert that it would be difficult for individuals to avoid items that may precipitate an attack under the existing labelling regulations for GE foods. Opponents use the instance of GE soybeans, which had a gene from a Brazil nut inserted into its genetic composition in order to boost the soybean's protein content, as an illustration of the potential risks.

One of the most frequent foods to which individuals are allergic is nuts. When these novel soybeans were examined using blood serum samples obtained from people with nut allergies, the results showed that they would have had an allergic response had they ingested the soybeans. Many who are against GE food contend that it may yield unanticipated chemicals. A plant may create increased levels of toxins that it currently produces in modest doses as a result of this genetic manipulation, or it may activate genes that might result in the production of a completely new toxin. They make reference to Dr. Arpad Pusztai's studies with GE potatoes that have snowdrop plant DNA inserted into them.

When given to experimental rats, the GE-snowdrop potatoes caused harm to their immune systems and key organs because they were chemically different from conventional potatoes. Opponents of the technique have also brought up the issue of L-tryptophan, a well-known nutritional supplement made by the Japanese business Showa Denko. The business created a method for genetically modifying bacteria to manufacture L-tryptophan in higher concentrations than normal. After utilising the substance, more than 1,500 individuals became sick, and 37 of them died away. While the specific reason is still unknown, some experts think that the GE bacteria-made supplement may have included trace levels of an extremely hazardous substance that is not often present in conventionally manufactured L-tryptophan.

The possible decline in quality and nutrition of GE foods is another area of concern. The negative phytoestrogen chemicals, known to help prevent cancer and heart disease, were found to be lower in GE soybeans than in conventional soybeans, according to research by Dr. Marc Lappe. Another possible risk is antibiotic resistance. An antibiotic resistance marker gene is a marker gene that gene engineers use to determine if gene splicing was effective. According to some studies, these ARM genes may unintentionally interact with harmful bacteria in the environment and pass on this trait of antibiotic resistance to those bacteria. The conventional antibiotics that are now available on the market could not treat these novel germs if they were to infect animals or people.

Food residues from pesticides will grow as a result of increased pesticide usage, which is another reason against food biotechnology. Several experts cite research that demonstrates GE crop growers use at least as many herbicides and insecticides as traditional farmers. Being resistant to certain herbicides is one of the key traits included via genetic engineering into crops. This approach is so common that in 1998, herbicide-resistant crops made up 71% of all GE crops planted globally. In order to increase the quantity of pesticide that farmers purchase from the corporations making these herbicide-resistant plants, they make them resistant to the herbicides that they produce. One of the deadliest plant killers on the market, Roundup, is resistant to a GE soybean that Monsanto makes. Roundup may be sprayed on a field of Roundup-resistant soybeans to destroy everything except the soybeans. It will be essential to apply more Roundup to crops when weeds develop resistance to it.

ISSN (Online) 2456 -1304
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Vol 10, Issue 2S, February 2023

D. Environment-related risks

Opponents are concerned that pollen from GE foods will be spread to fields with conventional or organic crops by wind, rain, insects, and birds, "polluting" such areas. Due to the near impossibility of eradicating GE crops once they are introduced into the environment, this genetic pollution will permanently contaminate conventional crops. Pollinators like bees have the ability to collect pollen from GE plants and transport it over long distances, cross-pollinating even far-off traditional crops. This kind of cross-pollination cannot be managed. According to a 1999 study, scientists planted a field of sterile oilseed rape plants up to 2.5 miles distant from a crop of conventional oilseed rape. Any seeds that were generated had to be the consequence of cross-pollination with the GE field since the test plot plants were all sterile. Five percent of the flower buds on the test plants had been pollinated, the researchers discovered. The spread of pesticides from fields with pesticide-resistant crops to fields with normal crops is connected to genetic contamination. Products like Roundup have a tendency to disperse, killing soybeans in nearby areas that have not been planted with Roundup-resistant varieties. The farmer who is not using such technology is compelled to do so. Living things often and readily exchange genetic material.

Food biotechnology opponents are concerned that herbicide-resistant GE crops would ultimately pass on those resistance genes to the exact weeds and pests that they were bred to be superior to, generating "superweeds" and "super pests," which they call "superweeds" and "super pests." Anti-GE literature includes research that indicates herbicide-resistant rapeseed transfer resistance traits to wild mustard plants, requiring larger and higher dosages of herbicides to control these "superweeds." Weeds and insects gradually become resistant to the pesticides employed to control them as a natural sequence of events. Weeds will sooner become resistant to Roundup because farmers will use it more often. Opponents worry that farmers would have even fewer options to control weeds in their fields because they will need to use more and more Roundup until it becomes completely ineffective. Another illustration of this risk is the soil bacteria Bacillus thuringiensis, which generates a natural toxin that organic farmers utilise as a biological pest management strategy.

Only select insects, particularly caterpillars, have digestive tract enzymes that may activate the toxin in naturally existing Bt bacteria. The Bt toxin gene has now been incorporated into crops, giving them an inherent pesticide. The Bt toxin is constantly generated in GE crops, unlike in the past when farmers would only sometimes use it when they had an infestation. Insects are thus continuously exposed to the Bt toxin, which shortens the time it takes for them to acquire Bt resistance. The majority of the target insects will acquire Bt resistance within three to five years, according to researchers who think some insects have already evolved the resistance. The Bt toxin found in GE crops has a slightly different form than the natural toxin, which raises the possibility that it might kill a larger variety of insects, including those that are helpful.

Some researchers are concerned that gene splicing will unavoidably lead to unexpected and harmful surprises since our grasp of molecular genetics is still in its early stages. The question being investigated is whether genetically modifying plants to tolerate certain viruses and diseases may result in those viruses and pathogens mutating into new and/or more potent forms. Introducing GE plants into an area might ultimately cause the native species to become dominant, much to how the introduction of alien species tends to lead to the decline of native species. Opponents assert that GE salmon would outcompete native kinds and lead to their extinction if put into ecosystems because they are larger and more resilient than the wild forms. This genetic bio-invasion may trigger a number of unanticipated environmental outcomes.

E. Social and economic risks

The lack of the promised advantages of higher agricultural yields from GE crops is criticised by opponents. They cite instances of significant crop failures caused by GE crops as proof that the plants don't perform as promised. Bt cotton was intended to be 90 to 95 percent effective against the bollworm when it was seeded in the southern United States in 1996. However, it's estimated that the plants were only 60% effective, and the area had a serious bollworm infestation that required emergency pesticide treatment to control. Studies suggesting that GE crop yields are really lower than those of traditional types are cited by opponents.

The FlavrSavr tomato, which was the first genetically modified product to be authorised for sale in the United States in 1994, is another illustration of this. It was intended to mature longer on the vine and be tough enough to endure plucking while being packed and transported. Nevertheless, the tomatoes were often mushy and damaged, which prevented them from being sold as fresh. The FlavrSavr briefly emerged on the US market before going out of existence.

Companies that produce seeds have begun creating sterile seeds that have undergone genetic modification. This implies that farmers cannot keep the seeds that the plants generate to grow the crop the following year. Farmers are compelled by this "terminator technology" to purchase fresh seeds every year, which many cannot afford. Opponents fear that businesses may create crops that need certain chemicals to thrive or germinate, forcing farmers to rely once again on the businesses that provide such chemicals. Farmers would be forced off their land, according to opponents, and a small number of multinational companies will control consumer food preferences [4]–[6].

Lastly, opponents contend that modifying plants and animals via genetic engineering robs them of their purity and holy traits and turns them into nothing more than another manufactured good, similar to a chair or a vehicle. They

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contend that the whole concept of food biotechnology upholds the notion that nature should be exploited, ruled, and made to produce more. These opponents advocate for the labelling of goods containing genetically modified ingredients so that consumers may avoid them by using their "right to know."

II. DISCUSSION

Food biotechnology proponents underline that modifying an animal's or plant's genetic composition is nothing new. By breeding, humanity has been using this method for centuries. The modern crops we consume such as rice, maize, apples, pigs, and chickens—have nothing in common with their wild, native forms. Breeders have prioritised or eliminated unwanted features while choosing and promoting favourable ones. Nature uses genetic engineering regularly to improve and modify organisms to better fit their surroundings. Food biotechnology used now is just a development of conventional farming practices. Supporters argue that modern genetic engineering poses no new safety risks because almost all of the foods we consume have been genetically altered over time, either by nature or by science. The production of genetic variety is constrained by conventional methods of breeding plants and animals. The ability of arctic fish to survive cold may now be transferred to food crops, making them frost-resistant. Genetic enhancement is what advocates of the technique refer to as genetic modification. The advantages of genetically altered goods are classified by their proponents into three categories: socioeconomic, environmental, and human health [7]–[9].

Human health benefits

The benefits of recently introduced products, according to their supporters, include improved flavour and freshness, increased nutritional value, and a decrease in the amount of saturated fat. They give the following benefits of food biotechnology to consumers as examples: Lycopene-rich tomatoes are believed to lower cancer risk. Soybeans have undergone genetic modification to contain fewer saturated fats. Cooking oils that have a more healthful fat content Peanuts and rice with improved protein content Fruits that are genetically engineered to produce vaccines for diseases. Potatoes with a higher starch content, thereby reducing the amount of oil absorbed during the production of french fries and potato chips Plants with reduced levels of natural toxins Fruits and vegetables fortified with higher levels of vitamins such as C and E.

Proponents agree that allergenicity is a key issue in food biotechnology. They see food biotechnology as being able to help people with food allergies by minimising or eliminating proteins in foods that cause allergic reactions. They point to a low-allergen form of rice developed in Japan as an example of how biotechnology can minimise the effects of food allergies. Proponents cite the same example of the discovery that the Brazil nut gene inserted into soybeans would cause an allergic reaction in some people as evidence that the system is working. Testing revealed the product was unsafe, so it was discontinued. While opponents of the technology criticize government actions concerning regulation, supporters feel the government is setting stringent food safety standards. Consumers can be confident that GE foods are safe and properly labelled so that those with allergies can avoid eating foods that will cause allergic reactions [10]–[12].

III. CONCLUSION

Countering opponents' claims of lack of research into the safety of these products, advocates cite years of research indicating that the benefits of agricultural biotechnology far outweigh any risks. Proponents claim that the scientific consensus is that risks associated with food-biotechnology products are the same as for other foods. They point to years of research and the absence of harmful evidence as indicators that biotech foods are safe. As for the L-tryptophan case, it is now thought that the problems came not from the genetically modified bacteria, but rather from impurities in the growth medium. Those in favour of food biotechnology consider the research by Dr Arpad Pusztai with GE potatoes to be flawed, poorly designed, and incapable of leading to meaningful conclusions. Supporters state that the chances of unintentionally transferring a naturally occurring toxin or other dangerous substance are greater with conventional plant breeding than with genetic engineering. They claim that modern biotechnology methods that target a single gene are more precise and predictable than traditional breeding techniques that transfer hundreds of genes.

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Food Irradiation Technology Evolution to Reduce Harmful Microorganisms

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Abstract— Irradiation of food is not a recent innovation. After World War II, President Eisenhower's "Atoms-for-Peace" strategy marked the start of research in earnest. The Atomic Energy Commission and the U.S. Army conducted a large portion of the early research. The Food and Drug Administration authorized the use of food irradiation for the first time on a commercial scale in 1963 to get rid of insects in wheat and flour. Because of worries about its safety, food irradiation has been slowly introduced on a large scale in the United States. The importance of pathogens as a source of food safety concerns has rekindled interest in food irradiation..

Keywordss— Food Soilage, Food Safety, Foodborne Disease, Radioactive Media, X-Ray Irradiation..

I. INTRODUCTION

Irradiating food is a technique for reducing the number of harmful or spoilage microorganisms in food and agricultural products. Irradiation employs gamma energy, electron beams, or X-rays for processing instead of heat or chemicals. It's also known as "cold pasteurization" at times. Similar technology is used to sterilize medical tools and equipment so they may be implanted and used in surgery without running the danger of contracting an infection [1]–[3].

Depending on the radiation dose, there are several applications for food irradiation. Mold, vegetable sprouting, insect pests, bacterial infections, and, at the highest dosage, food sterilization may all be controlled with it. Irradiation may be used in place of chemical fumigation at low dosages to kill insects. Modest dosages have been used to prevent potato sprouting and mold development in strawberries, extending the shelf life of both items. Tropical fruit from Hawaii was radioactively treated before being sent to the mainland between 1995 and 1999, amounting to over 800,000 pounds. As a result, there was no longer a need to fumigate them in order to get rid of fruit flies that would spread to the mainland. Spices are the product that has undergone the most irradiation, accounting for around 25% of the global spice trade. Irradiation is now being promoted in order to eradicate germs and parasites that may otherwise result in foodborne sickness. Almost seven million times more radiation than a chest X-ray is required to destroy Salmonella in poultry. Food that astronauts consume in space is irradiated by NASA. Their food has undergone sterilization-level irradiation.

Three distinct irradiation techniques use gamma rays, electron beams, and X-rays, respectively. The first technology makes advantage of radioactive material's radiation. This might be either a radioactive form of cobalt or a radioactive form of cesium. Gamma rays, which are high-energy photons that are released by these compounds, may penetrate food up to a depth of several feet. These specific compounds do not radioactively affect anything in their immediate vicinity. For more than 30 years, this method has been regularly used to sterilise home, medicinal, and dental goods. It is also used in radiation therapy for cancer.

E beams, sometimes known as electron beams, are created distinctly. A stream of very energetic electrons known as the "e-beam" is released from an electron cannon. A bigger version of the mechanism that fires electrons onto the TV screen at the front of a TV tube to illuminate it is this electron gun contraption. It is easy to turn on or off the electron beam generator. There is no radioactivity present. Food must not be thicker than that since electrons can only pierce food up to a depth of around an inch. Food that is twice as thick may be treated with two opposing beams. Since at least 15 years ago, e-beam medical sterilizers have been in use.

The most recent innovation is X-ray irradiation. This is a branch of e-beam technology that is still being worked on. The X-ray machine is a more potent version of the equipment used to capture X-rays in many hospitals and dental offices. A thin gold or other metal plate is struck by an electron beam to create the X-rays, which result in a stream of X-rays emerging from the opposite side. X-rays, like gamma rays, may penetrate dense materials. The gadget, like X-rays, can be turned on and off, and there are no radioactive materials present.

Microbes are killed by irradiation causing Genetic damage. Since they contain more DNA, larger organisms like parasites and insects are more vulnerable to radiation. As bacteria contain less DNA than human cells, a larger dosage is required to kill them. Viruses are often resistant to irradiation at the dosage permitted for use in foods because they are very tiny and contain very little DNA. Not every food can be radioactively sterilized. Certain goods, like eggs and shellfish, lose quality before it becomes acceptable to consumers. The flavour and texture of food are some of the other qualities that are altered by irradiation. Similar to

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Vol 10, Issue 2S, February 2023

normal cooking, the effects become more noticeable as the dosage is increased.

The FDA and USDA are in charge of deciding if irradiation is safe, establishing the maximum dose levels, and authorizing packaging components. A precise maximum dosage for that food is established when FDA and/or USDA approve the irradiation of a particular food product. Moreover, packaging materials that will be exposed to radiation alongside the food product must be authorized. The Department of Transportation is in charge of assuring the safe transit of radioactive materials, while the Nuclear Regulatory Commission is in charge of ensuring the safety of the facilities themselves. The FDA division that oversees medical X-ray equipment also keeps an eye on e-beam and X-ray sources. Irradiation regulation may also fall within the purview of state authorities.

A. The case in support of radioactivity

The technology to irradiate food to make it safer has been there for decades, but individuals opposed to it kept the legislation in limbo. The 1994 deaths of four children who ate hamburger meat tainted with E. coli O157:H7 from a fast food restaurant sparked the present rush of effort in support of food irradiation. Adding fuel to the flames was the 1997 recall of 25 million pounds of hamburger meat from a large Nebraska meat processing facility.

The safety of irradiated meals has allegedly been investigated by feeding them to both humans and animals, according to proponents of the practice. These large investigations include long-term studies on animal nutrition including a variety of species, including mice, rats, and dogs. These well-controlled experiments have not shown any indication of harmful health impacts. Around three milligrams of unique radiation per kilogram of food, or three drops in a swimming pool, are produced by irradiating food. Even anything hazardous, which these compounds aren't, wouldn't be harmful at that concentration. While they are in space, NASA astronauts consume food that has been sterilized by radiation to the maximum extent possible. The nutritional value of irradiation foods and non-irradiated foods are similar, according to research cited by advocates of irradiated food. Thiamin levels are somewhat lower, but not by enough to cause a vitamin deficit.

Proponents of irradiation stress that it is not a replacement for proper hygiene. The food that is to be irradiated must already be clean for irradiation to be effective. More initial contamination would need a larger dosage of radiation to get rid of any potential germs, and the food would alter in flavor and quality more. Hence, irradiating subpar or ruined food will produce a product that is inferior after irradiation and therefore unmarketable. Irradiating wholesome, hygienic food is in the best interest of business. Irradiation is only one weapon in the armory used to combat foodborne diseases, adding an additional layer of protection to food.

In this nation, medical sterilizing facilities have been in use for more than 30 years without experiencing a tragic mishap. These facilities, as well as at least as many bone marrow transplant facilities and medical radiation therapy facilities, are presently licensed. There are no known incidents in this nation that exposed the general public to radioactivity. Cobalt 60, used in the majority of irradiation facilities, degrades by 50% over five years. Solid cobalt is kept in long cobalt "pencils" that are transported back to a nuclear reactor to be recharged.

Advocates are certain that if Americans understood irradiation better, they would embrace it. They have conducted polls that show people will support the procedure if they are informed about it upfront. Food is put within a shielded chamber, an energy source is given, the food absorbs the required quantity of energy to achieve the desired result, and the food is then taken out of the chamber and is instantly prepared for further processing or consumption. The aforementioned description might as well apply to traditional oven cooking as it would to high-tech food irradiation. An ordinary kitchen oven would serve as the "chamber," and gas or electric heat would be the "energy source." From the description, it only seems to be a "high-technology" procedure.

B. The Case against radioactive media

Food irradiation opponents assert that the nuclear industry, food processors, and agribusiness are pushing the practice on consumers. Opponents argue that the Department of Energy, the Nuclear Regulatory Commission, and the International Atomic Energy Agency are just using food irradiation as a public relations gimmick to portray nuclear power as safe and effective, citing a 1997 CBS poll that found 73 percent of Americans opposed food irradiation and 77 percent said they would not eat irradiated food. Similar to other biotechnology-related concerns, the food business actively engages in pushing Congress to enact legislation that benefits it. Political action groups from the food business donated $1,736,112 to the Democratic Party from 1995 to 1998 and $6,154,749 to the Republican Party. Also, the food sector makes large contributions to particular members of Congress whom it actively encourages to adopt its pro-irradiation stances. Food irradiation is still opposed by many who believe the hazards exceed any potential advantages.

The distinctive radiation products created throughout the irradiation process are what individuals who are against radiation most worry about in terms of their health. They worry that these brand-new substances haven't yet been named, much less put to toxicity testing. Irradiation, according to critics, destroys vital minerals and vitamins A, B, C, E, and K, with losses of 20 to 80 percent not unusual. Moreover, "superbugs" might evolve from viruses and bacterial spores that were not destroyed by irradiation. A non-pathogenic bacteria called D. radiodurans, which can endure very high doses of radiation provides evidence for this possibility. Opponents of radiation assert that radiation-resistant strains of Salmonella have been created in laboratories [4]–[6].

II. DISCUSSION

Irradiation opponents assert that there hasn't been any extensive research done to look at how eating irradiated food affects your health and that the few that have been done have shown negative results. They claim that the FDA itself has acknowledged that the safety-supporting studies were insufficient. Opponents point out that many of the studies demonstrating the safety of irradiation were carried out either on animals or in test tubes. While no human studies have been conducted, we are going to start very significant human research by putting irradiated goods on the market [7]–[9].

Consumer advocacy organizations that formerly opposed food irradiation for health reasons are now concentrating on the risk to irradiation plant employees. According to the Nuclear Regulatory Commission, since 1974, there have been 54 mishaps at 132 radiation facilities. They assert that the nuclear business intends to transfer the cost of nuke waste from the development of weapons to the general public. They acknowledge that cobalt 60 is now utilized, but assert that since it is scarce, the industry will instead employ cesium 137, a byproduct of nuclear power reactors [10]–[12].

III. CONCLUSION

Several organizations oppose irradiation because they think food processors will utilize technology to sterilize food produced in unhygienic conditions. They cite dirty farms, filthy slaughterhouses, and imported food manufactured with low sanitary standards as the primary culprits of unclean food. Feces cannot be kept out of meat products due to current large-scale production procedures that confine animals in unhygienic environments throughout the stages of growth, transportation, and slaughter. The organizations believe that rather than using irradiation to mask these issues, they should be resolved.

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Harmful Effect of the Pesticide Residues on Foods

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***Abstract*— Pesticide residues in food are covered in this section. Pesticide residues are traces of pesticide active ingredients and metabolites that remain on food after they have been applied on the farm or after harvesting handling, such as any specified derivatives that include degradation and the conversion products, metabolites, reaction products, and impurities that are toxicologically significant. Both environmental concerns and the health of people engaged in applying pesticide residues to crops are not taken into consideration. The health implications of food exposure to pesticide residues are a concern.**

***Keywordss*— Food Quality, Food Safety, Foodborne Disease, Pesticide Residues, Pesticide Regulation.**

I. INTRODUCTION

When a major television program featured a study tying Alar, a chemical used to regulate apple ripening, to childhood cancer, public concern over pesticide residues in food reached its apex, and it galvanized the public. In the annual Trends: Consumer Attitudes and the Supermarket poll conducted in 1989, during the height of the Alar crisis, 82 percent of customers regarded pesticides as a major concern. After then, the proportion continuously decreased, reaching 66% in 1997.

Pesticide regulation was changed as a result of the 1996 Food Quality and Protection Act due to more studies tying pesticides to cancer in laboratory animals and claims of inadequate government oversight of pesticides. The 1993 National Research Council study, Pesticides in the Diets of Infants and Children, is particularly noteworthy. The U.S. Congress asked NRC to investigate the scientific and ethical problems of pesticides in young children's meals. The federal government's capacity to evaluate risks and safeguard young children from potentially dangerous pesticide residues in their meals was questioned by the 14-member panel of specialists in pediatrics, toxicology, statistics, food science, nutrition, child growth and development, and epidemiology.

One of the primary complaints was that the government doesn't take into account how different babies and kids are from adults, particularly when it comes to their sensitivity to pesticides and their exposure to them. Children are not simply "little adults"; due to physiologic differences, certain pesticides affect children more severely than others. In certain circumstances, a child's immune system is underdeveloped renders them more vulnerable to particular substances. But, there are times when a youngster may not absorb a toxin as quickly as an adult, making them less vulnerable to it. Further laboratory toxicology research to examine how toxins affect developing animals was advised by the study. Children often consume less food than adults do. As a result, if a significant food item in a kid's diet includes relatively high amounts of a pesticide residue, the child may be exposed to that pesticide at a higher level than an adult who consumes a lesser amount of that food overall. The study recommended improving the classification of the meals that newborns and kids of various ages consume [1]–[3].

Pesticides used on farms, pesticides used post-harvest, pesticides used on imported foods, and discontinued pesticides that remain in the environment are the four main sources of pesticide residues in the American diet. The adage "The dosage makes the poison" applies to pesticides and other potentially harmful agents. In other words, it doesn't matter how harmful a material is as much as how much of it a person is exposed to. For instance, aspirin, a popular medication, may be helpful in modest amounts but lethal in very large quantities. Aspirin may have negative health consequences in certain people, even at extremely low dosages.

This implies that the toxicity of the pesticide and the chance of humans coming into touch with it both affect the danger of pesticide exposure to human health. There must be at least some toxicity and exposure for there to be a danger. For instance, there is no danger if no one is exposed to a very deadly pesticide. Conversely, if a substance is harmless but there is sufficient exposure, there is no danger. Yet, when pesticides are applied, there is often some toxicity and exposure, which creates a possible concern.

A. Regulations for pesticides

Three government authorities are jointly responsible for making sure that there are no harmful amounts of pesticide residues in food. It is in charge of advising the federal and state governments on technical pesticide manufacturing, usage, and safety problems. Its tasks also include proposing pesticide usage based on toxicity and appropriateness, establishing pesticide shelf life, and suggesting a minimum interval between pesticide treatments and crop harvesting.

B. Agency for environmental protection

An EPA registration is required before a pesticide may be used since that agency oversees its usage, sale, and

distribution. The pesticide's components, the specific location or crop it will be used on, the quantity, frequency, and time of its application, as well as storage and disposal procedures, are all examined by the EPA. Manufacturers are required to test their goods for short- and long-term health impacts, such as carcinogenicity, chronic toxicity, reproductive and developmental toxicity, environmental effects, effects on wildlife, and potential groundwater or surface water pollution. The level of a pesticide's toxicity, the likelihood that it will be consumed via residues left on food and in drinking water, and the quantity of exposure from other applications all contribute to how dangerous it is. Before registering a pesticide, the EPA performs a risk assessment of the proposed applications by examining the toxicity studies that are currently available as well as data on pesticide residue, food consumption, and associated factors. The text that appears on each pesticide label is also approved by the EPA. Only use a pesticide according to the instructions on the label that comes with it. The EPA limits when pesticides may be used throughout the growing season, how much can be used, and on which crops via the label.

The EPA determines a tolerance, known as the maximum residue level, which is the maximum amount of residue authorized in a food, feed, or food component if a product is to be used on food crops. For each pesticide and each food, there are certain tolerances. The EPA needs to know the highest concentrations of pesticides anticipated to be present in foods in order to establish tolerances. Studies of residues discovered on crops produced when pesticides are administered at the maximum rate permitted are used to make this determination. Both foods cultivated in the US and those imported are subject to the tolerances.

The quantity of a chemical that, if consumed every day for a lifetime, is not anticipated to have any negative health impacts on any segment of the population, from newborns to adults, is likewise determined by the EPA. The Reference Dose is this. It is computed by first determining the maximum concentration of a chemical that test animals may be exposed to without experiencing any detectable negative biological effects. The no visible impact level is used to describe this. The NOEL is then multiplied by a factor of between 10 and 1,000 to get the RfD. This additional margin of safety is used to account for the uncertainty in extrapolating results from animal studies to humans as well as for variations in sensitivity across different people. To identify levels that are unlikely to provide more than a minimal risk of cancer—defined as one cancer per million people during a lifespan of 70 years—EPA examines multiyear studies of animals. Studies created expressly to evaluate dangers to babies and children may also be required by the EPA. These include developmental toxicity studies, which look at the risks to developing fetuses from the mother's exposure to pesticides while she is pregnant, developmental neurotoxicity studies, which specifically look at the risks to the developing nervous system, and two-generation reproduction studies, which provide details on potential effects on the health of both the individual and their offspring.

All foods must adhere to EPA tolerances, except for meat, poultry, and certain egg products, which are regulated by the USDA rather than the Food and Drug Administration (FDA). In order to determine if any samples of foods imported or domestically manufactured with pesticide residues violate EPA limits, the FDA gathers and tests them. FDA may take regulatory action, including detaining the product or halting shipments of foreign products at ports of entry if residual levels are found to be over EPA standards. In addition to keeping an eye on foods intended for human consumption, the FDA tests and examines imported and domestic animal feed for pesticide contamination.

Every year, the FDA analyses 8,000 to 10,000 domestic and imported food products for pesticide residues as part of its regulatory pesticide residue monitoring program. To maximize residual levels, samples are taken as near as feasible to the place of production. Even bananas are evaluated for freshness unwashed and unpeeled. The majority of customers and food processors wash or peel the produce before using it in food items, therefore many of the samples that violate the FDA's regulations exhibit greater residual levels than would be predicted in everyday usage. Not estimating the quantity of residues on foods, but rather finding residues over the tolerance, is the aim of FDA monitoring efforts.

The quantity ingested, sometimes known as exposure, and a pesticide's toxicity defines how hazardous it is. Looking at what foods People eat and how much pesticide residue they would invest in that diet may help evaluate exposure to pesticide residues. The FDA conducts the Whole Diet Study, often known as the Market Basket Study, to achieve this. Four times a year, one in each of the four geographic areas of the nation, FDA employees go grocery or grocery shopping. They shop in three locations from each area, purchasing the same about 260 goods chosen from data from a national diet study to represent the typical American diet. The dish is then prepared by staff the same way a customer would. For instance, using the gathered supplies and a set recipe, staff members prepare meat and vegetable stew. In order to determine the dietary intakes of pesticide residues for Americans, ranging from babies to elderly people, FDA examines the prepared foods for pesticide residues. The research does not identify which foods contain specific residues since its goal is to assess the overall dietary consumption of pesticide residues. The EPA Recommended Dose may then be compared to this estimated food consumption of pesticide residues.

C. Farm service agency of the United States

With its National Residue Program, the USDA Food Safety and Inspection Service uphold EPA pesticide tolerances for meat, poultry, and processed eggs. Pesticide residues found in beef tissues or egg products that are over EPA limits are regarded as adulterated and illegal. FSIS

inspects both local and imported goods for residues. The Pesticide Data Program, a non-regulatory program run by the USDA Agricultural Marketing Service, has been gathering information on pesticide levels in food since 1991. Samples are taken as near to the site of ingestion as feasible in order to get the most accurate estimations. This considers customer habits including peeling vegetables before eating them and pesticide degradation during storage, preparation, and cooking. PDP screens for more than 160 pesticides from both local and imported goods in the raw and processed states of around 40 distinct commodities. Ten participating states gather the samples as part of a federal-state collaboration, and they are then examined in a mix of federal and state labs. The PDP focuses on identifying residues, regardless of size, as opposed to detecting just those that violate limitations. The data shown below show that although many samples had traces of residue, relatively few of them exceed EPA tolerance levels.

D. Act to protect food quality

The Food Quality Protection Act, passed by Congress in 1996, reinforced existing pesticide regulations. The rules under which the EPA controls pesticides were changed by the FQPA. It obliged EPA to take this into account. A new safety requirement the safety requirements that pesticides must satisfy before being authorized for use was enhanced by FQPA. The pesticide's permitted uses must be guaranteed by EPA to cause no damage with a reasonable degree of assurance. Exposure across the Board: The aggregate risk of a pesticide from all non-occupational sources, such as food, drinking water, and residential usage, must be estimated by EPA when assessing a pesticide. Cumulative Risk: The EPA is mandated to assess pesticides in light of possible shared harmful effects across several pesticides. An assessment approach is presently being developed by EPA.

E. The particular sensitivity of children to pesticides

The EPA must determine if there is a higher vulnerability to pesticide exposure in newborns and children. Also, the FQPA was signed on August 3, 1996, and as of that date, the EPA is reviewing all pesticide tolerances that were in place at that time. The goal of this work is to make sure that already-in-place tolerances and exemptions adhere to the new safety standard. The first third of the reassessment of tolerances and exemptions is to be finished by August 1999, with the remaining two-thirds to be finished by 2006. As there were around 9,700 tolerances in place at the time the FQPA was passed, this review is a significant undertaking. Pesticides that seem to pose the greatest danger are given top consideration by EPA.

F. Do pesticide residues present a risk

According to many health specialists, pesticide residues provide a considerably less threat to food safety than other issues such as microbial food contamination, environmental pollutants, and naturally occurring toxins. They draw attention to the fact that a diet high in fruits and vegetables is linked to a lower risk of chronic illness, including many types of cancer. The health advantages of consuming fruits and vegetables much exceed any potential hazards from pesticide residues. Studies demonstrating a higher incidence of certain malignancies among farmers and other individuals who use and apply pesticides provide human evidence on the cancer-causing potential of pesticides. Research has not shown a link between eating foods contaminated with pesticides and cancer. Yet, since exposure happens over several years and the development of cancer is poorly understood, it would be exceedingly challenging to demonstrate such a link. Accidents or abuse of pesticides have resulted in worker exposure owing to poor or insufficient handling and usage practises, such as not donning protective gear or wearing masks. Children accidentally poisoned by pesticides account for a significant part of pesticide-related mortality [4]–[6].

II. DISCUSSION

Danger perception often relies more on feelings than on facts. Since we believe that we have little control over the hazards, pesticides are a delicate topic. As opposed to voluntary, the danger is involuntary. Consumers are worried about the possibility of pesticide residues in their food yet have no problem driving onto a busy highway and the risk that entails. Research done in the late 1980s highlights the significant discrepancy between perceived dangers and known threats. On a scale from 1 to 30, with 1 being the greatest and 30 the lowest, three groups—college students, League of Women Voters, and businesspeople—were asked to rank different dangers. Pesticides were rated as having a danger rating of 4 by college students, 9 by female voters, and 15 by businesspeople. Nonetheless, a risk threshold of 28 was determined based on actual mortality statistics, which was lower than the risks associated with motorcars, swimming, bicycling, household appliances, electric lawnmowers, and skiing. According to estimates, 30 individuals each year pass away from pesticide poisoning, primarily youngsters. Comparatively, roughly 50,000 individuals each year pass away in car accidents, 3,000 while swimming, and 1,000 while riding bicycles. People believe they have a choice and at least some control over these other dangers, but they do not have any influence over the kind, quantity, or presence of pesticides in their food. Pesticide residues on foods are thought to pose real hazards, according to those against the use of pesticides. According to the Non-Occupational Pesticide Exposure Study by the EPA, which looked at 32 chemicals and pesticide residues, food exposure accounted for the majority of general population exposure. The majority of this occurred through dietary exposure via meals, with a tiny proportion coming from pesticide residues in drinking water and an even smaller amount from inhalation or other mechanisms. Several of the older pesticides that are currently in use were authorized before improved laboratory

techniques and stricter controls were in place. According to the Environmental Working Group's report, "Overexposed: Organophosphate Insecticides in Children's Meals," one million American children under the age of five are exposed to hazardous quantities of organophosphate pesticides every day, endangering their growing nervous system and brain [7]–[9].

The main unknown aspect of chemicals, including pesticides, is how they will affect people's bodies over the long term. There is limited information on the long-term consequences of pesticide accumulation in people; scientists can only do long-term investigations in animal models. While the medical world is still unsure of how and why cancer arises, carcinogens seem to build up over time, and pesticides are likely to weaken the immune system over the course of a lifetime.

The EPA's pesticide residue limits, according to some experts, do not correspond to safe levels. Tolerances are set up as monitoring and enforcement instruments to make sure that pesticides are used in accordance with the law. These maximum residue levels have very little to do with safety since the imposed tolerances are not based on harm to human health. As a result, it is difficult to say whether residual levels below the tolerances are acceptable or, conversely, whether unlawful residues are harmful. Scientists from the Consumers Union concluded after examining USDA data that the EPA's safety margins are insufficient to protect kids from pesticides' adverse effects.

The mechanism for approving pesticide registrations is cited by opponents of the EPA's attempts to regulate pesticides as being plagued with fraud and subject to manipulation by pesticide manufacturers. Manufacturers or labs that the EPA has contracted with develop and carry out the testing used to establish tolerances and reference dosages. Important testing laboratories were revealed to have fabricated crucial safety tests on pesticides twice, first in the middle of the 1970s and once again in the early 1990s. Since Congress does not provide EPA with the funding to conduct its own study, EPA is forced to depend on the information provided by manufacturers. It is unrealistic to expect the EPA to take up the task of evaluating all chemicals for safety given that there are 70,000 compounds in use today and hundreds of them are actively being reviewed at any one moment.

Some consumer and health groups contend that chemical firms bias scientific studies in order to promote the continued sale of hazardous goods. An accurate way to foretell a study's outcomes is to look at the funding source. Opponents assert that research funded by chemical industries often demonstrates that the chemicals are not hazardous to human health or the environment. Yet, research conducted by independent scientists from governments, universities, healthcare, and nonprofit groups often paints the substances in a negative light. Manufacturers have sometimes kept study findings from EPA when they don't like them. Manufacturers who turned in unpublished research that ought to have been submitted sooner received amnesty from EPA in 1991 and 1992. Around 10,000 studies proving that all classes of chemicals present on the market potentially pose a "substantial risk of damage to people or the environment" were suddenly generated by chemical corporations. The legislation mandates that the government get these types of never-published data right away [10]–[12].

III. CONCLUSION

Lastly, the revolving door phenomenon is brought up by critics. Two-thirds of the highest-ranking officials since the pesticide program was established have received at least a portion of their salary from pesticide interests, according to an EWG investigation of the employment of former top EPA pesticide regulators after they left the agency. This includes two out of every four past directors of the Office of Pesticide Programs as well as four out of the six former assistant administrators for pesticides and toxic substances. Twelve more former EPA employees who held roles critical to the assessment of pesticides transitioned to employment serving pesticide interests in the private sector. Over half of EPA officials, according to Fagin and Lavelle, who leave high-level positions in dangerous chemicals and pesticides go to work for chemical firms, chemical trade associations, or as lobbyists for the chemical industry.

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Analysis of Drinking Water Quality for the Beneficial of The Human Heath

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***Abstract*— This section examines human efforts to purify water so that it is safe to consume. Water is one of the most abundant and precious resources on the planet. The reader is shown instances of ancient water purification techniques before being given information about the public water supply in the United States. Regulations designed to address water supply dangers are looked at. Water with little or no contamination is considered excellent quality and safe to drink.**

***Keywordss*— Drinking Water, Drinking Water Quality, Quality Food, Food Safety, Foodborne Disease.**

I. INTRODUCTION

An apparatus for clarifying liquids, such as wine or water, by syphoning out settled liquid, is shown on the walls of Egyptian tombs from the fifteenth and fourteenth centuries B.C.E. As Cyrus the Great, King of Persia, led his army into war in the sixth century B.C.E., they went carrying containers of boiling water. At Alexandria, Egypt, circa 50 B.C.E., certain areas of the city utilised single, double, and even triple filtration to purify water, while water from the Nile River was delivered to the city by a network of underground aqueducts to cisterns where it was cleared by sedimentation. The first thorough account of a public water system was provided by Sextus Julius Frontinus, Rome's water commissioner in the year 97, in his Two Books on the Water Supply of Rome. Although these early water engineers had little knowledge of bacteria and were likely treating water to make it clearer, better-looking, and tasting, they nonetheless created the first water treatment systems [1]–[3].

During the major cholera epidemic in London in 1854, Dr John Snow used epidemiologic detection techniques to establish a relationship between sickness and drinking water. 13 pumps at the time offered free water to city residents. Dr Snow drew the locations of persons who died of cholera on a map of the city after several cholera-related fatalities in the area. He observed that the vast majority of fatalities were residents who drew their water from the Broad Street pump. After presenting this proof to municipal authorities, they were convinced to take the pump handle of the Broad Street pump, which ended the outbreak but not before more than 600 people had died. Before Robert Koch 1883 finally identified Vibrio cholerae as the causal agent of cholera, all of this occurred over 30 years earlier.

The first American city to have a public water system that pumped water from a surface source and supplied it to citizens via a network of pipes was Philadelphia in 1799. In the United States, there were more than 3,000 public water systems by 1900. While this significantly increased the amount of water that residents could use quickly, it did not always provide a clean water supply. A few such methods were a factor in significant illness outbreaks in the early 1900s. The pumped and widely dispersed water offered a mechanism for bacterial illness to spread across populations if the water sources were compromised. When the U.S. Public Health Service established bacteriological criteria for drinking water in 1914, federal regulation of the country's water supply officially got underway. These requirements were updated in 1925, 1946, and 1962, and all 50 states finally embraced them. Industrialization and the use of fertilisers to crops started to negatively affect the environment and the general populace after World War II. In the late 1960s and early 1970s, it became more obvious that there were more widespread issues with water quality than those addressed by the Public Health Service. Just 60% of water systems supplied water that met PHS criteria, according to a 1969 study. With water obtained from the Mississippi River that had previously been treated, 36 contaminants were found, according to 1972 research. As the public's knowledge of the issues with the water supply increased, federal environmental and health legislation addressing pesticides, toxic waste, and contaminated water was passed. This improved understanding of the fragility of the country's water supply also contributed to the 1974 Safe Drinking Water Act, which is covered in more detail below [4]–[6].

Water providers use a range of treatment techniques, depending on the circumstances and kinds of pollutants that are most likely to be present in a certain water supply. The majority of water systems combine two or more treatment methods. Key methods of treating water include:

A. Sedimentation/flocculation

Flocculation is the process of combining tiny particles into heavier ones known as floc. Then, by allowing them to form silt, the heavier particles may be eliminated. After the particles have settled, they mix to create a sludge that is subsequently removed.

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Vol 10, Issue 2S, February 2023

B. Filtration

Filtration By flowing water through a porous bed of materials or permeable cloth, filtration eliminates particulates from water. When it passes through soil layers with pores, groundwater is organically filtered. Microorganisms and other very minute particles may be removed by several filtering techniques.

C. Ion exchange

If inorganic elements like arsenic, chromium, excessive fluoride, nitrates, radium, and uranium cannot be properly transported by filtering or sedimentation, ion exchange techniques are utilised to remove them. Positive and/or negative ions are drawn to one side of a treatment chamber by an electric current so they may be removed.

D. Adsorption and disinfection

Organic pollutants that create unfavourable colour, taste, or odour may adhere to the surface of granular or powdered activated carbon via the process of adsorption. Killing hazardous germs is referred to as disinfection. Chlorination, ozonation, and UV treatment are the three most used techniques of disinfection. In contrast to Europe, where ozonation is more prevalent, the United States uses chlorination the most often.

E. Chlorination

Chlorine kills bacteria by generating hypochlorous acid, which interferes with their ability to reproduce, move materials, and use nucleic acids. Although viruses are less vulnerable to chlorine, the majority of bacteria are. Cryptosporidium cannot be easily eliminated by chlorination, while Giardia lamblia cysts are particularly resistant to chlorine. Trihalomethanes, a disinfection by-product created when chlorine combines with organic debris in the water, are of particular concern with this kind of disinfection. Certain DBPs may cause long-term exposure that raises cancer risk or has other harmful consequences on health. THMs are cancer category B carcinogens, meaning they have been shown to cause cancer in test tubes. The EPA has set a limit on how much of these by-products are permitted in drinking water.

F. Ozonation

By exposing the air to an electric current, ozone is produced. After being dissolved in water, the ozone gas kills bacteria by acting as an oxidant. The water must then be treated to eliminate the ozone before usage. After ozone treatment, the water still has to be chlorinated since there is no longer any antibacterial action. Since it seems to be the only disinfectant that is extremely efficient against Cryptosporidium, ozone has drawn more attention.

G. UV light

UV light does not truly destroy microorganisms. Instead, it effectively sterilises them, preventing them from procreating. Due to the necessity for the microorganisms to be near the radiation source, ultraviolet systems are only useful for tiny systems. Cysts of Giardia or Cryptosporidium are not rendered inactive by UV.

It is impossible to test the water supply for every kind of bacteria that might make people sick since there are so many different bacteria that can do this. The use of indicator organisms is preferred. Due to their ease of detection in water, coliform bacteria are the most common indicator species for drinking water. A family of bacteria known as coliforms is widespread in the environment and both human and animal digestive systems. While these organisms are safe in and of themselves, their existence suggests potential contamination with human or animal faeces. The total amount of coliform bacteria in water sources is analysed to determine the efficacy of disinfection. The presence of coliform bacteria in public water sources is unacceptable and indicates that treatment is necessary.

H. Risks to the water fuel

Many chemicals and other things readily dissolve in water because it is the universal solvent. Water resources may get polluted via a variety of channels, including chemical migration from disposal sites, animal waste and pesticide runoff into lakes and streams, and human waste discharge into receiving water supplies that eventually end up in drinking water supplies. Additional causes of pollution include industrial discharge, natural deposit erosion, corrosion of home plumbing systems, and septic tank leaching. Young children are particularly vulnerable to the dangers of nitrates, which are organic substances that may enter water sources via fertiliser runoff and sanitary wastewater discharges.

A condition known as "blue baby syndrome" may be brought on by excessive levels and restrict the blood's capacity to transport oxygen from the lungs to the rest of the body. The condition may be lethal if neglected. Drinking water may include pollutants that are naturally occurring. For instance, some kinds of rocks contain the radioactive gas radon-222, which may seep into groundwater. While taking a shower or doing dishes, people might consume water that contains radon. It would be difficult to completely purge our water supply of all toxins, just as with food. Many contaminants are typically safe at extremely low concentrations.

The majority of waterborne illness outbreaks are caused by bacterial and viral contamination, most often from human or animal faeces. Giardia lamblia and Cryptosporidium parvum are two diseases that are often linked to drinking water. Both protozoa are tough to eradicate because of their cystic gastrointestinal diseases. A large enough quantity of Cryptosporidium may get through water treatment filtration and disinfection procedures to be harmful to human health. The greatest epidemic of a waterborne illness to date in the United States occurred in Milwaukee, Wisconsin, in 1993. Filtration and disinfection are used to treat the Lake Michigan-sourced water that is used in Milwaukee. The treatment plant wasn't efficient because of an uncommon

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Vol 10, Issue 2S, February 2023

confluence of events at a time of significant rainfall and runoff, which led to a rise in the turbidity of the treated water. The filtration and disinfection methods were less successful as a result of the increasing turbidity. Around 400,000 people were impacted by the illness, over 4,000 were hospitalised, and over 50 people died away as a result of the illness. It's unclear where the contamination first came from.

Another source of risk to the country's drinking water is runoff from farms. The Environmental Working Group discovered more than 10 million people exposed to five herbicides at levels exceeding the Environmental Protection Agency's minimal cancer risk criterion of one extra case per million people in their study Tap Water Blues, which was published in 1994. Herbicides in the tap water of 29 midwestern communities were examined in second research published in 1995 called Weed Killers by the Glass. Once again, their findings demonstrate that People are exposed to dangerous chemicals at levels much over official health regulations in their drinking water.

I. Regulation

To ensure that all public water sources are secure, local governments, public water systems, the states, and the EPA collaborate. Whether it be groundwater or surface water, local governments have a direct stake in maintaining the quality of their drinking water supply. Monitoring land uses that may have an impact on the quality of untreated source water is a part of their responsibility for safeguarding the water supply. The main duty for ensuring that each public water provider complies with federal drinking water regulations, or more rigorous requirements imposed by the state, rests with state public health and environmental authorities. Municipal water systems do not control or test private wells, although they do test their water systems for contaminants. State and municipal health officials often set certain regulations for drinking water for homes with private wells, but it is typically up to the homeowner to maintain the quality of the water.

Standards for pesticides and other pollutants in drinking water are determined by the EPA Office of Water. EPA problems Maximum Contaminant Levels for more than 80 pollutants set upper limits on the quantity of each item that may be present in drinking water. To establish guidelines for drinking water quality, scientists employ a procedure known as risk assessment. The first stage in determining cancer and non-cancer hazards associated with exposure to a chemical in drinking water is to determine how much of the chemical may be there. The amount of chemicals that the typical individual is likely to consume is then estimated by experts. The exposure is the quantity in question. EPA bases its drinking water regulations on the assumption that an adult consumes two litres of water a day over the course of a 70-year lifespan. MCLs are established at concentrations that will keep a person's lifetime risk of developing cancer from that pollutant to between 1 in 10,000 and 1 in 1,000,000. Risk assessment gives an estimate of the exposure level below which no unfavourable effects are anticipated to occur for non-cancer consequences. Moreover, EPA considers the efficacy, affordability, and ability of alternative methods to address the contamination.

II. DISCUSSION

Public water systems may use any state-approved treatment to adhere to MCLs. Where establishing an MCL for a pollutant is neither scientifically or economically feasible—for instance, when the contaminant is difficult to measure EPA may instead demand the adoption of a specific treatment method. Almost 55,000 community water systems throughout the US are required to test for over 80 contaminants by the EPA. Statistics from 1996 show that fewer than 2% of systems reported treatment procedure standards breaches whereas 7%, or 4,151 systems, reported one or more MCL infractions [7]–[9].

A system may apply to the state for permission to test for certain pollutants less regularly if there are no issues with water quality. State authorities may approve the request to forego needless testing if, after conducting a scientific study, they conclude that it is improbable that future human or natural activities would have an impact on the water quality of the system. Testing is still done, albeit less often. The system is required to alert the state at the first sign of any issue—or the potential of an issue—and the state may give the system instructions to resume more frequent monitoring. lists the main categories of pollutants and the minimal testing frequency required for water systems.

Act to protect drinking water

In accordance with the 1974 Safe Drinking Water Act, EPA was given the power to create national, legally binding health standards for pollutants in drinking water. Each state maintained its own drinking water programme and established regional standards prior to 1974. As a consequence, state-by-state variations existed in drinking water protection requirements. The Surface Water Treatment Regulation, which mandates that public water systems filter and disinfect all surface water sources, strengthened the legislation in 1986. In 1996, the statute underwent yet another amendment to safeguard drinking water from the source to tap. The 1996 amendment's provisions cover:

Demanding that customers be given additional details regarding the quality of their drinking water sources. Water providers are required to inform consumers of EPA standard violations "that have the potential to have substantial detrimental effects on human health as a consequence of short-term exposure" within 24 hours. If such a violation takes place, the system is required to publicly announce it and tell the public about any possible negative health impacts, the procedures being taken to address the violation, and the need to utilise alternate water sources until the issue is resolved. Water providers may be forced to issue "boil water notifications" when microorganisms, such as those that

suggest faecal pollution, are discovered in drinking water. The pathogen-causing organisms are destroyed by boiling water. Boil water advisories impacting more than 10 million people have been issued by at least 725 localities, including New York City and the District of Columbia.

Public water systems must also create Consumer Confidence Reports following the SDWA modifications. They are meant to educate people on the source of their water supply, the toxins found in it, and the potential health risks associated with contaminants found over the set safety limit. Systems are required to create and publish the reports yearly starting in 1999.

1. Following the new amendments, each state is required to create a programme to identify possible contamination hazards and assess how susceptible drinking water sources are to activities that might endanger the source of water.

2. The new legislation mandates that water systems be managed by trained experts. Each state is required to implement an "operator certification programme," which includes instruction and certification for those in charge of running the drinking water facility. Before it was required by federal law, the majority of states required operator certification.

3. Up to $9.6 billion over the next six years will be made available for improving the drinking water infrastructure under the 1996 SDWA Amendments. To update their facilities and guarantee compliance with drinking water requirements, water systems are eligible to apply for low- and no-interest loans. Under the Rural Utilities Service of the U.S. Department of Agriculture, other financing sources are also accessible to water systems. RUS administers a water and wastewater loan and grant programme as part of the Water 2000 effort, which aims to provide clean, safe, and cheap drinking water to all rural families. Under the RUS programmes, rural communities, small cities, and municipalities may be eligible for loans or grants to modernise an outdated water or wastewater infrastructure, restore a depreciating water supply, or create new systems.

4. If states decide to run such a programme, substantial federal funds are made available to them for evaluations and source water protection measures. States and municipalities are being urged by EPA to implement source water protection programmes.

Last but not least, Healthy People 2010, a nationwide project for illness prevention and promotion of health, has two objectives regarding water quality. Boost the percentage of people who are serviced by community water systems and get a supply of drinking water that complies with the Safe Drinking Water Act. The 2010 objectives seek to raise it to 95% from the current baseline of 73%. Decrease outbreaks of waterborne diseases among those supplied by community water systems. Presently, it is thought that six outbreaks a year start with community water systems. The objective is to reduce it to two outbreaks annually [10]–[12].

III. CONCLUSION

Water, the liquid of life, served as the foundation for both ancient and contemporary civilizations. Two-thirds of our bodies are made up of water, which is essential for all living. It seems that knowledge of potential food risks developed far earlier than knowledge of how certain water sources induced discomfort while other water sources did not. In 2000 BCE, Vedic medical literature suggests boiling contaminated water, exposing it to sunlight, and filtering it through charcoal.

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A Brief Overview of the Investigation of the Food Safety Act

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***Abstract*— As there is so little information in the historical record from other regions of the globe on how, or if, food safety was controlled, this chapter begins with a summary of early efforts to do so. The focus is mostly on the United States. Early food regulations in the Western world focused less on ensuring food safety and more on prohibiting economic deception and food adulteration..**

***Keywordss*— Food adulteration, Food safety, Foodborne disease, Food Safety Act, United State.**

I. INTRODUCTION

Food adulteration is typically described as "the addition or removal of any substance to or from food, affecting the natural composition and nutritional value of the food substance." Adulteration occurs when ingredients are intentionally removed from food or the natural qualities of food are purposefully altered. Covering up rotten or degraded goods with spices or colour, particularly when it comes to meats. Diluting a product, such as wine with water. Eliminating vital components of a meal, such as spice's essential oils. Replacing an inferior product or ingredient in a dish, such as substituting apple peel and core for fruit in apple jelly.

Foods may be tampered with purposely for financial advantage, but they can also be done negligently or inadvertently, for instance, by dirt, bacteria, or insect parts. Food became more vital to the Roman Empire as cities like Rome grew in size and armies journeyed to distant places. As a result, Roman civil law included rules to safeguard the public against tainted meals. Cato provided a way for figuring out if traders diluted their wine in 200 BCE. Several years later, Pliny the Elder wrote about how dishonest Roman traders tampered with food items including olive oil, cereals, herbs, and wine.

In about 1266, the English enacted the Assize of Bread, their first food legislation, to stop the adulteration of bread with less expensive, subpar ingredients. The beer had an Assize of Beer to control its price and quality since it was a similarly significant and contaminated food product. A statute from the same period called The Judgment of the Pillory laid out the procedures for conducting investigations and punishing criminals via fines or, in the case of repeat offenders, the pillory or other forms of corporal punishment. It addressed meat and fish infractions as well as contraventions of the Assizes of Bread and Beer:

And if any butcher sells meat that is infectious or that was plague or pestilence-dead. Also, they must question any cooks who boil meat, fish, or other animal products with bread, water, or any other ingredient that is not healthy enough for a human body, or who keep food for an extended period before boiling it once again and selling it.

Food adulteration persisted over the centuries, becoming increasingly sophisticated and difficult to spot. Bread made with ground peas and beans, spices diluted with everything from water to oil of turpentine, spoiled grain mixed into good grain to hide its deterioration, flour mixed with chalk, spices diluted with every conceivable non-edible ingredient, and wine and alcoholic spirits were all fairly common. A Treatise on Adulteration of Food and Culinary Poisons, written by Frederick C. Marcus under the pen name Accum in 1820, disclosed several of the prevalent food adulterations of the time. A 1939 publication, Deadly Adulteration, and Slow Poisoning Unmasked or Disease and Death in the Pot and the Bottle, described how "artistes au lait" could resemble cream by deftly blending precisely the right amounts of the dye annatto, water, and milk. This illustrated how the situation with food adulteration had changed somewhat. Less experienced cooks could substitute arrowroot, flour, starch, or rice powder. A guy who robs a fellow subject of a few pence on the highway should be condemned to death, but he who spreads a gradual poison to an entire town should go unpunished, the author said, noting how weak the rules were to punish food adulterators. The Sale of Foods and Medicines Act was finally enacted by the British Parliament in 1875, and it served as the country's fundamental food regulation for many years. At the turn of the century, the majority of other European nations likewise had universal rules that forbade food adulteration [1]–[3].

Early food safety regulation in the United States the initial rules in the new colonies also focused on appropriate weights and measures, ingredient purity, and fair pricing. The earliest regulations were enacted by the early colonists to guarantee the quality and wholesomeness of the goods being sold from the colonies to Europe, not to safeguard the residents. Early food rules were created with trade in mind rather than with food safety in mind. Massachusetts was a pioneer in the field of food safety, passing numerous important regulations. To

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Vol 10, Issue 2S, February 2023

demonstrate that the colony produced and exported high-quality food items, the Massachusetts Meat and Fish Inspection Law of 1641 addressed meat intended for export. A regulation governing bread's quality, pricing, and marking of each loaf so that its origin could be traced was enacted in Massachusetts in 1646.

The legislation allowed inspectors the right to enter bakeries and weigh the loaves to spot economic fraud. In addition, Massachusetts enacted the first thorough food adulteration legislation in 1785, punishing individuals who offered for sale food that was contaminated, corrupted, infectious, or unwholesome. Unlike earlier laws, which exclusively covered certain commodities, this one included all foods. The law, titled An Act Against Selling Unwholesome Provisions, was succinct but to the point. Whereas some evilly disposed of individuals have been introduced to sell diseased, corrupted, contagious, or unwholesome provisions to the great detriment of public health and peace: Be it enacted by the Senate and House of Representatives in General Court assembled, and by the authorities of the same, that if any person shall sell a

During the early 1800s, other additional states, including Virginia, Iowa, Oregon, New York, and California, established food laws. Up until the late 1800s, state and municipal governments were in charge of regulating food safety. Early in the history of the nation, food was farmed and produced locally, therefore local rules were sufficient to address issues. Most folks were familiar with the nearby farmer or baker. As a result, they could tell whether they were trustworthy and if their goods were of high quality.

The breadth and dispersion of the food supply expanded as the population grew and shifted from rural to urban areas. Because so much of their food was produced outside of their neighbourhood, people no longer had a personal relationship with the farmers. Many people believed that Congress did not have the power to regulate subjects of health and safety following the US Constitution. With the adoption of some of the first federal food safety legislation, the tide started to shift in the late nineteenth and early twentieth century.

The Impure Tea Act of 1883, which forbade the importation of contaminated tea into the United States, was the nation's first food legislation. Early in the 1890s, there were widespread reports in Europe about the ill health of food-producing animals in the United States, which were often genuine. American meats developed a reputation for being unsuitable for consumption. Congress established the 1891 Meat Inspection Act, which mandated the inspection of all live cattle destined for export, in order to safeguard the export meat industry, which was a significant source of revenue at the time. Also, if any cattle, sheep, or pigs were to be sold in interstate commerce, they had to be examined before being slaughtered. Meat inspections after death may also be conducted if judged necessary. For the first time, Congress approved the labelling of beef as "Inspected and Passed." Sadly, no funding was provided for the initiative, hence its complete execution took some time.

A. Food safety legislation in the United States throughout the 20th century

A comprehensive food law was initially proposed by chemists from the U.S. Department of Agriculture in 1879, but it took 27 years until the time was ripe for it. The department's 10-volume Bulletin 13, Foods and Food Adulterants, which described widespread adulteration in all areas of the food supply, was issued from 1887 to 1901. A Popular Treatise on the Extent and Character of Food Adulterations, a reprint of these comparatively technical treatises, was published for the general public. This work was highly publicized in the media at the time. Customers who read it learned that virtually all of the food they bought was contaminated or mislabelled.

The notoriety of the man many consider to be the father of the Food and Drugs Act of 1906, Dr. Harvey W. Wiley, was added to this brew of public outrage over an increased intolerance for food adulteration. In 1883, Dr. Wiley was appointed the head chemist of the USDA Division of Chemistry. Dr. Wiley, a skilled public speaker, and esteemed scientist, worked on numerous fronts to aid in the passage of the 1906 Act. He ignited public interest through his many speeches and writings in popular newspapers and magazines, lobbied Congress for 20 years for the passage of food safety legislation, and spearheaded the publication of Bulletin 13 and the Poison Squad.

The Poison Squad was a group of 12 chemists from the USDA, which was formed in 1902 to study preservatives used in food products. The group’s job was to consume food made with chemical preservatives and then to note the effects on their health. They ate all their food at a USDA kitchen. Department scientists analysed everything they ate and everything they excreted. During these studies, they ingested boric acid, sulphurous acid, sulfites, benzoic acid, copper sulfate, saltpetre, and formaldehyde. While none of the Poison Squad succumbed to their job, they did find that many of these chemicals were harmful to human health. This was the start of the federal government’s role in approving chemicals used in food production, a process that is still one of the main duties of the federal government.

B. The food and drugs act

The Food and Drugs Act defined food as “all articles used for food, drink, confectionery, or condiment by man or other animals, whether simple, mixed, or compound.” It forbade adulteration of foods, drinks, and drugs in interstate commerce specifically “preventing the manufacture, sale, or transportation of adulterated or misbranded or poisonous or deleterious foods, drugs, medicines, and liquors, and for regulating traffic therein, and for other purposes.” The act considered foods misbranded if they were labelled to deceive the public, if the contents in terms of weights and measures were either incorrect or not present on the package, or if the

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Vol 10, Issue 2S, February 2023

label contained any false or misleading statement concerning the ingredients of food. The federal government had the authority to seize adulterated or misbranded foods. Violators were guilty of a misdemeanour and subject to fines of up to $500 and/or imprisonment of up to one year for the first offense.

Capitalizing on the Food and Drugs Act, Dr. Wiley and his chemists looked at the 80 food colorants that were in use in 1907. Of those, 30 had never been tested for safety, and 26 had been tested but the results were contradictory, experts considered eight to be harmful, and the remaining 16 were thought to be more or less harmless. From that list of 16, only seven passed final scrutiny to be certified under the Food Inspection Division 77, issued September 25, 1907. This legislation certified those seven colorants and established procedures for colorants to be certified in the future. Of those original seven certified colorants only three, erythrosine, Naphthol Yellow S, and Indigo Disulfonyl Acid, Sodium Salt, are now allowed in foods, drugs, or cosmetics.

C. The federal meat inspection act

The situation with the meatpacking industry was different from the rest of the food suppliers. The meat industry favoured government regulation. They felt that a federal meat inspection program could reopen markets for American meats in Europe, as most major European countries banned the import of American meats in the 1880s. Having federal inspection would add legitimacy to their products. Already Congress started the process with the Meat Inspection Act of 1891. This earlier act was successful in that several European nations did remove their bans on American meat products in 1892. However, in the 1891 act, Congress did not allocate money for the cost of the federal inspection program, weakening its effect.

The Jungle had a great impact on the meat industry. Upton Sinclair's novel was meant to highlight the horrible working conditions of the nation's working class. The fact that the novel took place in a meatpacking plant was secondary. The nation, though, was more horrified at the thought of rats and other undesirables mixed in with their sausage than of the poor treatment of workers. Sinclair later wrote, "I aimed at the public's heart and by accident hit it in the stomach". Domestic meat sales declined by half within weeks after the publication of The Jungle, which further fuelled the industry's desire for regulation. Earlier draught versions of the 1906 Meat Inspection Act placed the burden of cost on the packers by charging an inspection fee for every animal. The meatpacking industry lobbied hard against this and in the end, Congress appropriated federal money for meat inspection.

This is still a contentious issue today, with the USDA regularly requesting inspection fees and the industry trying to persuade Congress not to grant them. The Federal Meat Inspection Act of 1906 protected consumers by "assuring that meat and meat food products distributed to them are wholesome, not adulterated, and properly marked, labeled, and packaged." The act mandated inspection of cattle, sheep, goats, and equines, both before and after slaughter. It required continuous USDA inspection of slaughter and processing operations and established sanitary standards for the industry. What the act didn't do was cover poultry products or meat that were not intended for interstate commerce. That would come much later. The quality of food overall, sanitation in food plants, and the shipment and handling of foods improved under the Federal Meat Inspection Act and the Food and Drugs Act.

D. The food, drug, and cosmetic act

The Food and Pharmaceuticals Act had some serious faults from the outset, even though it got off to a fantastic start and achieved a lot. It was almost hard to show that a product was adulterated since it did not establish rules for what specifically should be in a certain dish. For instance, the government attorneys were unable to demonstrate that a product with nearly no strawberries in it was not strawberry jam because they lacked knowledge about the quantity of strawberries that was supposed to be in strawberry jam. A further requirement of the statute was that the government had to demonstrate that the suspected lawbreakers intended to mislead or poison customers with their goods. In court, the defendants claimed they were unaware of the consequences of their acts. The rule forbade deceptive labelling, but producers were not required to disclose the components in their goods. Even yet, until the early 1930s, when a new reform movement began, the act persisted as the primary legislation governing the food supply with just a few minor revisions.

The wildly successful book 100,000,000 Guinea Pigs: Dangers in Common Foods, Medicines, and Cosmetics was written by Arthur Kallet and F.J. Schlink in 1933. While the book was prejudiced and full of errors, it also had a lot of truth. It once again inflamed public outrage about the state of the food they were consuming since it was written in typical muckraking fashion. The fundamental assumption of the book was that owing to inefficiency and a lack of effective legislation, the federal government was unable to protect consumers from unsafe food and medications. The Food and Drug Administration, which would subsequently be moved out of the USDA entirely, replaced the USDA's Division of Chemistry its name in 1930. Walter Campbell, the director of the FDA, proposed a measure in 1933 to replace the 1906 statute. Before Congress enacted the new statute, there would be several conflicts and five years of legislative wrangling.

Similar to when the 1906 legislation was passed, the necessity for change was made clear to Congress by strong public opinion. The FDA brought its message directly to the public by speaking at women's clubs, to civic groups, and on the radio since a large portion of the media supported the food manufacturing sector's opposition to change. At one time, Walter Campbell gathered hundreds of goods that had defrauded or hurt customers in order to be ready for Senate hearings on the bill. He made a point of saying that the 1906

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Vol 10, Issue 2S, February 2023

statute did not control these items enough to stop similar incidents. To illustrate the need for new regulations, the displays were photographed and made into posters.

These were on exhibit at FDA presentations and in the FDA's main office museum. The display, dubbed the "Chamber of Horrors," inspired the FDA's chief educational officer, Ruth deForest Lamb, to write The American Hall of Horrors in 1936. Compared to the preceding 100,000,000 Guinea Pigs, it was more thorough and precise since it was written from inside the government. Ms. Lamb presented a few little-known, background information about the food industry. She wrote this about a new technique developed by an FDA scientist for testing butter for contamination: Analysis of only a few samples by this new technique was enough to shock and amaze regulatory authorities. Butter that at first glance seemed spotless and healthy had a history of dirt going all the way back to the farm. The astonished eye was shown hay, bits of chicken feathers, maggots, clumps of blue, green, white, and black mold, grasshoppers, straw chaff, beetles, hair from cows, dogs, cats, and rodents, moths, grass and other vegetable matter, cockroaches, dust, ants, fly legs, broken fly wings, metallic filings, and the remains of rats, mice, and other animals—all stained yellow from the

She made the case for a new food and drug law by pointing out that the laws from 1906 were obsolete due to new ways of living, new products, new manufacturing and selling techniques, new tricks of sophistication, and new scientific discoveries, all of which called for a more contemporary method of control. As part of the New Deal's campaign for more robust food and drug legislation, Congress finally approved the federal Food, Drug, and Cosmetic Act in 1938, and President Franklin Roosevelt signed it into law. This law continues to be the primary mechanism for controlling foods, despite several adjustments and changes. Many of the objectives of the 1906 legislation were maintained, but the extent of federal regulation was expanded and numerous loopholes were closed.

All food types sold across state boundaries as well as any naturally occurring and inadvertently added ingredients were covered by the new law. Foods from both imports and exports were covered. The FDA was given regulatory authority over food and drug advertising under the initial law, but this was removed from the final version. The Federal Trade Commission, however, was given this power. The Food, Drug, and Cosmetic Act is one of the few laws that significantly affect People's lives and health. The main goal of the legislation was to stop the sale of dangerous or dishonest food and medicine items.

Initially, seafood inspection was not covered by the Food, Drug, and Cosmetic Act. This is because the 1934 Seafood Inspection Act was already in effect. The FDA only regulates fish voluntarily, as opposed to other food products. Early in the 1930s, manufacturers of canned shrimp discovered that the FDA was seizing increasing quantities of their product due to deterioration. The deterioration of shrimp goods was mostly caused by inadequate fishing techniques and poorly managed packaging processes.

The canners asked Congress to pass an inspection statute because they were unable to persuade fishermen and packers to handle the goods better on their own. Packers of any seafood product may ask an inspector to go over their facilities, tools, processes, containers, and supplies. They may utilize such information on their label if the inspection turned out well. The canned seafood business particularly that of shrimp, benefited almost immediately from the new seafood inspection scheme. The industry was able to restore customer faith in their goods when product quality increased. The FDCA was amended in 1943 to include the Fish Inspection Act.

E. Insecticide, fungicide, and rodenticide federal act

The use of pesticides in food production is regulated by the Federal Insecticide, Fungicide, and Rodenticide Act of 1947. Whereas FIFRA is concerned with pesticide registration, environmental protection, pesticide usage, and user safety, the FDCA is focused on pesticide residues. Pesticides were back then referred to as "economic poisons" and had to be registered. Moreover, any claims made about the product's effectiveness had to be supported. FIFRA mandated more thorough labelling, which had to include a warning message, a list of contents, and use instructions. When the environmental protection agency was established in 1970, it took over the administration of FIFRA from the USDA. Over 25,000 pesticide products have FIFRA registrations.

The Food, Drug, and Cosmetic Act has been amended. The Food, Drug, and Cosmetic Act was amended three times, giving FDA more regulatory authority. Procedures for establishing safety limits for pesticide residues on unprocessed agricultural products were outlined in the Pesticide Residue Amendment of 1954. Any food to which a harmful ingredient was introduced was deemed adulterated under the original 1938 Food, drug, and cosmetic act. Certain compounds, nevertheless, are necessary for the synthesis of food and are not harmful at low concentrations. According to the 1954 modification, if the additional component was within acceptable limits, the meal was not deemed adulterated. In order for new food and colour additives to be utilized in food, the Food Additives Amendment of 1958 and the Colour Additive Amendment of 1960 required manufacturers to first demonstrate the safety of the additions. It was forbidden to put any substance into the food supply for the first time without first receiving confirmation of its safety. According to the legislation, pre-January 1958 additives that were considered safe because of a long history of safe usage were to be deemed widely recognized as safe and excluded from the requirements of the Additives and Colour Amendments. Any food additive or ingredient that has been shown to cause cancer in people or animals was not permitted under the Delaney Clause of the Additives and Colour Amendments.

ISSN (Online) 2456 -1304
International Journal of Science, Engineering and Management (IJSEM)
Vol 10, Issue 2S, February 2023

F. Further controls on chicken, meat, and eggs

"It is essential in the public interest that the health and welfare of consumers be protected by ensuring that poultry products distributed to them are wholesome, not adulterated, and properly marked, labelled, and packaged," declared Congress when it passed the Poultry Products Inspection Act in 1957. Consumers had some control to prevent poultry butchered in unhygienic circumstances earlier in the century since local butchers usually did it in full front of the public. The poultry business grew rapidly after World War Two. A national law was needed as the chicken industry grew more consolidated and the meat was delivered over longer and longer distances. If chicken or poultry products were to be sold in interstate or international commerce, the legislation mandated that they be examined both before and after slaughter. Poultry traded within states has previously been examined by several states. Because the state did not have its inspection program, the statute was amended in 1962 to include items in intrastate trade [4]–[6].

II. DISCUSSION

In accordance with the 1974 Safe Drinking Water Act, EPA was given the power to create national, legally binding health standards for pollutants in drinking water. It mandated notice to inform consumers of water system infractions and promoted federal-state collaboration in maintaining the nation's water supply. The legislation was reinforced in 1986, adding more regulated pollutants and establishing a monitoring program for uncontrolled contaminants. It now requires all water systems to be disinfected and all surface water sources to be filtered. The statute was amended in 1996, extending protection to drinking water sources to the tap. To update their facilities and guarantee compliance with drinking water requirements, water systems are eligible to apply for low- and no-interest loans. According to the legislation, municipal water systems are required to provide consumers with yearly Consumer Confidence Reports that explain the origin of their water supply, the pollutants found in it, and the health impacts of contaminants found beyond the prescribed safety limit. The legislation also mandates that states evaluate each source of drinking water, identify potential contaminants, and assess contamination susceptibility [7]–[9].

A. Act on saccharin research and labelling

Saccharin was administered to rats in very high dosages, and a Canadian researcher discovered that this led the rats to develop bladder cancer. Any additive that was shown to cause cancer at any dosage in any animal was to be prohibited under the Delaney Provision of the Food, Drug, and Cosmetic Act. It made no difference when the rats were given the equivalent of 800 Diet Pepsi cans each day by the researchers. As a result, the FDA suggested banning saccharin. There was a significant public uproar since it was the only artificial sweetener in use at the time. The Saccharin Research and Labelling Act, swiftly enacted by Congress, put a two-year hold on any ban on the sweetener while further safety research was carried out. Also, the rule mandated that all saccharin-containing goods include a label warning consumer that using the product might be harmful to their health. Saccharin, which is included in this product, has been linked to cancer in laboratory animals.

B. The act on infant formula

The 1980 Baby Formula Act included a new amendment to the Food, Drug, and Cosmetic Act; however, it was not technically related to food safety. Formulas must have all the necessary elements since they are sometimes an infant's only source of nutrition. A soy-based baby formula in 1979 contributed to the chloride-deficient illnesses that affected 120 new-borns. According to the law, the baby formula had to be manufactured using acceptable manufacturing procedures and include a certain amount of nutrients.

C. The act protecting food quality

The Food Quality Protection Act was enacted into law by Congress in August 1996. The new legislation significantly altered how the EPA regulates pesticides by amending the Federal Insecticide, Fungicide, and Rodenticide Act as well as the Food, Drug, and Cosmetic Act. The FQPA's Special Provisions for Infants and Children are among its standout features. Tolerances must be explicitly determined by EPA to be child-safe. Little information is available on children's pesticide intake, thus an extra safety factor of up to 10 times should be employed if required. Setting tolerance thresholds also requires taking into consideration children's unique susceptibility to and exposure to pesticide chemicals. Imposes a 10-year deadline for a review of all current tolerances to see if they still adhere to the new health-based safety standard. Includes tougher enforcement of pesticide residue regulations by enabling the FDA to charge offenders with civil offenses. Renewing pesticide registration. Requires the EPA to evaluate pesticide registrations regularly, to create a 15-year cycle, and to make sure that all pesticides adhere to the most recent safety requirements. Health-Based Safety Standard for Food Contaminated with Pesticide Residues. The new regulation most importantly creates a safety criterion for pesticide residues in all foods that are health-based. The general safety requirement is "a reasonable assurance that no damage" will come about from all sources of exposure taken together, including drinking water [10]–[12].

III. CONCLUSION

When the Meat Inspection Act was first passed in 1906, inspectors used their senses of smell and sight to evaluate if the meat was safe. It has become clear that this system is no longer efficient against the pathogens of today, which are microscopic microorganisms that are odourless and tasteless. The north-west United States' 1993 E. coli 0157:H7 epidemic in hamburgers served as a primary catalyst for changing the

system for inspecting meat. The Pathogen Reduction: Hazard Analysis and Critical Control Points System regulation was published by the USDA in 1996. This regulation mandates that the HACCP system be used in all 6,500 meat and poultry processing facilities in the United States.

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Food Safety Statistics and Potential Career Opportunities in Food Safety

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***Abstract*— Food safety is concerned with how food is handled, stored, and prepared to avoid illness and ensure that our food provides sufficient nutrients for individuals to maintain a balanced diet. But how many individuals become sick from water or foodborne sickness is one of the most difficult issues to answer. This chapter explores the reasons why it is difficult to provide an answer before examining some of the monitoring initiatives put in place to acquire data.**

***Keywordss*— Disease Outbreak, Food Safety, Food Service, Foodborne Disease. Food Safety Statistics.**

I. INTRODUCTION

Foodborne Diseases Active Surveillance Network is a surveillance effort to determine how many individuals get foodborne infections overall. The CDC Surveillance for Foodborne Disease Outbreaks 1993–1997, which tracks cases and outbreaks of foodborne illness. Reports of Waterborne Disease Outbreaks and Cases for the Years 1997–1998. The most recent information on the medical expenditures of foodborne diseases is provided. What individuals do or don't do regarding food safety is something that food safety educators are curious about. To do this, data from the Household Food Safety Survey and Behavioural Risk Factor Surveillance Systems are evaluated [1]–[3].

How many Americans suffer from food- or water-borne illness and/or die away each year? Where are they becoming sick, and what actions make them sick? What is the societal cost of this? Finding the answers to these questions might be challenging, even though they seem straightforward. Any responses are, at best, estimates predicated on a variety of assumptions. To direct preventative efforts and evaluate the efficacy of food safety rules, it is crucial to have reliable data on water- and foodborne sickness and pathogens.

This statistics collection is complicated by several variables. The overwhelming majority of incidents of foodborne and waterborne diseases are not reported. Many conditions must be met for an episode to be reported and so tallied. The sick individual must first seek medical attention. Without a serious sickness, this does not occur. The majority of individuals mistake diarrhoea or vomiting for the "24-hour illness" or, even if they do blame it on something they ate, they still choose not to go to the doctor. According to estimates, for every occurrence of Salmonella, a bacteria that generally causes non-bloody diarrhoea, 38 instances are not port, though. It is estimated that there are 20 unreported cases for every case that is reported with E. coli O157:H7, which causes more severe bloody diarrhoea. In the event that the patient does seek medical attention, the healthcare professional must collect a sample for laboratory analysis. Lastly, the proper diagnostic test must be run in the lab. Finally, the healthcare professional must inform public health authorities about the disease and/or test findings. This series of actions often breaks down somewhere along the way.

It may be challenging to determine if an infection is foodborne since many foodborne germs can also transmit via water or from person to person. Although certain infections, including Bacillus cereus and Clostridium perfringens, are solely transmitted by food, parasites like Giardia lamblia and Cryptosporidium parvum are only 10% of the time transmitted through food. Last but not least, certain cases of foodborne sickness are brought on by agents or bacteria that have not yet been discovered and cannot be diagnosed. Twenty years ago, major pathogens including Cyclospora cayetanensis, Escherichia coli O157:H7, Listeria monocytogenes, and Campylobacter jejuni were either unheard of or not even connected to foodborne disease.

Many instances of foodborne disease that have been recorded have an unknown pathogen. Current estimates of foodborne disease in the United States include 76 million cases, 325,000 hospitalisations, and 5,194 fatalities from foodborne pathogens every year when recognised pathogens and unknown agents are added together. When the pathogen is known, bacteria account for 30%, parasites for 3%, and viruses for 67% of foodborne infections. Yet, in terms of fatalities, parasites account for 21%, viruses for 7%, and bacteria for 72% of foodborne illness-related fatalities. Viruses produce a large number of illnesses, yet the number of sick individuals who pass away is extremely small.

Two bacteria have very high mortality rates: Listeria may cause 20% of deaths and Vibrio vulnificus may cause 39% of deaths. Almost 90% of foodborne illness-related fatalities are caused by only six pathogens: Salmonella, Listeria, Toxoplasma, Norwalk-like viruses, Campylobacter, and E. coli. FoodNet statistics from the years 1996–1997 show that each individual in the United States has 1.4 episodes of diarrhoea annually. There are 375 million occurrences

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Vol 10, Issue 2S, February 2023

annually with 267.7 million people living in the United States, many of them due to consuming hazardous food.

A. Network for active surveillance of foodborne diseases

FoodNet is a foodborne disease surveillance programme that aims to quantify the prevalence and severity of foodborne illness, the proportion of foodborne illness attributable to consuming particular foods like meat, poultry, and eggs, and the epidemiology of newly discovered and emerging bacterial, parasitic, and viral foodborne pathogens. Since its establishment in 1995, the U.S. Department of Agriculture, the U.S. Food and Drug Administration, and eight state sites have worked together to maintain it. Minnesota, Oregon, and Georgia, as well as a few counties in California, Connecticut, Maryland, New York, and Tennessee, are among the participating states. Overall, 29 million people, or 11% of the US population, are covered by FoodNet. Scientists will have a better understanding of foodborne infections and be able to develop novel preventative measures to deal with the public health issue of foodborne illness as a result of comparing data from year to year. Researchers and policymakers also use the data to evaluate how well food safety laws are working to cut down on the number of foodborne illness cases reported annually in the US.

The majority of methods for reporting foodborne disease data are passive systems; they depend on clinical labs to notify state health departments, who then notify the CDC, of instances of foodborne illness. These passive surveillance technologies only record a small percentage of real instances. FoodNet is an active surveillance system, which means that to discover fresh instances of foodborne illnesses, its investigators often get in touch with clinical labs. Public health officials can better understand the epidemiology of foodborne diseases thanks to this ongoing active surveillance, including who gets sick, how sick they get, which foods are most likely to make people sick, when in the year foodborne illnesses are more prevalent, and which pathogens are to blame.

B. Outbreaks of waterborne disease, 1997–1998

Water, in addition to food, has the potential to make people unwell. To maintain a surveillance system that gathers information on outbreaks of waterborne diseases from drinking and recreational water, the CDC, EPA, and the Council of State and Territorial Epidemiologists work together. This programme aims to identify which microorganisms in the water supply cause sickness and how many people become sick, similar to food surveillance programmes. Public health authorities may develop programmes to avoid waterborne illnesses by identifying how and why outbreaks happen, training public health workers in spotting and analysing WBDOs, and characterising the epidemiology of these diseases. The statistics, like other voluntary data submissions, understate the real frequency of WBDOs. The likelihood that sick people will see the same doctor, that doctor's knowledge of WBDOs, the accessibility of lab testing facilities, local regulations for reporting cases of specific diseases, and the capacity of state and local agencies to look into potential outbreaks are all factors that affect reporting. In the years 1997–1998, 2,038 persons became sick from drinking water and 2,128 from recreational water. Similar to foodborne outbreaks, there are more WBDOs in the summer, and the reason is often unknown.

There were 17 outbreaks in drinking water between 1997 and 1998. That 6 cases were brought on by parasites, 4 by bacteria, 5 by an unknown source, and 2 by chemical poisoning. The cause of both chemical poisonings was copper poisoning. Eight of the 17 WBDOs were connected to neighbourhood water supplies. Of these eight, three were brought on by issues with water treatment facilities, three by issues with the plumbing and water distribution systems of specific facilities, and two by issues with tainted untreated groundwater. All five of the 17 WBDOs were connected to groundwater systems and were connected to non-community water systems. The four epidemics that were connected to specific water systems also originated from groundwater. Gastroenteritis was the outcome of 18 occurrences linked to recreational water. As can be shown, the parasite Cryptosporidium was to blame for 9. The other epidemics were brought on by Norwalk-like viruses, Shigella sonnei, E. coli O157:H7, and unidentified causes. The other half happened in freshwater—lakes, rivers, or hot springs—while just over half happened in treated water—pools, hot tubs, or fountains.

C. Food-borne illness medical costs

What cost does food poisoning incur in the United States? The provided statistics, like previous estimates of foodborne disease, are simply estimates. Out of the 40 germs that cause foodborne disease, the USDA Economic Research Service evaluated the expenditures in 1996. They concluded that the six bacterial foodborne diseases had yearly medical expenses ranging from $2.9 billion to $6.7 billion. This covers the direct expenditures of medical care as well as lost output from sickness or early death. Just six pathogens were included in the research, and numerous long-term effects of foodborne disease are difficult to quantify, so these numbers represent an underestimation of the real costs to society. The expenses incurred by businesses, the government, and individuals to avoid foodborne diseases are also not included in these estimations. Also excluded are the tools used to monitor and look into foodborne outbreaks. Salmonella and Staphylococcus had the biggest costs, respectively.

D. Systems for behavioural risk factor surveillance

Understanding how individuals become ill from eating is also helpful. Surveys of human behaviour focus on actions that could lead to foodborne disease. As part of the Behavioural Risk Factor Surveillance Systems, the CDC, FDA, and many state health agencies survey consumers on a

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variety of topics related to food handling, preparation, and consumption. Adults are contacted by phone by the researchers, who enquire about their health-related actions and routines during the past 12 months.

The most often reported dangerous eating activity among individuals who engaged in it was eating hamburgers, particularly pink hamburgers. A significant portion of respondents also mentioned eating eggs that were undercooked and home-canned veggies. Over 20% of respondents admitted to not washing their hands or cutting boards properly. Fewer than half of respondents even recall seeing the safe food handling labels on meat products, but of those who did, three-quarters also recall reading them [4]–[6].

II. DISCUSSION

Because food safety is a component of so many occupations, there is no one route to a career in it. Although operating a restaurant requires far less education and does not necessarily need a background in science, becoming a researcher necessitates a high degree of education and a significant understanding of science. This chapter describes a few career opportunities and offers broad advice on how the reader might become ready for them. There are a few credentials available even if there are no colleges that provide degrees in food safety right now [7]–[9].

These are suggestions on where to obtain remote learning and continuing education programmes in food safety. The chapter concludes with suggestions on where to look for chances like fellowships, internships, and scholarships. A wide range of positions in the area of food safety need different degrees of education. To guarantee that the food we consume is safe and healthy, researchers from academia, business, and government develop and evaluate new technologies, disentangle the disease processes of foodborne pathogens, and manage germs that cause foodborne illness from the farm to the table. The biggest manufacturing sector in the US is food processing. To guarantee that food is produced securely, a large number of food protection professionals are required. The retail food service industry—restaurants, grocery shops, convenience stores, and institutions—is something that we have all experienced, even if most customers do not see much of the research and production components of food. To ensure that food is prepared and served in these places safely, food safety professionals also operate in the retail food sector.

Food scientists research the chemical, physical, and microbiological properties of food, as well as the factors that contribute to food spoilage, as well as techniques for examining both food and microbes. The food safety research team also includes veterinarians, microbiologists, chemists, and food engineers. In universities, some of these scholars do fundamental research. Others work for the government to create guidelines, rules, and laws that safeguard the food supply. The majority of food safety researchers work for the industry. Research on how to create and serve processed foods without producing foodborne disease has gone into every product that is bought in grocery stores or served in retail food service facilities. Veterinarians deal with food animals in the pre-processing stage to make sure they are wholesome and healthy. They are specialists in pathology, parasitology, and epidemiology and deal with issues like microbial resistance to antibiotics and animal medication residues.

Researchers' findings are put to use by food technologists in the choice, preservation, processing, packaging, and distribution of food. Food technologists need a solid foundation in the fields of statistics, chemistry, microbiology, quality assurance, and food science. The majority of food producers use quality assurance professionals to make sure that goods adhere to regulatory, business, and industry standards; to conduct microbiological testing on raw materials throughout processing and on completed goods; and to keep records of quality assurance. While technicians may have a two-year degree from a technical school with a focus on the sciences, most QA workers have a four-year degree in food science or another science. Equipment for the manufacturing of novel food items is designed by food engineers; this equipment must make food safely, not harbour microbes, and be simple to clean.

Workers in the food industry contribute significantly to food safety. They also must be knowledgeable about food safety as they handle the food. Nowadays, a qualified food manager must be present at food service enterprises in many states, counties, and towns. Obtaining a food management certification or other food safety qualifications may not need a college degree. At least 12 million people are employed in the food service sector. With such a vast workforce, there is a tremendous demand for educational trainers who can impart food safety concepts.

Both at the federal and municipal levels, the government employs a lot of experts in food safety. To safeguard the population and the food supply, health inspectors carry out the enforcement of sanitary laws about food, water, and sewage. Restaurants, grocery shops, convenience stores, institutions, fairs, festivals, and special events are all inspected by inspectors hired by states, counties, and localities. They also investigate outbreaks of foodborne disease and educate owners and managers of food outlets on food safety practices. At the federal level, scientists in the domains of chemistry, microbiology, and epidemiology are employed by the Food and Drug Administration and the U.S. Department of Agriculture as food technologists, food inspectors, and scientists. More than 1,300 veterinary medical officers work for the USDA. To make sure that they adhere to accepted food safety standards, USDA inspectors work in meat and poultry slaughter and processing plants, while FDA inspectors work in food processing and manufacturing facilities. Food safety also involves other professions. For the development of novel packaging

technologies, there are product package designers, risk assessment experts, and food toxicologists [10]–[12].

III. CONCLUSION

Universities do not currently offer undergraduate degrees in food safety. Since there are so many diverse employment options in food safety, the educational requirements for those occupations must vary. Food safety is a science since it includes the study of microbes, the relationship between food's qualities and microorganisms, and the interaction between germs and people or other animals. It would be beneficial for anyone who wants to work in food safety to have a solid general scientific foundation. A collegiate programme in environmental health, epidemiology, zoology, dietetics, general biology, food science, microbiology, and chemistry might be beneficial. But more people with training in culinary, teaching, and policymaking have joined the subject of food safety.

For those interested in a career in the food industry, including government regulators, trade association executives, food service professionals, and owners and managers of food-related businesses, George Washington University in Washington, D.C., offers a professional advancement programme in food studies. Food safety, writing about food, trends in food, and consumer advocacy for food safety are among the topics covered in the courses.

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Standard Operating Procedures, Effective Manufacturing Practices and Best Hygiene Practices

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Abstract— When the meat and poultry sectors were subject to HACCP requirements, sanitization SOPs were first put into place. All present signs point to the egg processing sector adopting these techniques. According to reports, bacterial counts for equipment surfaces and wash water correspond with counts for washed egg surfaces. Additionally, it was discovered that the eggs, not the apparatus, were the main source of contamination for the wash water.

Keywordss— Hygiene Practices, Direct and Indirect, Food Safety, Foodborne Disease, Manufacturing Technique.

I. INTRODUCTION

Direct and indirect touch surfaces, water, air, and humans are the main sources of contamination in processing facilities. Other potential sources of contamination during processing were drains, plant-wide transportation devices, and maintenance tools. A corporation may get a better knowledge of the program's efficacy by conducting an audit of the sanitation program at a processing facility. Publications that describe sanitation audits and quick procedures for sanitation sampling are available. Furthermore, sanitization may not necessarily result in a thorough cleaning. Many workers at processing plants fail to read the labels on the disinfectants they use [1], [2].

SSOPs are a crucial part of process control and often represent the initial stage in putting food safety laws into practice. The effectiveness of the cleanliness procedures employed in various shell egg processing plants was evaluated and compared by Jones et al. We assessed in-line, offline, and mixed operations. At several shell egg processing facilities in the southeast of the United States, sixteen direct or indirect egg contact surfaces were tested. Samples were taken after a processing day and once again the next morning before activities started. Enterobacteriaceae were counted and total aerobic plate counts were obtained. There are no obvious distinctions between

Although it seems that the shell egg business requires more stringent cleaning procedures, it's also critical to assess if this sector needs to adhere to the same hygiene requirements as the meat and poultry sectors. Even though shell eggs are raw goods, cleaned eggs have substantially lower bacterial counts than raw chicken carcasses. Also, the egg's inherent antibacterial properties aid in limiting the spread of microorganisms.

A. Excellent fabrication practices

Management techniques aiming at applying codes of good manufacturing practices should exist inside the food industry. For the production, processing, and preparation of diverse food items, GMPs provide broad guidelines. It strives to protect excellent sanitary and sensory quality qualities and might be seen as a duty to treat manufacturing with great care. The basis upon which the production of safe food is founded is currently recognized as being the GMP principles, which have been established over several years. The Food and Drug Administration established a Food GMP Modernization Working Group in July 2002 to assess the efficacy of the food industry's present practices. Since GMPs were established in 1986, the food sector has seen a great deal of change. The Working Group has been investigating the effects of both new rules and food GMPs on food safety. As of June 2004, one of the group's ongoing efforts is determining which components of the food GMPs must be kept and which should be enhanced. The FDA is now hosting open sessions to collect public feedback to aid in this endeavour. Guides to GMP are published by the Institute of Food Science and Technology in the United Kingdom. It is preferable for establishments to be situated away from ecologically dirty regions, places that are subject to floods, areas where insect infestations are common, and areas where garbage cannot be collected efficiently.

Structures and facilities should be created with a regular process flow from the arrival of raw materials to the completed product in order to support sanitary operations. To enable efficient operation, a sufficient quantity of potable water, natural gas, power, fuel, and other utilities should be provided. Moreover, suitable drainage and waste disposal systems, ventilation systems to reduce smells and vapours, air conditioning, and dust control should be provided. Moreover, ventilation systems must be easily cleanable and screened to keep insects and rodents out.

The layout, design, and construction of a food facility should allow for adequate cleaning and disinfection, shield the product from debris, particulates, and foreign objects, prevent condensation and mold growth on surfaces, guard against cross-contamination between and during operations,

and create an environment that is suitable for the hygienic processing and storage of raw materials and finished goods.

To minimize the build-up of filth, mold, and moisture as well as to limit the amount of dust that is shed, ceilings and overhead fixtures should be smooth, waterproof, impermeable, and without ledges or overhanging walls. Light fixtures need to be shielded. The materials used to construct floors should be impermeable, long-lasting, resistant to microbiological and biochemical assault, grease, cleaning chemicals, cracks, and fissures, and simple to clean.

Surfaces for floors, walls, and partitions must be made of materials that are impermeable, non-absorbent, washable, and non-toxic. The coating on floors should be nonslip. They should be built such that liquid drains to them, and drains should be equipped with stainless steel perforated traps to catch debris. Doors should typically either open automatically or have heavy-duty plastic strips installed to make them accessible to staff and vital traffic. Opening windows is not advised since roofing, which is often flat or slightly sloped and supported by trusses or beams, maybe a source of natural light.

Windows and sills should be impermeable, readily cleanable, and designed to prevent dirt build-up. To prevent their usage as shelves, sills should be slanted. Toilets, dressing and locker rooms, and rooms where food is inspected, processed, or kept should all have sufficient illumination. Equipment should be easily disassembled for inspection and manual cleaning, designed to protect the contents from external contamination, sanitized with approved sanitizers, and rinsed with potable water. All surfaces in contact with food should be smooth, not porous, inert, visible for inspection, accessible for manual cleaning, made of non-toxic material, corrosion-resistant, and designed to withstand extended use.

Equipment Supports Construction materials, structural forms, and their organization are all examples of equipment supports. Austenitic stainless steels like AISI 304, 316, and 316L are the most popular building materials because they exhibit excellent corrosion resistance in most situations except those with high chloride content, particularly in acidic environments. High chloride products demand specialized metals like titanium or alloys like Hastelloy.

B. Equipment dependability, accessibility, and maintainability

The equipment's dependability, accessibility, and maintainability are crucial factors in regulating both the output and the level of quality. Ebeling thought that equipment, operating circumstances, maintenance needs, and infrastructure facilities all had an impact on the RAM of a repairable system. In the context of pressure vessels, Zerwick noted that a methodical approach based on RAM principles aids in evaluating changes in inspection frequency, maintenance actions, or condition monitoring strategies leading to a decrease in the frequency of planned shutdowns, an increase in the time between statutory inspections, and a decrease in maintenance costs.

The strudel manufacturing line is made up of several series-connected workstations and machines that share a transfer mechanism and control system but have unique failure modes. The majority of the line upstream of the failed machine must continue to run without processing when a random failure occurs, but the material in the line downstream may need to be destroyed because of quality degradation during the pause. The production rate and line dependability are both negatively impacted by the failure.

The parameters of the theoretical distributions with the best index of fit were determined, and descriptive statistics of the failure and repair data were generated. The line's data collecting and analysis are valid for 16 months. Furthermore determined the dependability and danger rate modes for each workstation together with the whole manufacturing line. The models may be a valuable tool to evaluate the existing state and forecast dependability for improving the manufacturing line's maintenance strategy. Finding strategies to make characteristics more reliable and maintainable might therefore be valuable.

Tsarouhas et al. studied RAM analysis of the cheese manufacturing process over 17 months. The failure and repair data were fitted as closely as possible to the prevalent theoretical distributions, and the corresponding parameters were determined. Also, the full manufacturing line's dependability and danger rate modes were determined. The models are expected to be a helpful tool for determining the reliability of updating the maintenance methods for the manufacturing line and for evaluating the present circumstances. The availability of the cheese manufacturing line was discovered to be 91.20% and decreased to 87.03%. The main four failure mechanisms account for 62.2% of all failures on the cheese production line, with an average failure occurring every 12.5 operational hours and a mean repair time of 66 minutes. This examination will be extremely helpful in identifying both the active and dormant issues in the production of cheese and, ultimately, in resolving them.

Everything in the installation has the proper illumination. There may sometimes be controlled, artificial illumination provided by glow lights. At times, there is natural lighting available. The majority of the time, lighting fixtures in production areas are covered with plastic to prevent the spread of glass and product contamination in the event of breakage.

C. Airing ventilation

The ventilation is adequate and avoids unwelcome heat, steam, and dust accumulations. Most ventilation is done using fans, however, there are certain situations—like silos—where an automatic airing system with turbines is used. Natural or mechanical ventilation should reduce the danger of product contamination, manage environmental conditions, and avoid the excessive buildup of heat and relative humidity. For instance, Arvanitoyannis et al. claims that every booth in the aviary has an automated airing system

with filters that provide positive pressure. Also, a fully automated system of control is placed in the booths in the event of extremes in temperature and humidity [3]..

II. DISCUSSION

There should be suitable facilities for proper garbage management. Trash should be gathered outside the booths in trucks and transferred by the company. Solids have to be gathered at a different location away from the installation and turned into fertilizer for the crops. Containers for waste or harmful materials have to be impermeable and leak-proof. These need to be labeled as well. To avoid unintentional product contamination, containers used to store hazardous materials should be lockable [4], [5].

Sewage from the candling center is assembled in stainless siphons that flow to a separate cesspool from that for human sewage in the case of eggs, while human sewage is assembled in a cesspool that is already present in the installation. The company has created a boiler system for dead birds and unarranged eggs that cannot be sold in pasteurized industries. Eggs and egg products intended for human consumption must be kept free from contamination, therefore waste products must be disposed of in a hygienic, ecologically responsible way. Daily cleanup of the property and regular removal of all garbage from processing rooms are required. Unwanted eggs and egg products must be buried at an approved dumping site for disposal, and they cannot be utilized as animal feed unless they have undergone further heat treatment to kill germs. The Environmental Protection Agency's disposal recommendations for sanitizers must be followed. Litter and/or poultry manure can be removed off-site, spread on nearby land at an effective buffer distance to the poultry shed, or stored on-site in a dry weatherproof building at an effective buffer distance from poultry sheds. Dead birds shall be promptly collected and placed in waterproof, leakproof containers before incineration, burial, or other approved outdoor methods, away from the poultry shed. A buffer distance is less important in the case of mobile shedding.

Installations for hygiene in the production of eggs

Two distinct areas of closet-equipped lockers for employees exist in the business. Both the first and second ones meet the requirements of the staff who work in the aviary, the candling center, and the packaging area, respectively. Separate locations or rooms should be provided for the following tasks: storing eggs and unprocessed raw egg products; breaking eggs; processing eggs; storing processed egg products; storing additives; and storing cleaning and sanitizing supplies [6], [7].

III. CONCLUSION

"All precautions and steps, which are essential in the manufacturing, processing, storage, and distribution, in order to provide an unobjectionable, sound, and pleasant product which is suitable for human consumption," is the general definition of sanitation.

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Physical And Chemical Methods for Controlling Food Hygiene

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Abstract*— One strategy for ensuring appropriate hygiene practices and maintaining a high standard of sanitary food production is the use of microbiological studies of surfaces. Nowadays, the food business uses a variety of surfaces, including plastic, stainless steel, glass, and wood. Microorganisms that cause cross-contamination of food when it comes into touch with working surfaces may contaminate these surfaces. In this chapter, we discussed the physical and chemical methods for controlling food hygiene.

Keywordss*— Control Hygiene, Food Handling, Food Safety, Hygiene Management, Microbial Contamination

I. INTRODUCTION

For the prevention of problems with food safety, HACCP-based techniques are now often utilized to manage microbiological threats. Microbiological surface examinations are now one of the instruments used to regulate the cleanliness of goods as a consequence of this preventative strategy. Controlling hygiene requires a strategy for re-covering germs from various solid surfaces. Surface microbial contamination is not regulated, although food firms often create technical criteria to improve the quality of their goods and lower the danger of contamination. They list and explain the benefits and limitations of the most popular techniques, including swabbing, friction or scrubbing, printing, washing or immersion, sonication, and scraping or grinding. The recovery technique used must be appropriate for the size and kind of surface being examined for microbiological investigation. Modern fast and inexpensive technologies must be standardized and especially simple to use in the field [1]–[3].

The food business has created ways and procedures to recover microorganisms from surfaces, however, factors like the variety of experimental circumstances or samples make it difficult to choose the optimum approaches. There are presently no standardized procedures for recovering microorganisms from rough surfaces with particular porosity, like wood. The international standard ISO 18593:2004 specifies two techniques that are presently utilized for smooth surfaces but does not outline any specific techniques for materials such as scraped plastic or porous wood.

A. Crisis management, hygiene, and street food

You may find a broad range of SFs in China, including yang Rou paomo, goubuli baozi, Lanzhou lamian, and other regional specialties. The primary risk factors for SFs have been shown to include incorrect food handling, poor personal and environmental hygiene, and insufficient infrastructure, including a lack of access to clean water and inadequate trash removal. Numerous studies on the food safety knowledge and sanitation practices of SF vendors in various countries have revealed that the majority of SF vendors lack the necessary knowledge of hygiene and sanitation practices, which makes it more challenging for them to ensure the safety and quality of the SF. The general level of food safety in China has significantly increased, and continuing initiatives are being made to increase public understanding of food safety.

Food safety offences including meat adulteration and tainted bean sprout processing continue to happen often, alarming the public about these problems. Traditional local cultures are often reflected in SFs, which provide visitors and even regular customers with a distinctive cultural experience. The safety of SFs has been elevated to one of the top public health issues because of the rapid speed of globalization and tourism. Establishing a nationwide program to improve SF vendors' knowledge of and awareness of food safety is urgently needed in China.

We gathered information on the food safety procedures and understanding of SF vendors, the ability of inspectors to enforce regulations, and the shopping preferences of customers. Strategies for assuring the safety of SFs were suggested after analysing potential risks in SF preparation and selling. The research revealed that the use of unqualified raw materials, which is promoted by inefficient inspections, inadequate infrastructure at SF vending locations, and a lack of sanitary expertise among SF vendors are the main causes of the safety hazards in SF. More strict and efficient routine supervision and food safety procedures should be developed, and environmental conditions and facilities should be enhanced, to avoid the contamination of SFs. Moreover, SF vendors and food safety inspectors should have more regular training in food processing technology, food safety knowledge, and useful food safety assessment procedures.

Three underlying characteristics were discovered via factor analysis: knowledge of food pathogens, food service production, sanitary procedures, and sanitation rules and protocols. According to the importance-performance study,

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Vol 10, Issue 2S, February 2023

adherence to sanitary standards was necessary to maintain best practices for preventing food-borne illnesses and other key issues with food security. The findings highlighted the significance of creating a practical preparatory sanitation management strategy that would sustain high operational standards to assist in maintaining the quality of food and safeguarding the customer from contracting a food-borne disease. The findings of multiple regression showed that organizational development and organizational effectiveness in supporting a crisis management strategy were positively impacted by sanitation management parameters.

Many safety processes were found to be non-conforming, including improper thawing, cooking food at the wrong temperature, controlling the temperature of freezing equipment, cooking food apart from detergents and disinfectants, and managing waste, cleaning, and sanitizing procedures. Just 40% of the food service establishments assessed kept track of the temperature of prepared food. The audit of every food-service unit found non-conformities in the cleaning and disinfection procedures used on-premises and equipment. In 85% of units, the required labeling of stored objects had been done. All food handlers surveyed in this study handled garbage improperly. The primary causes of improper personal hygiene practices were a lack of resources and favorable settings for performing proper hand washing.

The number of meals prepared or served was not found to be significantly correlated with the practices and procedures related to food safety. More often than cooking units, distribution food units failed safety inspections in areas including food-handling procedures and temperature management of prepared meals. The findings highlight the critical requirement for managers to maintain constant management of employees' food safety training. It's crucial to establish standard operating procedures that emphasize food safety while enhancing staff incentives and accountability.

De Oliveira et al. used a food safety checklist that was validated for the school setting and a study of surfaces that come into contact with food to assess and categorize the sanitation and hygiene conditions in public schools in Porto Alegre/Rio Grande do Sul. On each item of equipment or utensil examined, the median mesophilic heterotrophic bacteria count was found to be 27.3 colony-forming units/cm2, 15 on cutting boards, 14.5 on blenders, 2 on plates, and 1 on refrigerators. All pieces of equipment and utensils that were subjected to adenosine triphosphate bioluminescence surface measurements had a median of less than 40 relative light units per 100 cm2, except the countertop surface, which had a median of 52.5 RLU/100 cm2. According to data collected from 120 schools, 33%, 64%, and 3% of students were identified as having high, regular, and low health risks, respectively.

The findings demonstrated that shortcomings, particularly concerning environmental cleanliness and procedures, exposed the majority of schools to cross-contamination. In this environment, failures linked to these elements may increase the probability of epidemics. The ratings utilized allowed for the categorization of school lunch programs and the identification of areas that need further focus. In this situation, intervention tactics that focus on many facets of food handling rather than just knowledge might be fruitful since they could address issues that primarily affect the food handler and encourage modifications to current food handling procedures.

Around half of the locations required better-refrigerated storage. The possibility of product contamination from ceiling condensation was a prevalent issue, but the smaller facilities were particularly vulnerable. Small FBOs need more details on how sanitation and cleaning can keep the process clean and prevent contamination of the finished product. Small processors also asked for help with the optimum method for calculating shelf life. L. monocytogenes was found in the product in 56% of the smoked salmon processors evaluated, and prevalence varied greatly across processors. The highest Est listeria prevalence processors were also the ones that were most worried about what microbiological tests should be done and how to gauge the caliber of their output. The majority of processors seldom ever went beyond the legal limit established by the European Union. Due to the high-test costs and a lack of technical know-how, the small manufacturers did not test their products for Listeria. So, it was determined that sharing knowledge amongst producers, particularly to smaller processors, would be advantageous in terms of protecting consumers.

B. Sanitation, hygiene design, and CIP

One of the most important parts of food processing to maintain consumer health and safety is cleaning and sanitizing of processing facilities. Producing high-quality food items, particularly those with a long shelf life, requires proper cleaning. In many dairy, processed food, beverage, and beer operations, cleaning-in-place has now largely replaced manual process system strip-down, cleaning, and rebuilding. The main commercial benefit is a significant reduction in the amount of time the plant is out of commission as well as the ability to use more powerful cleaning agents in confined spaces that cannot be handled safely with manual cleaning. CIP is described as "the cleaning of complete items of plant or pipeline circuits without dismantling or opening of the equipment, and with little or no manual involvement on the part of the operator" in the 1990 edition of the Society of Dairy Technology manual "CIP: Cleaning-in-Place." Under conditions of increased turbulence and flow velocity, the process entails jetting or spraying surfaces or circulating cleaning solutions through the plant.

CIP is an integrated process and hygienic design of the entire process, not just the provision of a CIP bulk unit. A CIP system consists of equipment to monitor the cleaning process, instruments to prepare and store cleaning chemicals,

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pumps, and valves to circulate the chemicals throughout the plant, and vessels to recover the chemicals. CIP is a technique for cleaning up product leftovers in a processing facility. It does not function as a method of removing microorganisms from the body. This is the function of post-CIP sanitization or sterilization processes, which use heat or chemical sanitizers to kill microorganisms.

The most recent advancement in CIP technology uses electrochemically activated water to create cleaning and sanitization solutions at significant cost savings over conventional chemicals. ECA water is created by electrolyzing a sodium chloride solution. Anolyte and catholyte will mix when there isn't a permeable membrane present. In essence, this is sodium hydroxide and hypochlorous acid combined. The two electrolytes can be separated by inserting a permeable membrane in between the electrodes. The entire process plant's construction materials must be nontoxic, smooth, nonporous, and free of crevices. They also must be resistant to the food and cleaning chemicals that will be used. Construction materials, surface finish, joints, fasteners, drainage, internal angles and corners, dead spaces, bearing and shaft entry points, instrumentation, panels, covers, and doors are all subject to hygiene requirements [4]–[6].

II. DISCUSSION

Standards have a significant role in determining manufacturing quality. Before ten years ago, welding for pharmaceutical applications would have been certified to ASME B31.3 and Section IX of the Boiler and Pressure Vessel Code by the American Society of Mechanical Engineers. While the weldments' structural integrity was guaranteed, the quality of the weld surface on the interior of the tube, which is crucial for bioprocess applications, was not specified. The dairy industry in the United States introduced the 3-A sanitary standards in the 1950s, mandating fully penetrated welds in sanitary piping systems and offering guidelines for materials and fabrication techniques. These standards also attempted to establish standards for workmanship and quality control, acknowledging that the ability to maintain a piping system in a sanitary or hygienic condition was dependent on the quality of the welds. Yet, it was thought that new standards were required to fulfill the greater quality requirements for the more complicated, often fragile, and very expensive bioengineered goods. It was thought that after the necessity for strength was satisfied, there was a need for design requirements for equipment that would allow it to be efficiently cleaned and sterilized as well as a focus on ensuring weld surface quality. To incorporate existing standards for vessels, pipes, appurtenances, and other equipment for the bioprocess sector without violating those other standards, a need for standardized definitions was also acknowledged. The ASME has created a new standard to give guidance for the design and construction of facilities in which pharmaceutical goods are generated using bioprocess technology in response to the unique demands of the biopharmaceutical sector [7]–[9].

In October 1997, ASME BPE-1997, the new Bioprocessing Equipment Standard, was published. The BPE Standard applies to all piping and equipment components that come into contact with finished goods, raw materials, or intermediates of finished goods during process development, scale-up, or manufacturing, as well as all equipment systems that are essential to the production of finished goods. This covers apparatuses like those used for clean steam, ultrafiltration, water for injection, and intermediate product storage. The BPE Standard does not apply to piping systems or components of piping systems that do not come into contact with the final product.

Hygienic design, which is defined as "of or pertaining to equipment and piping systems that by design, materials of construction, and operation provide for the maintenance of cleanliness so that products produced by these systems will not adversely affect human or animal health," is a key component of the BPE Standard. In accordance with this idea, the purpose of the design portion of the standard was to establish and explain recognized procedures that have been shown to lead to the manufacture of bioprocessing equipment that is both cleanable and sterilizable. For certain designs and production techniques, it distinguishes between preferred, recommended, and not recommended designations.

Instead of being disassembled for cleaning, bioprocess equipment is often intended to be CIP. The BPE Standard only covers automated or manual CIP operations and automated steam-in-place processes; hot water, 176°F sanitizing, and other sterilizing techniques are not included. The inside surfaces of plumbing and equipment must be smooth and devoid of crevices for CIP and SIP to be effective. This makes the surfaces cleanable and prevents microbial growth. A dead leg in a piping system is described as a pocket, tee, or extension from a main piping run that exceeds a set number of pipe diameters from the ID of the primary pipe. As a result, dead legs must be kept to a minimum in equipment design and fabrication [10]–[12].

III. CONCLUSION

All surfaces, especially the points where they intersect, must be smooth and devoid of any ridges or fissures that may act as a breeding ground for organic elements. Edges, recesses, and projections should be kept to a minimum. After removing any readily detachable components, all surfaces in contact with food must be quickly cleaned and, if feasible, disinfected. To make cleaning easier, curves on interior surfaces must be radiused. Food- and cleaning-related liquids, gases, and aerosols must be discharged entirely. Design and structure should keep animals and liquids out, and they should also prevent dirt from building up in places that can't be cleaned. Food should not come into touch with any supplementary materials due to proper design and construction. Compliance has to be examined.

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A Brief Overview of the Evolution of Food Hygiene

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***Abstract*— The practice of healing dates back nearly as far as humankind. Humans learned the craft of healing via instincts, desires, and experiences. Medicine and hygiene have always worked together to treat and prevent illnesses. For the most part, these professions have worked together to improve human health. The early facets of hygiene are covered in this introductory chapter, and if applicable, the intersections between illness prevention and treatment will be covered. With the discovery that germs are the primary cause of illness, the importance of cleanliness quickly gained ground and is currently regarded as the cornerstone of the production of safe food.**

***Keywordss*— Food Poising, Food Safety, Food Hygiene, Foodborne Disease, Public Health.**

I. INTRODUCTION

Asclepius, a healer who rose to the status of a Greek demigod and was known as the god of medicine or healing in Greek mythology, was the son of Apollo. He was the most significant of the Greek deities and heroes who were linked to healing and good health. Greece was home to several Asclepieia, or shrines and healing temples, where the sick would go to pray and seek relief from their ailments. The two most well-known of Asclepius' offspring are his daughters, Hygeia and Panacea. Hygeia rose to prominence as the goddess of healing, emphasizing the curative effects of cleanliness. She first suggested and encouraged bathing patients with soap and water. She was revered as a provider of health in the religion of Asclepius and had several hospital shrines. She was once regarded as the goddess of physical health. Later, she was also associated with mental health; the proverb "a healthy mind in a healthy body" refers to this. Like her father, her sister had to deal with medical treatment [1]–[3].

In various parts of the Greek and Roman world, Hygeia was honored. Throughout the fourth century BC to the end of the Roman era, she was sung about and portrayed by a large number of artists. Several well-known masters, including Skopias, Tomotheos, and Bryaxis, created statues of Hygeia. In the term hygiene and its parts, the name Hygeia has persisted. The symbol for medicine is her holy snake and the Asclepius rod.

A. Hippocrates

The most well-known physician in ancient Greece, Hippocrates, was known as the "Father of Medicine." Hippocrates founded medicine on impartial observation and inference. Principles and techniques for healing that he created at his medical school and sanatorium on the island of Kos have been used ever since. Hippocrates and his adherents developed a wholly logical system that was based on the categorization of the signs and symptoms of various illnesses. He advocated strengthening patients via nutrition and cleanliness, only turning to more extreme measures when required.

He made valid teachings about epidemics, fever, epilepsy, fractures, the distinction between malignant and benign tumors, general health, and most importantly, the value of hygiene, the therapeutic potential of food, and the requirement for high ethical standards in the practice of medicine, according to all historians. He put the most emphasis on nutrition and cleanliness, but when surgery or herbal treatments were required, he employed them. The book Magni Hippocratis Coi Opera Omnia provides a summary of Hippocrates' contributions to medicine. It includes all of the information that was attributed to Hippocrates up to the 17th century.

B. Added hygiene precautions

Humanity has developed the knowledge necessary to choose edible plant and animal species, as well as to grow, harvest, and prepare them for consumption. Much of this was accomplished by trial and error and years of expertise. Several lessons learned, particularly those concerning harmful impacts on human health, are mirrored in numerous religious taboos, such as the Jewish and Muslim prohibitions on consuming certain foods, such as pork. Some taboos demonstrated a broader understanding of food safety. Religious rules, for instance, forbade eating some foods that were considered to be "unclean" in India, such as meat that had been hacked with a sword, scented by a dog or cat, or meat that came from predatory animals. The majority of these food safety rules were created thousands of years ago, perhaps at a time when only religious laws were in force. Control measures were not included in civil law until considerably later.

C. Restoration of hygiene

During the Middle Ages, traditional medicine advanced quickly. To treat sickness symptoms, medicinal herbs, animal parts, and minerals were employed. Surgery was later used as a treatment. Beginning in the early 1800s, the people in the USA and Europe began to despise and mock the medical

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Vol 10, Issue 2S, February 2023

profession due to doctor overreach and the cottage industry of pharmaceuticals. Strychnine was the finest treatment option available to the medical community for paralysis and palsy for at least a century. To kill cats, dogs, and rats, it was used. But, when taken as medication, it served as a tonic, a nervine, and a treatment for persons with paralysis. It was common practice in medicine to deprive patients of water, and hundreds of them subsequently passed away from dehydration. As alcohol was a common element in many of the offered patent nostrums, it served as the basis for the various bitters that were sold to the public as tonics. Alcohol was the main ingredient in the remedies offered to treat alcoholism.

Physicians have routinely bled their patients to death in addition to drugging them to death. For cuts and head traumas that caused unconsciousness, bleeding was used. In addition to bleeding pregnant women, medical professionals also took blood from blue newborns. Patients were bled, blistered, purged, vomited, narcotized, mercurialized, or alcoholized into chronic invalidism or the grave at this time. A lot of people died, and the number of ill people who healed without sequelae was so small as to be insignificant.

Furthermore, at that time, sanitary standards were exceedingly low. Doctors not only disapproved of bathing but were against it. Hospital operating rooms were real pigsties, and surgeons performed procedures without washing their hands. Without first cleaning their hands, doctors would enter the delivery room from the post-mortem room and help deliver the baby. The sickness known as "child-bed fever" was very prevalent and had a high mortality rate. At this point, the insurrection known as "hygiene" remerged. Out of the inconsistencies, misunderstandings, confusion, and illusions that make up the science of medicine, a need for fresh ideas and a campaign for health reform emerged.

D. The idea of "natural hygiene"

Isaac Jennings was a pioneer who came first. In 1822, Jennings, who had been practicing medicine for 20 years, started giving patients starch powder, colored water tonics, and bread tablets as placebos while also counseling them on how to live a healthy lifestyle. Along with physiologist/minister Sylvester Graham, Jennings began enlightening the populace about the flaws and inconsistencies of modern medical philosophy and practice. Graham's persuasive speeches and publications led to the growth of a sizable Grahamite community. He suggested a vegetarian diet as a treatment for alcoholism to the temperance movement. He also promoted sanitary practices including bathing and sexual restriction.

E. Foodborne illness

By the 1880s, public health worries about foodborne illnesses began to surface. This came about because it was discovered that germs might spread infection. Koch and his collaborators developed methods for cultivating bacteria outside the body and came up with guidelines for determining if a bacterium is the root of a disease. Before then, two kinds of food-related illnesses were recognized. One linked to aging and the other with items often not connected with sickness and seemed impervious to adulteration, such as meat and fish. The final kind was for a long time connected to decomposition; in the early 19th century it was believed to be brought on by chemical toxins, then by ptomaines, or putrefactive alkaloids. Unripens or acidity was often blamed for this ailment in the case of uncooked fruit and vegetables, which were also linked to unsettled stomachs.

Before then, and sometimes for decades after, events were often defined by the specific food item in question: "cheese poisoning," "meat poisoning," "pork-pie poisoning," etc. It wasn't until the late 1880s that the general phrase "food poisoning" developed. The words for food poisoning mentioned above are still in use today despite Robert Koch's discovery of particular organisms that cause foodborne infections, such as anthrax, in 1876. Durham and Peckham, among others, have recorded epidemics of beef poisoning and pork pie poisoning, respectively.

Food poisoning is mistakenly thought to be caused by ptomaine consumption. The fundamental compounds created during putrefaction are referred to as ptomaine by Italian scientist Selmi. They may be any of the several amines produced by putrefactive bacteria, and they can be classified into numerous different families of chemical substances. Moreover, bacterial food poisoning replaced poisoning from pesticides in the 1880s. German researchers first began to highlight the links between septic and pyemic3 illnesses in animals used for food and meat poisoning outbreaks in the late 1870s. They began conducting bacteriological investigations into epidemics of meat poisoning in the early 1880s.

There is a dearth of concrete historical data about the prevalence of foodborne diseases in the 19th century. The fact that food poisoning was not reportable is one of the causes. Typhoid and epidemic diarrhea are the two markers for the behavior of food diseases in cities, however. In the 1830s, typhoid became a serious urban threat in the UK and was mostly water-borne. Tainted food and human carriers probably had a substantial influence. Typhoid mortality rates decreased significantly between 1870 and 1885 as urban water supplies improved, but then they stabilized until the early 20th century. Death rates dropped sharply and vanished about 1920 as a result of the identification of the human carrier, the food as a source of infection, and improved medical treatment. Food poisoning was exacerbated much more by epidemic diarrhea. Infant diarrhea, which accounts for 30% of newborn mortality before 1901, is included in the phrase. Huck's local research revealed a strong correlation between increased infant mortality and the development of industrial cities in the early 19th century.

A significant degree of repeated infections in homes was highlighted by other recent research that indicated newborn

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Vol 10, Issue 2S, February 2023

mortality to be simply the visible tip of the iceberg of extended family bouts of diarrhea. Ballard was the one who made the connection between the illnesses and tainted food. The Salmonellae family of bacteria emerged as the top candidates for cause when the first bacteriological examinations of epidemic diarrhea were conducted. The Salmonella bacteria, which the German Gaertner covered and called Bacillus enteritidis, was first identified and reported in 1888. He showed that the cow's carcass contained the microorganism that had given its meat-eating consumers gastroenteritis. Several similar species were swiftly found in the ground-breaking bacterio- logical labs of the 1890s, and the identification of particular disease pathogens turned into a sport. Despite new methods for isolating and identifying bacteria, the bacteriology of food poisoning and infection still seemed to be a very difficult subject to understand. This was partially due to the large number of different organisms that appeared to be involved in the process as well as the difficult questions surrounding their nature and habits. For instance, it was necessary to find answers to the problems of whether Salmonella was a normal resident of both human and animal digestive tracts, if it was found in animal meat, and whether it only appeared in sick animals [4]–[6].

II. DISCUSSION

The discovery of the agents responsible for foodborne illnesses and the study of their aetiologies started around the end of the 19th century when Van Ermengem's research helped to shed light on the causes of human botulism. Other turning points in this category included the identification of Bacillus cereus in the 1950s and Clostridium perfringens as a foodborne pathogen in 1943. Listeria monocytogenes infections in humans were widely recognized by the 1940s, and foodborne transmission was hypothesized, but solid proof wasn't found until an incident in Canada in 1981. In one instance, eating tainted coleslaw led to disease. Since then, additional foodborne outbreaks have been documented in several nations, and the food sector now has a significant problem in preventing listeriosis [7]–[9].

Internal contamination of chicken eggs led to the resurgence of Salmonella Enteritidis. Escherichia coli O157:H7, a novel emerging pathogenic, began to appear during the same period. Hemorrhagic colitis is brought on by this bacterium. Hemolytic uremic syndrome, which is marked by renal failure and hemolytic anemia, might occur in certain patients, especially the very young. 0 to 15% of those who have hemorrhagic colitis may also develop HUS. Kidney function may be permanently lost as a result of the condition.

Although research on foodborne illnesses made significant strides at the start of the 20th century, there was little occurrence reporting. The authorities were seldom made aware of cases of gastroenteritis unless there were one or more fatalities involved or a significant local epidemic. A deeper understanding of the nature of and contributing variables to bacterial food poisoning were noted as being hampered by challenges in reporting and proper investigations. Most cases of food poisoning likely went unreported before World War II. To improve the situation, the UK created the "Emergency Public Health Laboratory Services" in 1939. This network of 19 provincial and 10 metropolitan laboratories was designed to provide medical officers of health with free services for the investigation and control of infectious diseases.

Most people agree that the Second World War was a turning point in the history of food poisoning. Mass catering rapidly expanded both during and after the war, both in terms of feeding big crowds in canteens and restaurants as well as in terms of mass manufacturing of prepared dishes. This brought a lot of fresh issues. The usage of mass importation of American powdered eggs was linked to occurrences that resulted in considerable media coverage of egg-borne Salmonella illnesses. The internationalization of food trade for humans and animals exposed several European nations to many unusual strains of Salmonella from across the globe.

Personal hygiene among food handlers: food handlers frequently licked their fingers when dealing with wrapping paper; they blew into paper bags to open them; butchers frequently failed to wash their hands after eviscerating animals; the habit of fingering the nose and/or mouth, while serving food, was common. Glass washing: It was common for glasses to be dipped only in dirty water before being re-used.

Housewives in the UK were not fans of the idea when wrapped bread was first presented. One explanation is that many failed to realize that without wraps, the dirt would be on the bread when the wrappers were filthy. Most hand-washing facilities were absent, and those that were there were hardly utilized at first. Toilet paper was also hesitantly accepted, and when it was provided, the quality was quite low. It wasn't until 1938, when the UK's new Food and Drug Act went into effect, that it became obligatory to handle, package, and distribute food under sanitary circumstances and procedures. Food handlers also needed access to proper hand-washing facilities [10]–[12].

III. CONCLUSION

The treatment and disposal of residential and sewage wastes, together with the filtration of water sources to make sure that any infections present were not transmitted to consumers via drinking water, represented a clear advance in public health. Moreover, sanitary microbiologists were hired to audit dining and food processing enterprises to make sure that correct food-handling procedures were being followed. They contributed much to the creation of suitable hygiene standards.

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Exploring the Concept of Hygiene Concerning the Food

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***Abstract*— Food hygiene involves practising procedures and behaviours that keep foods safe to consume. It is a critical part of the healthcare system since numerous diseases may be spread to people via contaminated food. It was obvious in antiquity that illnesses could be beaten, either via active treatment or the power of cleanliness. In the past, a doctor's job was to treat patients' illnesses using medication. On the other hand, preventing illnesses fell within the purview of the hygienist.**

***Keywordss*— Food Production, Food Safety, Foodborne Diseases, Hygiene Practices, Raw Material.**

I. INTRODUCTION

Throughout time, medications took over as the primary method for treating illnesses. Yet, because of the many failures in the 18th and 19th centuries, cleanliness once again took centre stage. The "Natural Hygiene" movement began in the USA without addressing the underlying problem, which at the time was standard medical practice. Natural hygiene takes into account all facets of life, including those that have a beneficial impact on health and wellbeing, such as the environment, food, work, home, economics, spirituality, psychology, and politics [1]–[3].

Hygiene practices spread quickly once germs were identified as the primary causes of illness towards the end of the 19th century. At the turn of the 20th century, it was evident that taking preventative steps was the only way to manufacture safe food, and the field of food hygiene was established. These criteria lead to the conclusion that the idea encompasses all the required steps to create safe and nutritious food. The hygiene notion is seen to include all techniques for preventing contamination, cleaning up food once it has been contaminated, and improving its wholesomeness and suitability for eating. Personal hygiene, hygienic design of facilities, equipment, etc., as well as actions related to cleaning and disinfecting food premises and hygienic disposal of waste collectively referred to as "sanitation" are contributing factors.

A. Personal grooming

For the preservation of health generally, personal cleanliness is very important. Many bacteria are naturally carried by humans, and the hair, skin, mucous membranes, digestive system, wounds, illnesses, and clothes are some of the sources. The main goal of good personal hygiene is to fend off illness and pain. Together with leading a clean life, maintaining good hygiene is crucial. This includes brushing teeth, avoiding spitting, taking regular showers, etc. Waste management is also crucial. All of these actions are preventative and are simple to do.

B. Designing facilities and equipment in a clean manner

For food to be healthy and safe, the hygienic design of food production facilities, processing equipment, etc., is crucial. Food contamination and food poisoning episodes are readily caused by improperly built farms, factories, and equipment. Defective designs may also shorten manufacturing times, increase cleaning expenses, and cause product losses due to spoiling. These elements may also be environmentally problematic. The concepts and standards of hygienic design, such as those outlined in EU Directives 98/37/EC and 93/43/EEC, as well as Hygienic Design DIN EN 1672/2, must be understood by both makers and users of food processing equipment. Hence, hygienic food production relies on a mix of food processing techniques and sanitary building and equipment design, in complete accordance with the law.

C. Sanitation

The sanitary disposal or recycling of waste products, notably human faeces, is known as sanitation. As a result, cleanliness is a crucial public health intervention that is necessary for disease prevention. Food sanitation, which is described as "the sanitary procedures meant to ensure a clean and healthful environment for food production, preparation, and storage," is given special attention in the USA. This second concept establishes a closer connection between keeping a clean working environment and hygiene. Even in this case, hygiene standards go beyond the act of cleaning itself to include those components that enable efficient cleaning and permit the management of insects and other pests.

Foods may become contaminated while being grown and harvested for use as raw materials, while being stored and transported to the plant, and while being processed into final goods. After storage, shipping to stores, and storage and preparation by the customer, the finished product may

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Vol 10, Issue 2S, February 2023

become contaminated. The environment, animals, and humans are the primary sources of pollution. Contaminated surfaces, contaminated air, polluted water, humans, and pests are the major means of contamination transfer. Transport vehicles, packing for goods and equipment, and processing might all function as vectors. Food residue that has come into contact with an inert surface leaf behind food particles encourages the development of microorganisms. They have the potential to grow in size and become endemic in a processing facility over time. If surfaces are not thoroughly washed following cleaning and disinfection operations, chemical contamination may also occur when objects come into touch with them.

Non-contact surfaces including floors, walls, ceilings, overhead beams, and equipment supports may harbour physical and chemical pollutants in addition to being potential microbiological contamination reservoirs. They must be made with durability and efficient cleaning in mind. Animals are significant microbe reservoirs, and slaughtered animals bring a considerable quantity of germs into the processing facility. Many so-called zoonotic pathogens, which are found in the digestive and respiratory systems as well as on the skin, are among them. Another significant source of contamination is pathogens that are carried by hands.

When it comes to the transmission of pollutants to food items, air may be a major channel. Microorganisms will be present in the air if it isn't filtered, and air may also transport "light" foreign objects including dust, straw-like material, and insects. Chemical contaminations may be transported via the air and reach the producing area. In the food business, water is utilised as a cleaning agent, a processing aid, and an ingredient. It is crucial to utilise water with good microbiological and chemical quality since its usage as an ingredient or processing aid might result in microbial and chemical contamination. Water from the condensation of steam or water vapour, leaky pipes and drains, rainfall, and water used for hand washing facilities all represent potential problems. As bacteria levels may quickly rise under favourable settings, stagnant water is especially dangerous. The water utilised in cleaning initiatives must also be of sufficient quality.

D. Microbiological pollutants

The primary source of safety risk for the food sector is pathogenic microbes. Instead of being caused by chemical or physical pollutants, microbial pathogens account for the great majority of outbreaks of food-borne disease. They take a lot of time and effort to regulate and/or eradicate since they are often invisible to the untrained human senses and are capable of fast development under favourable storage circumstances. It is crucial to avoid contamination by following sanitary procedures since even if the bacteria in a product are eventually eliminated by cooking, they may have already generated poisons. In the same way that microbial infections may exist naturally or get into food, rotting organisms can also do so. Increased numbers of spoilage organisms will often result in a shorter period during which the food is appropriate for consumption, even if this is not an issue for food safety. This may have an impact on product quality and, in turn, how consumers see the product.

Microorganism growth is influenced by a variety of variables, including temperature, humidity/water activity, pH, the availability of nutrients, the presence or absence of oxygen, and inhibitory substances like preservatives. For optimum development, different species need various environments. Bacterial growth is accomplished by the straightforward division of one cell into two, and in a favourable environment, their population will rise exponentially. There may be a mutual dependence between how temperature, oxygen, pH, and aW affect microbial activity. At temperatures close to growth minima or maximum, microbes often become more sensitive to oxygen, pH, and aW. In anaerobic circumstances, bacteria often thrive at greater pH, aW, and temperatures than they do in aerobic environments. Lower-temperature growing organisms are often aerobic and have high aW requirements.zThe development rate of spoilage bacteria is drastically reduced by lowering aW by adding salt or preventing oxygen from foods that are kept at a chilled temperature.

Ordinarily, some microbial growth takes place when any one of the variables regulating the growth rate reaches a limiting threshold. Microbial development is severely restricted or even halted if more than one element becomes restrictive. Hence, detailed knowledge of the development circumstances that favour different species is essential for the effective management of harmful and spoilage microorganisms. Using this knowledge can help reduce contamination of incoming raw materials, inactivate microorganisms during processing, and stop recontamination of decontaminated food. If growth circumstances are favourable, it's also critical to understand where and how bacteria might establish themselves.

They are drawn to surfaces in particular because they provide a steady environment for survival and development. Surfaces that are exposed to the air are always weak unless they are regularly and successfully cleaned and disinfected. Surfaces inside of closed machinery, however, could potentially be exposed. Even when processing lines are properly planned, residual product residues often persist in some locations for longer than is ideal. Despite the likelihood of fast-moving liquids, some products will cling to equipment surfaces even if "dead" zones have been built out. On such surfaces, microorganisms could survive long enough to reproduce and contaminate the product. When a process has areas where the product may stand still, the issue is made worse.

Little breaches may also allow microbes to enter. There is a lot of data to support the idea that they can go through tiny apertures extremely quickly and that pressure differences may slow but not stop their passage, even if they are as high

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Vol 10, Issue 2S, February 2023

as 0.5 bar. Serratia marcescens is a kind of bacteria that can travel at a pace of 160 mm per hour. In a leak, motile bacteria may propulsion themselves against the liquid flow. They may also enter by creating a biofilm on the surface, motile or not.

Microbes are deposited, adhere, and start growing when drawn to a surface. The freshly produced cells adhere to one another and the surface as they develop and proliferate, establishing a colony that is expanding. A microbial biofilm forms when this clump of cells enlarges to the point that it may contain waste, nutrients, and other microbes. Biofilms are created in two steps. Initially, the surface and the microbe experience an electric attraction. At this point, the procedure is still reversible. The organism then moves on to the next stage, which is the formation of an extracellular polysaccharide that securely fastens the cell to the surface. The cell grows more and more, eventually developing into microcolonies and biofilm. During cleaning procedures, it is quite difficult to remove these coatings. The pathogens Staphylococcus aureus and Listeria monocytogenes seem to be more challenging to eradicate as a result of biofilm development. According to recent research, heat treatment is more efficient than using chemical sanitisers, and Teflon is thought to be simpler to clean of biofilm than stainless steel.

If circumstances support microbial growth, biofilm formation may occur on any kind of surface and is difficult to avoid. Even in adverse environments, such as the presence of disinfectants, many organisms, including several diseases, produce biofilms. Even bacteria are stimulated by unfavourable environments. The pasteurised product may become seriously contaminated by thermophilic bacteria when they build a biofilm in the cooling portion of a milk pasteurizer, sometimes in as little as 5 hours. Biofilms may accelerate corrosion on metal surfaces, causing the emergence of small holes. Such pinholes let the entry of germs, potentially contaminating the final product. Biofilms will impact heat transmission in heat exchangers, much as other fouling factors do. Biofilms on temperature sensors may significantly reduce heat transmission and, as a result, measurement accuracy. It's possible that lessening the efficiency of heat treatment may encourage more bacterial growth. Biofilms may contaminate cooked or washed items, which are presumed to have been rendered pathogen-free by the temperature treatment undergone, on conveyor belts and the surfaces of blanching equipment, for example.

Biofilms could be far more difficult to get rid of than regular dirt. Decontamination of the surface by heat or chemicals may fail if the cleaning process utilised is unable to entirely remove the biofilm since a biofilm significantly enhances the resistance of the embedded organisms. Even when the exposure duration was extended to 10 minutes, they discovered that sanitisers alone had no impact on the adhering microbes. Conversely, unattached cells showed a 5-log decline in population after 30 seconds. In general, peracetic acid, chlorine dioxide, and acidic quaternary ammonium compounds were the best sanitisers for getting rid of adhered cells. Chlorine, iodophors, and neutral quaternary ammonium compounds were the least efficient. Before being treated with sanitisers, the connected organisms were subjected to cleaning agents, which quickly inactivated the germs.

E. Controls for hygiene in food processing

With the introduction of common precautions like washing and disinfection, recontamination prevention, and treating food items to destroy any microbial pathogens present, hygiene in food processing got its start. Even before the fundamental causes of foodborne disease were understood, heat treatment was added to the food processing process. In 1800, Nicolas Appert in France and Peter Durand in England developed food canning and thermal processing. Yet neither Appert nor Durand could figure out why foods that had undergone thermal processing did not go bad and could still be consumed.

Over time, it became evident that specific antimicrobial treatments had predictable outcomes. Esty and Meyer established performance standards for eliminating Clostridium botulinum spores from low-acid, canned goods, while Enright et al. established process standards for eliminating Coxiella burnetii during milk pasteurization. Predictions pertaining to several additional processes, including acidification, drying, and the use of curing chemicals in meat products, on both pathogenic and spoilage organisms came forth as a consequence of the further study. A new era in the manufacturing of safe food was inaugurated by this information. The split of hygiene precautions between particular activities that can be controlled and other general precautions, the consequences of which are now mostly unpredictable, characterizes this age.

F. Standard hygiene procedures

In addition to end-product testing, one of the earliest safety methods created by the food industry was the use of good manufacturing practices. GMP includes every facet of manufacturing, from raw materials, facilities, and machinery to employee training, and the WHO has produced comprehensive rules. Moreover, GMP provides a foundation for sanitary food manufacturing, often known as good hygienic practice. The foundation of GHP is the result of extensive practical experience and includes the following key elements [4]–[6].

II. DISCUSSION

A. Building and equipment design

This covers the positioning and design of the facility to minimize hygienic risks and enable the production of safe food. Always consider cleanliness when designing food processing and handling equipment, particularly how easy it will be to clean.

B. Management of the manufacturing process

Across the whole supply chain, control procedures are implemented, covering the product as well as elements like raw materials, packaging, and process water. The administration and control of the whole process, as well as effective documentation methods, are crucial components.

C. Cleaning and maintaining the plant

Building structure and processing machinery should both be kept in excellent condition. For plant cleaning and disinfection, appropriate programs must be created, and their efficacy must be regularly checked. Solutions are also required for trash management and pest control.

D. Personal grooming

Regarding the use of protective gear, hand washing, and general conduct, employees are expected to uphold high standards of personal hygiene. In these ways, visitors must also be tightly restricted. Employee health should be periodically assessed, and any illnesses or injuries should be documented.

E. Transportation

This approach is critical to ensuring food safety in the food processing industry. Food transportation covers a variety of forms of conveyance. Road, water, air, and train are examples. The usage and upkeep of transport vehicles, including their cleaning and disinfection, should be subject to rules. The use of vehicles has to be controlled and monitored.

F. Information about the product and customer awareness

It is crucial that the finished product be appropriately labeled and that the customer is given all pertinent information on how to handle and store the product, including a "use-by" date. For complete traceability, the product's batch and provenance should be disclosed on the label [7]–[9].

G. Staff education

All employees should obtain the proper training and be fully informed of their respective obligations with regard to food hygiene and safety. Such instruction needs to be repeated and modified as necessary. The GHP idea is generally irrational, and its advantages are often qualitative rather than quantitative. While it has no direct bearing on the product's safety status, its use is seen to be a crucial preventative strategy in the creation of safe food. The Hazard Analysis Critical Control Point idea may be used for hygiene practices that have predictable results and are susceptible to management. This idea aims to, among other things, eliminate the use of end-product microbiological testing as a way of regulating food safety. Such testing is time-consuming and quite expensive, and it may be unable to differentiate between batches of food that are safe and dangerous. Yet, the usage of GHP is necessary for the HACCP principle to be used effectively.

H. HACCP

The HACCP idea is a systematic method for locating, evaluating, and controlling risks in a specific food business. At crucial points in the manufacturing process that is essential to guarantee the safety of food, it seeks to detect issues before they arise and implement strategies for their management. Control is proactive and based on scientific knowledge since solutions are implemented before issues arise. The important factors can be divided into four categories: the caliber of the raw materials used, the process type (heat treatment, irradiation, high-pressure technology, etc.), the product composition (adding salt, acids, or other preservatives, for example), and storage conditions (including storage temperature and time, gas packaging, etc.) [10]–[12].

III. CONCLUSION

The remaining three categories have predictable and rather simple implications for the final product's sanitary state. All food safety regulations may be satisfied with the help of these categories' efficient management. To achieve this, standards for process performance, product composition, and storage conditions must be established. The risk manager is responsible for establishing such criteria, and the HACCP concept is the management instrument that guarantees that the requirements will be satisfied in reality.

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A Brief Overview of the Pathogen Resistance to Disinfectant Chemical

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Abstract*— In the food industry worldwide millions of tonnes of safe and healthy food are produced every year, by many people using a large amount of equipment. In producing food, the equipment used gets soiled by both products and microorganisms. To avoid recontamination of the fresh product due to fouled surfaces, each piece of equipment or processing line needs to be cleaned and disinfected at regular intervals. Therefore, cleaning and disinfection are important unit operations that are carried out in each food factory regularly.

Keywordss*— Food industry, Food safety, Food hygiene Foodborne disease, Mode of Action.

I. INTRODUCTION

Within the dairy industry, for example, cleaning and disinfection are carried out daily, sometimes several times a day. For condiments the frequency differs per batch of product; however, the equipment is cleaned and disinfected usually after 8±16 hour's operation. In the beverage industry, because of the acid character of fruit juices and soft drinks, cleaning and disinfection are applied after 60±100 hours of production [1]–[3].

Without proper cleaning, disinfection is useless, as the remaining product will inactivate the disinfecting agent and the microorganisms present will survive the disinfecting treatment. In practice, 90±95% of the microorganisms present are removed by an efficient cleaning protocol. Disinfection reduces the amount of remaining microorganisms. This means that, in general, a disinfected surface/piece of equipment is not sterile and means that disinfection is not equal to sterilization where viable microorganisms can no longer be detected.

Disinfection can be performed by using physical or chemical methods. In general, physical methods are preferred as they are very reliable and leave no residues behind. However, physical methods cannot always be applied owing to restrictions such as temperature, the safety of personnel, and the design of the equipment. In those cases, chemical disinfectants are used. In this chapter, the mode of action of the main disinfectants, the behaviour/ response of pathogenic bacteria towards chemical disinfectants, and some future developments are discussed. The effect of physical methods is not discussed.

Factors influencing the effectiveness of cleaning and disinfection are Halogen-releasing agents And Quaternary ammonium compounds. Quaternary ammonium compounds are peroxygenase, alcohols, aldehydes, phenols, and biguanides. Each of the different groups has its applications within the food industry and its restrictions in use. It is important to realize what the proposed effect of a disinfectant is on a target organism and what possible protection mechanisms are present within the organism. In the following sections, the different compounds, their mode of action, and their applications are discussed.

II. DISCUSSION

A. Halogen-releasing agents

Chlorine-based compounds are the most frequently applied HRAs. They include sodium hypochlorite, chlorine dioxide, and the N-chloro compounds such as sodium dichloro isocyanurate. A very cheap and frequently applied formulation is an aqueous solution of sodium hypochlorite-producing hypo- chlorous acid. HClO is the active component and results in the inactivation of all types of microorganisms such as bacteria, and viruses.

Another applied form of chlorine is chlorine dioxide. It is synthesized by the reaction of chlorine and sodium hypochlorite. However, chlorine dioxide is much more unstable than a standard hypochlorous solution and decomposes chlorine into a gas at temperatures higher than 30 degrees Celsius when exposed to light. This can lead to dangerous situations as high concentrations of chlorine gas are explosive. However, when the solution is kept cool and protected from light the disinfectant can be kept stable at concentrations up to 10 mg^{-1}.

B. Mode of action of hypochlorous acid

Although the exact mode of action is not known, the main disinfecting effect of chlorine is caused by oxidative activity. In particular, nucleic acids and proteins are destroyed, resulting in irreversible changes and disruption of DNA-protein synthesis. The mechanism of killing spores differs owing to their thick proteinaceous coat. Therefore, higher concentrations are needed than for the inactivation of vegetative cells. Young and Set low concluded that

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Vol 10, Issue 2S, February 2023

hypochlorite affects spore germination possibly because of the severe damage to the spore's inner membrane.

C. Mode of action of chlorine dioxide

Chlorine dioxide, if applied properly, appears to be 2.5 times more oxidative than sodium hypochlorite, and is effective against bacteria, viruses, and spores. The action of chlorine dioxide involves disruption of the cell's protein synthesis and membrane permeability control mechanism. It produces no harmful by-products such as trihalomethane, nor does it react with ammonia. After treatment with chlorine dioxide, spores of Bacillus subtilis can undergo the initial steps in spore germination but the process stops because of membrane damage. An aqueous chlorine dioxide treatment of alfalfa seeds inoculated with E. coli for 10 min at a concentration of 25 mg^{-1} resulted in approximately.

D. Iodine

Iodine is widely used for sanitizing food processing equipment and surfaces. Iodine is less reactive than chlorine and less affected by the presence of organic matter but also has disadvantages such as staining human skin, and plastic parts of equipment, and also has a relatively high price as compared with chlorine. Solutions of 15% active chlorine are commercially available for 0.20±0.30 per kg whereas a 6% solution of iodine in 70% ethanol costs approximately 400 per kg. Iodine is applied in three possible formulations: ethanol-iodine, aqueous iodine solutions, and iodophors. The ionophores are most frequently applied and have high solubility in water, produce no vapor, are less corrosive to stainless steel than chlorine-containing solutions, and are generally effective against Gram-negative and Gram-positive vegetative cells, yeasts, molds, and viruses. Bacterial spores are more resistant to iodophors and higher concentrations are necessary to achieve inactivation [4]–[6].

E. Mode of action of iodine

Similar to chlorine, the exact mode of action of iodine is not known. Iodine penetrates microorganisms and attacks specific groups of proteins, nucleotides, and fatty acids in a way comparable to chlorine. QACs combine antimicrobial properties with surface-active properties and are therefore useful for hard surface cleaning and deodorization. Compared with chlorine they are more expensive but have the advantage of having residual action. QACs remain active on surfaces for approximately 1 day and therefore discourage further bacterial growth. This adherence to the surface also has disadvantages. Removing the disinfectant from the surface by flushing it with water becomes difficult, resulting in possible residues in the product.

F. Mode of action

The principal actions of QACs are lowering surface tension, inactivation of enzymes, and denaturation of cell proteins. As a result of the adsorption of QACs onto the microorganism's surface, the cell's permeability is changed dramatically. This results in the leakage of intracellular low-molecular compounds, degradation of proteins and nucleic acids, and cell wall lysis by autolytic enzymes.

G. Peroxygens

Hydrogen peroxide and peracetic acid are the main representatives of the group of peroxygenases. Hydrogen peroxide is widely applied within the food industry and is commercially available in concentrations varying between 3% and 90% w/v, with 35% routinely used in the food industry. It is applied for sterilizing packaging material before filling contact lenses and sterilizing the surface of fruit and vegetables. Hydrogen peroxide is both bactericidal and sporicidal in general a concentration of 6% is bactericidal. Peroxygens are generally more active against Gram-positive bacteria than Gram-negative bacteria. To achieve a sporicidal effect, concentrations between 10 and 30% are necessary. Peracetic acid is commercially available in 15% solutions as a mixture of water, hydrogen peroxide, and acetic acid and acts faster than hydrogen peroxide.

H. Mode of action

It has a broad spectrum of efficacy against viruses, bacteria, yeast, and spores. The mode of action of peroxygenase is based on the free-radical oxidation of essential cell components such as lipids, proteins, and DNA. Peracetic acid not only attacks the proteins in the cell wall but also migrates into the cell and disrupts inner cell components as well.

I. Alcohols

In food production areas, alcohols are particularly used for the decontamination of hard surfaces of equipment. The most effective concentration is between 60 and 70% v/v. The concentrations to achieve the reduction of growth or complete inactivation are higher than for chorine solutions or organic acids. Alcohols are quick reacting, have a broad spectrum of antimicrobial activity, and inhibit the growth of vegetative bacteria, viruses, and fungi. Spores are rather resistant to the effects of alcohol; however, a combination of 70% v/v concentration with temperatures up to 65 degrees Celsius results in the inactivation of spores, for example, Bacillus subtilis spores. Compared with other disinfectants the concentrations applied are much higher and alcohols are only effective if used as the substance itself, instead of a low-concentration solution. This property makes alcohol more expensive in use compared with chlorine and QACs, and therefore is not frequently applied on a large, industrial scale but is used mostly for applications such as small, difficult-to-reach spots in equipment, temperature probes and quick wipe-downs of working surfaces and scales.

J. Mode of action

The general mode of action for the inactivation of microorganisms by alcohols is by denaturation of proteins, with the primary site of action being the cell membrane. As a

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International Journal of Science, Engineering and Management (IJSEM)
Vol 10, Issue 2S, February 2023

result of the deterioration of the plasma membrane, the cell wall starts to leak essential cell components such as ions and low molecular weight solutes such as peptides and amino acids. Therefore, the mode of action and its effect on the metabolism of the microorganism depends very much on the concentration. Molds and actinomycetes are most susceptible to alcohols and are inhibited at 4% whereas most bacteria can still grow at these concentrations. Application of 5.5% shows a bacteriostatic effect on E. coli, but to kill this microorganism concentrations of 22.2% or higher are necessary. Yeasts can grow at higher alcohol concentrations, which is not surprising since they are responsible for the production of beer and wine. Spores are affected by ethanol. Set low and co-workers showed that the sport coat can be permeabilized. Consequently, ethanol in combination with other components or with high temperatures is more effective than ethanol itself in activating spores.

K. Aldehydes

Two aldehyde compounds are mainly used for disinfecting, glutaraldehyde, and formaldehyde. Aldehydes are active against a wide range of bacteria, viruses, molds, and spores, are easily removed from surfaces, and are degradable. However, the activity of aldehydes is very easily influenced by remaining fouling, which necessitates sufficient cleaning before disinfecting. From a toxicological point of view, aldehydes do not cause problems for humans when used within the prescribed concentrations On the other hand, it is possible that formaldehyde can have mutagenic effects [7]–[9].

L. Mode of action

The mode of action of glutaraldehyde involves a strong association with the outer layers of bacterial cells. The cell's chemical reaction with glutaraldehyde results in metabolic and replicative inhibition. The way formaldehyde reacts is most probably the same. Concerning processing conditions, an alkali environment is more favourable than an acid environment as more reactive sites will be formed on the cell surface. Applied concentrations vary between 0.08 and 1.6% for inactivating E. coli. For a sporicidal effect, a solution of 2% is normally sufficient.

M. Bisphenols

Bisphenols are hydroxy halogenated derivatives of diphenylmethane, diphenyl ether, and diphenyl sulphide, and are active against bacteria, fungi, and algae. Triclosan, a derivative of diphenyl ether, is known as an ingredient in some medicated soaps and hand-cleansing gels and toothpaste and is effective against staphylococci it is currently applied as an antimicrobial layer in packaging material and conveyor belts.

Unfortunately, depending on the impurity of the starting material, Triclosan can contain concentrations of dioxin and dibenzofurans, both substances highly toxic to humans. Therefore, it is of great importance that the origin and way of production are known before application in food production areas. Hexachlorophene has been used in soaps as well; in 1972 it was restricted in use by the US Food and Drug Administration to levels less than 0.1%. Nowadays, application as a surgical scrubber in case of certain infections is permitted.

N. Mode of action

The exact mode of action is unknown so far but it is suggested that Triclosan affects the cytoplasmic membrane. However, current research shows that Triclosan inhibits one specific enzyme of the fatty acid synthesis of E. coli. This increases the risk of resistance against Triclosan as one mutation of a gene can result in a decreased efficacy of the disinfectant. Hexachlorophene affects bacteria by inducing leakage, causing protoplast lysis, and inhibiting respiration.

O. Biguanides

The group of biguanides is represented by chlorhexidine, alexidine, and polymeric biguanides. Chlorhexidine is probably the most widely applied biocide in hand-washing and oral products such as mouthwash, mouth spray, and throat lozenges. Chlorhexidine has a broad spectrum of activity and is pH-dependent; its efficacy is greatly reduced by the presence of organic matter. High concentrations of chlorhexidine cause coagulation of intracellular constituents. Chlorhexidine is only sporicidal at elevated temperatures and is in general more prostatic. it has little effect on the germination of the spore but does not prevent the outgrowth of the spore. Alexidine and polymeric biguanides are used only on a small scale. Polymeric biguanides are used in particular by the food industry and also for the disinfection of swimming pools. An example is poly hydrochloride which is the main active ingredient of Vantocil, which is widely used in the food industry, hospitals, nursing homes, and consumer households [10]–[12].

III. CONCLUSION

Disinfection is defined as the treatment of surfaces/equipment using physical or chemical means such that the amount of microorganisms present is reduced to an acceptable level. Before disinfecting, cleaning the surface is necessary to remove organic compounds that adhered to the surface. Disinfection does not always clean filthy surfaces or eradicate germs, but it may reduce the risk of illness spreading by killing microorganisms on a surface after cleaning. The most evident and advantageous benefit of employing these items is the elimination of viruses, germs, and fungi. Given that all three of these infections are very hazardous to the human immune system, preventing their spread makes logical sense.

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Factor Involved in the Improving Aerosol Contamination

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***Abstract*— Aerosols are made up of airborne particles. The particles may consist of both solid and liquid particles and liquid droplets. Aerosols containing microorganisms are the ones that should be avoided the most in food facilities. Every entrance that joins low- and high-care areas, such as doors, hatches, drains, and other openings, might allow aerosols to enter production areas. In this chapter, we discussed the various factors involved in improving aerosol contamination.**

***Keywordss*— Aerosol Contamination, Air handling, Food Safety, Food Hygiene, Foodborne Disease.**

I. INTRODUCTION

Many things, such as unprocessed materials, humans, packing, and moving or spinning machinery, may produce aerosols. Restricting the production of aerosols is the greatest strategy for lowering contamination through the airborne pathway. Once particles are in the air, it is challenging to regulate how each one moves because of several factors, including advection, turbulent dispersion, gravity, and thermal convection. Nonetheless, the majority of airborne particles may be prevented from contaminating exposed foods with the proper specification and use of air-handling equipment. These systems rely on three strategies: using enough air exchange rates and filtration to remove the particles from the air; providing enough air to maintain a positive pressure in the high-care area and preventing airflow from low-care areas; and making sure air flows do not create lower-pressure areas close to doorways, hatches, and other openings that could allow contamination to enter from nearby low-care areas. These strategies have advanced greatly in industries that make use of clean rooms, such as those that produce electronics and medical equipment [1]–[3].

Food production regions vary from these settings in that they are often damp, include many more sources of aerosol, have a greater population, and focus more on microbial than total particle pollutants. Nonetheless, the food business uses the broad strategies mentioned above, but often with less control than in other industries. The particle concentrations detected in clean rooms and high-care food production settings may be interestingly compared. Several standards are used to categorize clean rooms, with the Federal Standard 209E being one of the most often used. According to this guideline, there shouldn't be more than 100 particles with a diameter of 0.5 m or greater in every cubic foot of air in a Class 100 environment.

Similarly, there shouldn't be more than 100 000 particles per cubic foot with diameters of 0.5 m in the air in Class 100 000 environment, sometimes referred to as a "white room." Normally, these concentrations wouldn't be monitored in the presence of operators. One of the key elements in regulating the amount of airborne particles in rooms is filtration. Most air-handling systems for high-care spaces are equipped with F9 filters, H11 filters for high-care and high-risk areas, and H13 or even greater degrees of filtration for clean rooms. The majority of particles larger than 1 m in diameter are removed by F9 filters, those larger than 0.5 m by H11 filters, and those larger than 0.3 m by H13 filters.

The rate of airborne particle creation, particle sizes, and speeds, the quantity of organism-containing particles, the direction of air movement in space, exposure period, and food surface area all affect the risk of food contamination in high-care situations. These elements are crucial because they affect how far an organism travels, how long it takes for it to fly, and how close together its organisms are in space. Each of these critical variables may be measured using various techniques. As an aerosol often contains both liquid and solid particles, the word "particle" will be used to refer to both in the next sections of this chapter.

A. Generation, size, and speed of drops

The majority of droplet production, size, and speed measurement techniques rely on laser technology. At high concentrations close to cleaning processes, phase-Doppler analysers have been utilized to detect the sizes of extremely fine particles, up to 40 m. Light is dispersed at the junction of the two laser beams used in these devices. Examination of the scattering may be used to determine the flux, velocity, and particle size distribution. To assess the size and velocity of particles beyond the size range examined by a phase-Doppler analyser, image-based methods use a laser and high-speed camera. Clean rooms often use air particle counts, which also rely on laser technology. Instead of analysing the aerosol in place, they take a sample of air for examination.

To evaluate the deposition of airborne organisms, settle plates may be utilized. Several vendors also provide equipment that enables measurements of the concentrations of airborne organisms. The majority of persons employed in

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Vol 10, Issue 2S, February 2023

the food industry depend on the organism's impaction onto a solid medium in a Petri dish as factory air is pulled over the plate. The number of organisms in the dish is then converted to an airborne concentration using calibrations.

Since they may spread pollution throughout a business, the speed and direction of the airflow in the production area are crucial. Hotwire anemometers can measure airspeed, and vane anemometers can measure speed and provide a rough idea of flow direction with caution. Both of these tools may be used in tandem with a "wind indicator," such as a short length of freely suspended fabric filaments, to show which way the air is flowing.

B. Spread of aerosols

Huge particles that are longer than 100 m may collect close to the cleaning procedure. Medium-sized particles may evaporate to produce tiny particles, below 20 m, which may readily disseminate across the manufacturing area, or they may collect close to the cleaning activity. In facilities that produce chilled food, the airborne particles of most concern are those that carry germs and have a diameter of at least one meter. In tests, surfaces were covered with a Bacillus subtilis via globigii solution, cleaned, and settle plates were used to determine the organisms' airborne distribution across a room.

Measurements made in factories, controlled environments, and with the use of computer models have produced several crucial results. The danger of product contamination is highest when airflow is directed from a source of contamination toward the meal. The smaller the particle, the longer its flight time and the further it may go. Typically, fewer than 1% of the particles formed in high-care production locations will settle. The air exchange rate, the effectiveness of the filtration, the rate of particle generation, and the leakage of the room all affect the temporal change in concentration of very small particles, around 1 m diameter, with the majority being removed by the filtration system or escaping through doorways and hatches.

C. Techniques for lowering the danger from airborne pollution

Five kinds of techniques are used to lessen the danger of food contamination via the airborne route: monitoring, equipment design and operation, factory design and operation, and equipment design and operation. Many articles, including those in this book and those from the UK Chilled Food Association, have been published regarding the sanitary design and operation of chilled food facilities. Here, our focus is on open cleaning activities, their design, and air quality control.

The proper management of the air in a high-care facility has various needs. Make sure there is enough air blowing into the space to keep the pressure positive. Check to see that air extraction does not lower the pressure in the high-care area below that in adjacent rooms. While designing, take into account air loss from the high-care area. Think about the impact opening doors, etc. will have once the plant is running. If more air extracts or hoods are later added to a production area as a result of the installation of new equipment, for instance, provide more air. Aim to keep air extracts away from hatches and entrances leading to low-care regions when placing them in high-care sections.

Provide an air-handling and distribution system that is simple to access, clean, and maintain. There shouldn't be any pollution coming from the system. Consider potential modifications to the plant, such as an expansion. Previous research has shown that cleaning procedures may be significant sources of airborne pollution. The following examples of good design and operation techniques may assist to lessen their impact: Poorly cleaned equipment can become a substantial source of contamination [4]–[6].

A set timetable should be followed for cleaning and sanitizing cleaning equipment. Hosing produces significant amounts of aerosol and should be avoided during production; space should be made available for cleaning outside the work area. Cleaning techniques that generate the fewest aerosols should be considered if it is necessary to clean during production; for instance, using a "scraper blade" or cloth may be sufficient and produce far fewer aerosols than hosing. Compressed air lines are occasionally used to remove contamination, but this can also produce aerosols. Also, this practice's employment throughout manufacturing needs to be avoided.

Offer facilities for the disposal of water from cleaning activities, such as the wash water from the tank of a mechanical floor scrubber. Prevent locations in the design of the equipment where water might gather, as in the reel casing of a retractable hose. These are but a few instances that highlight the fundamental guidelines for excellent open cleaning operation design and management. The design and operation of factories may also significantly affect how aerosols disperse; thus, appropriate practices are again crucial.

Good practices include keeping cleaning far from the manufacturing area and exposing both the product and the packaging for just brief durations. It goes without saying that because "deep cleaning" activities generate significant aerosol concentrations, it is crucial to enable particles to settle or be removed by the air-handling system following such cleaning. Whenever possible, the air-handling system should not be utilized while thorough cleaning is being done. Otherwise, germs that are released into the air during the cleaning process may end up on the refrigeration system's cooling coils. If feasible, it's a good idea to run the air-handling system at full extract following a comprehensive clean.

II. DISCUSSION

A rise in the use of zoning in factories and, more recently, the adoption of cleanroom technology in certain factories may be attributed to the expansion of the high-care and high-risk chilled food industries. These two subjects are

discussed elsewhere in this book. It makes sense to create settings that become cleaner the closer they get to the food. The length scale on which the graduation or zoning is conducted is in doubt. Presently, high-care/risk areas and low-care regions are the key zones in the majority of chilled food facilities in the UK that produce items with a limited shelf life. Also, some firms are adopting localized air delivery systems that guide air of an even higher calibres than typical at meals. Burfoot et al. displays a variety of designs that have been taken into consideration for this use. They include the circulation of clean air around the meals or the vertical or horizontal direction of clean air towards the edibles. It has been discovered that localized air distribution lowers food airborne contamination. These systems also have the benefit of potentially saving energy if cold air is provided locally, enabling the plant to operate at a greater temperature [7]–[9].

Also, by keeping the food at a constant temperature, they minimize the need to chill the goods after they leave the production area. Nevertheless, the majority of components must have been chilled before entering the high-care/risk region for this strategy to provide significant energy savings. Localized air distribution is starting to be used; however, many believe that such strategies should only be used for goods whose shelf-life extension is a top priority. Providing ultra-clean air near the product certainly has less of an applicability for items like prepared salads that have a substantial microbial load or products that have a very limited shelf-life owing to quality decline rather than microbial decomposition [10]–[12].

III. CONCLUSION

Regarding airborne contamination and air handling, there are several sources of knowledge and guidance. This book's other chapters make apparent that the information they relate to each other. Information may be found from engineering research organizations and food research organizations like Silsoe Research Institute and Campden and Chorleywood Food Research Association in the UK. A reliable source of information is a recognized trade or professional organization. Examples are the British Heating and Ventilating Contractors Association and the American Society of Heating, Refrigeration, and Air Conditioning Engineers. Particularly helpful are the handbooks and standards from ASHRAE. Links to several manufacturers and sellers of tools for detecting particle sizes, concentrations, and air velocity are available on the Internet.

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Consumer Perceptions of Risks from Food

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***Abstract*— The health effects of food poisoning are severe and quantitative, in contrast to several other public health issues, largely as a result of the easy identification of causative agents. As a result, microbial food contamination is an issue of public health that, in principle, may be resolved by proper risk management. In actuality, the prevalence of foodborne illnesses continues to be a serious public health issue.**

***Keywordss*— Food safety, Food hygiene Foodborne disease, Public health, Risk communication.**

I. INTRODUCTION

Since this trend is not constant, there is some evidence that the public has continued to place less importance on reducing microbiological hazards than other food-related problems for many decades. Consumers' continued bad health is not explained by the fact that this decrease implies a low customer preference for risk avoidance. This is because consumer behaviour towards food preparation must also be considered, since correct, sanitary food preparation techniques by the consumer might significantly reduce the hazards linked to food safety.

The introduction of food safety goals is intended to advance public health objectives by lowering the incidence of foodborne diseases. Generally speaking, regulating consumer behaviour is difficult, if not impossible. Even if a product satisfies food safety standards at the point of sale, improper storage, improper food preparation, and cross-contamination may still happen, leading to disease. The deployment of relevant and efficient information interventions is the only way to achieve the objective of enhancing public health [1]–[3].

The question of where in the food chain these food safety goals should be established and whether they should be benchmarked at the point of sale of food goods or the point of consumption has received a lot of attention recently. Setting food safety goals at the point of consumption is significantly more beneficial from the standpoint of public health since the home environment is the area of the food chain that is least within one's control. Public health, however, ultimately depends on the consumer's selected degree of food preparation safety. During a recent conference of the Codex Alimentarius, it was decided to define food safety goals at the point of consumption. This suggests that improved information delivery must be made to optimise household hygiene habits that are pertinent to food preparation.

Thus, it is crucial to research to identify any possible obstacles to consumer adoption of good food hygiene practices and to use this knowledge to create successful intervention techniques that are especially aimed at changing consumer behaviour. It is crucial to build a knowledge of consumer risk perceptions related to food safety and correlate it to real consumer behaviours while preparing food to achieve this. Understanding individual variations in attitudes and behaviours is also crucial since certain demographic groups may take more risks than others. When evaluating risk vulnerability, where certain demographic groups may be more at risk than others, this may be especially troublesome.

This chapter seeks to provide a succinct summary of the research on consumer risk perceptions and how they may be used to understand why people engage in potentially dangerous behaviours. We'll review prior studies that look at consumer behaviour and household food hygiene standards and provide suggestions for further studies. Lastly, risk communication insights will be offered about the creation and use of best practices for information interventions. Consumer risk perceptions and technical risk evaluations are not the same.

Individual reactions to risks are influenced by perceptions or ideas about hazards, which may seem to have nothing to do with technical risk estimations. In fact, the larger context in which various dangers are situated makes it impossible to understand consumer reactions to distinct hazards in isolation. The psychometric paradigm created by Paul Slovic and his colleagues offers a useful beginning point for comprehending consumer risk perception. Individual reactions to various hazards are determined by psychological characteristics, according to research conducted under the psychometric paradigm. They include, for instance, whether people believe the danger to be unnatural, catastrophic, or involuntary. Certain dangers' threat values are increased by these psychological elements, whereas others see a reduction in the same component. In certain cases, the apparent advantages of a given risk may outweigh the perceived risk.

This suggests a comprehensive, multifaceted, and perhaps holistic weighting of risk variables. In general, lay perceptions include more categories and multidimensionality than expert views and are often richer and more complicated. Think about the difference between choice and involuntary exposure to radiation, for instance. The hazards most people identify with the nuclear business are often greater than the

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Vol 10, Issue 2S, February 2023

possible concerns of both medical and natural radiation for the following reasons.

Artificial radiation increases the danger in an environment where it was previously absent. Natural radiation, in contrast, is tolerated since it is a component of the natural order. So, public excitement for efforts to reduce the hazards of natural radiation may not be equivalent to their hostility against the nuclear business. Medical radiation is seen to provide benefits for the community at large. This may not be true for the nuclear sector, since risks are borne by the general public and the environment while the public perceives that financial rewards go to firm stockholders.

In very general terms, it could be helpful to separate possible hazards into two groups: those connected to technology and those related to lifestyle decisions. People's views of technological risks are influenced by ideas that these hazards are unmanageable, out of the ordinary, and somehow add needlessly to the risk environment. In the past, there has been a lot of work in the field of technology adoption that has centred on balancing expert and popular viewpoints. Getting the public engaged in the discussion of how to manage and commercialise technical advances has received more attention lately [4]–[6].

A. Positive bias

Lifestyle hazards are linked to high levels of positive bias or unwarranted optimism, in contrast to technology risks when the public assess the dangers as greater than specialists. When a certain lifestyle danger is present, people often see their risks as being lower. Optimistic biases are far more prevalent for lifestyle risks than for technology used in food production when it comes to food dangers. In addition, individuals believe they have better control over their exposure to certain dangers and are more aware of the risks related to lifestyle choices than other people do. The beliefs of personal awareness and control about technologically associated food dangers are different from this. As a result, this optimistic attitude makes it possible to pinpoint a barrier to effective risk communication concerning lifestyle concerns.

Consumers believe that information about risk reduction is intended for other individual consumers who are more vulnerable to the hazard, have less control over how much of it they are exposed to, and are less knowledgeable about self-protective behaviours. It is commonly known that individuals with optimistic bias may not take preventative measures to lower their chance of exposure to hazards. In-depth reviews of the significance of optimistic bias and methods for lowering the discrepancy between perceived danger to oneself and others may be found elsewhere. Here, a succinct review of topics related to optimistic bias and food poisoning will be given.

Generally speaking, two key areas have been the focus of study on optimistic bias in the food industry. The first discusses risk assessments for detrimental health effects linked to dietary choices, while the second focuses on risk factors linked to certain behaviours. Both are probably important for consumers and food safety. This is due, in part, to the fact that consumers are inclined to compare their risks of food poisoning with those of those they believe to be more susceptible than they are. Also, they could exaggerate how effective their health-protective behaviours are.

Empirical studies have looked at ways to lessen optimistic bias. This involves enhancing the perception of responsibility related to a person's risk assessment. It may be done by informing individuals about real risk-taking behaviours, or by forcing them to compare themselves to someone similar to them or the person who is receiving the risk information.

Barriers to effective risk communication and risk perception. It is obvious that attitudes towards microbiological dangers and food handling procedures will depend on how risk is perceived. Attempts to reduce the negative effects of poor food hygiene on public health are probably hindered by optimistic bias. Attitudes about food technology that were developed to address issues with microbial concerns are another obstacle. New food processing techniques, including food irradiation or high-pressure processing, may not be acceptable to consumers as a result of public anxiety about food technology.

Microbiological food dangers tend to be somewhat feared by consumers but are also thought to be highly known, which lessens their threat potential, according to research carried out under the psychometric paradigm. The fact that certain consumer concerns are highly unique to certain hazard domains as is very much the case in connection to food poisoning is another aspect to take into account in the field of public perception of microbiological risk. The optimistic bias effect has been validated through qualitative research. The findings showed that respondents were upholding positive biases about their risks from food safety by contrasting themselves with those who were seen as being more "in danger" than they were. Also, respondents consistently reported that they were aware of and used the best food hygiene standards. Also, they said that specific product categories, such as eggs, were the focus of media "hype" and exaggeration of microbiological hazards.

Other dangers kinds did not raise the same worries. For instance, views of BSE were heavily influenced by concerns about animal welfare. Concerns about the environment and the possibility of unexpected consequences have been related to genetically modified food. Neither BSE nor genetic alteration was linked to beliefs that seemed to be skewed in favour of optimism. The ultimate objective of communication on food handling procedures is to promote better household cleanliness among customers to enhance public health. As a result, to structure risk-related messaging such that customers adjust their attitudes about the risks, communicators must understand how the general public views risk and hazards.

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It was discovered that attitudes altered differently depending on how much cognitive effort was put into digesting the information when less effort was put out. Because of this realisation, dual-processing persuasion models, including the elaboration likelihood model, were created. According to the elaboration probability model, an individual will only alter their attitude in the long run if they thoroughly and attentively evaluate the arguments made in the message, also known as the primary route to information processing. The message will not be handled in such an extensive manner and will instead choose a side road to process if there is no incentive or cognitive capacity to do so.

The basis of the peripheral processing method is a person evaluating a cognitive or emotive cue connected to the persuasive message. Without resorting to complicated information processing, they may choose whether and how to analyse the information as well as whether and how to judge the merits of the arguments presented in the information. If such peripheral processing results in an attitude change, it is likely to produce transient changes that are more sensitive to counter-persuasion and result in less consistent behaviour.

The extensive analysis of all arguments is somewhat resource-intensive, resulting in, for example, tiredness, and is a major feature in all dual-process theories. So, the primary goal of these models is to provide an understanding of when and how the less complex peripheral solutions are implemented vs these expensive procedures. The core route to persuasion is used by consumers until the motivational or ability needs are not satisfied, according to the elaboration probability model, which assumes that people seek to base judgements on the best potential solutions. The cognitive miser assumption is often used to describe this careful management of cognitive resources. Both models characterise the impact of motivation and the availability of cognitive resources on information processing, even though the assumptions that underlie the selection of the processes vary.

The heuristic systematic model makes the premise that heuristics are employed throughout the process until cognition is required; this implies that in practice, frequently a combination of heuristic and systematic processes take place. There is a second, more structural distinction. On the other hand, the elaboration probability model posits that processing is heuristic only when cognitive processing is completely impractical, leading to either the central or peripheral path to attitude modification. A sequential mix of processing modes may be explained by the fact that heuristic cues might result in the central processing of information.

It would be ideal to build the communication strategy in such a manner that it enforces the central or systematic process to run its course for risk communication regarding hygiene-related food safety risks to be effective over the long term. In light of the dual process approach, the topic of risk communication is: What kind of information should be provided, or how should the information be provided, to influence the message recipient's decision to process information centrally or peripherally. The incentive to carefully absorb information is likely to be strong if it is very relevant to the individual receiving it. The message's arguments must, however, be compelling and of high quality in order to meet the demand for resources; otherwise, the consumer could wish to address the reasons but be unable to do so. Every time risks are conveyed; great attention should be given to constructing these high-quality arguments as it has been shown that the quality of arguments is a crucial prerequisite to processing information if the intended consumer is motivated to process information via the primary route.

Encouraging customers to use the centralised processing approach. Instead of focusing on the impact of message quality in this chapter, we will concentrate on customer motivation. So, the customer will consider and apply the arguments if the information is very relevant and the information is well-structured. Hence, it would be helpful to be able to encourage customers and, of course, to understand how to offer the information to accomplish the central processing of information and the associated enduring attitude adjustment. Increasing people's degree of anxiety is one strategy for encouraging them to digest information whilst studies using fear as a motivator have been done, there has generally been a minimal study on how emotions and dual-process model-based persuasion efforts relate to one another. As we shall explore towards the conclusion of the next section on peripheral processing of information, using fear may have certain unintended consequences.

B. Application of integrated food safety and consumer behaviour research

Instead of real consumer behaviour observations and what this would mean for the frequency of food poisoning, food safety consumer studies often concentrate on measurements of self-reported behaviour or attitudes regarding food safety. To our knowledge, microbial contamination, related consumer cognitive representations, and resultant consumer behaviours have not been investigated together. The results of several investigations do some convergence. It is still completely unknown, however, what consumer behaviours and activities lead to what degrees of microbial contamination, how these behaviours and activities differ amongst people, and how human information processing and affect play a role in creating successful communication strategies. It is recommended that social and natural sciences must be integrated to fully grasp the link between these many fields, which may point to the necessity for a new research agenda in this field.

Much more thorough information on risk-related attitudes and behaviours is required, as well as what the effects of these are on individual health outcomes, to be able to customise information campaigns to individual information requirements. The risk levels to consumers in a national campaign aimed at population-level audiences are often

applied, and it is doubtful that specific customers would pay attention to the information in risk messages. Contrarily, customised or targeted advertising must concentrate on the information requirements of demographic groupings or subgroups.

Realistic risk estimations and any uncertainty regarding these estimates should be disclosed in order to create a successful campaign. Failing to do so might damage confidence in the information source. Of course, if we want to learn more about the individual psychological attitudes, beliefs, and values of distinct customers, we must also learn more about their specific behavioural patterns. To put it another way, the results of the risk projections made by microbiologists should be presented to the target consumer group in a manner that suits their motivations and values.

II. DISCUSSION

Only by combining knowledge from several fields can these demands be addressed. Experts in food safety and, in the case of microbiological hygiene food, microbiologists are required to evaluate and forecast the unique food safety threats. Consumer psychologists are key players in the ability to forecast consumer behaviour based on the attitudes, values, and beliefs of certain groups and to create tailored information tactics. Food microbiologists must then evaluate the effect of risk communication on consumer health. This suggests tight collaboration between social and natural sciences in general and consumer psychologists and microbiologists in particular [7]–[9].

Before demonstrating these concepts via a current research project, we would like to point out that collaboration needs work from all engaged researchers and is therefore not an easy task to do. Researcher willingness to collaborate across social science and natural science fields is a prerequisite for collaboration. This means an openness to the research paradigms and techniques used in the many disciplines, and it necessitates an effort to avoid jargon and communicate in a manner that the partners can understand [10]–[12].

III. CONCLUSION

The study incorporates recent findings from theories of risk perception and communication with an eye on lowering dangerous behaviours. After risk communication, it is suggested that three psychological issues need to be addressed if individuals are to adopt appropriate household food hygiene practices. The following psychological factors must be taken into consideration: the resistance to attitude change induced by optimistic bias; the consumers' limited motivation and mental capacity; and the observation that consumers process information using an experiential and affect-driven strategy rather than a formal logical one.

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Improving Zoning Within Food Processing Plants

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***Abstract*— Factories have always required to be compartmentalized or split into several zones for several reasons. The primary reasons for these were environmental protection, the separation of raw materials and finished items, the separation of wet and dry materials, the supply of mechanical and electrical services, and health and safety considerations. In this chapter, we discussed the methods for improving zoning within food processing plants.**

***Keywordss*— Food Safety, Food Manufactures, Food Hygiene, Foodborne Disease, High Risk..**

I. INTRODUCTION

Because the nature of food manufacturing has changed, particularly with the advent of ready-to-eat products, enterprises have begun to further segment or "zone" production portions for sanitary reasons. A variety of greater hygiene, or cleaner, zones have been created to help protect the product from microbiological cross-contamination situations after it has been heat treated or decontaminated. It has also been noted that non-microbiological risks, such as allergies, must be addressed by being kept apart from other product ingredients [1]–[3].

Not to mention, worries about label claims like "suitable for vegetarians," "organic," "does not include GM ingredients," or "Kosher" has forced food manufacturers to think about how raw materials are handled and processed. This is particularly important if producers are working with substances like meat, non-organic products, GM foods, or non-Kosher components. Even if, for example, the existence of animal leftovers in a vegetarian product is not a safety risk, it will cause a problem with the ingredients statement and might damage the brand's reputation.

In addition to the regular issues with food production, unrestricted access to industrial sites by the media, bioterrorists, and small-time criminals has inevitably brought site security to light. A system of up to three barriers has historically been used to protect food during manufacture against contamination in general. The production facility, the surrounding area, any high-risk or high-hygiene zones, and any areas where goods are contained are all included. With this method, environmental control is increased to the point where fully processed commodities are finally handled in environments that actively exclude contaminants.

In terms of segregation requirements, foods and drinks may be loosely categorized as low- and high-risk goods based on their stability or if the final customer or the food manufacturer will prepare them further. Low-risk items, which are generally either raw materials or ambient shelf-stable commodities, include eggs, raw meat and fish, fruit and vegetables, dry goods, canned foods, bakery and baked goods, confectionery, snacks, morning cereals, oils and fats, and drinks. Cooked and smoked meat and fish, prepared vegetables, prepared fruit, milk, cream, cheese, yoghurt, ice cream, sandwiches, and ready meals are among the products with a high risk of contamination and short shelf life. These things often need to be chilled in the refrigerator.

The findings of the Hazard Analysis Critical Control Point study, which will take into consideration the nature of the food product, the kind of hazard, and the characteristics of the eventual consumer, will indicate the number of factory barriers required. For low-risk objects, the first two barriers are often all that is required. For high-risk goods, the third barrier must be implemented to assure microbiological control. Although certain fully prepared, ready-to-eat foods with long shelf lives could benefit from the additional controls provided by this barrier, the fourth barrier is required for aseptic products, where it is crucial to keep external contamination at bay. Although it is not required owing to hazard control, producers may choose to prepare food in higher hygiene zones for a variety of reasons. They could comply with local laws, believe it would be more cost-effective to add higher-risk products to their product line now rather than later, or just do it because they believe it would make trademark protection simpler.

A. Barrier 1: Place

Careful consideration of the site's design, construction, and upkeep, from the outside fence and surrounding area up to the factory wall, provides the opportunity to establish the first of many barriers to protect industrial processes from contamination. This group provides defense against environmental hazards such as prevailing winds and surface water runoff, unauthorized human entrance, and avoiding insect breeding sites. At the site level, a variety of activities are possible, including the following:

The place should be marked and/or fenced off to prevent unauthorized public access, the admission of domestic or wild animals, etc. To lessen the chance of flooding-related pollution of the ground level, the manufacturing building may sometimes be positioned on the highest point of the land. By minimizing food sources, well-designed and maintained

landscaping on the property may help reduce rats, insects, and birds. If at all feasible, culverts should be built over open streams since they might attract animals such as birds and insects. It is best to locate processes that might produce microbiological or dust aerosols away from production areas, such as effluent treatment plants, waste disposal facilities, or any preparatory cleaning activities.

A minimum 3-meter buffer zone surrounding buildings should be kept clean of plants and covered with a thick layer of gravel, stones, asphalt, roads, etc. This process helps maintain control over the manufacturing building's structure. Avoid storing items like tools, utensils, pallets, etc. outside if at all feasible since they may operate as a harbor for pests. It is best to avoid sitting throughout the process stages if possible. Another known fire hazard is wooden pallets stacked close to structures. To prevent unauthorized access to food goods by people or pests, they should be properly turned off if it is not practical to leave them on. Security lights should be placed away from commercial entrances to lure insects away from them, helping to prevent flying insects from entering businesses. While not in use, equipment needed to connect transport equipment to outdoor storage facilities should also be kept out of the way.

B. Another obstacle is a factory

The building structure is the second and most crucial barrier because it guards against contamination and deterioration of produced commodities, processing facilities, and raw materials. Protection is offered against internal dangers including microbiological, chemical, and physical threats as well as exterior threats like rain, wind, surface runoff, delivery and dispatch vehicles, dust, odours, pests, and trespassers. The industrial buildings, which should be constructed and organized to fit the activities carried out there, should ideally not limit how the equipment is arranged or how the process is carried out.

While it is obvious that the facility cannot be completely walled off from the outside world, entries to the structure must be controlled. Few laws specify where food factories may be placed and what can be built around them. Thus, it is the responsibility of the food manufacturer to ensure that such risks are minimized using the appropriate precautions. Using the following standards: The ideal production floor height or depth should differ from the surrounding ground. A minimal amount of openings should be kept, and outside doors shouldn't open directly into manufacturing areas. Contamination, such as dirt and other objects, is minimized by limiting direct entrance into the plant at the ground floor level.

While not in use, outside doors should always be closed. If they must be opened often, they should be constructed with a quick opening and closing mechanism. Only use plastic curtains and strips inside since they are weather-damage-prone. If necessary, either an interior or an exterior porch may have a single door. On an external porch, the layout is often a solid external door and a flyscreen door inside; on an internal porch, the arrangement would be the opposite. Air jets directed over entrances that are meant to maintain temperature differentials when chiller/freezer doors are opened may make it more difficult to keep pests out. Industrial opening locations should be chosen with consideration for the surrounding environment, particularly for wind and drainage fall directions.

If possible, structures should be one story or have varying headroom, with mezzanine levels to allow material to flow by gravity as necessary. This prevents debris or other substances from infiltrating between layers. Also, it has been observed that drainage systems serve as air distribution channels, allowing dirty air to move between rooms. When the water traps are empty and the drains aren't used often, this frequently occurs. Many food manufacturers and retailers consider glass to be the second biggest food threat after pathogenic microbes. Because of this, glass shouldn't be utilized in construction. If the glass is to be used, for example, as viewing windows to allow visitor or management observation, a glass record documenting all the types of glass used in the plant and their locations should be established.

Windows must be polycarbonate-glazed or laminated. Air-only opening windows must be screened, and the screens must be durable enough to withstand being pulled out or being incorrectly utilized. Flyscreens must be constructed of removable stainless-steel mesh. If a filtered air supply is required to processing areas and the supply will include ducting, then a minimum degree of filtration of >90% of 5 m particles is required, e.g., G4 or F5 filters, to provide both suitably clean air and minimize dust gathering in the ductwork.

Most businesses in the building have separate areas for food preparation and utility storage. The fundamental reason for doing this is to make it obvious which procedures are used to produce food and which are required of the producer. This may be done to lessen the risks posed by microorganisms or foreign objects as a result of amenity functions, but it is always done to assist food workers in cultivating the mindset that "you are now entering a food processing area."

The traditional divisions of food production areas include raw material intake, raw material storage, processing, packaging, and final product warehousing and distribution. Also, the flow of raw materials and final products is set up such that, in a perfect world, raw materials enter at one end of the plant and are shipped out at the other. According to Shapton & Shapton, the flow of air and drainage should run from "clean" to "dirty" areas, and the flow of raw materials or finished items shouldn't cross or go in the opposite direction of the flow of discarded outer packaging materials. There are no personnel hygiene barriers stopping food workers from easily traveling between the segregated portions, which is the primary distinction between segregation barriers at this level and the one below.

Several components are blended while being processed, yet they may need to be stored separately after the processing

is over. Depending on whether the storage is temperature- or ingredient-related, separate stores may be required for fruit and vegetable, meat, fish, dairy, and dry ingredient storage. Moreover, non-components like packaging and other food items like allergens should be stored separately. Segregation may also be used at the first stages of food production when dry intermediary ingredients, like pie dough, are made separately from the pie's filling. The degree of segregation for storage and processing of components and intermediates is mostly controlled by the lack of water, notably in how they are cleaned, i.e., dry cleaning. This applies to areas where cleaning is done exclusively using vacuum cleaners, brooms, brushes, etc. Although these areas are typically cleaned dry, when a little amount of water is utilized, they may sometimes be cleaned entirely or partially wet saturate cleaning. This is accurate when a space or area is always cleansed with water. The contents are wet cleaned with the appropriate amount of cleaning agent.

In addition to separating dry areas from the requirement to exclude water, some regions would need to be separated due to excessive water use, which may cause condensation and the production of aerosols. Such places include the tray washer and other cleaning stations. The only way to effectively manage the germs in food processing zones is to include third-level barriers. Nevertheless, additional dangers, in particular allergies, must be managed at the second barrier level.

By doing this, the possibility of unintended contamination with allergies found in other goods or things free of allergens is reduced. Allergic and non-allergenic products should be produced in separate facilities to prevent cross-contamination from other chemicals. Food manufacturers in Europe and the USA have spoken about this issue and concluded that it is unlikely to be viable to prepare food at various sites. To avoid cross-contamination, allergenic components must be segregated in the same place.

As an alternative to using several factories, it could be possible to separate the whole process—from product entry through raw material storage and processing to initial packaging—on the same site. If this is not feasible, segregation must be done chronologically, for instance, by placing goods containing allergens last and non-allergens first. After careful washing and disinfection, the production of goods free of allergens is subsequently restarted. If segregation by time is to be taken into consideration, a thorough HACCP analysis should be done to examine all aspects of how the allergen is to be maintained, transported, processed, packed, etc. Details on the allergen's progress through the process, the degree to which washing eliminates it, and the effects of any dilution of residues left over after cleaning in the next product flow would be included.

Food manufacturers have been prompted to think about how raw materials are segregated, albeit to a lesser extent and because it is not a safety issue, by label declaration issues like non-organic ingredients in organic foods, genetically modified ingredients in GMO-free products, vegetarian foods with non-vegetarian ingredients, and 'non-religion' processed ingredients in religious-based foods. When it comes to allergenic substances, segregation is often achieved via the use of various ingredient storage methods and timing. Shops housing essential components, such as meat in a factory producing vegetarian components, are often locked to prevent unintentional exploitation of key commodities. Such shops' locking and unlocking procedures might be recorded in the quality system.

The development of methods for product authenticity testing may lead to the separation of legally required components in the future. Think about a case where a meat manufacturer, for instance, produces beef and pig sausages. If he promoted and sold pork sausages that, let's say, included 50% beef, either he was lying or something went wrong during manufacture. Nevertheless, is it "illegal" if 0.5% of beef was detected in his pork sausages, or may leftovers from a previous batch of beef sausages turn up in a subsequent batch of pig sausages? Has the meat company been forced to split its pig and beef sausage production lines since such minute amounts of a component may be found?

In addition to preventing product contamination, segregation inside factories may be required for worker safety and health issues with food. This may be done for process protection, such as the dosing of chlorine into a system for cleaning items, or for chemical protection, such as the need for separate chemical storage. The food industry has known for a long time that certain heat operations, like ovens and fryers, or fire hazards, such as bulk storage of oils and fats, need segregation and compartmentation, and these areas are divided by incombustible materials.

Segregation is also being considered more and more as a means to increase production flexibility. By breaking up large processing zones into smaller sub-units, for example, cross-contamination across lines may be reduced. This is particularly true when certain production lines must be shut down for maintenance or cleaning while others must remain in operation. Major, multi-site, international food manufacturers are also considering how to split and organize both new and existing facilities so they can process a variety of food items. In order to benefit from changing economic conditions, the company is able to swiftly change the kind of product being produced at the site [4]–[6].

C. High-risk/care areas are a challenge

The third barrier at a factory divides the space where food products are handled or processed further after being decontaminated. It is a place where a food product is delivered after having its microbial content reduced. In line with pharmaceutical terminology, this third-level processing facility has been referred to as a "clean room," a "high-hygiene," a "high-care," or a "high-risk" location, among other terms. In many sectors, particularly chilled, ready-to-eat items, manufacturers have also employed

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contrasting labels to describe second barrier zones, such as "low risk" or "low care."

There are many ambiguous terms used here, particularly the concept of "low" areas, which can give the impression to workers and other people that lower overall standards are acceptable in these areas where, for example, operations involving the reception, storage, and initial preparation of raw materials are carried out. In reality, it is necessary to complete all food production-related tasks to the highest standard.

Due to inadequate standards in so-called low-risk zones, the "barrier system" separating the second and third-level processing areas may be put under higher stress. In an attempt to eliminate this confusion, the UK's Chilled Food Association created guidelines to describe the sanitary state of chilled foods and pinpoint the regions where they should be addressed following any heat treatment. The three tiers that were discussed are high-risk locations, high-care areas, and outstanding manufacturing practice zones. They defined themselves as follows:

D. HRA

A processing area known as an HRA is used for components that have all undergone a 90°C or 70°C heat treatment, respectively, and where there is a potential that the heat treatment or the packing sealing may have been contaminated, endangering the safety of the food.

E. HCA

A processing area for components where the possibility of contamination between heat treatment and pack sealing might endanger the safety of the food. Several of these components have undergone a 2-minute heat treatment at 70 °C. The definition of HCA has been expanded to include the extra processing of items that have previously completed a decontamination process, such as fruit and vegetables after washing in chlorinated water or fish after low-temperature smoking and salting.

F. GMP

A processing area for parts where there is a potential for contamination before packing sealing that might endanger the safety of the food and where none of the parts have been heated to 70 °C for two minutes. Where GMP processes are used in practice is at the second barrier level of processing. Many of the criteria for the design of HRA and HCA operations are similar because they both emphasize preventing contamination in HRA and minimizing contamination in HCA operations. Food producers must carefully assess the risks and hazards associated with their present and future product lines, as well as any possible changes that may occur shortly, to decide if high risk or high care is required and, as a consequence, what requirements should be met. If finances are available, it is always more economical to build from the ground up to the highest standards rather than having to modify or rebuild afterward.

In general, high-care/risk areas should be maintained as small as possible since they may be very expensive to manage and control. If there are several high-risk or care sections at a plant, they should be situated adjacent to one another or, to the extent possible, linked by similar-type closed halls. This is done to ensure that just a few different hygiene procedures may be performed during routine working activities.

Between the "low-risk" and "high-risk" level zones of the second barrier, some food manufacturers designate transitional zones. They are also known as "medium-risk" or "medium-care" sites. These locations cannot be regarded as separate zones in their own right since they may be easily accessed from low-risk areas without the need for protective gear or staff hygiene barriers as required at the low/high-risk area contact. By restricting activities and access to the medium-risk area from the low-risk area, these areas may be kept relatively "clean" and lower the degree of microbial contamination very adjacent to the third-level barrier.

The physical design, tools, and processes utilized in high-care/risk production and assembly locations offer the third barrier level. This barrier has been continually enhanced since the late 1980s or early 1990s as a part of a three-pronged approach meant to help reduce the incidence of infections, especially L. monocytogenes, in the final product while also managing other contamination sources. It was accepted that the major pathogen source was probably the raw materials used in the low-risk part of the facility, as well as any pathogens that may have entered the low-risk area through dirt associated with people or vehicle movements. The guiding principle is to use as many barriers as you can to keep Listeria out of the high-risk area; to stop any growth or spread of the organism while the product is being produced; and, after production, to use a suitable sanitation system to make sure that all organisms are eliminated from the high-risk area before production recommendations are made. The building structure and a range of various sub-barriers or components are combined to create the third level barrier, which is designed to prevent pollutants from entering at high risk via the following routes:

G. Defects in the structure

Using a decontamination process, a product enters a high-risk area. Via a heating procedure, the product is exposed to a significant danger. The outer packaging may need to be decontaminated if a product has been heat treated or decontaminated off-site but is entering a high-risk location.

II. DISCUSSION

It is technically analogous to putting a box within another box to erect a third barrier level. In other words, the high-risk zone is sealed off to prevent microbial infiltration. Even though this is the ideal situation, the box still has to have openings for people, supplies, and packing as well as

completed items and waste to pass through and out. Openings should always be kept under check and minimized as far as is practical. To ensure that all seams are fully sealed, the box's edge should also be frequently examined [7]–[9].

The design of the high-risk food processing facility must take into account five important factors: processed materials and maybe specific components; processing equipment; individuals using such equipment; packaging materials; and finished items.

According to a widely accepted notion, all other demands should be seen as subordinate to these five essential criteria and should be kept out of the high-risk processing region whenever possible. Cleaning and disinfection aid in preventing contamination. Among these secondary requirements are the factory's structural steel framework, water, steam, and compressed air service pipes, electrical conduits and trunking, artificial lighting and ventilation ducts, compressors, refrigeration units, and pumps, as well as maintenance personnel for any of these services.

The heating device must be constructed in a manner that, to the maximum degree practical, it forms a solid, physical barrier when a product's heat treatment provides a barrier between low and high risk. When it is physically impossible to establish a solid barrier around the heating equipment, air gaps should be minimized, and the low-risk floor connection should be entirely sealed to the greatest extent practical. Other heating-related problems that need specific care include the following. The heating apparatus has to be designed to load goods in low-risk locations and discharge them in high-risk ones.

The surfaces of the heating device, which cycle through phases of expansion and contraction, must be suitably isolated from the barrier structure, which has a different thermal expansion than those surfaces. Sealing is crucial at the floor level, where ovens may sit on a vacant area or "sump." Ovens shouldn't drain into high-risk areas directly because sumps may collect debris and washing fluids from oven operation, which might foster the growth of Listeria. Moreover, cleaning should be done in a way that stops cleaning chemicals from moving from low to high risk [10]–[12]

III. CONCLUSION

In order to properly perform a thermal disinfection cycle, cooked product oven racks that must be moved into high-risk areas for unloading should thereafter be transferred back into low-risk areas via the ovens. Although ventilation from high-risk regions may attract a lot of low-risk air into high-risk areas, any ventilation system in the kitchen should be designed to draw air from low-risk locations.

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Food Safety Rules and Regulations During Transportation

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***Abstract*— Nowadays, the sanitary aspect of food transportation is causing concern among transport businesses in Europe. As national governments pressed transport corporations to take action on food safety, this trend started to emerge in 1990. On the other side, retailers and food producers are pushing transportation providers for greater hygiene standards. A growing number of hygiene rules must be followed by transport firms to be qualified to participate in transportation bids made available by significant retailers and food producers.**

***Keywordss*— Food Supply, Food Safety, Food Hygiene Foodborne Disease, Wooden Pallets**

I. INTRODUCTION

Every food supply chain has a minimum of a few transit stages and sometimes many. The duration, level of conditioning applied to food products, and kind of transit operations may all differ greatly. This means that each of these transporters will have different food safety characteristics. The hygiene problems are often lower than those related to the long supply chain segments since the majority of food transit is short relative to the length of the whole supply chain. Naturally, the food supply chain also includes several more delicate transfers, such as live animals, hanging bodies, etc [1]–[3].

A. Legislation

The Food Hygiene Directive requires that goods be transported hygienically and is the most important European transportation and sanitation law. The article's general recommendations are not especially clear. The General Food Law holds both retailers and food producers responsible for the quality of the goods they sell. The application of appropriate sanitary practices must thus be demanded from suppliers by food makers and retailers.

Nevertheless, on January 1, 2006, the European Union will start implementing new rules in the field of food safety, which might entail new norms and implications for transportation businesses. To regulate the internal market and protect consumers, a total of 16 current directives dealing with sanitation and food safety have been developed gradually since 1964. The EU has realized that these 16 Directives are excessively convoluted and interconnected, and is attempting to create a more simplified, open-and-shut rule. Long-term discussions and negotiations over this new law are now almost finished. The 16 Directives will be replaced by three statutes (852/2004, 853/2004, and 854). The first piece of law will deal with food hygiene; the second, with the hygiene of foods derived from animals; and the third, with the proper procedures for conducting official inspections of foods derived from animals. Only a few changes are now predicted for the food transport business since the laws are not yet final and might yet be changed.

The FAO/Codex WHO Alimentarius Commission has also developed international norms for the management and transportation of food commodities. Standards have been developed for several food products that provide direction on transit temperatures, hygiene, packaging, and labeling. In essence, it states that all equipment used to carry food consists of the following: Foods should be appropriately separated during combined transit to prevent cross-contamination, and they should be cleaned thoroughly in between different loads to prevent cross-contamination. Should be kept tidy and in good condition. Are not to be used for anything other than moving food, since this might contaminate the food.

Under this regulation, there are no specific criteria for controlling temperature and hygiene. The Dutch transport board's hygiene code and the establishment of a certified Hazard Analysis Critical Control Point system by transportation firms are not requirements. The majority of people agreed with the cleanliness code. The number of transportation firms with individual HACCP strategies is rising. Given that it is a large document that covers all modes of transportation and food, the hygiene code is not precise and unambiguous. It does include information on things like the optimum methods to stack pallets in trucks to allow for the circulation of cold air, draughts for cleaning schedules, listings of the minimum and maximum shipping temperatures for products, etc. The HACCP plans for individual transport operators contain thorough daily work schedules that outline when and how to clean their transport equilibrium units as well as how to evaluate the efficiency of the cleaning process. Moreover, they outline how to regulate these temperatures as well as the temperatures at which meals are carried.

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The hygiene policies and HACCP plans of any transport company are not made available in any sort of publication. It is thus hard for interested parties to verify whether a certain transport company makes an effort to maintain cleanliness. Shops and food enterprises that request transportation often are well aware of the hygienic procedures the operator follows. Customers or independent researchers cannot access these programs. Customers are informed that a transportation provider is ISO-certified or follows the BRC standard, yet this information is mute on the vehicle's real cleanliness. To gain the public's confidence by proving that transit operators care about food safety, it would be a good idea to be more open about these hygiene problems. For instance, transportation companies may begin by outlining on their websites how often and properly their cars are cleaned.

De Greef Woudenberg BV, a transport company in the center of The Netherlands, goes to great lengths to ensure that all of its transportation activities meet a high level of cleanliness. The majority of the shipping commodities are packed fresh meat products and whole-round Dutch cheeses. Sometimes, hanging bodies are transported. The company has its own HACCP plan, and the Netherlands Regulating Authority for Milk and Milk Products audits it twice a year. The temperature set points and the procedures required to monitor them are carefully described in the HACCP plan, which also forbids mixed shipping.

Cleaning guidelines are also included in the design. The 20 privately owned automobiles are washed once a month using a high-pressure water sprayer and an aqueous solution of a biodegradable detergent. Before using a steam spray cannon to treat the whole inside of the car and applying a disinfectant at the end, stains are first removed from the inside by sanding. This procedure was developed over five years. Microbial surface sampling and testing are utilized twice a month to assess its effectiveness. To gather samples, ten different areas both inside and outside the car were examined. The average score after cleaning shouldn't be more than 1.4 cfu/cm^2. This cleaning technique rarely fails. When that happens, the car has to be cleaned once again. This company not only runs its fleet of vehicles but also serves as a center for other Central European transport companies. The same cleaning procedure is used on all Central European trucks each time they stop at Woudenberg, not just to maintain the interior's cleanliness but also to clean the often extremely filthy exterior. This transportation company's one employee is always busy cleaning and maintaining cars. As a consequence, maintaining a high degree of cleanliness requires meticulous planning and significantly increases overall costs.

In the meat and cheese sector, where regulating temperature and avoiding cross-contamination are critical, Greef-Woudenberg BV is a cutting-edge example. Not all transit providers are represented. The transporters of fruits and vegetables are on the other end of the cleanliness spectrum. Both closed and open vehicles are utilized by them. Washing the vehicles takes less care because cross-contamination is seldom a concern when delivering fruits and vegetables. This might vary in the future, especially for extremely perishable commodities like strawberries. There are several initiatives ongoing to minimize the early Rhizopus load on strawberries to lengthen the fruits' shelf life. To keep the burden low and the shelf-life longer once they are effective, they must be transported in clean vehicles.

Europe has extensive rules controlling the sanitary transportation of food, but such laws are projected to grow easier in the coming years. Shipping companies have complied with the law and developed protocols to control the temperature and prevent cross-contamination. This is useful. Maybe the lack of openness for outsiders is the sole drawback. There are several unresolved difficulties.

B. Temperature control

The insulation and refrigeration systems of refrigerated trucks are built to be able to keep the chilled cargo at the proper temperature even when it's hot outdoors in the summer. Often, they cannot chill the cargo during transportation. To certify insulating materials and truck refrigeration systems, the European Agreement on the Transport of Perishables created test requirements. Still being researched are thinner, lighter, and more energy-efficient insulating materials as well as more energy-efficient refrigeration systems. When chlorofluorocarbon blowing agents were banned, insulating foam performance temporarily suffered. But, the foam industry is always creating new, superior foams with improved insulating qualities that don't include CFCs. The cost of transporting refrigerated goods will decrease marginally as a result of these advancements, which are anticipated to continue in the years to come.

When a supply chain's temperature was improperly controlled and cargo was exposed to excessive heat, the issue most often wasn't the fault of badly refrigerating cars. A few outliers have been noted in the past, including drivers who shut off the loud refrigeration units for the night to get a decent night's sleep and pallets that were stacked too closely together in front of the chilled air outlet. As long as the pallets are hollow and there is enough head space above the load and between the load and the rear doors, pallet stacking is often no longer an issue. The engine at the top front will be able to circulate cold air over the cargo, through the rear doors, through the hollow pallets, and back to the front with such a configuration. These days, neither issue often arises. The hygiene code, training the loaders and drivers, and the growing usage of dataloggers are some of the factors contributing to this. Dataloggers efficiently identify temperature misuse and are often mounted in the back of the car. After the truck was returned, the dataloggers were removed from the vehicle, and the data were loaded into the operator's computer system, the initial data log systems could only identify an abuse scenario after the transport had ended. Current data log systems may instantly inform the transport operator's headquarters through cell phone networks and

even warn the driver of temperature misuse scenarios while in transit. The driver can take action thanks to these contemporary technologies and prevent the loss of a whole load owing to temperature abuse.

While loading and unloading vehicles and whenever the load's supplier neglected to properly lower the load's temperature before travel, temperature abuse is more likely to occur. Although cooling loads may take a while up to a day for carcasses there is a significant incentive for rushed suppliers in the hectic food supply chains to hurry off the pre-cooling. As refrigerated trucks are not designed to maintain a cargo cold while being carried, the outcome might be disastrous. To avoid claims, contemporary transport operators would personally verify the load's temperature before loading it or they would utilize a sophisticated data log system, which would record temperature abuse from the start of the journey.

Nowadays, controlling temperature is essential for the transportation of fruits and vegetables. Two temperature zones have historically been used to divide the fruit and vegetable business. As retailers and shipping businesses are under pressure to save costs, all fruit and vegetables are often delivered at a temperature of about 7 degrees Celsius. This reduces the food quality of tropical fruits and convenience products. Bananas and other tropical fruits are becoming more often harmed by cold, while the shelf life of pre-cut vegetables is decreasing. The significant growth in sales of convenience vegetable products as well as the propensity to transport these goods at excessively high temperatures are contributing to an increased awareness of the shelf-life problem.

Temperature abuse occurs during unloading during shipment to retailers rather often. At small firms, the goods receiving area is not frigid. As the driver dumps the goods at reception, there may not always be shop workers on hand to help. Our datalogger analyses of Dutch supply lines have sometimes shown cooling-freedom times of up to two hours for shipments. The establishment of a data log system will again be advantageous to the transport operator when claims are filed because of temperature abuse during unloading. To avoid these situations, some supermarkets allow drivers to transport chilled loads directly to cabinets or only let trucks unload when personnel is on hand to take chilled loads. Particularly for commodities with low specific heat capacities, such as bakery goods, maintaining the temperature of a conditioned conveyance during food transit with multiple stops and door openings is a special challenge. Lamellae and air curtains at the car doors may significantly minimize the amount of heat lost during loading. With our modern supply networks, air freighting of chilled goods is increasing. Transporting chilled items via air has unique difficulties. As ordinary refrigeration systems are not permitted aboard airplanes, cargo is either transported uncooled, insulated or in specially designed containers that are chilled using dry ice. Most chilled cargo is properly precooled and flight-insulated.

The size of an air cargo hold, this container allows for the addition of dry ice in a separate cabinet. The evaporation of the carbon dioxide cools the load. A fan is used to circulate the air within the container. These Enviradenes' fairly expensive lease prices have now limited their use. As a consequence, most loads are pre-cooled and insulated. Temperatures may be mistreated when airplanes are loaded or unloaded slowly. Before food or flowers may be flown across borders, the cargo must first pass veterinary or phytosanitary inspection. These could take a long time to attend to and check out at airports. Unless the inspectors grant their clearance, the insulated container will stay outside the aircraft for that time, sometimes in direct sunlight. A few hours of continuous sunshine in a tropical area might have disastrous effects on the load's temperature. Upgraded air freight containers might come with amenities like electric Peltier coolers and improved insulating materials in the near future [4]–[6].

When compared to conditioned truck transport, the former often outperform the latter. The Cool Box initiative in North West Europe has improved fresh fruit logistics during the last several years decade. It allows for rapid and accurate transit conditioning. By incorporating inland transportation and controlled environment storage technologies, it is predicted to rapidly expand into central and southern Europe over the next years.

The complaints of temperature abuse onboard seagoing boats sometimes include unconditioned transportation. For instance, it has been noted that unconditioned containers traveling through the tropics at the top position on a boat may achieve temperatures of 80–90°C. These very high temperatures have a deleterious effect on the food within the heated container.

Cross-contamination may be avoided by taking the appropriate precautions. Some commodities need to either not be transported at the same time or ought to be kept separate by a barrier, such as pallet sleeves or covers. Instead, if there was a considerable risk of contamination, shipping containers for liquids, bulk goods, and hanging corpses may be cleaned before and after transportation. In the past, cross-contamination problems have been brought on by return freights and wooden pallets.

Return logistics like returnable plastic bottles might taint retail vehicles. These vans collect PET bottles that have been returned and deliver food to several retailers from a single distribution center. These old bottles' sugar-rich leftovers provide the perfect breeding ground for germs. A tiny proportion of bottles are mishandled by consumers and contain impurities including motor oil, pesticide, urine, and others. On a pallet rack, the returned bottles' drippy stack is caused by a lack of tightly connected screw caps. The spilled fluids will contaminate subsequent cargo when they land on the truck's floor. There have been a number of recorded

instances of returning bottles in the past. These days, retailers collect these bottles in sizable bags or airtight crates. These bags or boxes are closed, put on pallet trolleys, and transported without causing any hygiene problems.

Another difficult return freight item is rotten meat. Fresh meat that has gone bad in the shop has to be gathered separately and burned off in a specific spot. Several supermarket companies also use standard transport trucks to convey this merchandise back from the shops to the distribution centers. If the ruined meat was packaged in altered atmospheres, there is no problem, but if not, it has to be airtightly sealed before being returned by truck. Empty plastic containers make up another large return load in the retail shipping industry. This return load, which is often uncooled and is associated with loads of chilled food products, may interfere with the correct regulation of temperature.

There has been significant debate over the hygiene of wooden pallets since cutting boards and other wooden objects contain microbial flora. the differences in structure and cleanability imply that plastic pallets will probably be more hygienic than wooden pallets. As a result, several online pallet suppliers promote cleanable plastic pallets as being more hygienic than wooden pallets. Sadly, the existing body of scientific research does not allow for its validation because

Revealed that hardwood pallets are really less hygienic than plastic or metal pallets. Wooden and plastic pallets have different microbial floras, according to research, but both are acceptable to use as long as they are not left outdoors or in very moist conditions. In reality, however, imports on wooden pallets are prohibited in many countries to reduce the likelihood of the spread of plant pests. Several countries only allow the importation of heat-treated or fumigated wood pallets. Also, many small food companies won't allow customers to bring in shipments on wooden pallets. Also, starting on 1 March 2005, the European Union prohibited the importation of pallets made of inadequately treated wood. Heat treatments and methyl bromide fumigation are both acceptable according to ISPM regulations. The treated wooden pallets must have the International Plant Protection Convention symbol. Pallet sales of both metal and plastic are increasing as a consequence [7]–[9].

II. DISCUSSION

The new contracts that transport companies will sign with food producers and retailers will contain financial claims in the event that temperature abuse is found at the destination. In order to eliminate erroneous claims, transport companies are using data log systems. Because they capture the actual temperature within the piece of transportation equipment, these devices are useful in refuting erroneous claims. In their most recent generations, these systems include a lot of additional capabilities, such as alerts for temperature abuse that is obvious to the driver. These temperature control systems will advance and are projected to fully integrate with sophisticated supply chain management solutions in the not-too-distant future. The precise contents of the load will be identified by radiofrequency identification tags on pallets, crates, and individual packages. The location of the truck will be continuously tracked by a global positioning system, and the actual temperature inside the truck will be continuously measured by data loggers. Occasionally, all of this data will be sent between the transit providers' main computers and their users' mobile devices. The real-time stock levels, relative quality, and location will be continuously explained by powerful computers as they analyze this deluge of data. In the case of temperature abuse or the presence of forbidden mixed loads within a transport unit, these devices will continuously monitor the loads' temperatures and sound alerts. Further analysis of the incoming supply chain data will be done to optimize the price and distribution of perishables based on recent market data

III. CONCLUSION

Most of the value of perishables is now lost in the supply chains as a result of ignorance about stock levels, load quality, and price. Consumables often lose between 5 and 10% in wealthy nations and up to 40–50% in developing nations, resulting in a yearly economic loss of at least 25 billion euros. The implementation of modern quality-differentiated stock management systems for perishables that help to reduce shrinkage to a few percent would improve the financial performance of retailers. The impact of food supply chains on the environment will also be significantly reduced by using these techniques. Although some people may see these technologies as foggy science fiction, it is reasonable to predict that the lowered costs will stimulate their adoption in the next year [10]–[12].

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Methods For Improving the Control of Insects in Food Processing

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Abstract— Post-harvest management has just recently started to get greater focus than pre-harvest agriculture, which formerly dominated management efforts. The hygiene management of dry goods, such as grains, dried fruits and vegetables, spices, flour products, and other forms of dry food, whose moisture content is less than 17%. In this chapter, we will be briefly discussed a method for improving the control of insects in food processing

Keywordss— Carbon Dioxide, Dry Foods, Grain Bulk, Intergranular Air, Methyl Bromide.

I. INTRODUCTION

At least 7,000 years ago, when humans first started to colonise and settle the country, they also started to preserve food. Food preservation has two important arguments. Secondly, to provide the farmer with the choice to hold onto the commodity until a fair price can be negotiated. Second, for security concerns, countries import food for internal use; they must have emergency stocks of grains and other commodities on hand. Nowadays, grains are used to create the vast majority of the world's food. Including wheat, rice, millet, sorghum, rye, barley, legumes, soy, cassava, sweet potatoes, coconuts, and bananas, the bulk of the food that people eat is produced by plants. The majority of poor nations consume 180 kg of grains annually per person, compared to wealthier nations where the bulk of the proteins required by people come from animal sources [1]–[3].

Thailand is the leading grain producer in the East, where rice is the staple grain, followed by China, Japan, and Indonesia in terms of distribution. Yet, in the Western world, maize is the more common grain, whereas wheat is the most common in South America, Australia, and Europe. Every year, over one billion tonnes of grains are produced worldwide. Developing countries suffer storage damage ranging from 5% to 40%, depending on how long the grain is kept. In addition to the metabolic processes of bacteria and insects spoiling the items, oxygen is used, and heat, water, and carbon dioxide are released. Hot spots in the grain mass are produced by this biological activity and may go as hot as 60 °C. Unsaturated fat oxidation causes chemical heating, which keeps the biological heating going. The heat produced during this process, which may exceed 300 °C, ignites the materials. It should be mentioned that certain insects may survive grain with a moisture level of only 1.0%. Thus, controlling the cleanliness of objects that are dried and preserved is essential for safe storage.

A. The majority of the grain in terms of ecological

It is believed that the bulk of the grain is a dynamic system. While seeds are living organisms, they are in a latent state and not highly active. For the best storage conditions, the seeds should be allowed to dorm longer. To understand the ecology of storage, one must conceive of a grain mass as an ecosystem. Environmental factors such as temperature, air gases, and moisture have an impact on both the biotic and abiotic parts of the grain bulk ecosystem.

B. Biological elements

Grain, hazardous insects and mites, and toxic microbes are all examples of "biotic factors," which are living substances. Abiotic factors or nonliving substances include Storage structures, intergranular air, dust, and foreign objects. Dust, dockage, and odd items. Insects and fungi may flourish in these favourable settings. Between the granules of airThe distance between sand, grain, or other substance grains. It occupies 20–50% of the volume of the bulk grain. The intergranular air is essential for the following reasons:

Based on the amount of air in the grain, it is possible to compute the weight of seeds that may be kept in 1 m^3. For instance, 500 kg/m^3 for flour and around 700 kg/m^3 for wheat. The intergranular area enables air currents to travel from one place to another and convey water vapour, which permits fumigation treatments for insect control. It is possible to regulate or prevent the growth of insects and fungi by changing the quantity of atmospheric gases in the intergranular air.

C. Vaporized hydrogen

Water vapour is present in the intergranular air. Convection currents and condensates will move the water vapour from the hot to the cold area of the commodity if there is a temperature differential. Water increases product humidity, promotes the development of fungus, and eventually ruins the product. Storage building structures

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make it simpler to transport goods between places, aerate them, and fumigate them, storage buildings are essential.

D. Temperature

Most of the insects found in commodities that have been preserved come from tropical and subtropical areas. Insects' rates of development and reproduction fluctuate with temperature and decrease with lower levels since they are unable to control their body temperatures. The majority of key stored product insects need temperatures between 28 and 34 degrees Celsius for optimal growth and development. They may also develop between certain minimum and maximum temperatures. Temperatures 5-10°C below ideal will hinder their capacity to reproduce and consume, while temperatures 5-10°Cover optimal will be lethal.

E. The role of moisture

Moisture is the most important component in storage. Life and water are intricately interwoven, and this must constantly be kept in mind. Hence, the less water there is in the items, the better we can preserve them. For instance, oxygen and water may revive seeds, which are in a condition of deep dormancy. This is a harmful, permanent process that encourages the development of fungi that eventually poison the good. Humidity may be divided into two groups.

The presence of water in the product or seeds. The quantity of water a commodity contains has a considerable impact on how long it can be kept. High humidity promotes the growth of bacteria and other biotic factors, which ruins the product. Grain and the products depend heavily on water, which is as valuable in the market as the commodity.

The relative humidity or water content of the surrounding air. Cereal grains adjust their moisture content to balance with the surrounding air because they are hygroscopic. If dry products are kept in humid air with a relative humidity of 80 to 90%, they will absorb moisture until they attain equilibrium with the ambient air's moisture. In contrast, the moist grain will start to lose water in dry air with an RH of 50–40%. The dynamic equilibrium between product moisture and ambient air moisture is referred to as equilibrium moisture content. This is one of the most important factors in figuring out how much grain can be kept. Depending on the grain's kind, age, and chemical makeup, grain EMC values might vary. EMC increases when relative humidity increases and temperatures decrease.

Another important factor is the grain's necessary moisture content since below it, grain is not storage-resistant and encourages bacterial development. Each kind of seed has a distinct CMC. For instance, the RH of the ambient air is between 70 and 75 percent, while the CMC of wheat is approximately 15%. In comparison to seeds with low oil content, high oil-content seeds often have a lower CMC. Techniques for measuring grain humidity include direct methods and oven drying. These methods are often exact. The usual method is oven drying methods.

Whole grains or milled commodities are dried in a single step following the temperature and time specifications provided for each kind of grain or its products. You may either wet or dry test the moisture content. Wet weight is calculated using the product's overall weight. Electronic moisture metres are indirect methods. The product's dry weight is what remains after the water has been taken out. They depend on the electrical conductance or capacitance of grains, which is significantly impacted by the moisture level of the grain. This method helps determine the moisture content of grains or other commodities. Electronic metres are reliable, rapid, and cost-effective for each test. These moisture metres are available in many different styles and are used for many different things.

F. Gases in the environment

By changing the ratios of the various gases in the intergranular air, elevating the CO_2 concentration or lowering the O_2 concentration, for example, by using hermetic storage or a different environment, it is possible to limit or impede the development of insects and microflora.

G. Moisture movement inside the grain mass

This also refers to the transfer of moisture brought on by inconsistencies in temperature inside the grain bulk. Water vapour is also moved by convection currents in the intergranular gap from hot to cold areas of the grain bulk. Cold temperatures cause water to condense and seed humidity to increase, which speeds up the development of microflora and the formation of hotspots that cause the products to deteriorate biologically. In metal silos, this event happens often. Dry items must be stored in this way because hermetic storage has restrictions owing to moisture migration. To prevent moisture migration, it is recommended to aerate the grain before cooling it and to separate the storage locations that accumulate moisture scorching sun the bottom of the storage compartment in sack storage is often where we locate damaged grain or other products. When the floor is cold, moisture travels from the hotter, upper sections to the lower ones. To get around this problem, place the bags on wooden beams [4]–[6].

H. Heating using both wet and dry grains

Heat, water, and CO_2 are also released during the metabolism of insects and microflora, using up oxygen. Hotspots start to form at temperatures as high as 40 C because the grain has a very limited thermal conductivity, which prevents heat from dissipating. The process of dry grain heating is brought on by insects. Insect development is hampered by high temperatures, so the active forms move to cooler areas to create new ones. Convection currents also deposit metabolic water as condensation at the chilly surface after transporting it through the bulk as water vapour. As a consequence, moisture is transferred from the heated to the cold area of the grain bulk, and insects' dry-grain heating is often followed by microflora's wet-grain heating.

ISSN (Online) 2456 -1304
International Journal of Science, Engineering and Management (IJSEM)
Vol 10, Issue 2S, February 2023

I. Infestations in items being kept

The insects that are discovered in stored items are often tropical or subtropical in origin and prefer warm, humid climates. Due to their small size, they may slither into cracks and crevices to hide. They eat dishes that are not very moist. Due to their fast rate of reproduction, the majority of stored goods insects reach their mature stage in a month under optimal circumstances. Populations of red flour beetles, for example, may increase by 70 times in a single month. It should be mentioned that hazardous pathogens that cause human diseases are not known to be transferred by insects that consume stored commodities.

J. Both main and secondary insects

Two typical examples of major infesting insects are the rice weevil and the Angoumois grain moth, which attack crops in the field just before harvest in North America's warmer areas. In actuality, this primary harvest illness affected the grain storage facilities, silos, truck transports, ship holds, and warehouses of modern commerce at some time. Because of unique anatomical and physiological modifications, primitive insects may target the specific food supply with which they have long coevolved. The primary insect's larvae and adults consume the grain kernels, or they chew through the outside of the grain or cereal to reach the inside. Sitotroga cerealella, Sitotroga oryzae, Sitotroga granaries, Sitotroga zeamais Motschulsky, Rhizophertha dominica, Lasioderma serricorne, and Trigoderma granarium Everts are the major insects that are most common.

Grain is only consumed by opportunistic secondary insects after a primary insect has physically or physiologically removed the seed covering. Usually, secondary insects feed on items that are ruined, damp, or have some mould growth on them. Some unintentional insects consume the mould rather than the meal ingredient. In most cases, secondary insects insects that infest and attack the stored food supply are not visible in the area where the first primary damage was done. While secondary infesters are not necessarily expressly trained to attack the food source in the field, they have evolved to target food sources that have previously been damaged by primary field insects. One outstanding example of this is the saw-toothed grain beetle, a secondary pest that often attacks dry fruits and vegetables, flour, and cereal grains. Other common secondary insects include Tribolium castaneum, Tribolium confusum, Cryptolestes sp., Plodia interpunctella, and Ephestia cautella.

K. Insect Damage

Few individuals outside the pest control and sanitary design sectors are aware that insects take value from humans to store and distribute food and other consumable commodities. It is estimated that insect infestation in cereal and grain storage causes a global loss of 10% or more per year. Depending on how long an item is stored, damage may represent up to 40% of the overall cost in poor countries. We may greatly increase the likelihood of averting starvation by feeding people in developing and overpopulated countries with these crops and grains. There would be enormous positive economic savings if we could eliminate or greatly reduce this loss.

Infested packaged foods, infected grain, or contaminated cereal are common ways for insects to enter a home or a warehouse. With the right conditions, insects grow quickly and may fly or crawl into uninfested food. They can fit through very small openings, and under some conditions, they can nibble or drill completely through the packing.

In addition to eating the food, insects contaminate the meal with their waste, webbing, insect parts, and foul-smelling metabolic byproducts. Keep in mind that processed and packaged contaminated commodities are considered tainted and cannot be saved by fumigation or cleaning. In most cases, once the material has been polluted, it must be destroyed. Millions of dollars are lost by food producers and processors as a consequence. The metabolic waste products of the grain weevil are a great example of unrecognised adulteration. For hungry people in many developing countries, corn provides a stable food supply. Yet even before the maize has reached the end of its storage shelf life, the weevils' synthesis of uric acid can render it unpleasant to eat. This severely reduces the food's nutritional content and, unavoidably, has an impact on the economy.

Five insect bits per 50g of dry food is the maximum allowed. Keeping this level could prevent certain countries from exporting commodities. Immunological tests based on the quantity of proteins specific to insects, including myosin, have been developed in an attempt to standardise the insect fragment technique.

L. Ecology of pests in commodities in storage

The climate has a significant impact on insect ecology since it may help or hurt an insect's competitors. The most significant component, climate, may have an impact on the geographic dispersion of insects. Although certain insects thrive in tropical environments, others may survive in more temperate ones. Most insects can grow and reproduce fast in an ideal habitat.

M. Effects of insect density, food, light, temperature, atmospheric gases, and humidity

1.1 Humidity

Primary infesters such as rice and grain weevils cannot multiply there when provided with grain with a moisture content of 8.0% or less and will die. Flour beetles and saw-toothed grain beetles are two examples of insects that can reproduce in low-moisture environments. The flour beetle and the saw-toothed grain bug can both withstand moisture levels as low as 6.0% and 1.0%, respectively. |

1.2 Temperature

The bulk of insect pests that attack stored products cannot thrive at temperatures higher than 40 °C, and they can only grow slowly at lower than 21 °C. The capacity to reproduce is

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International Journal of Science, Engineering and Management (IJSEM)
Vol 10, Issue 2S, February 2023

greatly hampered for primary grain infesters because they cannot lay eggs below 18 C.

Food store insects eat plant matter, except those in the family Dermestidae, which depend on animal skins. Yet, the kind of food that insects consume directly affects how quickly they can reproduce. A great example of this is the cocoa moth, which needs vitamin B to grow, thrive, and compete in addition to the proteins and carbohydrates it needs to build its body parts and provide energy. The bulk of bugs that live in dry storage acquires their moisture requirements from the solid food they consume, while certain insects that bite and chew their meal can drink water. Some insects that infest especially dry food material may acquire their water supply via condensation as a result of temperature fluctuations in the foodstuff.

1.3 Light

The relevance of changes in photoperiodicity or light intensity has been shown concerning the maturity of the reproductive organs in stored-product insects.

1.4Vaporised gases

Two atmospheric gases, oxygen and carbon dioxide, directly affect an insect's ability to survive. In truth, insects need oxygen to survive. Since live wheat emits the same amount of carbon dioxide, grain insects confined in airtight containers, whether or not they contain wheat, die as soon as the oxygen level is low. Also, wheat has the perfect amount of moisture to maximise carbon dioxide production. When stored in airtight containers with the right amount of moisture, wheat will develop insect resistance. Insects get intoxicated by high carbon dioxide levels, although they are not as hazardous as the effects of falling oxygen. Even at lower temperatures, insects can withstand high carbon dioxide concentrations for a long period. Some animals show higher levels of tolerance throughout their developmental phases than they do as adults.

1.5 Bug population

For food and other resources, insects may compete with one another as well as with parasites and predators. Amongst species that like the same temperatures and humidity levels as well as having similar nutritional demands, there is the strongest food rivalry. Insects may compete fiercely while conditions are favourable for both species; nevertheless, a drop in temperature or change in the amount of moisture in the air may be damaging to one species.

Yet, no effect could be had on the competing species. This often works in favour of the species that have been used to the change in temperature and moisture. A big infestation or population of insects, however, may make them more susceptible to parasites and predators. An insect that grabs, drags away, and consumes its victim is said to be predatory. An insect that lives within or is related to its victim or host is considered a parasite. Sterility is a well-known effect that a parasite has on its host. Not all parasites kill their host. Pathogens caused by bacteria and protozoa have been shown to eliminate up to 90% of an insect population's larvae. The larger and denser the population, the more susceptible it is to threats like food shortages, environmental changes brought on by metabolic waste products, and internal bacterial and protozoan parasite transmission.

N. Methods for locating insects

Comprehensive inspections are one of the most effective detection methods available to the entomologist and sanitarian. It is necessary to examine the structure where dry items are produced and stored, as well as the equipment used to prepare and package them. The frequency of inspections must match the target insect's life cycle. This may be accomplished by inspection of the inside surfaces of the processing equipment, especially at dead ends or other inoperative areas of the pneumatic piping used to transport the commodities. Moreover, dust control systems must be regularly inspected since activity in this area is unavoidably caused by tainted ingredients or processing machinery.

In addition to the larval and adult insects themselves, webbing in the food, rips in the packaging, insect faeces, and odours produced by the metabolism of insects may all be utilised to detect pest infestations in stored goods. Together with numerous more insects that infest dry products but weren't listed above, all of the aforementioned insects cause grain mills and storage facilities to suffer millions of dollars in damage. To prevent the introduction of insects into the production process, incoming raw materials must also undergo a thorough screening procedure. This may be achieved by correctly sorting the materials and looking for adults and larvae in the tailings.

O. Techniques for constraint

The prevention and control of infestation is the dry goods industry's ultimate objective. The effective control of pests, which is a very challenging endeavour, requires the use of a variety of tools and disciplines. The process starts with the application of integrated sanitation practises, suitable hygienic equipment and facility design, bug-free ingredients and packaging materials, stringent inspection standards, a thorough understanding of the behaviour and ecology of insects, and efficient pest control methods and systems. The three basic groups into which control measures may be separated are preventative measures, chemical control, and physical measures.

P. Preventative measures

1.1 Storage-space layout, sanitation, and cleanliness

Cleanliness and proper housekeeping are two of the most important aspects of pest management. The first level of defence is to design storage facilities without false ceilings, porous insulation, fake walls, and many gaps and crevices where dust may collect and insects can breed. The presence of dust and insects must be considered while designing a facility for the processing of dry goods. Adequate dust

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Vol 10, Issue 2S, February 2023

management systems must be designed to keep all product dust confined in an easily accessible, completely cleanable sealed dust collecting system. All equipment must be installed to facilitate pest control, cleaning, maintenance, and inspection.

Deadends and other dead accumulation sites must not exist in pneumatic conveying systems or equipment used to treat dry goods. Access doors and ports must be shrewdly constructed to inspect and clean interior process surfaces during the insect's life cycle. All insect attractants must be removed from the building or warehouse. The ground shouldn't have any low spots or areas where water may accumulate; instead, it should slope away from the wall. Weeds and tall grass must be removed from the whole site, and any rubbish must be picked up as quickly as possible. Trash must be maintained in insect-proof containers that are placed on a slab of smooth concrete with a hose and washing station, with the whole slab draining to a sanitary drain.

The slab must also be supplied with a washing station and a cleaning station for the hose. All windows must have functioning screens, all doors going to the outside must be firmly locked, and all openings leading to the outside must be completely sealed. All vents, ducts, exhausts, and air inlets must be examined to make sure that they are sufficiently sealed, screened, or blocked off to prevent insect invasion. Every storage within the plant and warehouse must be at least 0.45 m away from walls to allow for inspection and the use of insect monitoring and control devices. Columns and doors that encroach on the space must be taken into consideration, and there must be at least 0.45 m of space provided for access beyond each column and door.

Sanitation is crucial for managing insects and preventing infestation. By keeping the accumulation of food items to a minimum by frequent cleaning, infestation hazards may be reduced. Also, it is required to inspect and clean plant production storage spaces and machinery on a timetable that coincides with the life cycle of the target insect. A master sanitation schedule must be made to guarantee that all locations connected to processing equipment and facilities are cleaned. Cleaning up stray food or dust from ceilings, above pipes, cracks and crevices in walls and floors, as well as from any other areas that can gather dust and act as an insect breeding ground, is essential. A firm that sells dry goods will get contaminated without a proper cleaning procedure, and it will be difficult to get rid of the infestation. Without a robust sanitation programme, the infestation's core cause cannot be eliminated, even though fumigation and other management techniques may considerably decrease insect activity.

1. Monitoring and inspection
2. Direct techniques

As previously said, it is essential to regularly inspect large inventories of stored materials and items for signs of infestation to put control measures in place before the infestation gets out of hand, particularly if they are not used or moved about often. One of the greatest ways to discover insects in raw materials is to install and inspect sifting equipment. The first and most effective method is passing the contents over the screen while sifting the components through the screen and removing the insects. The sifting screen's mesh size must be as tiny as possible for it to efficiently filter out all forms of insect life, including eggs. The finer the component's particle size, the better. Grain products, food products based on grains, and dried fruits and vegetables contain the bulk of stored-product insects. To get rid of adult stored-product bugs, a screen with a mesh aperture of at least 30 meshes is required. The 30-mesh will also eliminate the vast majority of insects that are in the larval stage. A critical detection method is to often inspect the tailings for indications of insect infestation. By doing this, the amount of large infestations brought into the processing and storage system is considerably decreased. For bulk loads of goods entering the sifter, tailings must be assessed at the start, middle, and conclusion of the unloading procedure. Once every shift, during in-process inspections, tailing should be inspected for indications of insect infestation.

Systems for detecting Flintrol UV light are another kind of detection. The UV wavelength produced by these units attracts a lot of adult flying stored product insects, and when they fly into the unit, they are electrocuted and fall into a collecting pan. A weekly inspection of the collecting pans may reveal the earliest sign of a problem with an ingredient or finished product stored in a warehouse or processing plant. Glueboard zone monitors are designed to be fastened to walls, columns, or pallets and are used to monitor insect activity in a manner similar to rat glue boards. Several different types of zone monitors employ a food attractant to increase their effectiveness.

Pheromone traps are specialised monitoring devices that use a sex pheromone attractant to entice a particular insect to the trap. This device is extremely useful since it can monitor activity throughout a significant area of the structure. Because you don't want to attract local insects that are native to the area where the storage/processing facility is situated, it is necessary to use care while setting up this trap. As a result, they need to be handled with extreme care.

1.2 Indirect methods

Almost always, insects that dwell in things that are kept boost the temperature. Thus, it is essential to continually monitor the temperature to be aware of changes in the temperature of the grain bulk. The measurements may be made using either moveable temperature probes or permanently affixed thermocaples, which may give data from all depths of the grain bulk. Determining how well grains can be preserved depends heavily on moisture measurements. For the measurements, specialised moisture metres and laboratory methods are employed.

ISSN (Online) 2456 -1304
International Journal of Science, Engineering and Management (IJSEM)
Vol 10, Issue 2S, February 2023

Q. Physical and chemical control techniques

It is practically impossible to stop insect eggs from entering grain storage areas and dry products processing and packaging facilities, despite the fact that there are several technologies and strategies for avoiding insect infestation. A number of pharmacological and physical control techniques are available to supplement preventive measures.

R. Chemical protections

It must be kept in mind that the majority of pest control techniques often employ chemical agents. Aerosols, fumigants, and residual insecticides are some of them. Fumigation is the most effective method of controlling insects. At certain temperatures, the fumigant may enter bulk grain and packaging materials, destroying all stages of insect life. The pieces must be handled with utmost caution due to how hazardous they are. Nonetheless, because of their toxicity and penetrating strength, they are exceedingly effective. A hazardous substance is applied to a structure or enclosure during fumigation, or it is put below gas-proof sheets that can be kept sufficiently gas-tight for this purpose. The building or container must be evacuated once the required minimum timeframes and concentrations have passed in order to reach the necessary gas concentration. The amount of fumigant applied depends on the target insect, temperature, and degree of container or building tightness.

Two crucial fumigants that are often used to fend off insects that harm stored goods are methyl bromide and phosphine. Being a major ozone-depleting substance, methyl bromide will soon be phased out of use in all industrialised countries. Studies show that insects are growing increasingly resistant to phosphine. Moreover, PH3 is slow-acting and corrosive with an exposure period of 4 to 28 days, depending on temperature and the commodity. There are several ways to take PH3, such as bags, plates, pellets, tablets, sachets, and the cylinder formulation known as phosfume. Three distinct solid phosphine formulations have been developed for various applications: methyl phosphide for insect resistance, magnesium phosphide for cold settings, and aluminium phosphide for hot situations. Among other fumigants, sulfuryl fluoride is mostly employed as a space fumigant to control termites, dry wood insects, and other pests of buildings. Ethyl formate and methyl iodide are presently not licenced.

The bug could inhale fumigants or come into touch with them on their skin since they are combustible chemicals. Dry food goods, ships, and buildings are all fumigated. PH3 is sprayed as a solid, which is different from how they are typically applied. The desired insect is killed when hydrogen phosphide gas is produced as a result of interaction with moisture in the air. Fumigants lose all of their properties and are entirely effective after ventilation.

Aerosols are effective against exposed adults in warehouses and processing plants. Aerosols are very effective in killing insects because the pesticide is incorporated into water- or oil-based emulsions and the aerosol generator creates a mist or fog of small liquid particles. Before the minute particles come into touch with an insect, they may float in the air for hours. When they do, the particle adheres to the bug, eventually penetrating its waxy exterior, entering the bug's body, and poisoning it. The benefit of this treatment is that it may effectively treat large regions utilising the ULV principle, and the pesticide droplets are carried to the insects by ambient air currents.

Bigger particle sizes are less effective because they escape the environment too quickly; usually, droplet sizes between 1 and 15 m are the most efficient. This treatment is most effective against flying insects, but it may also aid with crawling insects in cracks and crevices or larval stages in food sources. Aerosols have the disadvantage of only addressing surface-level infestation activity and needing frequent reapplication to maintain control. Large facilities now have aerosol systems installed that are designed to provide certain pesticide droplet sizes using strategically placed spray nozzles that offer complete coverage of the area being treated.

An insecticide used in residual insecticides is applied in a way that ensures long-term effectiveness. Dust, sprays, and lacquers are used to disseminate long-lasting insecticides, which an insect may eventually come into contact with. A number of contact insecticides that work against a range of stored items are often utilised in grains and other commodities. Methoprene is a juvenoid, and its dose is 2.4 mg/kg. For treatment against R. dominica and other stored product insects, a combination of 4–8 mg/kg of pirimiphos-methyl and 0.3–0.5 mg/kg of deltamethrin is recommended. Pirimiphos-methyl is an organophosphate, and its dose ranges from 4–10 mg/kg. Deltamethrin is a synthetic pyrethroid. Pump sprayers or gravity-based techniques may be used to apply the chemicals to the grain while it is being moved to the bin.

1.1 Embodied activities

Use these environmentally friendly techniques instead of chemical remedies whenever possible. Entoleter This device has been around for a long. Entoleters are used in flour mills and flour-receiving facilities to mechanically get rid of insects. The flour that has been transferred to the encounter is shot into the machine. The flour is moved between two flat steel discs or plates that fast revolve around a central shaft using centrifugal force. Two rings comprised of tiny, rounded, hardened steel posts are closely spaced apart from the two discs. The flour's impact on the revolving discs and posts and the machine's casing kills any insects and mites in all stages, including eggs that may be present in the flour. The processed flour is ejected from the machine's base via a spout.

1.2 Heat treatment

Heat treatment is often used to get rid of insects from grains and dried fruit. Many bugs may be removed if the

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Vol 10, Issue 2S, February 2023

dried items are exposed to temperatures between 55 and 60 °C for an hour, depending on the insect and stage. However, the difficulties of obtaining high temperatures in an insulated grain mass restrict the applicability of this technique.

1.3 Freezing

Some invaders that are frozen for an extended period of time may also help to completely destroy all phases of insect development. Certain products may be stored at 18 °C or below for 14 days without the eggs, larvae, or adults dying. Maintaining the material at 18°C for the whole 14 days is a crucial requirement.

1.4 Aeration and refrigeration

Aeration includes cooling things with fresh air from the outside. Ambient air is transported via a refrigeration system to lower its temperature before being blasted into the grain. To prevent biological destruction of the items and moisture evaporation, insect infestation development must be delayed.

1.5 Ion-induced radiation

This provides a way to eliminate live insect infestations from items without leaving any chemical trace. Many types of living creatures are more or less susceptible to ionising radiation. For instance, compared to us, insects are over a hundred times more radiation resistant. An insect's vulnerability to gamma radiation depends on its species and developmental stage. Eggs are more fragile than larvae and adults. A maximum of 10 kgy of gamma radiation may ever be present in food. In addition to preventing potatoes and onions from sprouting, radiation is often used to treat microbiological infections in meat, spices, and meat products.

This method has a number of disadvantages, including its high cost, difficulties transporting the product into the radiation zone, lack of proof that the product underwent any chemical changes as a result of radiation, and consumer acceptability of the radiated product.

1.6 Hermetic closure

For hermetic storage, grain or other items are placed in an airtight container. The associated insects and fungi, as well as the insects and fungi that are present in the grain, reduce the oxygen content and increase the carbon dioxide content to a level that is lethal to them.

1.7 Regulated settings

This technique of storage employs gas produced outside to eliminate the intergranular gases. Insect and fungal infestations are delayed or controlled by either increasing carbon dioxide to around 80% or decreasing oxygen concentration to about 1%. Inert dust is created using diatomaceous earth, various clays, silica aerogels, and other silicates. The dust cause insects to bleed and suffer cuticle damage, which causes them to lose water and eventually die from desiccation. This control mechanism's use is limited by its high cost, cleaning needs, and staff health hazards.

II. DISCUSSION

Methyl bromide and phosphine are the two most often used fumigants for avoiding pest infestation in grain cereal, dry food items, and quarantine insects. We now face two problems: industrialised countries will soon phase out methyl bromide and certain stored goods insects have developed phosphine resistance. Methyl bromide is believed to be the sole fumigant that can replace it in a particular circumstance due to its wide range of effectiveness. This issue will have major implications for companies and consumers that rely on this fumigant for structural fumigation and post-harvest commodities in the interim until acceptable substitutes are identified [7]–[9].

This situation has led to the development of several fumigants. One of them, sulfuryl fluoride, is used to control dry wood termites and other pests in buildings as well as for space fumigation. Also, it was shown once again that carbonyl sulphide might take the place of methyl bromide. Technology that recently came into being and combined heat, carbon dioxide, and phosphine has shown to be highly effective [10]–[12].

III. CONCLUSION

Future trends suggest a drop in the use of hazardous substances, which are bad for both people and the environment: using integrated pest management this approach puts a lot of emphasis on routine cleaning and inspection to spot problems before an outbreak occurs. The use of various traps is quite advantageous. A lot of studies are being done to see how well essential oils from aromatic plants work to keep insects out of stored products. Insect growth inhibitors are applied. Methoprene, a residual insecticide, is very efficient. Physical methods of restraint. It is also possible to use biopesticides like Bacillus thuringiensis and Baculovirus. These environmentally safe strategies should be used instead of risky chemical methods whenever possible. They consist of heat treatment, radio frequency waves, cold storage, and irradiation. For the different goods that need to be treated, the various control approaches should be customised

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Vol 10, Issue 2S, February 2023

Improving Contamination Risks in Food Packaging Materials

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***Abstract*— The majority of the raw materials used in the packaging and hygiene industries are supplied by the pulp, paper, and board industry. More than 90 million tonnes, or almost one-third of the global total, of paper and paperboard were produced in Europe in 2002. Around 10 million tonnes, or 11% of global output, of fibres-based food contact materials were produced. In this chapter we discussed the factors which involved in the improving contamination risk in food packaging materials.**

***Keywordss*— Food Safety, Packaging Material, Microbial Contamination, Raw Materials, Risk Assessments.**

I. INTRODUCTION

The first line of defence against external dangers must be packaging. The entry of rodents, insects, or pathogens via packages or unfavourable interactions between packaging and food might nonetheless cause issues. As a consequence of stronger regulatory requirements, fiercer international rivalry, and greater consumer expectations, the significance of cleanliness has dramatically increased in the paper and packaging business. This chapter will pay specific attention to any possible microbiological and hygienic concerns associated with packaging materials, as well as how the paper and packaging sector achieves a very high level of sanitary requirements for food packaging materials [1]–[3].

Paper and packaging manufacturers may not have traditionally valued safety and sanitary standards as high as the food industry does. Yet as the importance of food safety and cleanliness has grown, paper and package companies are becoming more aware of the value of packaging. Manufacturers of food packaging materials are becoming more aware of consumer expectations related to worries about food safety. Manufacturers of packaging materials are required to raise their standards of cleanliness since they are significant suppliers of raw materials to the food sector.

The necessity for cleanliness and microbiological control has significantly grown as a result of the package's expanded purpose and modifications made to the way fibre-based packaging materials are made. Longer selling seasons and greater transportation distances from the production site to the market have increased the length of time that food packaging is in contact with food. The package is often used as a tray in which food may be heated up and served in addition to its original use as a cover for food commodities during transit and storage. The food is more prone to microbial contamination since customers nowadays choose minimally processed meals that lack preservatives, are low in fat, sugar, and salt, and have a long shelf life. Major microbial growth-enhancing modifications have also occurred in the manufacture of paper and board, highlighting the need for cleanliness and effective microbial control. Examples include reducing water use and using more recycled fibre as a raw material. The law already mandates chemical quality for raw materials and food packaging, but microbiological controls are sometimes absent. There are no limits to the materials' microbiological quality under the legislation governing food contact materials. A policy statement about items made of paper and board that are meant to come into contact with food was published by the Council of Europe. Specifically, pathogens should be taken into account for materials designed for contact with watery and/or fatty meals. It also stipulates that materials intended for food contact should be of satisfactory microbiological quality, taking into account the intended end use. The Council of Europe Resolution will eventually serve as the foundation for new laws. In comparison to the current Framework Directive 89/109/EEC, the proposed resolution would impose far stricter microbiological criteria [4]–[6].

A. Potential packaging microbiological issues

During the production of fibres-based food contact materials, a variety of microbial issues might arise. Nevertheless, it must be emphasised that food itself is almost usually the most significant source of microbial contamination and that the harm posed by packing materials is more speculative. No known instances exist where germs from packing materials have gotten into food, proliferated there, and harmed people. Yet, there have been instances when germs from packaging affected food products. Because of the favourable conditions that paper and board machines give for their growth and multiplication, microbes may be rather numerous, but this will not significantly affect the product's run ability or safety. So, characterising the bacteria is more crucial than precisely counting them. In the paper business, microbiological issues may be grouped into the following categories: Microorganisms that cause raw materials to deteriorate, such Pantoea agglomerans and

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Bacillus subtilis, breakdown starch, cellulose fibres, casein, and rosin sizings.

Staphylococcus aureus, Bacillus cereus, and Klebsiella pneumoniae are just a few examples of bacteria that might be dangerous to process safely. Additional dangerous bacteria could be present in raw materials, the atmosphere during manufacturing, and final goods. The microorganisms that cause deposits and slime, such as Burkholderia cepacia, Deinococcus species, Bacillus Molds, Bacillus cereus, Staphylococcus aureus, coliforms, and other microorganisms that reduce the quality of the finished product, bacteria that may cause colour flaws in products, and microorganisms that compromise the cleanliness of the finished product, are all problems throughout the process. Microorganisms that, as a consequence of microbial metabolism, may produce volatile, unpleasant-smelling compounds, which might cause scent or taste abnormalities.

Microorganisms have the ability to contaminate the finished product both during the manufacturing process when they are located within the goods and afterwards during recolonization when they are found on the product's surface. Raw resources including fresh water, raw materials, and additives like fillers, pigments, starches, and coatings may all introduce microorganisms into the manufacturing facilities. Moreover, packaging, shipping equipment, open windows, doors, openings, air conditioning, insects, rats, and humans might all introduce hazardous germs into the manufacturing facilities. The danger of contamination is affected by the source of the contaminant, the quantity and quality of microorganisms, the environment in which production takes place, the availability of nutrients, and the effectiveness of control methods. The sections that follow provide descriptions of the characteristics of some important groups of pollutants. in finished products, spore-producing microorganisms

Bacterial vegetative cells are commonly destroyed by the heat and steam of a dryer. However certain bacterial species produce endospores that are very resistant to ionising radiation, UV light, disinfectants, heat, desiccation, disinfectants, chemical biocides, and disinfectants. Unless favourable climatic circumstances allow them to germinate and grow into vegetative cells, the live-free spores may survive. The transfer of poisons and heat-stable enzymes into delicate foods is another possible issue. Because of the product's thickness, which shields the bacteria from heat during the drying process, this is more often the case with high-grammage items. Due to their adhesion to the mineral crystals, microorganisms may also tolerate heat successfully in finished items containing minerals. The most crucial microorganisms for the safety of the final product include actinobacteria, spore-forming bacteria, pathogenic bacteria, certain moulds, and anaerobic bacteria.

In nature, there are many different types of aerobic endospore-forming bacteria. Heat, desiccation, disinfectants, ionising radiation, or ultraviolet light do not kill the spores. Both board samples and the constantly cycled mill water contain spore-forming microorganisms. An extremely varied and little-understood category of potential end-product pollutants is the anaerobic Clostridium species. As by-products of fermentation, the majority of clostridia create butyric, acetic, propionic, and valeric acids, which may cause issues with finished items having an unpleasant odour. There are several dangerous species among the anaerobic bacteria that generate spores. In systems used to make paper, C. sporogenes is a typical organism. This spore-forming bacterium may be found in recycled fibre, dirt, water, broken glass, and recycled sludge. Food poisoning may be brought on by a different kind of Clostridium called C. perfringens. A typical natural organism is C. perfringens. Spores produced by anaerobic C. perfringens are very resilient to environmental stressors including heat, radiation, and desiccation. For instance, it may be isolated from sand and dust or the intestines of domesticated animals and people. C. perfringens is the cause of two different human illnesses, including Food may transmit diseases like necrotic enteritis and food poisoning. The majority of C. perfringens type food poisoning cases occur in industrialised societies.

The genetic variety of the anaerobic bacteria found in paper mill environments has been the subject of a recent study. One isolate from each ribo group was then identified using partial 16S rDNA sequencing out of a total of 177 isolates that had been cultivated anaerobically and evaluated for aerotolerance. Of these, 67 were shown to be obligate anaerobes using automated ribotyping. Whereas the mesophilic isolates showed eleven different taxa within the genus Clostridium, the thermophilic isolates only revealed four taxa within the genus Thermoanaerobacterium. The clostridia C. magnum, C. peptidivorans, C. puniceum, and C. thiosulfatireducens were the closest cousins of the most abundant clostridia. The bulk of the mill isolates are predicted to belong to new species or maybe taxa based on their phylogenetic placements. Nonetheless, their spores were resilient to the process's heating up and were also discovered in the completed products. Slime and clay were shown to be useful homes for these species in paper mills.

B. Actinobacteria and yeast in the final items

Fungi may provide a risk of food spoilage due to their ability to degrade, ferment, or convert substrates as well as produce offensive metabolites and mycotoxins. Paper and paperboard often support the growth of fungi, especially in conditions with a lot of moisture and little light. Most fungi are present as a result of air and water post-contamination during and after product manufacture. Species of Aspergillus, Cladosporium, Fusarium, Mucor, and Penicillium have been isolated from fiberboard boxes. Suihko and Hoekstra isolated yeasts and moulds from fibre pulp and recycled paperboard. They found that throughout the drying stages of the paper and board making processes, but not during the heat dispersion, the fungus that was present in the recycled fibre pulps and process water was largely eradicated. While there was mould

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Vol 10, Issue 2S, February 2023

in every sample of paperboard, the levels were hardly detectable. The most frequent species found in all of the recycled fiberboards were Gilmaniella humicola, however, Paecilomyces variotii was also found. The chemicals used to make the boards or the mill setting were considered to be the most likely causes of contamination. The low level of microbial contamination on food-grade paper surfaces demonstrates the low risk of food contamination. Yet, when pasteurised and sterile commodities are packed, there is a considerable demand for packaging materials. Fungal ascospores may infect low-pH products during long-term storage if they travel via pinholes. According to studies, carton material-derived Penicillium species may cause fruit juice to deteriorate.

Actinobacteria are a diverse group of Gram-positive, physiologically and physically diverse bacteria. Its DNA sequence has an extraordinarily high GC content. Micrococci and organisms that produce branching filaments are included in the morphological variation. Actinobacteria include species from the genera Actinomyces, Mycobacterium, Frankia, Nocardia, Micrococcus, and Streptomyces. Actinobacteria produce organic odours most often. The mycelial actinobacteria are able to cause problems with the production of paper and board as well as odour difficulties in the end product by producing volatile metabolites, particularly geosmins. A variety of streptomycetes have also been shown to produce antibiotics, and some, like S. anulatus, may even produce genotoxins. Board samples manufactured from recycled fibre pulps have been shown to contain thermophilic actinobacteria up to 102 cfu g^1 dry weight.

C. Translocation of microorganisms into food from packaging materials

The majority of packaging materials have shown to be 100 percent microbial resistant. As the microbiological burden of fresh food products is disproportionately high compared to the amount of germs that may enter via packing, this problem may often be disregarded. Yet, even a little quantity of bacteria in the packaging material might be an issue for aseptic items if germs spread throughout the box. Some of the ways that packing materials might contaminate food include surface contamination, cutting dust, or direct contact with the rough edge of the paperboard. Skiving is a common method of removing the sharp edge from cartons intended for aseptic packaging and liquid commodities with a long shelf life. Dust generated during the skiving process may end up on the internal surface of the carton. Chemo thermomechanical pulp cartons with skiving have been shown to degrade more often over time than cartons without skiving.

confocal laser scanning microscopy High-density paper and paperboards used for food packaging that was coated with polyethene, mineral pigment, or a biodegradable polymer were the subjects of Suominen et al. investigation on the microbiological barrier properties of these materials. They said that a microscope might reveal bacterial cells that are dispersed irregularly within the paperboard. At the point where the polyethene covering and cellulose fibres met, there were 100–200 times more bacteria present than there were within the cellulose matrix. Even after continuous exposure for up to 90 days, no growth was seen inside the fibre web, but the bacteria at the interface and the mineral coating layer grew as a result of having access to nutrients and water. The limited access to free water was probably the limiting factor for bacterial growth and movement inside the fibre web, even under very moist conditions. The scientists assert that the polymer layer of the paperboard that is exposed to the food may contain microorganisms that might contaminate it. Mineral-coating pigments may include contaminating germs, according to research. Thus, it is essential to use hygienic, high-quality surface-sizing chemicals.

D. Improving efficient manufacturing and management

The two main goals of microbial management are to prevent the introduction of microorganisms into production premises and to remove them from production facilities if they have already entered the premises. As sterile conditions are impossible to achieve, preventative efforts should focus on making the control of germs realistic from an operational and economical perspective. Microorganisms that harm, injure, or provide a risk to a product, process, worker, the environment, or a customer should be the main emphasis. The ultimate goal of all these microbial risk management techniques is prevention.

In the past, biocides have been employed to prevent the growth of microorganisms in paper mill environments. Nevertheless, the quantity of bacteria present is not always inversely connected with the severity of microbial problems. The two most important factors in the application of biocides are the optimal feeding strategy and the selection of the right agents. Due to the richness and complexity of the microbial flora present in paper mills, no single biocide would be adequate for microbial control. Microbe resistance is a problem that often arises. Also, new methods are always being researched due to environmental issues. Combining many control systems is becoming more and more popular right now. Excellent housekeeping has been emphasised as being essential to successful microbial control. Maintaining effective control over the whole process and plant operation, minimising unnecessary delays for swiftly decaying goods, and routinely and completely cleaning tanks, containers, and equipment are important housekeeping-related factors. The process parameters are often left alone to control microbial growth. Nevertheless, microbial activity is greatly reduced by the rise in temperature from 45°C to 70°C, especially in tanks containing raw materials that are microbiologically sensitive.

E. System for managing safety and hygiene

A quality management system based on the ISO 9000 series is used by the majority of paper and packaging industries. Good manufacturing practices are a crucial part of quality control and product safety. GMP sets the underlying

principles and defines the fundamental requirements. Preventive microbiological risk management in the paper and packaging industry is generally carried out via GMP and the creation of a hygiene and safety management system, which is suggested to be based on the HACCP concept.

The biggest microbiological risk is posed by the use of glues made of starch and water-soluble lacquers in businesses that further process paper or board, where conditions are often dry. On the other side, it is believed that sanitary problems brought on by poor pest control and cleaning programmes, employee work habits, or air pose serious risks to product safety. The adoption of GMP is crucial in sectors that process paper or board further.

The food industry is particularly compelled to establish a thorough hygiene and safety management system by legal requirements and restrictions, while in the paper and packaging industry, customer demands take precedence. As in the food business, the reputation of a company that takes safety and hygiene concerns seriously is becoming more and more important in the paper and packaging industry. The food industry continues to undoubtedly have stronger employee attitudes about HACCP-related duties, which are mostly handled by line staff, and their awareness with food hygiene and safety problems than the paper and packaging industry. While GMP rules have been implemented in the food and packaging industries, the paper industry has placed most of its attention on creating a successful HACCP programme.

Although being used as a technique for monitoring food safety and receiving widespread acceptance and agreement, it is openly acknowledged that certain firms have had trouble putting HACCP into practice. If product safety and quality issues are combined, the evaluation might result in too many and/or overlapping CCPs, making the programme difficult to run and making people less interested in carrying out the control measures recommended for each CCP. Yet, it may be difficult to distinguish clearly between quality and safety considerations, especially in the paper and packaging sectors. The dedication of management and personnel is necessary for the creation and implementation of hygiene and safety management systems. Moreover, it has been difficult to create specialised HACCP programmes with written documentation that would allow for validation and reassessment, particularly in small and medium-sized enterprises or in environments where record-keeping is not a part of the corporate culture. The need for a more methodical, quantitative approach to risk assessment at the production level is a significant concern. An accurate evaluation of risks should be carried out by a team with the necessary skills and experience, and a risk assessment technique should be supported by scientific information. The four parts of this hazard analysis are hazard identification, hazard assessment, control measure assessment, and a combination of control measures. Industry, which usually lacks the requisite resources, frequently lacks this kind of expertise.

A new ISO standard emphasises the use of more powerful tools for assessing and managing risks. To help with at least some of these problems, a practical and user-friendly risk assessment tool is being created for the pulp, paper, and packaging industry. This tool will be used to execute GMP and HACCP concepts. Paper HYGRAM is a risk assessment model based on the concepts of HACCP and GMP for conducting and maintaining risk assessments of process hygiene and safety factors in the pulp, paper, and packaging industries. As the programme is Windows-based, much computer experience is not required. The HYGRAM tool was developed expressly for assessing risks in the food industry and served as the basis for the development of a unique model for the paper industry.

The model includes software-assisted education for the procedure together with a databank on risk assessment and problematic microorganisms in the pulp, paper, and packaging sectors. Paper HYGRAM includes a background information sheet about the factory, the process, and the products that will be assessed, a checklist for adhering to GMP requirements, an analysis tool for locating, outlining, and evaluating the risk groups of a HACCP programme, as well as additional risk groups chosen by the user. Any pertinent data may be included in the model, which is easy to update when a process change occurs. There is now just a Finnish version of HYGRAM and Paper HYGRAM available, but an English version will be produced shortly.

II. DISCUSSION

The majority of potential infections are not very virulent, and it is extremely unlikely that bacteria would transfer from packaging materials into food, according to research results thus far. Also, with the aid of simple, practical technologies that are now being developed, the paper and packaging industry will be able to assess and administer GMP and HACCP programmes. This will ensure that packing materials are safe and sanitary in the future [7]–[9].

Microbiological expertise is required to carry out an accurate risk assessment and to focus the risk assessment measures efficiently and inexpensively. Also, for microbiological risk assessment and risk management operations at the industrial level, significant volumes of microbiological analysis using appropriately sensitive and rapid detection methods must be performed. Traditional cultivation methods are frequently not sensitive enough to detect pathogens that may cause illness at very low concentrations, and there is a clear need for new, quick, and sensitive detection as well as identification methods. This is because traditional cultivation methods are much too slow in comparison to the turnover of fibres-based products.

The past 10 years have seen tremendous progress in both traditional and modern methods for the detection and identification of bacteria in industrial settings. The identification and classification of bacteria have relied heavily on conventional phenotypic evaluations, which take

an organism's appearance, behaviour, and enzymatic activity into account. Despite this, bacteria are small, have few physical clues, and their physiological features may vary. As a consequence, it has been shown that genotypic studies are very beneficial and accurate in identifying and classifying these bacteria. Yet in order to use the type methods successfully, the right identification libraries need to be created. Isolates often show great environmental adaption and lack any characteristics that would identify them as a member of a known species. Physiological, chemotaxonomically, and SDS PAGE analytical results and biomolecular testing do not match up well, and it has been proposed that the isolates may represent a novel species.

Bacillus cereus has historically been culture-isolated from paper and board and validated using further biochemical testing. This is slow and difficult. a fast and semi-quantitative real-time PCR-based method for detecting B. It was recently revealed that cereus group bacteria were directly obtained from various papers and packaging materials. Quantitative data may be obtained in only one day, however, plate count and API results need a minimum of one week. The industrial industry can quickly respond to changes in the microbiology of the production process and get trustworthy data on contamination routes and the presence of B thanks to the detection technique. Bacteria from the cereus group in finished goods.

Another example of improved contamination detection in the paper industry is the molecular identification of sulphate-reducing bacteria. The identification of SRB has so far been hampered by the insufficiency of culture to precisely define the number and type of these bacteria. According to Maukonen et al., desulfovibrionaceae-related bacteria may be reliably and promptly identified from samples from the paper sector without prior enrichment [10]–[12].

III. CONCLUSION

A cautious choice of packing material for a given food product should be made after evaluating its final components and their conceivable interactions, in addition to the resulting influence on food safety and quality. The desire for improved detection and characterisation methods based on molecular biology is connected to the need for better assessment and control of microbiology in industrial raw materials, processes, and products. Molecular techniques that are practical for industrial use must be developed to efficiently manage bacteria in industrial processes.

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Improving the Cleaning of Tanks and Design of Heating Equipment

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***Abstract*— The cleanliness of the surfaces used in food processing has a significant impact on the caliber of the finished goods. Thus, the process design and integration must take the sanitary requirements of the cleaning technique into account. All operations need a high level of hygiene because they cannot proceed if it is feasible for germs to enter the system via surfaces and apparatus used in conjunction with the tank. Due to lengthy processing durations with nutrient-rich raw materials, contamination on tank surfaces may be deadly to the product quality**

***Keywordss*— Air Gap, Carbon Dioxide, Fluid Dynamics, Heat Transfer, Heat Exchange, Spray Ball.**

I. INTRODUCTION

Microbial growth causes significant product batches to be discarded. It has been shown that cleaning in closed process systems is controlled by certain hydrodynamic characteristics. Both in cleaning and manufacturing, fluid fluxes are crucial. A technique for enhancing the sanitary design of equipment components and their integration into the production line is computational fluid dynamics [1]–[3].

The functioning of food processing facilities depends on tanks. The storage of beginning ingredients and finished goods, buffers for intermediate products, fermentation, mixing, heating, and cooling are major uses. Breweries, dairies, and fruit juice production all need large tanks. The tanks used in dairies range in size from 100 L to 230 000 L. The silo tanks, which are used to collect and receive milk, are the largest tanks found in dairies. Other storage tanks at dairy facilities typically have to hold capacities ranging from 1000 L to 50,000 L. Moreover, there are various-sized mixing and processing tanks. Since fermentation operations are prone to contamination, the equipment, including tanks, must be clean, in some instances even sterile, from the beginning point. Fermentation is a fertile environment for microbes to develop. Hence, a few filthy niches containing dangerous microorganisms may start lethal fermentation contamination. In extreme circumstances, improper cleaning may result in the growth of biofilms on equipment surfaces, which can pollute the process, lead to corrosion, and even create health issues.

Tank cleaning is getting more attention as a result of the importance of tank hygiene in preventing contamination of the finished product. Process tanks used in breweries and dairies are among the particular situations examined. These tanks are built of high-grade stainless steel, although the exterior shell may sometimes be an inferior steel that has been painted with an anti-corrosion coating due to cost considerations. In order to facilitate simple total drainage, the bottom of a tank slope downhill with a downward gradient of approximately 6% towards an outlet. Dairies that don't properly clean their tank surfaces risk reinfecting pasteurized milk with thermotolerant or psychrotrophic bacteria. Moreover, thermotolerant contaminants have been observed to lengthen the fermentation process for milk products and promote unwanted development in closed systems.

Since it may take many weeks to ferment nutrient-rich wort into beer, including maturation in the fermenting tank, the cleanliness of process surfaces is equally important in the manufacturing of beer. Due to the prolonged manufacturing period, the parameters that limit the development of pollutants changed. Tanks in breweries typically range in size from 10,000 L to 900,000 L. For instance, the three largest breweries in Finland have primary fermentation tanks that range in size from 250 000 L to 510 000 L.

Batch sizes in minibreweries may be as little as 60 L. So, the consequences of contamination during fermentation might be severe for the beer's quality. Thus, it is crucial to consider how the manufacturing lines will interact with the cleaning process. In breweries, fermentation tanks typically feature conical bottoms with an inner angle between 70 and 80 degrees. They are useful because, as compared to tanks with flat and inclined bottoms, they allow for quick aseptic yeast emptying, efficient temperature management, simple cleaning using cleaning-in-place systems, simple carbon dioxide collection, and little beer losses. Tanks with flat and inclined bottoms are often used for stabilization and storage. The same tank, known as a combi tank, may be used throughout the whole fermentation process. The bottoms of these combination tanks are conical as well.

A. Variables influencing cleaning effectiveness

It is widely accepted that making sure the cleaning is done correctly is the most effective strategy to avoid microbial infection. In the food sector, longer manufacturing runs with fewer breaks for sanitation are becoming more common. Mechanical, chemical, holding time, and temperature effects

all influence the cleaning process. The design and economic and efficiency optimization of the cleaning systems remains a problem. This entails selecting the ideal spray ball for a particular tank in order to provide the necessary level of sanitary conditions across the tank. The process water, steam, and other additives that will be utilized should be of high quality while developing the cleaning process. The fluid dynamics, surface topography, material qualities, particular microbial flora, and other soil elements all have an impact on cleaning effectiveness. Yet, several investigations have shown that there are only shaky correlations between surface roughness and cleaning effectiveness. The use of water, cleaning agents, and cleaning time must all be kept to a minimum in order to keep expenses as low as possible.

The original sanitary design of the manufacturing equipment has a significant influence on lowering the possibility of food contamination during production, which also increases product shelf-life. The development of process equipment and components should start with hygienic standards in mind. Equipment is given a CE label based on EU Machinery Directive 98/37/EEC, which in principle should guarantee safe food, however, regrettably, this legislation falls short of hygiene criteria. A certification and assessment program created by the European Hygienic Engineering & Design Group assures that there is process equipment on the market that has been hygienically built. Hygienic equipment design criteria, Document No. 8, Hygienic design of closed equipment for the processing of liquid food, Document No. 10, and A method for the assessment of in-place cleanability of food processing equipment, Document No. 2, are the guidelines that are significant in evaluating the hygienic design of process equipment and components in closed systems.

In closed cleaning systems, pre-rinsing with cold water is used to get rid of loose dirt. Normally, the CIP treatment is carried out using a hot cleaning solution, but handling fat-free goods allows for the use of a cold solution as well. The agents made of chlorine dislodge the biofilm from the surface, break it up, and then get rid of the bacteria. Chelating chemicals in the cleaning solution make biofilms easier to break up and remove. The producers of cleaning agents are able to provide realistic cleaning programs that may be used in most real-world circumstances. To achieve stainless characteristics on the tank surfaces, post-treatment methods like mechanical grinding, chemical bathing, or passivation are utilized. Using an oxidizing acid, such as 20% nitric acid at 0–60 °C for 3–5 min, may be used to achieve the passivation.

The primary detergents used in breweries are sodium hydroxide-based. These substances are quite good at getting rid of organic dirt. The principal drawback of using these agents in brewery tanks is the removal of valuable carbon dioxide from the process vessel as a result of their reaction with carbon dioxide to create a less useful carbonate salt. Two kilograms of sodium hydroxide, or 100 liters of a 2% w/v solution, may be neutralized by one cubic meter of carbon dioxide at one atmosphere and 20 degrees Celsius. Beerstone and hard water deposits are easier to remove and may be avoided with the use of acid-based sanitizers. A CIP approach that includes an acidic phase and a disinfecting step for tank cleaning in breweries is a more sophisticated, effective cleaning method that operates at low temperatures and carbon dioxide pressure. For lightly soiled tanks, a typical classical acid-cleaning regime, which is mostly used in breweries, includes a 5–7 minute pre-rinse with recovered water, 40–60 minutes of acid cleaning with 1.5–2.0% v/v detergent, a 5–7 minute intermediate rinse with water, 25–30 minutes of acid sanitation and beer stone prevention with a 0.5–0.6% v/v circulation acid sanitizer, and a 10-minute post rin.

Breweries should base their cleaning process on the amount of oxygen still present in the tank after cleaning and sanitizing. Cleaning techniques for CIP using acids and alkalis were compared by Dirksen and Duca. The steps were 10 minutes of water rinsing, 20 minutes of washing with acidic detergent, 10 minutes of water rinsing, and 10 minutes of sanitizing with peracetic acid, as well as 15 minutes of water rinsing, 25 minutes of washing with alkaline detergent, 10 minutes of water rinsing, and 10 minutes of sanitizing with peracetic acid, respectively. They discovered that caustic cleaning significantly increases the quantity of oxygen supplied into the tank compared to acid cleaning. Beer flavors oxidize due to high oxygen levels. If regular concentration and drainage times are maintained, peracetic acid-based sanitizer solutions also provide very little oxygen to beer. In research to determine if chlorine dioxide solutions could effectively replace hot water disinfection in the brewery CIP treatment of blending tanks, finishing tanks, and process lines under carbon dioxide pressure, the findings indicated that chlorine dioxide could.

Chlorine dioxide disinfection has the benefits of being more efficient and using less water and energy. Experience with the improved new sanitation technique has shown no significant issues with the quality of the beer. Moreover, fewer production pauses have occurred, and equipment is not under as much temperature stress. Han et al. demonstrated that exposure to 10 mg/L of chlorine dioxide gas for 30 min at 9-28°C with a high relative humidity or at 25-28°C with a relative humidity > 69% was beneficial in suppressing spoiling organisms in fruit juice production in epoxy-lined storage tanks.

Spray balls' construction and functionality have been modified to better cleaning, and currently a variety of providers may create customized systems with outstanding cleaning effectiveness. Spray balls have hollow interiors and are typically spherical, measuring 35 to 150 mm in diameter with an intake tube of around 25 to 50 mm. To achieve the correct spray dispersion, the body is drilled with a number of holes that range in diameter from 1.6 mm to 2.4 mm. The conventional static spray ball offers a quick way to apply the cleaning solution to the tank walls. Rotating spray heads

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deliver a consistent pattern of spray to the walls, and the combination of mechanical impact and cleaning patterns eliminates dirt more quickly and efficiently than a static spray ball.

The rotating nozzle head is especially useful for tanks with intricate internals because, thanks to its horizontal revolution, a single revolving jet strikes the numerous tank components from all sides. In general, the removal of soil entails soaking the polluted material first, softening or dissolving it afterward, and then completely removing it by impingement or irrigation. There was more than one way to clean with a jet that had a steady diameter of less than 4 mm. The soaking area above and below the point of impingement determines how well a spray ball works. The temperature of the water and the use of a little amount of detergent were two of the most important factors to impact the wetting rate, according to experiments by Morison and Thorpe. Surface wetting is improved when the jet's pressure is raised.

B. Clean design test procedures

Finding the hardest crucial locations in cleaning equipment may be done using hygienic design test methodologies. These tests do not represent how the equipment would operate in scenarios requiring industrial cleaning; rather, they are meant to serve as basic screening tests for the equipment's sanitary design. These techniques are based on established protocols. Due to their high sensitivity, they can detect even the smallest defects or poorly built regions, such as crevices caused by improper gasket construction. There are usually three phases in the sanitary design test procedures. Initially, the equipment has to be polluted with tracer-containing standard soil. The dirt is dried to the surface of the apparatus, and it is then cleaned using a modified cleaning technique that ought to leave some soil residue on the surfaces being examined. Finding any remaining dirt in the equipment is the last stage. It is crucial to have a reference for which the cleanability level is known to remark on the equipment's cleanability. The evaluation of the test equipment's capacity to be cleaned might then be compared to the reference. Microbes in the soil are used as tracers in the majority of published test procedures. An organic or inorganic non-toxic tracer should be used to evaluate the cleanability of large-scale equipment or whole process lines in the industry.

An 80 L stainless steel pilot scale tank with a conical bottom and an inner diameter of 400 mm was tested at Bio Centrum-DTU. A spray ball was put in the tank lid. The spray ball's revolving tip was 50 mm in diameter and its shaft measured 145 mm in length. The spray ball was situated 60 mm from the tank's center. In the first instance, yeast cells from beer had contaminated the tank. In the second instance, the tank was contaminated with sour milk spore-containing milk that had been left to dry at ambient temperature for three hours. A pilot plant CIP cleaning system was used to complete the cleaning, which included a pre-rinse with cold water for 1 minute, cleaning with a 60 C detergent solution for 10 minutes, and a final rinse with cold water for 1 minute. The tank lid's spray ball was placed in the pipe, and the mean flow velocity was changed to 1.5 m/s. using the use of contact agar techniques and ATP-assay, the tank's sanitary condition was investigated. Samples were obtained from several locations on the tank walls as well as the spray ball and tank lid. During the cleaning process, the smooth areas of the tank were found to be free of any microbiological contamination based on the detection techniques utilized. Nevertheless, the tests revealed that some residual bacteria were still present on the tank's rougher surfaces. These locations included the lid's screws, the gasket that seals the tank from the lid, and several unsanitary scrapes on the tank wall.

C. Checking tanks for cleanliness

Validating the cleaning technique is a constant issue when working with closed processes. A visual examination is sometimes an option, as it is for big tanks. Commercially accessible assays exist to measure cleaning effectiveness using fluorescent materials. UV light makes gunk that is invisible in regular bulbs or daylight apparent. Despite this, it might often be difficult to tell whether shining was caused by fouling rather than the surface polish, kind of steel, or both. A dull white and sometimes pink film covered the fouling. In rare cases, a substantial layer of fouling was discovered on gaskets, around lids, and in pipes connected to cleaning nozzles. As Jacob and Brandl observed the effectiveness of the cleaning and disinfection operations in tanks in breweries, they discovered limits in the visual examination as well.

Also, they have employed UV light to find deposits, Fuchsin to find proteins, and Lugol's iodine to find starch. A commercial ATP-bioluminescence system, according to Paez et al., may be used to assess the cleanliness of milking equipment, bulk tanks, and milk transport tankers. The most crucial areas were the plate cooler outlet, the bulk tank outlet pipe, and the inside surface of the manhole cover in the milk transport tanks. Findings showed that bioluminescence tests for rinse water were unreliable, necessitating the use of swabs to complete the sanitary evaluation. Odebrecht et al. investigated the viability of using bioluminescence techniques for hygienic testing in yeast tanks and beer fermentation and maturation tanks in breweries. Findings showed that the bioluminescence approach was not appropriate for microbial contamination identification since the results did not match those from traditional microbial culture methods. Nonetheless, it could be helpful as a way to keep track of how well tanks, pipes, and other brewery equipment are cleaned and sanitized. Computing fluid dynamics is used to evaluate closed process lines' capacity to be cleaned.

To simulate the bulk properties of fluid flows, CFD is widely employed. The study of cleaning processes is interested in being able to determine what occurs in certain places on and near walls thanks to recent model advances. Tank CFD models are available to optimize the performance of operations including mixing, heating, and cooling. It gives details on how two-phase flows behave when they are

churned by two turbines with pitched blades that are positioned differently. The research's findings are put to use to minimize energy use for mixing and maximize mixing effectiveness. To build further linkages between surface properties and the cleaning impact of fluid flow, the extension applies to fusing Jensen's models for the prediction of the hygienic design of valves, pipelines, etc. with traditional tank flow models. This is expected to provide a tool that can be used to assess the effectiveness of cleaning methods in tanks. The idea is that CFD models may be used to help and enhance both the design of an appropriate cleaning system and the validation of the cleaning process. The objective is to determine if CFD simulations are appropriate for estimating and improving tank cleaning and to carry out cleaning experiments in a pilot plant in order to establish a connection with the findings of CFD simulations. The wall shear stresses in the tank and the flow rates in various portions of the system are revealed by the findings of the CFD simulations. Studies on the flow simulation appropriate for the precise assessment of the hygienic status of tanks before and after spray-ball cleaning have been conducted.

Further basic research is required to determine how hydrodynamics affects tank cleaning procedures. It has been shown that CFD is an effective tool for optimizing the sanitary design of simple, closed-process equipment. In both simple and complicated flow systems, it is possible to forecast regions that are not thoroughly cleaned by combining wall shear stress, fluid exchange, and turbulence conditions. While surface roughness is challenging to include in flow models, the aforementioned findings on its significance in cleaning are supporting the use of CFD simulations as tools for optimizing the cleaning method. Using the CFD modeling software the flow phenomena, such as fluid exchange and wall shear stress, are employed to forecast the cleanability of the flow systems. Surface topography, fluid dynamics, and surface microbiology work well together to analyze and resolve hygiene-related problems in closed systems [4]–[6].

II. DISCUSSION

The basic case study was conducted using the preliminary experiment findings, which provided strong support for one another. This has supported the premise that the hygienic design of the integrated tank and CIP cleaning systems benefits greatly from a combination of expertise in fluid dynamics and microbiology. As an appropriate CFD model needed to be established to simulate this kind of process system, the experimental component has received the majority of attention. The CFD model has to be expanded to include various tanks and spray balls, and it should be verified using new microbiological test procedures. Future investigations will need the development of these test methodologies. A technique for renovating beverage storage tanks has been patented by Chism and Smith. A fluid jet is used to clean the internal surface of the beverage storage tank of impurities and surface lining. Before being used again, the inside surface of the beverage storage tank is prepared by abrasive blasting and coated with a coating substance that is beverage-safe. Another trend for the future is to cover tank surfaces with better coating materials to make cleaning easier[7]–[9].

Perhaps the most often utilized unit operation in the food business is heat transfer, which is the foundation of several important procedures including pasteurization and sterilization. Convection, conduction, or radiation are the possible processes involved in heat transfer however, often a mix of these three is used. Heat transfer may be administered on a batch or continuous basis. Additionally, heat transfer can occur directly across a heat transfer surface or indirectly across the service medium.

The most typical practical operations involving heat transfer are Heating, cooling/chilling, freezing, evaporation, condensation, radiation, and drying. evaporation, freezing, and drying are examples of processes where heat transfer procedures may entail a phase transition. The subject of this chapter is restricted to heat transfer equipment for applications without phase changes since these changes in phase processes are complicated procedures in and of themselves.

While tanks and containers may also transmit heat, heat exchangers are the most often employed piece of technology. Many other heat exchanger geometries may be utilized in reality the main ones that are used for food applications. The design of any heat exchanger strikes a compromise between accomplishing the intended thermal duty and the related startup and operating expenses from the perspective of merely heat transfer. Heat recovery and process integration strategies are being used significantly more often as a result of the rising cost of energy.

In reality, many product and process variables may have a big influence on the design of the exchanger, making the design process more complicated than just heat transfer. Also, the design of the heat exchanger is sometimes just a tiny, although crucial, component of the whole line. Also, it is becoming more and more necessary for individual heat exchangers to handle a diverse variety of goods with significantly disparate characteristics. This makes optimization problematic since the heat exchanger will need to be built to handle the most difficult fluid.

The current heat exchanger design recommendations for the food sector focus more on the total process in which the equipment is used than on specific heat exchangers, especially when it comes to hygiene-related concerns. Although the more current EHEDG recommendations are centered on the underlying concepts, the guidelines have been designed with a significant emphasis on the dairy business.

ISSN (Online) 2456 -1304
International Journal of Science, Engineering and Management (IJSEM)
Vol 10, Issue 2S, February 2023

A. Modifications to heat exchanger design

Even though heat transfer is a relatively advanced technology, there have been several important advancements in recent years. Because of the turbulent flow on both sides, plate exchangers are the most efficient. The importance of a high heat-transfer coefficient and significant turbulence owing to even flow dispersion cannot be overstated. A plate heat exchanger regenerator, on the other hand, is limited to low viscosities.

B. Incremental increases in the efficiency of heat transfer

The metal thickness of the plates in plate heat exchangers has decreased in recent years from an average of 0.8 mm to 0.4–0.5 mm. Due to this, the weight of the material used and the price have both decreased by 40–50%. As a consequence of the thinner metal's lower thermal resistance, heat transport will also be improved. Only in cases involving turbulent flow and both fluids with low viscosities will the benefit be noticeable. The performance of heat transfer will be improved by 8% for a typical application with equivalent thermal resistances of 104 m^2 K/W on the product and service sides.

Corrugated tubes offer improved heat transfer performance in tubular heat exchangers when used in lieu of traditional plain tubes. By disrupting the laminar boundary layer as the fluid passes over it, the corrugations are said to improve heat transmission. Nevertheless, given that the corrugations are unlikely to have a significant impact on the fluid dynamics near the heat transfer surface, it is expected that this improvement would only be slight for higher-viscosity fluids.

To solve the technological shortcomings of present designs, alternative geometries

C. Helix tubes

Since many years ago, coiled tube designs have been employed to create more compact exchanger designs. Recent studies have shown that mixing and heat transfer performance are improved when the fluid is moved continuously in a spiral as opposed to what would be expected by standard heat transfer design correlations for linear systems.

D. An air gap between two plates

The two fluid streams in typical plate heat exchangers are isolated from one another by a single, relatively thin metal surface, which raises many hygiene issues. Cross-contamination between the two streams is a possibility if this surface is degraded by, for instance, corrosion or flow-induced vibration. It is possible to contaminate the heat-treated product with the raw, untreated product if heat recovery is utilized to heat entering cold product with a hot product.

Maintaining a greater pressure on the pasteurized/sterilized side to make sure any flow is from processed to raw product is one of the current methods of minimizing this danger. Nevertheless, because germs may travel against a pressure gradient, this does not provide total certainty. Another strategy is to prevent direct product-to-product contact by using a secondary water circuit with a recirculation pump. Because of the significant increase in the heat transfer area, the recirculation circuit has to be carefully maintained.

It has been created to employ two plates with an air gap to provide further protection against cross-contamination. With two plates instead of the valve seats and an air gap leading to the atmosphere between them, the idea is based on that of the double-seat valve. Any flaw in one of the plates will cause fluid to leak out into the atmosphere via the air gap. Yet, intentionally introducing an air gap into the heat transfer channel to provide more heat transfer resistance is counterintuitive. By employing a 3–5 m air gap and 3 mm thinner plate materials, equipment makers have minimized the loss of thermal efficiency. The performance loss will be larger in applications where there are two low-viscosity fluids as opposed to one or more viscous fluids, where there are fewer total heat transfer resistances on the fluid side. Reducing the air gap helps minimize the decline in heat transfer performance, however, there are a number of possible hygiene concerns:

Surface tension effects may prevent fluid from draining out of the system by gravity if fluid enters the small air gap between the two plates as a result of a defect. If a defect does occur, it will be challenging to ensure that any product in the gap can be cleaned effectively due to the small amounts of cleaning fluid that can be delivered into the gap through the defect. Any leftover product within the air gap could serve as a source for recontamination.

E. Heat exchanger with a fluid bed

A fluid bed exchanger, which fluidizes minute glass, ceramic, or metal particles within vertical parallel tubes by the upward flow of liquid, has been developed over a number of years for industrial applications with highly fouling liquids. The solid particles have an abrasive impact on the walls of the heat exchanger tubes, which helps to reduce the build-up of fouling deposits, as well as a disruptive effect on the laminar boundary layer to promote heat transmission. It is said that these methods are appropriate for use in the food business, such as heating fresh juice.

F. An increase in operating pressure capacity

Much work has gone into expanding the working pressure range that the plate heat exchanger can function within in addition to lowering metal thickness. While running at working pressures of 20 bar is now possible thanks to modified designs, tubular systems are still significantly improved by this.

G. Decreasing the identification of defects

Physical and chemical stressors that occur over time may cause heat exchanger surfaces to deteriorate, leading to fractures or pinholes that might allow chemicals or microorganisms to contaminate the product. Before employing a dye penetrant approach or sending the plates out for a supplier inspection, plate heat exchangers must typically be disassembled. A method has been devised in which an electrolyte is forced through the heat exchanger's product side while being circulated under pressure. Water is circulated and the conductivity is observed on the surface. If a defect is present, electrolytes flowing through it while being affected by a pressure difference will cause a change in conductivity that may be felt. It is said that the sensitivity of this technology is comparable to that of conventional dye penetrant techniques.

1. Upcoming trends

2. The design of heat exchangers may be improved in a variety of ways in the future.

3. Application of a surface covering

It has long been understood that the lower the surface energy, the less adherence to fouling deposits on surfaces. Surface coating using ceramics, polymers, or other non-toxic materials has been tried. Nevertheless, due to their poor thermal conductivity, such coatings must be applied thinly to prevent a reduction in heat transfer efficiency. This reduces the metal surface's ability to adhere to the coating and endure mechanical forces. Recent studies utilizing composite coatings of Ni-P-PTFE showed better mechanical strength and a greater than 99% reduction in the adhesion of thermophilic streptococci.

H. The surface of the material has been altered

By using electrolytic deposition, sputtering, or ion implantation, new low-fouling surfaces have been created. They benefit from enhanced abrasion resistance and powerful adhesion. Findings for diamond-like carbon and sputtered composite coatings revealed decreases in thermophilic streptococci of between 80 and 99 percent.

I. Alternative shapes to increase the area-to-volume heat transfer ratios

With a heat transfer area to volume ratio of 150–350 m^2/m^3, plate heat exchangers are often regarded as the most compact commercial heat exchanger types. They are brought on by the basic design idea, which employs a tiny gap, measuring 2.5–6.0 mm, between the heat transmission surfaces. Cross-corrugated polymer film heat exchangers with gaps between 0.3 and 1.5 mm have been developed in the lab as an extension of this strategy, producing volumetric heat transfer areas of 500–2500 m^2/m^3 [10]–[12].

III. CONCLUSION

Throughout the food business, heat transmission will continue to be a crucial unit activity. The creativity of the heat exchanger designers will continue to be tested as they look for new methods to improve the process in the face of rising cost constraints and flexibility requirements. The modification or coating of surfaces to prevent fouling and facilitate cleaning may be one of the most promising areas for development.

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Improving the Hygienic Design of Valves, Pipes and Pumps

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***Abstract*— Sanitary valves are ubiquitous throughout processing systems. Without them, modern processing systems would be cumbersome and inefficient. Valves provide operators with the ability to stop, direct, meter, and control the flow of products and ingredients throughout the process. Because of their widespread use, valve design and sanitation can impact every particle of product passing through the processing system**

***Keywordss*— Mechanical Seals, Mechanical Cleaning, Manual Cleaning, Stainless Steel, Valve Body.**

I. INTRODUCTION

Valves come in multiple configurations. They are well developed to operate in systems that process fluids, semi-fluids, fluids with particulates, viscous products, and dry products. Some valve designs operate well in more than one of these different environments [1], [2]. Valves are commonly used in fluid product processing systems. The following are descriptions of valves commonly used in processing systems for fluid products, including viscous products and products with semi-solid or solid particulates within the product stream.

A. Plug valve

A simple design consisting of a tapered plug inserted into a tapered body. The valve can be configured as a shut-off valve or with one or more ports to direct flow to different product streams. The valves are most commonly manually operated but can be affixed with a power actuator. Plug valves are not generally used in dry product applications. This design is not suitable for mechanical cleaning techniques and requires complete disassembly for manual cleaning [2].

B. Leak protection valve

A leak protection valve is a specialized plug-type tank. Outlet valve that is used on vat pasteurization equipment. The design includes special features that will prevent leakage past the valve by controlling how far the valve may be turned and the inclusion of grooves to provide leak detection. This design is not suitable for mechanical cleaning techniques and requires complete disassembly for manual cleaning.

C. Compression valve

This design uses a valve seat located on the end of a stem or rod that lifts the movable seat off from a valve seat incorporated into the body of the valve. These valves operate efficiently when located in a variety of positions and have a large, unobstructed valve body to permit optimum flow through the valve. This design is generally suitable for mechanical cleaning methods [3].

D. Mix proof valve

A mix-proof valve is a specialized compression valve that uses double seats that can be operated independently, separated by a self-draining opening to the atmosphere between the valve seats. The primary design advantage of these valves is to accommodate the separation of two different product streams or products from cleaning fluids during mechanical cleaning.

E. Diaphragm valve

This design uses a flexible diaphragm to form the seal. The valves are used to shut off or regulate product flow. They work well with semi-solid and fluid products containing particulates. Diaphragm valves are not commonly used in dry product applications. The valves can be mechanically cleaned provided they are equipped with a power actuator and are installed properly to assure drainage of the valve cavity. Many designs include an orientation mark on the housing to assist with installation [4].

F. Tank outlet valve

Outlet valves come in a variety of configurations depending. On whether they are mounted horizontally or vertically. To eliminate or reduce the amount of product that may be retained in the outlet passage, the design provides for the valve to be as close coupled as possible to the product vessel. They may be manually or mechanically operated and cleaned depending on their design features.

G. Pressure-reducing and regulating valve

These valves are designed to control product outlet pressure by responding to outlet pressure changes using a self-acting actuator. The self-acting actuator raises or lowers the valve seat within the valve body using fluid forces within the valve body.

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Vol 10, Issue 2S, February 2023

H. Check valve

Check valves permit product flow in only one direction. A reversal of product flow or pressure will result in the valve sealing. The actuation of the valve is self-acting through the use of internal balls, valve flaps, or spring-loaded valve seats. Because of their basic design, spring-loaded check valves must be fully disassembled for manual cleaning [4].

I. Ball valve

This design uses a ball connected to an actuation shaft. Product flow is directed or stopped through single or multiple passages within the ball. This design incorporates body cavity fillers or encapsulating seals to prevent product flow around the exterior of the ball. This design is not suitable for mechanical cleaning techniques and requires complete disassembly for manual cleaning [5].

J. Cage ball valve and a pinch

This is a variation of the ball valve design. In this design, a solid ball is retained in a movable cage attached to an actuator shaft. Actuation of the valve positions the loosely retained ball so that the product pressure within the valve body causes the ball to block a port of the valve. The action is similar to that which occurs within a ball check valve. Depending upon the design of a specific model of the valve, it may not be suitable for mechanical cleaning. A pinch-style valve consists of a flexible rubber or polymer liner within a metal tube. The flexible liner is pinched between metal components to restrict or stop the product flow.

K. Blender discharge valve

blender discharge valves come in a variety of shapes and sizes according to the manufacturer of the blender. In most cases, the valves are located on the bottom or one end of the blender. They consist of either sliding gate types or hinged lift gate types. A pneumatic or hydraulic cylinder often powers the valve actuators. These designs require disassembly for cleaning.

L. Butterfly valve

This design utilizes a more-or-less flat, round disk attached on the edges of the disk to an actuator and support shaft. The shafts pass through a circular rubber or polymer seat that is clamped between two flanges. The valves can be set to regulate or block the flow through the valve. While often cleaned by mechanical means, this design will allow products to migrate along the shafts due to the product pressures in the system and should, therefore, be disassembled for manual cleaning.

M. Rotary valve

A rotary valve also known as a rotary airlock valve or a star valve, consists of a multi-chambered shaft that rotates within a cylindrical housing. The valves are particularly efficient for transferring product between zones of differing pressure or vacuum. Some manufacturers have designed models specifically to meet the requirements for mechanical cleaning [6].

N. Iris valve and the Inflatable seal duct valve

An iris valve features a fabric or multi-section metal diaphragm that opens or closes by a twisting motion of the valve's outer housing similar to the action of a camera iris. these valves use a rubber bladder attached to the inflatable seal duct valve. An outer circumference of a valve disk. After the valve is rotated into the closed position, the bladder is inflated to obtain a seal with the duct's interior.

O. Flip-flop and the Diverter valve

A flip-flop valve has two movable valve disks or flaps, located one above the other, which cycle alternatively by mechanical means. The product is passed into the intermediate chamber between the two valve disks before passing through the valve body. Like rotary valves, flip-flop valves can transfer product between zones of differing pressure or vacuum.

P. Diverter valve

As its name implies, a diverter valve consists of two or more. Ports into which the product stream may be directed. Depending on the number of discharge ports provided, the actuating mechanism may be a simple flap valve, a positioning slide valve, or a rotary port plate.

Q. Hygienic aspects of valve design

The ubiquitous nature of valves within processing systems places them in a position to potentially have an impact on every particle of product passing through the system. Valves can be small or very large; simple or very complex in design. Therefore, their hygienic design is vital to producing a high-quality, safe product. Valve design plays a major role in whether or not a particular valve or design is suitable for its intended application. Valves that are intended to be mechanically cleaned or cleaned-in-place require special design features. The design and operation during cleaning must assure that all components potentially contacted by product will also be contacted by cleaning and sanitizing fluids with sufficient turbulence or flow to thoroughly clean and decontaminate these areas [7]. Generally speaking, any manually operated valve, regardless of its type or design, and valves used in dry product processing systems should not be considered as suitable for mechanical cleaning methods. The inability for automatic cycling of the valve during cleaning prevents cleaning and sanitizing solutions from reaching all areas of the valve seats and other seals. These valves are only suitable for disassembly and manual cleaning. As with other equipment, hygienic design is based on such features as materials of construction, internal surface texture, accessibility for cleaning and inspection, draining, elimination of cracks, crevices, and niches, internal angles and corners, process and installation concerns, and the materials of construction.

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Vol 10, Issue 2S, February 2023

Traditionally, hygienic valves for the food industry have been fabricated in stainless steel. The American Iron and Steel Institute, AISI series 300 stainless sheets of steel, and their equivalent cast grades have been the materials of choice for the metallic components of the valves. Non-metallic components for seals, valve seats, diaphragms, plungers, and plug encapsulations are to be acceptable to the convening regulatory authority and be non-toxic, relatively inert, non-porous, non-absorbent, and compatible with the environment of intended use, cleaning, and sanitization. Care must be exercised to assure that proper non-metallic materials are selected; with particular emphasis on the fat content and temperature ranges of the products intended to be processed.

R. Internal surface texture

Product contact surface finishes at least as smooth as a Ra of 0.8mm on stainless steel free of imperfections such as pits, folds, and crevices in the final fabricated form will clean satisfactorily and are recognized by most hygienic equipment standards. Any deviations rougher than this minimum should be part of the manufacturer's specifications so that the buyer can make an informed decision to use the valve.

S. Accessibility for cleaning and inspection

The normal cycling of valves during processing and cleaning subject valve components to high stress and wear of movable components. In large fluid lines, these stresses can force products past seals or removable valve seats. Valves in dry product processes may be subjected to materials that are quite abrasive. Therefore, it is vital that valves be both accessible when installed in a processing system and easy to disassemble so that the wear and cleanliness of components can be periodically inspected. Valves that are supplied with automatic power actuators generally are required to have at least a 25 mm space between the actuator and the valve shaft seal that is open to the atmosphere so that a failure of the seals is readily observable. Valves such as diaphragm or pinch valves that have internal components subject to failure, require a drain opening to the atmosphere to signal component failure. The drain opening shall be at a point low enough so that leaking products cannot collect within the valve housing.

T. Draining

Most valve designs have addressed the ability of the valve to be self-draining when properly installed. However, care must be exercised before installation, as some manufacturers still require attention to the drain ability of their designs. Upon installation of any multi-port valve, care must be taken by the installer to assure that dead pockets are not created in the product flow when a port is closed. Some valve designs, such as most diaphragm valves, are inherently non-self-draining. In these cases, the valve should have a clearly identified orientation mark on the valve body to indicate proper installation angles. Self-draining is not a major consideration in dry product processes. These systems are designed to go for extended periods of time with only dry cleaning. In those rare instances where wet cleaning is necessary because of a contamination or a major maintenance project, the entire system, including any valves, must be disassembled to clean and thoroughly dry the wetted surfaces.

U. Elimination of cracks, crevices, and niches

Some valve designs, even with automatic actuators, are inherently not suitable for CIP or mechanical cleaning methods. These designs tend to have large sliding seal areas such as a plug, ball, iris, inflatable seal duct, and diverter-type valves. The sliding seal will contain a film of the product throughout production. The tolerances of the sliding seals prohibit the transport of sufficient cleaning and sanitizing fluids to achieve cleaning and decontamination. Compression of elastomeric components. The compression of the elastomeric components must be controlled so that the materials cannot be over-compressed, causing them to extrude into the product flow. Additionally, the compression must be sufficient to assure a tight seal across the full temperature range of processing, cleaning, and sterilization.

The attachment of elastomeric components to metallic components shall assure that the intended flexing of the elastomeric components does not create crevices or cracks to open between the components as they are cycled. Lip seal valves can be used only under special conditions where cleaning and sanitation have been validated and documented [8].

V. Internal angles and corners

Sharp or decreasing internal angles and corners within a valve must be avoided to assure that hard-to-clean areas are not created in the design. This is especially important on valves that are subjected to manual cleaning procedures. The internal radii must be sufficiently large to allow for the cleaning implements to reach the surfaces. Generally, internal radii of 3 mm are recognized as adequate to accomplish the cleaning. Smaller radii are permitted for smaller components within the valve. In these cases where smaller radii are required, they should not be less than 0.8 mm. The manufacturer of the valve should specify the presence of such radii.

W. Process and installation

When designing a process system there are additional concerns that must be taken into consideration. Are there legal requirements of the regulatory authority? For example, pasteurization systems, including both batch and continuous systems, have special requirements for the valves used to segregate pasteurized from unpasteurized products. This may require special leak detection and rapid response times for valve actuation. Aseptic systems require valves that can be demonstrated to be bacteria-tight.

ISSN (Online) 2456 -1304
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Vol 10, Issue 2S, February 2023

Generally, valves will be designed for self-closure in the event of a power failure during processing. However, there may be instances where it is more beneficial for the valves to remain open so that the systems can self-drain. Therefore, care must be exercised in the selection of the valves and their placement within the system [8].

It is quite common to use a `block and bleed' configuration of valves to assure the separation of different streams. Installers should pay extra attention to assure that the bleed lines properly drain and do not retain fluids. The food industry would be greatly helped by the availability of valves that provide the security of a `block and bleed' system while greatly simplifying draining and avoiding stagnant products. Installers must be careful not to create a common installation error that produces a `block± block± bleed' configuration. Care must also be exercised to assure that valves can be easily accessed for Periodic maintenance and inspection. Valves commonly include components, which wear and require periodic replacement.

X. Improving the hygienic design of pipes

The main function of piping in a food processing plant is the transport of material. Next to the transport function, piping can be used for the processing of material, for example by heating/cooling, mixing, or providing holding time. This chapter starts by summarising the current requirements for the design of stainless steel piping and then gives the possible applications of plastic and flexible piping. The chapter also discusses the growth of microorganisms in piping systems and the use of antimicrobial coatings and antifouling coatings. Product recovery from piping systems is briefly discussed, followed by some thoughts on the design of the food manufacturing plant.

Y. Piping design: good practice

A unit of pipe is cheap and easy to clean in comparison with vessels, pumps, extruders, and other equipment. To maintain this inherent benefit of simple cleanability some guidelines must be followed when designing pipework: Piping material should be food-grade, non-absorbent, and resistant to the product and cleaning-in-place fluids. Internal surfaces should be smooth also where piping is welded. Couplings should be avoided when possible. The first option should be bending followed by welding. When unavoidable, hygienic couplings should be used and a preventative maintenance scheme drawn up for seal replacement. Pipe diameters should not vary too much.

Although a piping system designed according to the principles described above should be easy to clean, this could be hampered by complexity. When the piping system contains many branches one has to be very careful when designing the CIP system as usually sequential and repeated switching of CIP valves is needed. Options4 for the design of piping systems are given in Baumbach and Hoogland [9].

Z. Materials of construction

The default choice for piping systems is stainless steel; however, alternative materials should be considered. The use of plastic piping systems for low-pressure applications could have the following benefits: The welding procedures are mainly automatic, requiring a low level of skill. They are able to handle highly corrosive products. Plastic has superior insulating properties ± avoid condensation when transporting cold products or reducing heat losses when used for heat treatments. The possibility of making lightweight systems in case the plant needs to be mobile. Next to these benefits, there are a number of uncertainties about the use of plastic pipework. Plastic is more sensitive to wear. Welding requires special equipment. The cleanability of plastic piping needs to be verified. Limited availability of hygienic valves and couplings. Depending on the local situation, plastic piping might be a good alternative to stainless steel. Trends such as `late customisation' customization on demand 'and Distributed manufacturing' often require intermediate products to be stored, transported, and coupled to a second process later. A simple way for doing this is the use of containers that can be connected to the processes by flexible tubing. This kind of system is available from a number of suppliers. The selection of a system should be based on the required level of hygiene and the cost of operation. The current trend of healthy/fortified foods might lead to the need for aseptic coupling of containers to processes, for example, post-dosing of flavors and micro-nutrients to ultra-heat treated sterilized products.

AA. Product recovery

To minimize product losses during cleaning and or change-over it should be possible to purge the system. The simplest way is by purging the system with water or product. This becomes less effective for very long pipe runs as the mixing zone increases. Also for viscous products purging with a low-viscosity fluid such as water is not effective, as the water will push a hole through the center of the pipe and the majority of the viscous product will stay behind. The most attractive way of reducing the environmental implications for closed systems is product recovery by `pigging'. The so-called `pig' is sent, by means of compressed air or water as the driving force, through the pipeline, and expels most of the product from the system. The pig is often designed from an elastic material such as silicon rubber with a closed surface. Sponge-like pigs are not recommended, as they are difficult to clean. The early pigging systems were operated manually. Today's pigging systems are fully automatic and are cleanable in place, avoiding any chance of contamination by the operator. Also, unless the manual system is carefully designed to prevent the pig from escaping from the line under pressure, it can present a potential danger to the operator.

The drawbacks of these systems are the requirements they put on the design and construction of the piping system, such as All pipes should have the same diameter. Pipe roundness is

important, especially in bends. No valves or sensors protruding into the pipeline. No welds protruding into the pipeline. Branches should be constructed in such a way that it is impossible for the pig to go in the wrong direction. Often these requirements are difficult to meet especially in slightly older existing plants. For some of the issues mentioned above, there are solutions. To avoid protruding sensors some suppliers did develop retractable systems for temperature sensors, and pH sensors. Also, full-bore ball valves have been designed which are claimed to be cleanable in place.

As standard ball valves are not `cleanable-in-place' since the area between the seals cannot be cleaned, this has now been overcome in an inventive way by the use of inflatable seals which are deflated during CIP, allowing the CIP fluid to flow around the ball. The design incorporates two inflatable seals that grip the ball when inflated and released from the ball when deflated. These valves are also available in a three-way version and form the basis for a pigging system as provided by Hygienic Pigging Systems Ltd. The alternative approach is to make the pig more tolerant of geometrical. This has for example been done in a UK-LINK scheme led by the University of Bristol where the pig was made from slush ice. The university has patented this development. It should also be possible to make the pig from food-grade biopolymer [10].

BB. Microbial growth in piping systems

Most of the product will remain within the system for a shorter time than that needed for the microorganisms to multiply. Only a very small fraction of the product flows closes to the pipe walls and resides sufficiently long to allow growth. Would the growth in this very small volume be able to increase the number of microorganisms in the main flow? To verify this, a simple simulation was made for a viscous Newtonian flow through a straight pipe with an average residence time in the pipe of 5, 8, and 16 minutes, much less than the doubling time of 20 minutes. The initial concentration is 100 microorganisms/ml.

When surfaces contain a high level of microorganisms directly from the start of the process, the growth curve will be much steeper. This can be caused by insufficient cleaning, leaving product residues behind that will protect microorganisms against subsequent disinfection. Next to being a source of microorganisms, the residues present a problem in other areas such as heat transfer, source of allergens, etc. Cleaning could be facilitated by the use of non-stick material. Non-stick material is not usually suitable as a material for construction and therefore needs to be applied on the surface of a construction material as a coating. In general, the material of construction needs to be resistant to the product and CIP fluids, otherwise, any damage to the coating would inevitably lead to local corrosion that continues behind the coating. Often this will lead to stainless steel as the material of construction. From a hygienic point of view, it is important that the coating will not blister off the material of construction, even when the color of the coating matches the color of the product. As this is very difficult to avoid it could be considered to develop a coating whose integrity could be monitored online continuously.

CC. Plant design

Building on this simplicity the ideal plant should be continuous and consist only of piping. Raw materials could be supplied in containers, which are directly coupled to the piping system and are returned without cleaning to the supplier. A wide range of equipment is already available as pipes. Most unit operations and sensors can be done in piping, static mixers, hose pumps, tube-in-tube heat exchangers, membrane pressure and temperature sensors, etc. However, it is clear that these devices have their limitations and often need to be replaced with in-line devices that differ in geometry. As long as the devices have a similar cleaning characteristic as a piece of pipe, the principle does not change. To avoid all problems related to piping such as cleaning, product loss during

Cleaning and change-over, and residence time distribution, the concept of the pipe-less plant could be applied. Here, small vessels move to the factory, from a dosing station to a processing station, to the filling machine. Such a system requires no piping at all and gives very accurate control over the residence time. There is still a need to clean the vessels before preparing a new batch. This could be overcome by applying an internal disposable lining, which could be removed easily, for example a thin, plastic foil, shaped to match the vessel. Current developments in automation make this option more and more attractive.

In automated food processing technology, pumps are used for the transport and the increase of pressure of low-viscosity, liquid products. To ensure a hygienic- ally and microbiologically perfect condition of the product, high standards are applied to turbo machines and positive displacement pumps with regard to hygiene and cleaning technological requirements. These standards apply to all pumps used in the food processing industry, including centrifugal pumps, piston pumps, rotary pumps, peristaltic pumps, diaphragm pumps, water ring pumps, positive-displacement pumps, screw pumps, gear pumps as well as to homogenisers, dampening devices and finally all valves integrated in the pump body.

Concerning centrifugal pumps, it is common practice to flange the pump directly to the motor. This has the advantage of a more compact pump design. Open couplings as used in the conventional pump design where the motor is mounted on a ground plate are not needed. If motors with special shafts are used, the impeller is plugged on to the motor shaft or the pump shaft is plugged on to the motor shaft of a standard motor. In this case, depending on the pump size and/or axial forces, reinforced bearings, integrated bearing flanges and measures against axial thrust are required.

DD. Components used in pumps

Impeller

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Vol 10, Issue 2S, February 2023

Open impellers without a front cover plate are generally used on centrifugal pumps. The advantage is an easier manufacture of the impeller. The impeller blades are mechanically accessible and can be treated to achieve the desired surface roughness. Depending on the specific speed nq, the wheel types are either slow-running radial wheels or medium-running radial wheels.

Mechanical seals

Mechanical seals have replaced the stuffing box used so far in food technology. The design of the mechanical seals should provide that the pressing spring for the sliding ring located in the product chamber is encapsulated. Exposed threads or similar should not be located in the product chamber. Garter springs are not permitted on the product side of the seal.

For normal application in breweries and dairies, single-acting mechanical seals are used, often in hard/soft pairings. For abrasive media hard/hard pairings are the better choice. For products that crystallize out or paste, quenched mechanical seals are used. For toxic products or in pharmaceutical applications double-acting mechanical seals are used with pressurized sealing water. The construction of the shaft and the arrangement of the mechanical seal chamber and lantern should allow for the installation of customer-specific mechanical seals or retrofitting of other mechanical seals for the adaptation to changed media.

II. DISCUSSION

A lantern should be installed between the pump housing and the driving motor. Apart from the geometric connection function between the housing and the motor flange, the lantern is used to connect the pump safely with the motor, in order to make leakage visible in case of damage. In case of leakage, the product or cleaning solution must not be allowed to enter the shaft area of the motor where microorganisms could grow unnoticed. The penetration of leakage fluids or splash water from the lantern port into the shaft area of the motor during outside cleaning can be avoided effectively by providing a splash ring on the shaft and a labyrinth seal between the shaft and the lantern housing.

A. Filling and drainage of the pump housing

For an optimal start of a self-priming pump, the discharge socket should be arranged in a way that air can evacuate autonomously at any operating point. In this case, a radial upwards-directed discharge socket is most suitable. With this arrangement, suction and discharge sockets are located on the same axis, which simplifies piping and plant layout.

Non-aqueous products and mainly pharmaceutical applications require the drainage of rinsing water from the pump housing. The European Hygienic Engineering and Design Group stipulates this as an option for pumps. Drainage valves used in this case must be without dead ends to ensure that the production process is not endangered.

B. Cleanability, surface finish, and other requirements

The cleanability of all parts in contact with the product inflow without the need for disassembly is imperative. The product chamber must show no dead ends and gaps. If the impeller is plugged, the hub of the impeller must be sealed towards the pump shaft and the shaft nut. The seal rings must be clamped in a way that they are exposed to and cleaned by the detergent stream. Centering and guiding must be located outside the seals. The NPSH req value of the pump should not exceed 2 m. The reason is that food pumps are often used as CIP pumps with hot CIP media supply. The chamber of the mechanical seals must have free access for cleaning and cooling the mechanical seals. For all internal corners with an angle < 135ë, the radius must be >3.0 mm. All edges must be deburred. Exposed threads, keyways, or splines should be avoided. The outer contours of the pump must ensure free drainage of cleaning solutions, condensation water, and similar.

C. Surface finish

The surface finish influences the cleanability of pump parts. The cleaning times decrease with improved surface finishes. Typically, high relative velocities and turbulence are created by the rotating elements of pumps during cleaning. Test results have shown that the pump type and operation have a significant influence on the cleanability and cleaning of hygienic pumps.

D. Gentle product handling

Gentle handling of the product may be an important aspect of food pumps. The shearing strain acting on the product must not be excessive. The core parameter for this unit is the flow velocity in the impeller channel. The meridian absolute flow velocity should not exceed the calculation point cm ˆ 2 m/s. This is also to the benefit of the NPSHreq value of the pump. The flow channels should all be designed in true alignment and without dead ends. The use of spiral housings with a logarithmically shaped spiral, if applicable, would be an advantage.

E. Additional requirements for aseptic equipment

The equipment shall be designed to be impermeable to external microorganisms. The design must allow for steam sterilization at 121 degree Celsius for 20 min as a minimum. During steam sterilization, all product contact surfaces shall reach the required temperatures. The dynamic seals should be double seal arrangements to allow for a secondary barrier of steam or sterile liquids. The static seals may comprise a single seal arrangement, provided that it does not allow any external contamination under any operational conditions. If the satisfactory operation cannot be assured with a single seal, then a double seal arrangement with a continuous sterile barrier must be provided. Depending on the application, in particular, on the length of the production period, the sterile barrier may consist of a sterile fluid or an antimicrobial fluid.

F. Materials and motor design

All product contacted parts generally consist of stainless steel, 1.4306 , 1.4541 , 1.4401 , 1.4404 -2, 1.4571 , 1.4435 , 1.4581 , 1.4462 , 1.4460 ,1.4405 , 1.3974 , 1.4542 . Suitable non-metallic materials are carbon, silicon carbide, tungsten carbide, ebonite, nitrile rubbers, ethylene , propylenes, fluoro rubbers , silicone rubbers, urethane rubbers, natural rubbers, PTFE), ETFE , polyamide, perfluoroelastorners , ceramics and aramides. Products in contact with elastomers should be Food and Drug Administration, Code of Federal Regulations or Bundesinstitut fuÈr Risikobewertung approved.

Standard three-phase asynchronous motors are preferable to motors with special shafts because they can be easily replaced throughout the world. Each pump manufacturer sees to it that the modular design of the pump ensures maximum use of standardized parts for cost reasons and for adapting the pump capacity to any hydraulic requirements.

III. CONCLUSION

These pipe systems are developed and constructed to reduce bacteria development and corrosion, resulting in a high-quality cleanable piping system for the client. This is critical for preventing product contamination in a drugstore or biotech facility. To produce food products in hygienically and microbiologically perfect condition, high standards are given to food pumps concerning hygienic design and cleaning technological requirements. The main aspects in this respect are hydraulic efficiency, flow characteristics, pocket-free design, and low-cost manufacture. This chapter has described the special requirements of the food industry on components, seals, cleanability, material composition, and surface quality.

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An Overview of the Improving Hygienic Control by Sensors

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Abstract— This chapter discusses the potential contributions of sensor systems to hygiene management in the food processing sector. The many sensor kinds are described. With an increasing need of better control systems for many food processes, interest has become focused towards on- or in-line control at the production stage. The food processing industry needs a fast, standardised, objective and cost-effective tool to control and improve quality

Keywordss— Food Industry, Food Processing, Metal Oxide, Physical Sensor, Reference Electrode, Real Time.

I. INTRODUCTION

Sensor applications range from security controls to landmine detection and from health screening to quality control. In this chapter we want to describe the possible contributions of sensor systems towards hygiene in food processing, i.e., sensors that control the quality of food by giving a response to a certain property of food. The chapter can provide only an overview of highlights in the field of sensors; these examples of the main principles as well as many other systems are described in much more detail in dedicated books [1], [2].

Samples in the food industry are diverse and variable and the food industry has a great need for rapid sensor techniques on the production line. These techniques should be low cost, easy to operate and fast, in the best case on-line for real time quality monitoring of raw material, processing and final product. For Hazard Analysis Critical Control Point purposes, physical sensors have found their application in the food industry off- and on-line. They represent the critical parameters of pressure, temperature, relative humidity, water activity and pH, which are some of the factors for controlling the microbial hygienic environment in the production plant. However, there is still a need for rapid sensor techniques for determining the microbial and sensory quality in the production line for the detection of bacterial contamination. Physical sensors will therefore not be discussed, because they are not directly related to food quality control, and have been well covered elsewhere.

Looking at the heart of a sensor system, the sensor element, the task of this Apparatus is to respond to a physical stimulus by producing a signal that provides direct or indirect information about the status quo. The classification of sensor systems results from their material, the operating temperature or their signal/measurement category.

As for all analytical instruments, the critical performance requirements for sensor systems are sensitivity, reproducibility and selectivity. Furthermore, industrial needs have to be taken into account, i.e. fast measurement times, physical robustness, no need for skilled personnel and cost effectiveness. Several companies tried to fulfil these needs by the production of commercial sensor systems. Many of these systems are like standard chemical- analytical devices, which can be used only in laboratories.

This situation adds one of the most important issues: the ability to use sensor devices as an in- or on-line tool, i.e., direct process monitoring, starting with the incoming goods inspection. In a next step, process monitoring could start directly on farm-side, which would again increase the sensor requirements, especially robustness and ease of handling. The following section is divided into two parts. The first will concentrate on devices that are capable of controlling by air sampling chemical sensors, while the second one will concentrate on liquid detection, i.e. Devices such as electronic tongue devices and biosensor systems.

A. Sensor types

1.1 Volatile detection ± electronic nose

Sensors for volatile detection are already used in automobiles, medicine, and process control and laboratory measurements. The response of these solid-state gas sensors is usually not very specific, for example towards reducing gases, oxidising gases or ammonia and molecules with ammonia structure. To overcome the problem of non-specific detection or cross- sensitivity, Persaud and Dodd proposed in 1982 the concept of so-called `electronic noses', the detection of volatiles by sensor-arrays. Gardner and Bartlett defined electronic nose `as an instrument, which comprises an array of electronic chemical sensors with partial specificity and an appropriate pattern-recognition system, capable of recognising simple or complex odours'.

To ensure the sensors receive a large amount of information, the systems are equipped with an array of sensors of the same working principle or with sensors of different working principles. The amount of raw data from up to 30 single sensors requires complex statistical data

processing. Evaluation software of sensor systems often includes functions for these sophisticated statistical approaches such as principal component analysis, partial least squares or artificial neural network calculations.

Commercial instruments appeared on the market and in the scientific laboratories, in the early 1990s and since that time hundreds of publications about possible applications have been written. The advantages of these devices are relatively low costs for the device itself, its maintenance, as well as its easy handling. The disadvantages are effects such as sensor signal shift and sensor drift and its often-unspecific detection abilities. However, these issues have partly been solved recently by computational methods.

Metal oxide sensors and metal oxide semiconducting field effect transistors the metal oxide semiconductors are the most frequently used sensors for gas sensing and belong to the group of solid state based chemosensory. First developed in the 1960s as detectors for liquid petroleum gases they consist of a metal oxide layer on top of a semiconductor. The gas sensing principle is based on the reaction between adsorbed oxygen on the oxide surface with incoming molecules. The output signal is derived from a change in conductivity of the oxide caused by the reaction with the incoming molecule. There are two types of MOS sensors, the n-type, which respond to reducible gases, and the p-type, which respond to oxidisable gases. The sensors operate at high temperatures between 300- and 450-degree Celsius. The metal oxide in the surface layer determines the selectivity of the sensors, an optional added catalyst will also influence selectivity as well as their operating temperature. They have a sensitivity range from 5±500 ppm, and are relatively insensitive to water in the humidity range from 30±80% relative humidity. Metal oxide semiconducting field effect transistors also operate at elevated temperatures. They consist of three layers: a doped silicon semiconductor, an oxide layer as insulator and on top a catalytic metal layer. This catalytic surface will interact with volatiles by a change of potential ± the output signal corresponds to the change of voltage necessary to keep a constant present drain current, i.e. both, operating temperature as well as metal layer thickness/kind of metal, will influence the sensitivity and selectivity.

1.2 Acoustic wave devices

Which are made of quartz, lithium niobate or lithium tantalite. These crystals are an inherent part in electronics, electric data processing and high-frequency technology. The general principle is based upon a physical characteristic of the quartz crystal, the essential part of the system: piezoelectricity. This `piezo-effect' refers to the production of electrical charges by the imposition of mechanical stress, i.e. these systems apply an oscillating electric field to create a mechanical wave. Their transformation towards a sensor is achieved by coating with a polymer material, e.g. Known from chromatographic stationary phases. The coating is achieved by dissolving a chosen polymer in an organic solvent; after this airbrush or spin coating techniques can be used to coat the sensor surface.

The two aspects of this technique, bulk acoustic wave and surface acoustic wave, have different modes of oscillations: the three- dimensional BAW travels at 5± 30 MHz through the crystal, while the two-dimensional SAW range at frequencies ranging from 10 MHz to 2 GHz. The sensing layer consists of a polymer, which can interact with a given analyte, i.e., the major measurement parameter is the change in the resonance frequency due to the change in mass, which results from this. Practical consequences of the different layouts are a higher sensitivity of SAWs combined with the need for a more sophisticated control set-up. A sensor array will deliver a `fingerprint' of the sample if the different polymers attract different volatiles and therefore the variation in mass will induce different frequency shifts in a reproducible way, as long as temperature and humidity are kept constant.

To overcome the disadvantages of relatively insufficient sensitivity pre-concentrating units were combined with these devices, e.g. Tenex tubes or solid phase micro-extraction. This SPME±SAW coupling was used for proof of principle experiments within process control, off- flavour recognition and fruit storage control. Other research studies used BAWs as a tool to predict the optimal harvest date of apples or to monitor the ripening process of Emmental cheeses, during which the concentration of 2-heptanone changes characteristically.

1.3 Conducting polymers

Conducting polymers have a relatively long history as sensors; Bartlett and Ling-Chung described the measurement of methanol vapour and so formed the basis of several of the earlier generation of commercial electronic noses. They operate, unlike MOS and MOSFET, at room temperature. Beside this a wide range of materials can be synthesised, which can respond to a broad range of organic volatiles. Therefore, a thin polymer film is deposited between gold-plated electrodes.

The detection principle is based on the change of the electron flow in the system if volatiles are in interaction with the conducting polymer; i.e., the change in voltage across the conductive polymer is measured. This change is caused by the disturbance of the conjugated - electron system, which extends over the whole backbone. Different sensitivities and selectivity are achieved by substitution of side groups of this backbone, the selection of doping ions, the variation of the polymer chain length and condition of the polymerisation.

Although possible applications such as the discrimination of microorganisms were described by Gibson et al. And Craven et al., serious problems such as ageing effects and poisoning should be solved before using these devices in a `non-lab' environment. Further disadvantages are the poor batch-to-batch reproducibility during production, high temperature sensitivity, strong humidity interference and an unpredictable drift due to oxidation processes.

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Vol 10, Issue 2S, February 2023

1.4 Liquid detection ± electronic tongue

In the food industry there are a number of liquid and semi-liquid products where liquid sensors may be applied for quality control purposes. Quality properties that may be analysed in the liquid phase may be related to the chemical, microbial or sensory quality of the product. The term `electronic tongue' has been used for liquid sensor systems containing an array of unspecific working electrodes in combination with multivariate pattern recognition methods. If properly calibrated, the electronic tongue is capable of recognising the quantitative and qualitative overview of important ingredients in multicomponent solutions of different natures, e.g., beverages and foodstuffs.

Different techniques have been used for liquid sensing. Used are based on potentiometry or voltammetry. Potentiometric devices include ion-selective electrodes, a reference electrode and a potential measuring unit. A typical ISE is the glass-electrode based pH meter. Recently, ion-selective field effect transistors have been developed. In potentiometry a potential is generated between the reference and working electrode when immersed into a liquid electrolyte solution. The reference electrode is of constant potential and the working electrode responds to target molecules. The output signals correspond to the potential generated across a surface region on the working electrode relative to the reference electrode. A voltametric device also consists of one or several working electrodes and a reference electrode, but instead a fixed electrode potential is applied to drive an electron transfer reaction, and the resulting current is measured. The size of the electrode potential determines whether the target molecules will lose or gain electrons. Thus, electroactive chemical species are measured. The technique may be used for measuring ions, redox active compounds, heavy metals, charged particles, conductivity and pH.

Another way of using voltammetry is by large or small amplitude pulsing of the potential. These two techniques generate complex multivariate output data and require chemometrics for the data processing and analysis. Piezoelectric sensors such as the SAW devices have also been applied to aqueous phases [3], [4].

B. Biosensors

Clark and Lyons developed the first biosensor, an enzyme-based glucose sensor, in 1962. Since then, hundreds of biosensors have been developed in many research laboratories around the world. Over a thousand research papers about biosensors, including reviews and books, have been published since 1995. Their authors classified sensors according to their biological or transduction element, which is used in this chapter to illustrate these classification options. Further classifications are the `way of identification' and scaling of `bio element integration'.

Advantages of these devices are relatively rapid assay times, low cost, great selectivity, little sample consumption; they can be miniaturised and integrated into one chip, and easy handling. Disadvantages include the dependency towards pH, temperature, limited lifetimes and other general conditions. As a consequence, their superior selectivity is limited by their biological component which requires mild conditions. This also includes the relatively short lifetime of biosensors compared with conventional instrumentation. Because of these specific premises it is important to consider the following aspects: Which bioreceptor transducer combination with which immobilisation method. Contamination risk biosensor sample host system. The packaging of the sensor system. Required measurement range and linearity. User-friendly maintenance. Although the biosensor food pathogen testing market was expected to grow to $192 million by 2005, new developments are mainly driven by in vivo applications for medical diagnosis. As a consequence, new developments do not find intermediate use in the agricultural and food industry. A list of companies producing biosensors for food control is given by Kress-Rogers and Brim low. Table 19.3 provides an overview of advantages, disadvantages and application examples of the different biosensor systems.

1.1 Electrochemical biosensors

Electrochemical sensors can be classified according to their transduction principle as amperometric, potentiometric or conductometric sensors. The amperometric sensor for blood glucose concentration based on glucose oxidase is commercially widely used, but systems for food analytes such as ethanol, ascorbic acid, free fatty acids and different carbohydrates have been developed. For this kind of transducer, the current produced by an electroactive species is measured and correlated to the concentration of the analyse.

It is also possible to use an amperometric bi-enzyme system as described as an dairy industry application by Scheller et al. described a combination of galactosidase and glucose oxidase has been used to determinate lactose concentration by the reduction of oxygen in reaction or the oxidation of H_2O_2; measurements were performed using a Pt-Ag/AgCl oxygen electrode. In potentiometry a membrane is measuring a potential resulting from the difference in concentration of H+ or other positive ions across the membrane. Examples are described by Verma and Singh for quality control in milk, and by Ercole et al. For Escherichia coli detection in vegetable. Conduct metric sensors use conductive polymers, which convert the biochemical interaction into an electrical signal. Recently, Muhammad Tahir and Alocilja used this technique for the detection of E. coli and Salmonella.

In contrast to chemical or physical sensors enzyme assays are in general unusable for continuous measurements, i.e. enzymatic efficiency is not constant over time. To enable constant measurements the flow injection analysis provides a solution by constantly sending samples with recovery phases between each sample. This recovery is used to clean the

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Vol 10, Issue 2S, February 2023

sensor from sample and to return the response back to base line.

1.2 Thermal biosensors

Thermal biosensors were first developed in the early 1970s and used for continuous measurements and enzyme-reactor control, but they are rarely used for food control. The principle is characterised by immobilised enzymes, which evolve heat during their catalysed reaction, which is in proportion to the amount of substrate in the sample. The advantage of this technique is the independence of optical properties, which enables to measure a broad range of bioanalyses with one instrument.

1.3 Optical biosensors

Optical biosensors, which can be classified into two groups, depend upon the special properties of light. In general, they offer advantages such as miniaturisation and disposability, and there is no occurrence of electrical interference. Classical optical biosensors consist of fibreglass, which has been coated on one side with an enzyme or antibody. Direct information will be given by such techniques as optical waveguide light-mode spectroscopy or scanning angle reflectometry. In contrast to this the second group's information is obtained at the expense of a complete description of the adsorbed layer; their most known examples are surface plasmon resonance and total internal reflexion fluorescence or spectroscopy.

More than 4000 articles have been published since 1990, describing numerous applications. Rich and Myszka , Baird and Myszka and Mehrvar et al. Give overviews in their review articles about recent developments. The SPR technique has been the backbone of a very common commercial biosensor for biomolecular interaction analysis since 1990. Biacore AB developed this instrument, which is now the platform for diverse applications ± 90% of published optical biosensor research is performed by these devices.

1.4 Piezoelectric biosensors

Piezoelectric devices are mainly based on the detection of a change of mass density, mostly represented by BAW and SAW. Janshoff and Steinem give an overview about the working principle of these systems in liquids. Owing to high energy losses by measurements in liquids, the sensitivity of these devices is rather low compared with optical devices. Because of their advantages they are still part of some typical bioanalytical research topics.

Bacillus cereus was detected by Vaughan et al. With label-free quartz crystal microbalance sensor with a detection of about 104 cells/mL. Mannelli et al. Developed a DNA piezoelectric sensor for the detection of genetically modified organisms. LaÈnge et al. Created an immunosensor on the basis of a SAW device, which was able to monitor urease binding at anti-urease-coated SAW devices in real time with good resolution.

C. Common industrial applications and future trends

Sensors have a great potential for future use in the food processing industry for process and quality control. The application areas are in the field of pathogen detection related to raw material, processing and quality control of final product. So far, most of the sensors that have been implemented in the food industry on the production line have been for the purpose of environmental monitoring of hazardous gases such as hydrocarbons, ammonia and hydrogen sulphide that may occur during the production process. However, these kinds of sensor, also including physical sensors, provide information on the performance of the process, which in the best case may indirectly contribute to controlling the hygienic quality of the process, but does not provide direct information on the quality of the product being processed. For this purpose chemical and biosensors are helpful, also with regard to their on- and in-line options. Since most research has been conducted under laboratory conditions these options strongly depend upon the application and the process surroundings.

Two fundamental trends will have the strongest influence on applied research in the field of sensor techniques, which are strongly connected: because of public opinion and resulting political actions food safety issues have become one of the most important topics in daily life. Therefore the industry should be eager to prove food quality. In this connection the most effective way is to verify quality from the production side of raw material via industrial processing to supermarket shelves. The main requirements for this approach are automation and miniaturisation; i.e. the need for an instrumentation that can work without supervision and that can be implemented in an existing process technology in order not to disturb the ongoing process.

So far, the existing methods cannot serve these needs of regulatory agencies and food producers. Future real-time testing with reliable sensor technology will provide value to food producers through reduced treatment costs and reduced product recalls. As the demands for food safety increase, the request for fast sensing technologies will only increase. A miniaturised total analysis system, as described in Section 19.3.3 for biological and medical applications, could fulfil these requirements.

1.1 Chemical gas sensors

Chemical gas sensors have become a useful industrial tool for bioprocess monitoring. They represent a cost-effective tool for rapid assessment of the chemical and microbial status of raw materials, process streams and end-product. Extensive and costly rework or disposal of products that do not fulfil their specifications can be prevented. Most biological processes that can be found in the food and biotechnology industries are probably suited for the application of gas-sensor arrays. This is because they involve significant concentrations of aromatic compounds or volatile secondary metabolites produced by the microorganisms. In a typical

bioprocess, cells are grown under sterile conditions in tanks on liquid media that provide essential nutrients, vitamins, etc. The products from bioprocesses range from enzymes and single cell protein to biopharmaceuticals, which naturally all impose high demands on product quality and safety. Gas sensor array systems have been shown to be very useful for both quantitative and qualitative bioprocess monitoring, which allows real- time determination of cell status, growth rates and product concentration. Another advantage with this technology is that it can be used to discover bacterial contamination on-line in real time in the bioreactor tank after only a few hours of processing, which is a significant gain compared with traditional microbiological methods. The application of non- invasive on-line monitoring methods such as gas-sensor arrays could therefore certainly contribute to improve the quality of bioprocessed products. This has also been documented by several studies.

1.2 Biosensors

Although the market is generating a need for pathogen-detecting biosensors, only a few are commercially available or are approaching commercialisation Up to now medical applications have had the largest market segment. For the determination of fruit, vegetable, meat and fish freshness, biosensors have been developed for different biogenic amines based on specific oxidase enzymes in combination with amperometry transducers with detection.

For rapid detection of bacterial contamination in food, commercial biosensors based on immunochemical assays and DNA hybridisations in combination with different transducer principles have been manufactured. The use of analyte-specific sensors makes it possible to discriminate between different micro- organisms. Several commercial systems exist on the market for detection of specific bacteria in foods. Bia core AB delivers biosensor systems for the detection of food pathogens based on immobilised antibodies in combination with SPR technology. Gene-Trak Systems delivers diagnostic products based on DNA assays for the rapid detection of foodborne pathogens in food. It delivers probes with specificity for respectively Listeria, Salmonella, E. coli, Campylobacter and Staphylococcus aureus [5]–[7]

II. CONCLUSION

The company Applied Biosystems offer systems based on DNA hybridisation in combination with fluorescence detection for pathogen detection. The Taqman Detection Systems allow quick determination of the presence of pathogenic bacteria and fungi and for further identification of genus and species, the Micro Sequence system is used. The Micro Sequence system is based on comparison of the gene sequence from an unknown sample with genes from known strains. With these pathogen detection biosensors bacterial cells can be detected down to 200±103 cells/ml from 10±20 minutes up to 2 hours. However, it should be emphasised that it is the sample clean-up and extraction step of the sample matrix that represents the time- consuming step in these analyses and this may vary from 20 minutes to several hours. Therefore, these techniques are in principle based on on-line analysis. They are available as portable devices, automated analysers and laboratory instruments. Very few biosensors are used on-line, but in combination with flow- injection systems they could in principle be applied on-line.

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A Brief Overview of the Improving Hygiene Management and Methods

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***Abstract*— Hygiene GMPs, such as personal hygiene, good housekeeping and cleaning and disinfection, are established to ensure that contamination of foodstuffs from the processing environment is minimised and controlled. Monitoring and verifying that these GMPs are effective is thus essential for food product safety and quality. In this chapter we discussed the method for improving hygiene management and methods.**

***Keywordss*— Food Safety, Food Hygiene, Hazard Characteristics, Pasteurised Milk, Risk Assessments**

I. INTRODUCTION

It is fundamental, of course, to construct a manufacturing environment, select appropriate food processing equipment and environmental materials and adopt personal hygiene practices that can be intrinsically controlled by hygiene measures. Taking cleaning and disinfection as an example, food processing equipment and environmental surfaces must inherently be capable of being cleaned to an acceptable level. In addition, it is necessary to have some understanding as to how deficiencies in equipment or surface design, together with changes due to production practices and wear, will affect such cleanability. Equally, the selection of appropriate cleaning equipment and chemicals along with the design of a suitable cleaning and disinfection programme is an essential prerequisite [1]–[3].

The control of hygiene GMPs should follow the same principles as adopted by HACCP plans for the food product. Again taking cleaning and disinfection as an example, `critical control points' could be identified as the number of cleaners needed, detergent and disinfectant concentrations, water temperature and pressures and contact times. Such CCPs can be monitored before or during the cleaning and disinfection programme, and if out of specification, would negate the requirement for further assessment as the programme would not have been undertaken optimally and would need to be rectified.

The ongoing operation of hygiene GMPs can be monitored firstly by visual audits. These may be undertaken within a time frame such that if faults are found, control measures can be implemented immediately. For the hygiene of surfaces, rapid methods are also available that can detect the presence of soiling, beyond visible cleanliness, in a time frame allowing process control. Such methods include the detection of specific chemical markers of soiling, e.g. adenosine triphosphate or physical parameters such as pressure drops or heat transfer rates.

Verification of the success of hygiene GMPs is usually undertaken by microbiological sampling. Samples can be analysed for markers of overall hygiene , indicators of poor hygiene practice or specific pathogens. Results are available within an extended time frame such that process control is not possible. Verification results are thus used to assess the overall performance of the GMP, and can be trend analysed over time periods to ensure that the GMP is effective and/or can be improved.

Finally, if problems do occur, troubleshooting exercises can be undertaken to identify any failings in the system. Modern microbiological approaches using genetic fingerprinting techniques now allow a much more in-depth assessment of the microbial ecology of food manufacturing plants than was hitherto possible and are leading to enhanced detection and control of environmental microbial niches [4], [5].

If one searches the Internet for `risk assessment', the result is a long list with a large variety of web pages. These pages relate to a wide range of disciplines such as medicine, safety at the workplace, finance, insurance, fire-fighting, and on-line gambling. Risk assessment is a tool that has been used since the earliest history and is used in almost any area, also in daily life.

Central in every risk assessment is a `hazard': an event with a possibly negative impact that is poorly predictable or has a random character. In a risk assessment one evaluates the probability of occurrence of the hazard and the adverse effect of the hazard. As a daily-life example of a risk assessment, we can think of a commuter who takes the bus to work every morning to arrive at 8:20 at the office. A couple of times a year the bus has a delay that causes him to arrive at 8:35. One morning, this commuter has an important meeting at 8:30. He decides to take an earlier bus to make sure he arrives at the office in time. Of course, the probability of having a delay is no different from any other day, but the negative impact of the delay will be much larger on the day of the meeting. The `risk' for the commuter, which is a function of probability

and adverse effect, is thus unacceptably high on the day of the 8:30 meeting, hence his decision to take an earlier bus.

As a risk assessment is an evaluation of the probability of occurrence and the adverse effect of a hazard, every risk assessment can be thought to consist of four parts: identify the hazard, determine the probability of occurrence, determine the adverse effect, and combine the above to estimate the risk. Not every risk assessment scheme mentions these four parts explicitly, yet the microbiological risk assessment according to the Codex Alimentarius

Because part of a risk assessment is the estimation of probabilities, it relies heavily on statistics. Quantitative risk assessment in almost every field needs large amounts of data and/or statistical model calculations. The development in the past decades of powerful computers that analyse statistical data and perform model calculations has boosted the use of risk assessment studies in all fields. Although risk assessment has been used in various areas since the earliest history, its application to ensure hygienic food production is relatively new. This is mainly because knowledge on food hygiene was very limited until the first half of the 20th century.

Even long before the underlying causes of foodborne diseases were known, there were rational approaches to the control of food safety. Experience and trial and error resulted in rules for food hygiene that were often expressed as religious taboos. A well-known example is the ban on eating pork in the Jewish and Muslim religions. In the absence of knowledge about the causes of foodborne diseases, legislators used an approach similar to religious taboos. This approach is also known as the prohibition principle: it was prohibited to produce or consume certain types of food after it was realised that a specific food could cause illness or death. As an example, in the Middle Ages, in the Swiss cities of Zurich and Basel, it was forbidden to sell fish that had been left over from the day before. Even nowadays, although knowledge on food safety has increased dramatically, legislators sometimes use an approach comparable to the prohibition principle, now called the precautionary principle. This approach implies that policy should err on the side of caution when scientific evidence on the food safety of new technologies is incomplete, so that the risk to the consumer is minimised. The precautionary principle was for example invoked in the Cartagena Protocol on Biosafety. The document states that even when there is a lack of scientific evidence that products produced through biotechnology are likely to cause harm, a country can ban the import of those products.

Heat treatments can be used to destroy microorganisms in food. With this increase in understanding a new, more sophisticated, way emerged to guarantee food safety. This relied on the use of certain process conditions that would guarantee the destruction of a target microorganism in the food under consideration. A well-known example is the development of process conditions for the sterilisation of low-acid canned foods by Esty and Meyer. They derived minimum time temperature values for the destruction of spores of Clostridium botulinum, in order to minimise the risk of botulism.

During most of the 20th century food safety was guaranteed by process conditions as described above, combined with hygienic manufacturing practices, and microbiological testing of the final product to verify the process. Originally there were attempts to routinely test prepared foods for all pathogenic organisms and toxins of concern, but that approach was impractical owing to the large number of possible organisms and toxins in most foods. In the 1950s and 1960s the approach thus shifted towards the testing for `indicator organisms' that are not pathogenic but that would indicate under-processing or recontamination of the food. Escherichia coli was often used as an indicator organism. Total aerobic count was another frequently used indicator for under- processing or recontamination. It was, however, realised that microbiological testing of final products had its limitations. If one wants to ensure that a target pathogen is absent from a certain batch of food, uneconomically large numbers of samples must be taken. This led to the understanding that food safety management should not be based on control of the final product, but on control of the food production process. This invoked the introduction of quality management systems such as GMP and HACCP in the 1970s and onwards.

Hygienic manufacturing practices, such as the use of cleanable equipment and personal hygiene of the operators, have been used for many years. Their use, however, had been non-systematic and non-verifiable. The quality management system GMP aims to place these manufacturing practices, which are the results of long practical experience, in a more systematic framework. Still, the GMP system is largely subjective and qualitative in its benefits. It has therefore been extended by the introduction of HACCP. HACCP is a systematic approach to the identification, assessment and control of hazards at a food processing plant. HACCP was originally developed around 1970 for the NASA space program, to guarantee 100% food safety. In the 1970s it became mandatory for canned food production in the USA, but only in the late 1980s its application was broadened to various categories of canned and non-canned foods inside and outside the USA.

An important step in the implementation of HACCP is the systematic assessment of possible hazards in foods and their associated risks. Increased use of HACCP in the 1990s thus led to an increased need for knowledge on systematic risk assessment in food processing. At the same time, the development of risk assessment was strongly stimulated when in 1995 the World Trade Organization was established and a free trade in safe food was agreed. This was formalised in the Agreement on the Application of Sanitary and Phytosanitary Measures, the SPS agreement This agreement requires that food safety legislation be scientifically based and that the process of risk assessment be

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Vol 10, Issue 2S, February 2023

applied, for example when using microbiological criteria for controlling imported foods. The SPS agreement also requires that countries should take into account the risk assessment technique developed by relevant international organisations. As a result of this the Codex Alimentarius Commission of the United Nations Food and Agriculture Organisation and the World Health Organization began to provide member countries with principles, guidelines and examples of food safety risk assessments. Although these documents are aimed to support governments in developing food safety legislation, the principles of risk assessment are equally valid for the individual food processor. Moreover, the examples of risk assessment provided by the CAC contain many details that are of interest for the individual food processor, although the extension of these example assessments is well beyond the scope of the risk assessments typically carried out by the food industry.

A. Quality management and risk assessment

1.1 Risk management: HACCP and its validation

HACCP is the most important food safety management programme around the world. It is recommended by the Codex Alimentarius Commission in the General Principles of Food Hygiene , recognised by many governments and regulatory authorities and encouraged by food processors and suppliers as a means to enhance food safety. HACCP is a systematic and scientifically based protocol that focuses on prevention of problems occurring. It identifies specific hazards and measures for their control to ensure the safety of food. HACCP is based on the application of seven principles. There are, in addition, a number of prerequisites that need to be accomplished before the application of the HACCP principles. These prerequisites include assembling a team that will assume the responsibility to develop the HACCP plan, and obtaining knowledge about the product, its intended uses and all the processes involved from primary production until consumption. The seven principles are summarised below:

1.2 Principle 1

Conduct a hazard analysis. The HACCP team should list all the hazards that may be reasonably expected to occur at each step from primary production until the point of consumption. Hazard is here defined as `a biological, chemical, or physical agent in, or condition of, food with the potential to cause an adverse health effect'. Moreover, the HACCP team should conduct a hazard analysis to identify which hazards are of such a nature that their elimination or reduction to acceptable levels is essential to the production of safe food. The evaluation of hazards should include are the likely occurrence of hazards and severity of their adverse health effects. The qualitative and/or quantitative evaluation of the presence of hazards. Survival or multiplication of microorganisms of concern. Production or persistence in foods of toxins, chemicals or physical agents and conditions leading to the above. The HACCP team must then consider what measures can be applied to control each hazard.

1.3 Principle 2

Determine the Critical Control Points. The HACCP team must identify the CCPs or steps in the production process where control can be applied and is essential to prevent or eliminate a food safety hazard or reduce it to an acceptable level.

1.4 Principle 3

Establish critical limit. A critical limit is defined as a criterion that separates acceptability from unacceptability. The critical limit must be specified and validated, if possible, for each CCP.

1.5 Principle 4

Establish a system to monitor control of the CCP. Monitoring is the scheduled measurement or observation of a CCP relative to its critical limits. The monitoring procedures must be able to detect loss of control at the CCP. Further, monitoring should ideally provide this information in time to make adjustments to ensure control of the process to prevent violating the critical limits.

1.6 Principle 5

Establish the corrective action to be taken when monitoring indicates that a particular CCP is not under control. Specific corrective action must be developed for each CCP to deal with deviations from the critical limits. The actions must ensure that the CCP has been brought under control. Actions taken must also include proper disposition of the affected product.

1.7VPrinciple 6

Establish procedures for verification to confirm that the HACCP system is working effectively. Examples of verification activities include review of the HACCP system and its records, review of deviations and product dispositions and confirmation that CCPs are kept under control.

1.8 Principle 7

Establish documentation concerning all procedures and records appropriate to these principles and their application. Documentation and records are essential to demonstrate safe product manufacture and that appropriate action has been taken for any deviations from the critical limits. Although the use of HACCP is widespread, some of its details are relatively underdeveloped. For example, until recently the validation of critical limits, mentioned under Principle 3, had received very little attention. To fill this gap and provide guidance on how one should validate food safety control measures, draft guidelines were prepared by the Codex Alimentarius Committee. In these guidelines `validation' is defined as `the obtaining of evidence that the food hygiene control measure or measures selected to control a hazard in a food are capable of consistently controlling the hazard to the

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Vol 10, Issue 2S, February 2023

level specified by the performance objective'. Thus, validation of control measures requires that effectiveness is measured against an expected outcome.

The authors of the draft guidelines note that in the current environment of flexibility with the selection of hygiene control measures, the concept of validation acquires increased importance. For many years the use of mandated processing conditions was the main way to guarantee food safety, for example the pasteurisation of milk must deliver a lethality equivalent to or more than 72-degree celscius for 15 seconds. However, the emergence of new pathogens, increased knowledge of the survival capacity of pathogens, the development of novel processing technologies and the marketing of minimally processed foods create a greater need for process validation.

The draft guidelines set out a number of approaches that may be used to validate food hygiene control measures. One may make reference to previous validation studies or scientific knowledge, or conduct scientifically valid experimental trials on laboratory or pilot plant scale. Other approaches to validation are the collection of biological, chemical and physical contaminant data, both during process establishment/commissioning and during normal operating conditions and the use of statistically designed surveys. Mathematical modelling is also mentioned as an approach.

B. Risk assessment

The globalisation and liberalisation of world food trade, while offering many benefits and opportunities, also presents new risks. Because of the global nature of food production, manufacturing and marketing, infectious agents can be disseminated from the original point of processing to any place in the world. To assist governmental bodies to achieve an appropriate level of protection derived from the free international trade of food, the Codex Alimentarius Commission has published guidelines with generic principles of risk assessment. According to the CAC, risk assessment consists of the following steps.

Hazard identification, exposure assessment, hazard characterisation and risk characterisation. In addition to these steps and prior to the beginning of a particular risk assessment, the specific purpose of the risk assessment should be clearly stated and the output form and possible output alternatives should be defined. Other important principles are that the risk assessment should be based upon science, should be transparent and its risk estimation should not be influenced by preferential application of particular control measures of the risk.

Hazard identification consists of the identification of biological, chemical and physical agents capable of causing an adverse health effect, which may be present in a particular group of foods. Information on hazards can be obtained for example from scientific literature and studies of government agencies or international organisations.

Exposure assessment is the evaluation of the likely intake of biological, chemical and physical agents via food as well as exposures from other sources if relevant. For microbiological agents, exposure assessment determines the likelihood of consumption and the likely dose of the pathogen or its toxins to which the consumers may be exposed in a food. Exposure assessment is one of the most uncertain aspects of microbial risk assessment. Hence it is normally based on predictive microbiology modelling and simulations. A number of relevant factors have to be considered to determine the frequency and level of contamination of a pathogenic agent in food. These include the initial contamination of the raw material, the processing, packaging, distribution and storage methods of the foods and preparation steps prior to consumption. Also, consumption patterns may be considered which are related to socio-economic and cultural backgrounds, seasonality, age, etc. The level of microbiological pathogens may also increase considerably in case of exposure to abusive conditions. Therefore, the exposure assessment may predict the range of possible exposures depending on the effects of process conditions such as hygienic design, cleaning and disinfection, time/temperature conditions, food handling and consumption patterns.

Hazard characterisation is the evaluation of the nature of the adverse health effects associated with the hazard. In the case that data are available, a dose± response assessment should be performed. For microbiological hazards it relates to the ingestion of microorganisms or their toxins. The factors to be considered can be divided into three groups: factors related to the pathogen, the food or the human host. The factors related to the pathogen are its virulence and infectivity, which may depend on its interaction with the host, and its capacity of resistance, adaptation, replication and transmission in specific conditions. The food matrix and food process conditions can affect the pathogenicity of a microorganism. High fat content may protect the organism from stomach acid and hence increase the chances of survival and consequent infection. Factors to consider related to the host are the variation of susceptibility depending on age, health or immune status.

Risk characterisation is the final step of the risk assessment. It is the process of estimation of the probability of occurrence and severity of known or potential adverse health effects in a given population based on hazard identification, hazard characterisation and exposure assessment. Risk assessments may vary considerably in depth of assessment and structure, depending on the purpose of the exercise. Some of them are focused on one aspect, e.g. hazard characterisation, or do not use the Codex Alimentarius structure and definitions. Assessments conducted by national or international food safety organisations normally contain extensive literature reviews and in-depth dose response assessments. However, as these risk assessments cover whole sectors within the food industry and cover the total production chain, these assessments cannot focus on the details of the individual food processor. Risk assessments

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International Journal of Science, Engineering and Management (IJSEM)
Vol 10, Issue 2S, February 2023

conducted by individual food processors are less detailed on public health issues, but focus on the prevalence and concentration of a recognised pathogen in their food ingredients and finished product. Risk assessments conducted by food equipment manufacturers focus on the hygienic design to minimise the risk of trans- Ferring hazards to a food product during manufacturing.

Risk assessment consists of the evaluation of the probability of occurrence of the hazard and the adverse effect of the hazard. Such an assessment can contain valuable information for the implementation of a management programme, such as HACCP, which is the procedure that ultimately will set the means to eliminate, control or reduce the hazard to acceptable levels. Risk assessment assists during the implementation of the HACCP to identify the hazards associated with a product. In addition, risk assessments collect information about the influence of process or storage conditions that may affect the viability of foodborne pathogens. This will help HACCP to identify the steps in the food production that are critical to food safety and at which control actions would produce a great reduction in risk. Hence, it is of potential use for CCP identification. Finally risk assessments provide a valuable scientific foundation to determine the critical limits related with each CCP.

An assessment of the risk to public health from Listeria monocytogenes in selected ready-to-eat foods was conducted by the United States Department of Agriculture. This risk assessment estimated the potential level of exposure of three age-based groups to L. monocytogenes from 23 food categories and related this to public health consequences. The three age-based groups were perinatal, elderly and the intermediate-age group. Predictions from the risk assessment were given in two forms: the estimated rate of fatal infection on an individual serving basis and the estimated number of fatal infections per year in the US. For each food category and each age-based group the per annum risk is derived from the per serving risk by multiplying the latter by the yearly number of servings of the food category by that specific age-based group.

The risk assessment was based on the four steps according to the CAC. In the hazard identification step, the health effects associated with L. monocytogenes were identified. The main part of the study is the exposure assessment which estimates how often consumers eat food contaminated with L. monocytogenes and estimates the number of bacteria likely to be in that food. The contamination data used were from published and unpublished studies that mainly concerned food samples collected at retail. Mathematical models were then used to calculate the changes in contamination levels during refrigerated storage and reheating in the home, thus obtaining the contamination level at the moment of consumption. These models considered factors such as refrigerator temperatures during storage, the specifics of the various food categories, and the estimated length of time that food is stored. Finally, the number of servings, necessary to calculate the `per annum risk', was estimated for each food category and for each age-based group using data from two large nationwide US food consumption surveys conducted in the 1990s.

In the hazard characterisation step, a dose response relationship was described, as a percentage of each age-based group that will become seriously ill or die after being exposed to a particular level of L. monocytogenes. The dose response relationship was estimated from literature data on listeriosis outbreaks and from studies with animals. In the risk characterisation step, the results of the exposure assessment and the hazard characterisation were combined to estimate the likelihood of adverse health effects. This was done by running Monte Carlo simulations with statistical data resulting from the exposure assessment and the hazard characterisation.

Results from the risk assessment showed that the risk of listeriosis on both per serving and per annum basis varies greatly among the various categories. The category `deli meats ranked as highest risk on both per serving and per annum basis. The categories `pasteurised fluid milk' and high fat and other dairy products ranked moderate risk on a per serving basis but ranked high risk on a per annum basis, because of the high yearly consumption of these products.

Finally, the risk assessment model was used to calculate some `what if?' scenarios to estimate the likely impact of control strategies for foodborne listeriosis. It was, for example, calculated what the impact would be if home refrigerators could not operate above either 45 ëF or 41 ëF. These scenarios predicted that the total number of cases of listeriosis would be reduced from 2105 to 656 cases per year by ensuring that all home refrigerators operated at 45 ëF or less. The number of cases would reduce to 28 per year if home refrigerators would always operate below 41 ëF. Similarly, it was shown that reduction of storage time for deli meat from 28 days to 14 days reduces the number of cases of listeriosis in the elderly population by

C. Production line for pasteurised milk

Most food processors have carried out risk assessments of some kind on their production lines, often as part of a HACCP plan. Although such risk assessments are widely performed, very few of them are published owing to the confidential information contained in such assessments.

It is based on the experience of the present authors and on the work of Enroth. The mathematics used in the assessment is of an approximate nature and is meant to give rough estimates only. The production line to be assessed is schematically. This plant produces 108 litres of pasteurised milk per year, which corresponds to 200 000 L per batch. It consists of silo tanks for raw milk, a pasteuriser, buffer tanks and a filling machine. Numerous valves and sensors are present on the production line. This example-assessment considers a constant pressure valve present downstream of the pasteuriser and a temperature sensor placed on a T-piece

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Vol 10, Issue 2S, February 2023

downstream of this valve. The filling machine fills gable-top cartons of 1 L and is in open contact with the surrounding air. Water is used for chilling the fillers, for lubricating the conveyer chains, and for rinsing of milk residues.

The risk assessment is based on the four steps according to the CAC. In the hazard identification step, the microbiological hazards associated with pasteurised milk are identified. From literature reviews and past experience, it is clear that the main organisms of interest can be divided in two groups: Gram- negative psychographs and Gram-positive spore formers. The Gram-negative psychrotrophs are all killed by a suitably performing pasteurisation step, but they may be present in the final consumer packages due to recontamination before sealing the gable-top package. B. cereus spores survive pasteurisation, and are typically present in pasteurised milk.

The hazard characterisation step discusses the effect that above-mentioned microbiological species have on quality and safety of pasteurised milk. This step is totally based on literature reviews and is not dependent on the details of the production line. The group of GNPs includes well-known pathogens, such as E. coli O157:H7 and Aeromonas species. Moreover, many species of this group can cause product off-flavours, i.e., spoilage. It is therefore generally understood that the level of these bacteria in the final product must be below 106 to 107 cfu/mL

At the moment of consumption. B. cereus can cause food poisoning if present at high levels, and can produce quality issues in milk such as sweet curdling. For these reasons most European countries have set limit values of 104 or 105 cfu/ mL for B. cereus at the time of consumption. Pasteurised milk normally contains about 100 cfu/L of B. cereus. At a storage temperature of 7 ëC these will multiply in 8 to 10 days to 104 or 105 cfu/mL. Pasteurised milk may contain 0 cfu/L of GNP, but often contains a few cfu/L GNP. At 7-degree celcisus these will multiply in 8 to 10 days to 106 or 107 cfu/mL. It is thus clear that after a storage time of about 9 days both the level of B. cereus and the level of GNP may be at its maximum and spoilage can occur by either of these bacteria groups.

The exposure assessment step is the part of the risk assessment that relates to the specifics of the production line. It identifies the sources of contamination by the two groups of bacteria and evaluates the possible level of each group present in the finished product. A detailed on-site inspection of the production line indicated eight possible sources of contamination: raw milk, poorly cleanable heat exchangers/gaskets in the pasteuriser, constant pressure valve, poorly cleanable temperature sensor on T-piece, direct air contact in buffer tanks, water used at filling machine, air near filling machine, and packaging material . The contribution of each of these sources of contamination was investigated by microbiological testing. Three kinds of samples were collected: milk samples of 1 L each from various sample points along the production line during production, swab samples, taken after a production run and cleaning-in-place, after dismantling some parts of the production line, and environmental samples, such as air samples and water samples. Each sample was analysed for GNPs and for B. cereus.

Based on the results, the effect of contamination from the eight identified sources can be evaluated. These results indicate that recontamination of milk with B. cereus takes place in the pasteuriser: upon passing through the pasteuriser the level of B. cereus increases from 100 to 200 cfu/L. The most probable cause of this recontamination is a fouling layer which leaks B. cereus. The occurrence of difficult to clean layers containing milk soil and B. cereus spores on the plate heat exchangers and gaskets of pasteurisers is well known. The pasteurisation step works well and effectively kills off the GNPs, thus reducing the risk associated with GNPs in raw milk to a minimum.

When during the inspection the constant pressure valve was dismantled, it was seen that the diaphragm was not perfectly in place and that it contained crazes. The diaphragm was swabbed and this swab showed 50 000 cfu of GNPs. If these were to be released over one batch of milk, it would result in a contamination of 0.25 cfu/L. It is generally believed that swabs estimate only approximately 10% of the microflora sampled, i.e. the real number of GNPs in the diaphragm would be about 500 000 cfu. It is, however, very unlikely that all these bacteria would end up in one batch of produced milk. For the process line considered in this example assessment, it can be estimated that the total number of GNPs that can be detached by one batch of milk is roughly similar to the number of bacteria that can be detected by a swab sample: 50 000 cfu. The poorly cleanable annular gap around a temperature sensor placed in a T-piece was found to contain 10 000 cfu of GNPs, which would result in a contamination of 0.05 cfu/L if these 10 000 GNPs were to be released over one batch.

Upon filling the buffer tank with milk, these bacteria will be released into the milk, thus contaminating the pasteurised milk with 100 cfu/m3, i.e. 0.1 cfu/L. During filling, the milk can be recontaminated by bacteria originating from the air, from the rinsing water or from the packaging material. The level of recontamination is more difficult to estimate directly from the data. Based on literature data, rough estimations can be made: each of these three sources around the filler will contribute about 0.2 cfu/L GNPs.

If the contamination level of one of the two bacterial groups is increased during processing, that will probably be the limiting factor that reduces shelf-life. As stated above, during the 9-day shelf- life of the milk, the level of B. cereus increases by a factor of 1000, whereas the level of GNPs increases by a factor of a million. An increase in initial contamination level by a factor of two will thus have more impact for B. cereus than for GNPs [6]..

II. DISCUSSION

The development of risk assessment in food hygiene over the past decade has been very rapid. The two main drivers for this fast development were the SPS agreement that required food hygiene legislation to be based on risk assessment, and the increased use of HACCP and other assessment-based quality systems in the food industry. The Codex Alimentarius and other organisations have published a number of large risk assessments recently. These risk assessments tend to have a bias towards the developed countries of North America and Western Europe. It is to be expected that in future risk assessments will also be carried out on foods and production methods used in developing countries and non-western cultures [7]–[9].

In the past decade much effort has been put in the development of methods for risk assessment, and much knowledge has been gained from a number of published risk assessments. It is expected that in the coming years these methods and this knowledge will be used by food industry in hygiene management, for example by improving their HACCP systems [10]–[12].

III. CONCLUSION

A further trend may be towards using quantitative risk assessment approaches to assess the effect of hygiene control measures that normally do not fall under HACCP, but are included in GMP, such as hand-washing or the use of hygienically designed equipment. Moreover, computer programs for risk assessment and risk calculations will be further developed in the next years and may well be linked to extensive databases.

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Food Sector: Efficient Manufacturing Practices

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Abstract— What does "good manufacturing practice" in the context of food mean? The term "GMP" has legal standing in the United States because it is codified in the Food and Drug Administration's Current Good Manufacturing Practice Regulations for Foods, which include a general regulation that applies to all foods1 and specific regulations for particular food categories. It is abundantly clear that these are solely concerned with hygiene requirements for food safety. It's noteworthy to notice that there isn't a definition of "good manufacturing practice" in the list of definitions given; in its absence, it is presumed to include all of the listed legal standards. The FDA made its intentions and procedures for updating the 1986-revised GMPs for food use public in May 2004.

Keywordss— Cross Contamination, Good Manufacturing Practice, Food Safety, Food Control, Raw Materials.

I. INTRODUCTION

Since 1986, the four iterations of "Food and Drink Good Manufacturing Practice: A Guide to its Responsible Management" by the Institute of Food Science & Technology, more often referred to as "the IFST GMP Guide," have authoritatively defined and specified GMP in its broader dimensions. It is a credit to the IFST that it is hard to avoid reflecting on the nature, organization, or subject matter of what has been so persuasively explained in great detail in the IFST GMP Guide in this chapter. It has broad worldwide relevance even though it was created in the UK/EU context and when combined with national food laws in other nations. The GMP technique has been used in the USA in conjunction with other recognized systems, one of which being standard operating procedures [1]–[3].

Managers, scientists, and technicians in the food and drink sectors are aware of the specific obligations placed on them to create goods "safe" and consistently of the highest value and attractiveness for consumers, and therefore for their retailing clients. So what exactly does "safe" mean? Absolute safety cannot be guaranteed in its entirety. There are risks everywhere, and eating is no exception. To attain "an adequate degree of protection," which is a word taken from the World Trade Organization, there must be no unacceptable risk.

In the form of legislation and regulations, lawmakers define what is meant by ALOP. However, despite differences across nations, regulatory standards are not static and are subject to change. Naturally, nothing prevents a producer from attempting to get a greater degree of protection than the ALOP of the nation for which the food is designed. The Codex Alimentarius Food Hygiene Committee has accepted the strategy of risk analysis based on risk profiling concerning attaining ALOP. A risk profile including the pathogen and food commodity combination of interest. The public health problem. The current state of knowledge regarding pertinent food production, processing, distribution, and consumption practices. Risk assessment needs and risk management questions. The available information and knowledge gaps; and a recommendation for work and the kind of Committee documents needed. During the following creation of the proposed microbiological risk management guideline paper, it is anticipated that the information supplied within the Risk Profile will be helpful in further assessing microbiological concerns.

For practical reasons, "safety" and "safe" references in this chapter should be taken to imply "reaching ALOP." As a result, it is the responsibility of the food or beverage manufacturer to ensure that the manufacturing process results in a product that meets the ALOP requirements, provide as effective a level of freedom from contamination as is practically possible to achieve, complies with all applicable regulatory requirements, and consistently meets the quality parameters specified in the product specification. In this chapter, GMP will be considered in its broader definition. This strategy is used in later iterations of the IFST's "Food and Drink Good A Guide to Its Responsible Management". It is also used in the USA but under different terminology.

Management is a crucial term. The GMP's components are summarised in this chapter, however, several are covered in considerably greater detail in other chapters. More than the sum of these parts, GMP is more. GMP is first and foremost an integrated management system, necessitating full and thorough specification of the product as well as of all processes involved in creating, maintaining, and dispensing it. It also necessitates the management of the resources, materials, precautions, and measures to ensure that the specification requirements are met. According to this, firm chairmen, presidents, and top executives are more concerned about GMP. They are in charge of setting GMP policies and giving the functional managers and employees the authority, facilities, and resources even when they are not directly involved in planning or executing GMP procedures.

"GMP-literate," includes individuals working in law and regulatory enforcement as well as those in charge of instructing the next generation in all those management tasks. It is inadmissible for academics to claim that GMP is a matter

only for industry. It is clear that the manufacturing activities themselves and a quality control/quality assurance system, which may go by various names but which the IFST has named "food control," are two complimentary and interdependent parts of GMP.

These two elements need to be carefully planned out and executed. The administration of each of these two roles must be of a similar complementary character and interaction, with the authority and duties of each clearly defined, acknowledged, and agreed upon. In this situation, the management of the manufacturing function also serves as a crucial representation of other critical departments that provide the manufacturing function with direct services or advice. Controlling production processes and food quality.

The entire manufacturing operation, including all resources and facilities, premises and space, equipment, trained personnel, raw materials, packaging materials, storage, transport, operating procedures, cleaning procedures, the establishment of critical control points, management and supervision, and services, must be properly specified in advance and systematically reviewed on a regular basis. Moreover, it is also necessary that they be offered in the proper amounts, at the appropriate times, and in the proper locations, and that the completeness and efficiency of their usage be frequently checked. For manufacturing activities to go as planned, it is essential that: Operators are given pertinent written instructions that are directly appropriate to the facilities offered and are written in a manner that is instructive and straightforward. Operators are instructed on how to properly complete the steps. Records are kept at all stages of production to show that all steps outlined in the prescribed processes were completed and that the quantity and quality produced were as anticipated. There is an established traceability system to identify and monitor all inputs and outputs from the production process. Records are created and kept in a readable and accessible form so that the production and distribution history of a batch can be tracked. Every detail of production is detailed in advance, and all resources and facilities are listed, specifically. based on hazard analysis, critical control point measures, and safeguards. Reliable facilities and space and reliable equipment that has been well maintained. People with the necessary training. Suitable packaging materials and raw components. Suitable facilities for storage and transportation. established operating guidelines and cleaning plans. Should the need arise, there is a structure in place to handle unforeseen situations, such as terrorism, sabotage, or the necessity to remove or recall from sale or supply any batch of goods. Effective dietary control is the second key element of GMP that complements it.

In order to be effective. Management participating in the creation of specifications who is properly skilled and experienced in food control. sufficient personnel and resources to carry out the necessary supplier monitoring, inspection, material sampling and testing, process condition monitoring, and key parts of the production environment monitoring. quick information feedback to manufacturing staff, allowing for quick adjustments or corrective action to be taken, and enabling processed material to be either passed as fit for further processing or for sale as the case may be or to be segregated for decision as to appropriate treatment or disposal. Regarding the connection between food safety and food quality, there are two schools of thought. In particular, the preventative Hazard Analysis Critical Control Point technique should only be used to address risks to food safety, according to one school of thought, which also maintains that the two are distinct and should be regulated independently. The opposing camp maintains that if

Food safety is a crucially important component of quality and not anything separate if "quality" in this sense means continuously meeting the specification encapsulating the needs of the law and the marketplace. Additionally, if a hazard is described as "an intrinsic property of a system, operation, material, or situation that may, under certain circumstances, lead to an adverse consequence," then the preventive approach of HACCP can and should be applied to preventing the risk of unacceptable departures from other defined quality parameters. Thus, it is preferable to have a single integrated food management system rather than two distinct ones, one for food safety and another for other quality parameters. These professionals, such as food microbiologists, food chemists, sensory scientists, regulatory specialists, and process control technicians, are not excluded but rather required inside the food control system.

This chapter embraces the latter line of thinking. It is also the strategy used by the British Retail Consortium's Technical Standard, now further developed and known as the "BRC Global Standard Food." Introduced in 1998 to eliminate multiple audits by retailer technical and third-party technical representatives of food manufacturers supplying UK retailers with own-brand products, it has since gained significantly more international recognition for its content, format, and implementation. Its goal is to outline the standards for food safety and quality that must exist inside a manufacturer's organization to offer goods to UK retailers. The structure and content of the Standard are intended to enable an evaluation of the supplier's facilities and operational systems and processes by a qualified outside party, standardizing food safety standards and monitoring practices. Essentially, it is a GMP-based standard.

A. Employees and training

There should be enough employees at all levels, compatible with the size and nature of the firm, with the skills, education, and, when required, the professional and technical credentials essential for the responsibilities allocated to them. Their tasks and obligations should be precisely described and documented in job descriptions or via other appropriate channels.

For the needs of the job, prospective personnel should be well qualified. Consideration should be given to a candidate's

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prospective appropriateness for the job at hand. For instance, those who seem neat and orderly may be more likely to understand the rules for handling food hygienically than those who do not. If an employee's job is terminated for whatever reason, attention should be given to any potential threats to safety or quality that might arise from disengagement or a mere lack of ongoing interest and commitment from the affected personnel, and appropriate measures should be implemented as needed.

The principles of GMP, all pertinent facets of food hygiene, as well as the application and underlying concepts of the responsibilities allocated to them, should be taught to every member of the production and food control staff. Similarly, to this, all other employees who work in manufacturing environments or have responsibilities that affect manufacturing operations should acquire the proper training. The training of each employee should be documented.

Training must follow programs that have been authorized by the relevant functional managers. Training, which gives knowledge on what should be done as well as an understanding of why it is necessary, should not be seen as an appropriate replacement for instruction. Personal hygiene standards and the reasons they are crucial should be modeled in training. To allow staff to completely adhere to such criteria, adequate facilities must be provided. Training should begin with recruiting and continue as needed, be expanded upon, and improved. It is important to pay close attention to overcoming language or reading barriers during training as well as when addressing the need that staff members to be able to comprehend and execute written instructions and procedures, notifications, etc. There should be regular evaluations of training program efficacy and verification checks to ensure that specified processes are being followed.

B. Documentation

A fully functioning HACCP system, in particular, depends on effective documentation, which is a crucial component of GMP. Documentation is used to define policies, materials, operations, activities, control measures, and products. It also serves to communicate information needed before, during, or after manufacture, reduces the risk of oral communication errors, and is an essential component of the audit trail required for tracking the history of the components used to create the final product. As far as is practical, the documentation system should make it possible to determine the history of each batch of goods, including the use and disposal of raw materials, intermediates, and bulk or completed products.

Documents can be divided into four categories: those that outline policies; those that specify requirements, instructions, and procedures; those that outline programs to be carried out during specific times; and those that call for data entry prior to, during, and after manufacture to provide a record of what has transpired. Many of the advantages of GMP will be lost if proper records and documentation are not kept.

C. Building, machinery, product, and process design

Buildings should be situated, planned, built, modified, and maintained to be functional for the tasks performed there and to make it easier to safeguard materials and goods against degradation, contamination, and cross-contamination. The materials handled or the products produced should be protected from contamination, cross-contamination, or deterioration, and equipment should be designed, constructed, adapted, located, and maintained to suit the processes and products for which it is used. Equipment should also make effective cleaning easier.

GMP encompasses more than just existing goods and procedures. The chance to improve in terms of GMP is presented by the creation of a new product or process, or by making major changes to an existing product or process. Products and processes should be created in such a way that they meet consumer expectations for the intended and anticipated duration and usage conditions, and that the product design and performance have been thoroughly assessed for the required function in terms of microbiological safety, chemical safety, physical safety, and sensory quality. To achieve this, the importance of the multidisciplinary hazard analysis technique often referred to as Hazard Analysis Operability Studies is emphasized. It should ideally be used from the very beginning of the development of new products and processes to eliminate or reduce potential hazards whenever possible and incorporate efficient control parameters into their design.

Comparable factors must be taken into account whenever alterations are made to products that might compromise their integrity, safety, or stability. Changes to components, formulations or recipes, operations, equipment, processes or process parameters, packaging, storage, distribution, and customer usage are only a few examples of possible alterations. The list is not complete, but it is based on real-world examples of instances when failure to take such developments into account led to negative human, business, or both outcomes.

D. Operational and manufacturing processes

The activities and procedures employed in manufacturing should be able to consistently produce final goods that meet their requirements and are adequately shielded from contamination or degradation given the available facilities, equipment, materials, staff, and services. Definition and documentation of manufacturing processes, along with related activities and safety precautions, are essential to ensuring that everyone involved is aware of what needs to be done, how it needs to be done, and who is responsible for it. This helps prevent errors that could jeopardize quality or safety. This should be included in the master production instructions for each product.

Trials should be conducted prior to the introduction of MMI for a product to determine if the formulation, techniques, and processes defined therein are appropriate for

factory production and capable of reliably producing goods that meet the completed product standard. Unless these requirements are met, adjustments and further tests should be conducted as needed. The MMI should be followed, so that they still represent an efficient and acceptable way to achieve the specified product, and that they are still capable of doing so consistently. A similar evaluation should be conducted in connection with any significant proposed change of raw material, plant, or method. It should also be conducted periodically [4]–[6].

It is necessary to offer the necessary facilities, tools, and personnel. To be able to manufacture completed goods in the required number and quality, it is necessary to have the right amount and quality of employees, services, information, and documentation in each scenario. Production must be carried out in strict accordance with the MMI, and no deviation from it should be permitted without written permission from the managers responsible for the production and food control, respectively. These instructions must specify the reason for the deviation, be approved by both managers and bear their signatures.

While considering safety and quality, it is essential to prevent dangers. Nevertheless, if an incentive bonus program is offered as part of corporate policy, it should be created in a way that deters employees from taking unauthorized "short-cuts," such as using a formula for bonus computation that incorporates a "Quality factor" and/or a fine for an apparent departure In general, management and supervision are largely responsible for preventing unauthorized shortcuts. When operators have suggestions for streamlining or improving a process, they should be encouraged to share them so that they may be fairly assessed.

The relevant operators should be consulted as part of the creation of operating instructions for production operators in order to benefit from their practical expertise and to give them a feeling of "stakeholder ownership" of the instructions. Operation instructions should be prepared in an instructional style that is clear and unambiguous and should be a major component of operator training. The reading or linguistic needs of certain operators should be taken into consideration. Problems that could occur during stoppages, breakdowns, or crises should get extra attention, and there should be documented instructions on what to do in each situation.

E. Ingredients as well as packaging components

Each component should adhere to its requirements. The documentation should be set up so that any batch of finished goods can, if necessary, be compared to deliveries of the specific raw materials used in its production as well as to the corresponding laboratory records. Each delivery or batch should be given a reference code to identify it in storage and processing. Deliveries should be kept and labeled in a manner that prevents the loss of their identities.

Deliveries of raw materials should be held in quarantine until they have been examined, sampled, and tested. Only on the manager's authorization, who is in charge of food control, may they be allowed for use. The assumption that the description of a consignment of raw materials on the packaging or the associated invoice is correct may not always be sufficient. Each shipment of raw materials should have its identity examined to ensure it is what it says it is in cases when it is not completely clear who it is without a doubt.

A delivery of containers that seems from marks to comprise more than one batch of the supplier's manufacturing or delivery of containers that were repacked by a merchant or broker from a bulk source, should be handled with extra caution. Where necessary, rapid tests for off flavors, off odors, or taints should be made. In the case of additives, testing should also include a test of identification, which verifies that the material is what it claims to be.

Material that is being temporarily quarantined should be kept in a safe place and/or clearly identified to reduce the chance that it may be unintentionally utilized. If the material is determined to need pre-treatment before it can be used, it should be appropriately identified and confined until pre-treatment. Anything that is completely unsuited for use should be physically separated and appropriately labeled until disposal. Before allowing discharge into storage in the event of a bulk delivery by tanker, a preliminary quality evaluation should be conducted.

All raw materials should be kept in accordance with their specifications, in sanitary circumstances, and while taking into account any legal requirements for the storage of dangerous raw materials. To make sure that the raw material stocks in storage stay in good shape, they should undergo routine inspections, sampling, and testing as needed.

For the release of raw materials from storage, a formally defined method and supporting paperwork must be used. Unless the food control manager specifies otherwise, the proper stock rotation should typically be followed. Food Control should provide guidance on how to dispose of a raw material when it has been provided but is not being utilized as intended.

The dispensing of the required quantities of ingredients could take a variety of forms, including manual dispensing by weight or volume, automatic dispensing of batch quantities by weight or volume, or continuous metering by volume; the form taken will be stated within the MMI. These forms could vary depending on the product being manufactured, the ingredients involved, and the nature of the process and equipment. In every situation, the weighing and/or measuring apparatus should be capable, accurate, and precise enough for the task at hand, and its accuracy should be routinely reviewed.

If batch amounts of an ingredient must be physically poured into containers ahead of time, this should be done in a separate room. When manual pre-dispensing of relatively tiny and precise amounts is necessary, it should be carried out by laboratory workers or under their direct supervision. It is necessary to keep records so that the amounts of materials provided may be compared to the quantity or number of

batches of produced goods. To reduce the danger of an unintentional omission or duplicate addition, each component that is added to a batch under the supervision of an operator should be noted at the moment of addition on a batch production record.

Each kind of packing material must adhere to its specifications. The specification must be written in a way that. The product is properly safeguarded throughout the duration of its anticipated life under typical anticipated circumstances. There are no major negative interactions between the product and the packaging material when the packaging comes into direct touch with the product. When the packed product is subjected to further processing, whether by the producer, caterer, or customer, the packaging will be able to withstand the conditions of processing without negatively affecting the product. The packaging is capable of supplying the essential qualities. Integrity in which the pack is what ensures the product's preservation. The completed pack will include all necessary information in the proper form and place, including any applicable statutes.

The food control manager should make sure that the specification is updated as needed to comply with new regulatory provisions and that stocks of packaging materials that no longer comply are quarantined for modifications or destruction when packaging material carries information that is required by law. Each batch or delivery should be assigned a reference code to help identify it during processing and storage, and documentation should be set up so that, in case it becomes necessary, any batch of finished goods can be compared to the shipments of the specific packaging materials used in its production as well as to the corresponding laboratory records. Deliveries should be kept and labeled in a manner that prevents the loss of their identities.

Shipment of packing materials should be held in quarantine until they have been examined, sampled, and tested. Only on the food control manager's authorization may they be released for use. Operators must be instructed and urged to report anything out of the ordinary about the look, color, smell, or behavior of packing materials given out.

Locate and/or use any packaging that has been temporarily quarantined. Indicated to reduce the chance of unintentional usage before release Material that is completely unsuited for use in packing processes should be physically separated and appropriately labeled until disposal. All packing materials must be kept in sanitary conditions and according to their requirements. Regular inspections of store inventories of packing supplies are necessary to make sure they continue to be in usable shape.

The establishment and implementation of authorized procedures and documentation. For the problem with the stores packing supplies. Stock rotation should typically be followed when releasing packaging materials from the store for production usage unless the food control manager has authorized or stated otherwise. The utmost care should be exercised when a company produces multiple products or multiple variations of a single product to ensure that the proper packaging is issued for each product that will be produced and that no incorrect packaging materials from a previous production run of a different product or version are left in the production area where they could be accidentally used. Primary food packaging must never be used for anything other than what it was designed for.

Care should be made to ensure that only materials with the right date are utilized when packaging is reference-coded and date-marked prior to use. It is not acceptable to leave excess material from previous production with a reference or date that is no longer valid in the production area. Care should be taken to make sure that the marking machine is configured for the proper reference and date whenever the reference and/or date are applied throughout the production process. Organizing industrial processes for raw materials and final goods. Production architecture should be such that misunderstanding and potential cross-contamination are minimized when a firm creates many products or multiple versions of a product and has multiple production lines.

To prevent cross-contamination of one product by another, whether in single-line or multiple-line production, special attention should be given in terms of the production structure and procedures. This is crucial when handling ingredients or manufactured goods that unavoidably come into contact with those that do not contain one or more significant food allergens in the same premises. In a production line, the product's name and the proper reference should be prominently displayed.

The production area should be checked to make sure it is clean and free of any products, product residues, waste materials, raw materials, packaging materials, or documents that are irrelevant to the production being undertaken. This also includes making sure the right materials and documents have been issued, as well as the right machine settings. Checking for cleanliness and usability should be done on all machinery and equipment.

Processing must be done in exact compliance with the MMI, subject to any allowed changes, and according to the thorough instructions provided to operators in the Plant Operating Instructions. Process conditions should be tracked and controlled using the relevant tools, such as online verification of proper packing and date-marking as well as adequate sensory, instrumental, and laboratory testing. In cases where continuous recorders or recorder/controllers are in operation, food control should then review the charts [7]–[9].

The accuracy of any instrument used to monitor operations should be checked often and documented by the proper individuals. To guarantee that instruments are always accurately calibrated with precision according to national requirements, the frequency of checks should be determined.

Production facilities and equipment need to be cleaned thoroughly. Personal hygiene standards must be followed by

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everyone entering or leaving the manufacturing area, and suitable facilities must be available. General "good housekeeping" practices should be followed, such as the prompt removal of waste materials, precautions to reduce spillage or breakage, the prompt removal and clean-up of any spills or broken packaging that may occur, and the removal of any items that may enter the product as foreign matter. Foreign substance detectors should be employed as necessary.

F. Intermediary's goods

An intermediate product should be held in quarantine once it is prepared until the food control manager inspects and approves it for conformity with its specifications. If storage is necessary before further processing, it must be done according to the specifications, tagged appropriately for reference, and recorded so that it can be linked to the batch of completed goods into which it will eventually be included. A batch of intermediate product that has been proven to be faulty should be quarantined while it is being fixed, recovered, or rejected outright, as needed.

G. Completed goods

Once they are examined and authorized by food control for conformity with the relevant finished goods standard, packed finished products should be quarantined. The final product standard specifies the proper conditions for storage of an authorized batch, which should be appropriately tagged to identify it. When a batch of completed goods doesn't fulfill the requirements, the root causes should be carefully looked into. In the meanwhile, the defective completed product should be quarantined until the materials are recovered, reused, or, if necessary, disposed of.

H. Product transportation and storage

Prior to distribution, the following factors should be taken into account in addition to the particular references in previous sections to storage techniques for raw materials, packaging materials, intermediate goods, and completed products:

1. Only people who are working in such areas and other authorised individuals should be allowed access to material and product storage facilities.

2. Products and materials should be kept according to the guidelines provided in their corresponding specifications. Materials and products should be well shielded against contamination. The prevention of microbial tainting and cross-contamination should get special attention. If unique requirements are necessary, they should be consistently examined for compliance.

3. Materials and goods should be kept to make it simple to carry out cleaning, use pest control products without contamination risk, inspection, and sample procedures. It should also be possible to retain delivery identity or batch identity and rotate stock effectively.

4. Efficient cleaning of storage facilities and equipment must be done on a regular basis, following well-designed cleaning schedules and instructions, and using the materials and procedures provided.

5. Items that have been recalled, returned, or rejected for rework, material recovery, or disposal should be labelled accordingly and physically separated, ideally in a different storage location.

6. To prevent unauthorised or unintentional use of material deliveries or product batches temporarily quarantined for testing findings, they should be tagged, appropriately separated, and subject to adequate organisational safeguards.

7. The utmost care should be taken to protect a batch's precise identification if it must be temporarily kept unlabelled before being marked at a later time.

8. Storage rooms should be routinely examined for cleanliness and excellent housekeeping, as well as for batches of goods that have reached the end of their shelf life or, in the case of goods with dates on them, do not provide enough time for retail display.

I. Internal *movement*

When moving materials or goods within a factory, care must be taken to prevent identity theft, the mixing of materials or goods approved for use or despatch with those that are quarantined, the contamination of other materials with by-products, especially those not intended for human consumption, the spilling or breaking of the goods being transported, and the loss of their identity.

Aisles and assembly areas should be planned so that unhindered movement is possible to and from all parts of the warehouse. Proper stock rotation is important concerning foods with short shelf lives and date markings. Effective warehousing operations should be designed to ensure that all products are easily acceptable for load assembly as required. Additionally, maximum space utilization should be achieved, consistent with the aforementioned requirement.

The circumstances in which completed goods are stored and transported should guard against contamination, the growth of pathogenic or toxic microorganisms, unfavorable degradation of the products and the containers, and the delivery of healthy, nutritious meals to customers. Among the many factors contributing to this degradation are sources of flavor and odor taint, hazardous chemicals, pesticides, and contamination by insects, mice, and other vermin. Buildings, grounds, furniture, equipment, and vehicles used for food storage should be planned, built, modified, and maintained so as to make operations easier and minimize damage.

J. Certain specifications for some meals

All foods must adhere to the GMP standards outlined elsewhere in this chapter. Yet, certain dietary groups present more issues and have more needs than others. Foods that are heat-treated and intended to be microbiologically stable shall be heat-treated to the extent necessary to stop microorganisms from growing in the packaging and

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Vol 10, Issue 2S, February 2023

throughout the time that the food is meant to be kept. Unless the formulation, water activity, or both of the food are such that it can be proven that growth of strains or forms of the organism cannot occur, all low-acid foods with any part of them having a pH value of 4.5 or above and intended for storage under non-refrigerated conditions must be subjected to the minimum botulinum process, i.e. one that will reduce the probability of survival of Clostridium botulinum spores by at least 12 decimal

1.1 Cooling foods

The strictest hygiene measures must be taken while handling chilled meals since they provide a significant danger to the possible development of harmful organisms. The right evaluation of the hygienic quality of the ingredients, product formulation/characteristics, processing parameters, the intended use of the product, storage, and distribution conditions, manufacturing hygiene, and intended shelf-life must be done in order to determine the safety of the final product.

1.2 Iced foods

For frozen foods to be safely preserved, strict hygiene and careful cold chain maintenance are essential. The cold chain is an organized system that regulates the circumstances in which frozen foods are produced, distributed, and sold. It makes sure that the temperatures maintained during storage, distribution, and sale are consistent with the maintenance of quality and safety.

1.3 Stale food

With regard to cleaning, the potential for the production of an explosive dusty environment, and the dangers of cross-contamination by dust particles, dry foods and procedures employing dry materials have dust-related issues. In order to maintain a high level of cleanliness, it is crucial to keep dust as much as possible contained in an enclosed system and to use dust removal and extraction devices. An efficient air evacuation system should be established, and the surrounding area of the plant and equipment, including ledges and girders, etc., should be cleaned on a regular basis. Such a system needs to discharge via a filter and at a location that minimizes the chance that the discharge may contaminate adjacent items or plants. Dust extraction systems need to be regularly cleaned, maintained, and serviced since they accumulate a lot of dust within the ductwork and may become highly dirty during cleaning and filter changes.

A possibly harmful explosion should be addressed in dusty environments. Hence, it could be advisable to use flameproof motors and switches or to make sure that they are placed in an area that is generally clean. For individuals physically participating in cleaning activities as well as during manufacturing, if required, adequate protective clothing and other equipment should be given.

Foods that rely on attaining a specified quantitative composition for their preservation and/or specific qualities and maintenance of their quality throughout the course of their intended life are said to be compositionally maintained. The importance of such compositional elements should be emphasized throughout the training of production supervisors, operators, and quality control employees in goods where a quantitative compositional component is crucial. The desired composition should be regularly fulfilled via the use of production techniques and control systems.

K. Innovative meals and foods made using unique methods

The use of novel food or food components made from raw materials not previously used in the region of the globe in question for human consumption or manufactured using a new or significantly altered procedure not previously utilized in the manufacturing of food should be done with caution. This must take into account issues with food safety, adherence to the laws of the nation for which the product is intended, and the providing of label information to allow the buyer or consumer to make an educated decision.

L. Foods produced for use in restaurants

Foods produced for food service operations should also take into account any extra specifications related to the intended usage. The term "manufactured" in this context refers not only to food items produced by a food manufacturer and sold to a food service operator but also to food items that a food service organization prepares in a central production facility using factory-style processing for use in its own food service outlets, as opposed to preparation in "cook-serve" form. Special consideration should be given to the use circumstances and settings, the expected level of skill of the food service operator and employees, and the interactions that the product is likely to have with the environment in which it will be used. The maker has to be ready to advise customers technically on whether a product is suitable for the intended usage as well as any necessary safety measures.

M. Food products for vending machines

Foods intended for vending machines should consider potential interactions between the product, surroundings, and machinery. When creating products for these uses, the manufacturer should take precautions to be aware of potential risks like the environment inside the machine, the need for hygiene and cleaning, the flow characteristics of the product, the variability of throw or dispensation, interactions between the product and the machine, and interactions with other ingredients or products. Certain product performance criteria, such as dispersion at below-scalding temperatures or interchangeability with rival items in comparable vending circumstances, may be required for vending operations.

N. Handling complaints and product rejection

Product rejection is inevitable at times, thus appropriate disposal methods should be discussed and decided with the Food Control manager, the Production manager, and any

other interested parties like the Purchasing manager or Sales/Marketing Departments. When deciding how to dispose of anything, consideration should be given to cost recovery requirements, safeguarding the business or brand reputation, and complying with any applicable legal or local government regulations.

By using a suitable and authorized technique, material may be recovered, reworked, or reprocessed as long as it is safe and acceptable for the treatment, the finished product conforms to the applicable specification, and the associated paperwork properly reflects the events. It is impossible to be explicit about each situation here since there are so many distinct situations that may occur with various food items and methods. Nonetheless, the topics mentioned here may be divided into three primary categories: systematic, semi-systematic, and to prevent microbial contamination, the entrance of undeclared components, cross-contamination with allergies, or the entry of foreign matter, however, the necessary steps must always be followed.

The leftover meat or poultry from the day before should never be used again. The Food Control Manager should do a thorough risk analysis before approving the potential carrying forward of any more perishable material, and if permitted, safeguards against the substance it was integrated into being carried forward again should be taken. When a quantitatively known product residue from previous production is consistently used as one of the starting materials for the same or another product, this should be noted in the MMI, and the rate or conditions of use there specified should not be changed except through the established procedure for varying MMI.

The term "semi-systematic" refers to situations in which a variable amount of intrinsically satisfying but extrinsically unsatisfactory product happens and may be reused, or situations in which a useful beginning material can be retrieved from a wholesome but faulty product. In such cases, the MMI should include a provision for such recovery with a maximum cap on the rate of integration. Those cases that are not included in the aforementioned paragraphs are considered "occasional." Before choosing disposal, they should always be the subject of hazard analysis and critical review by the food control manager.

All distinguishing markings carried by the original labels for the re-labeling of packs should be carried by the new labels as well. If the pack has a label with a durability indication, the replacement label should have a date no later than the original durability indication.

O. The complaints process

Only when one is aware of prior similar complaints can one fully understand the relevance of quality concerns. Hence, a process must be established for the proper channeling of all reports of quality complaints. The process for handling complaints should adhere to written directives that specify the accountable party to whom the complaints must be directed. If the manager of Food Control is not the accountable party, he or she has to be properly informed and carefully consulted. The accountable party must possess the requisite expertise, knowledge, and power to determine what should be done.

Where feasible, the food control manager should fully investigate complaints about product quality with the assistance of all relevant staff, and a report should be produced as a basis for action and the records. Responding to the complaint and any relevant regulatory enforcement authority are also necessary actions. The faulty material that the complaint sample could represent should be dealt with, potentially via a product recall, when the complaint is valid. Steps should be made to eliminate or overcome the source and therefore avoid recurrence. Reports of complaints should be frequently analyzed, summarised, and evaluated for any patterns or signs that a product recall is necessary or that there is a particular issue that needs to be addressed. The corporate Board and Senior Management should get appropriate summaries with comparable data regularly.

P. Recalling products and taking other urgent measures

A product fault that is brought to the manufacturer's knowledge, whether via a complaint or another means, may necessitate the removal of the product from the retail distribution system or the requirement for a public product recall that also requires product returns from the general public. The capacity to identify items and track down their contents and packaging materials is critical in these circumstances. There should be a specified documented strategy that everyone can understand.

Concerned about the withdrawal or recall of a healthy but subpar product that the manufacturer intends to withdraw or recall, or for the recall of a product or a known batch or batches of a product known or believed to be dangerous or otherwise unsuitable. It is necessary to set up a crisis management team and protocol. To start and organize all withdrawal and recall actions, communicate with retailers, and serve as the point of contact for regulatory authorities on recall-related issues, a responsible person with suitable named deputies should be assigned. Designing production records systems, distribution records systems, and identifying outer cartons and individual packs should be done in a way that makes it easy to effectively track products and, if required, withdraw or recall them. The questionable material will be identified by a reliable method of lot or batch labeling, which will also assist prevent overzealous removal or recall.

There should be documented withdrawal and recall policies in place that may be quickly implemented at any moment, within or outside of business hours. By doing appropriate testing, it should be shown that the processes are workable and can be used within a reasonable amount of time. Regular reviews should be conducted to determine if revisions are necessary in light of evolving conditions or the roles of the responsible parties.

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Recalls or product withdrawals may occur in a number of situations, however, they often fall into one of three categories. When information and assistance from the manufacturer or importer are required when the regulatory authorities become aware of a risk or a risk that is believed to exist. The point at which the producer, importer, distributor, shopper, or caterer. Aware of or suspecting the presence of a risk. When a situation has arisen that compels the manufacturer, importer, or retailer to decide to remove or recall the concerned goods even when there is no known or suspected risk involved.

Even though a flaw or alleged flaw causing a withdrawal or recall may there should be immediate thought given to whether additional batches or production periods may also have been impacted and if they should also be included in the recall if new information about a specific batch or batches or a specific time of production has emerged. The processes should specify in detail how to inform and carry out a withdrawal or recall from all retailers, distributors, and items in transit, or from wherever the recalled or impacted product may be. There should be a process in place to stop the impacted items from being distributed further. The recall process needs to include a way to notify the public. The following details should be included in the recall notification. the product's name, pack size, and a sufficient description to identifiers for the batch in question.

Recalled material has to be quarantined until the best course of action is decided upon for treatment or disposal. Emergency plans should be made to address the likelihood of an actual or potential risk caused by intentional sabotage, product contamination, or ingredient poisoning by bioterrorists, extremists, or disgruntled employees. The first indication of a specific issue in this area could come from a number of sources, such as a complaint from a consumer retailer, the media, the police, the regulatory authorities, or employees. It could also come from personal contact with any company location or employee at any time via phone, email, mail, or personal contact with the regulatory authorities. Therefore, it is crucial that all employees working in manufacturing are aware of the company policies that must be followed when dealing with such threats during and after regular business hours, and that suitable arrangements exist for calling in key personnel outside of normal business hours in such an emergency. It should be clearly defined to what degree any emergency measures may supersede standard management practices. The aforementioned recall processes will be used in an emergency scenario, and the crisis management team in charge of addressing it should have access to the knowledge of individuals working in food control and other pertinent roles.

Due to the potential for such sabotage and even site invasion, certain security measures, such as the use of seals, locked rooms, and other measures, may be required in sensitive locations. Retailers, wholesalers, or food service providers are likely to be involved in any emergency or recall scenario, thus a seamless and effective interaction with their processes should be developed as early as feasible during the crisis.

Q. Own-brand products and other contract manufacturing

Except in cases where responsibility is expressly excluded by mutual agreement between the Contract Giver and the Contract Acceptor, the Contract Acceptor is responsible for ensuring that production is carried out in accordance with GMP in the same manner that would be anticipated were the manufacturing for distribution and sale on his own label, private label, distributor's own brand, contract packing, or similar operation. If the Contract Acceptor has the BRC Global Standard for Food certification, this may be made easier.

The Contract Acceptor is responsible for ensuring that the contract's conditions are expressly set down in writing and that the specifications for raw materials and finished goods are complete and accurate. Quality control, record transfer, coding, rejection, dispute, and complaint processes should be developed and agreed upon, and any specific GMP standards should be made very apparent. It is advisable to identify any potentially sensitive information and jointly agree on any necessary measures.

It is customary for contract givers to attach clauses that guarantee GMP and quality standards. This is ideally accomplished, at least initially, by the Contract Giver's food control manager paying a visit to the production facility. The following goals should be covered throughout the visit. To guarantee that the food can be produced safely in the industrial environment. To come to an agreement on a comprehensive product specification that addresses all elements of the product, process, pack, and delivery, including the criteria to be utilized for approval or rejection and any applicable legal requirements. To determine sample plans to be utilized in the event of a disagreement and the levels of final product sampling by the customer. To assess the manufacturer's control resources, systems, practices, and records to ensure they are adequate. It should agree on objective assessment procedures wherever feasible; whereas subjective measures should, if possible, adhere to recognized and accepted norms. Each manufacturer/customer business relationship must have an agreement in all five areas, and it should be advantageous to both sides.

R. Proper laboratory control procedures

A controlled laboratory should be organized in such a way that it can provide an efficient service at all relevant times required to satisfy GMP criteria. It should also be planned, furnished, maintained, and have enough room to accommodate the activities to be done there. This should contain space for writing, recording, and storing papers and samples, as well as, if necessary, refrigeration for sample storage. The kind of testing materials will determine the resources needed. Facilities must be suitable for the demands

of the tests, whether they are chemical, physical, biological, or microbiological. Staff members need to be appropriately managed, motivated, and trained. The highest standards should be established, and they should be maintained by paying close attention to authorized and agreed-upon techniques, method checks, and, where necessary, trustworthy outside experts. Care should be used while selecting methods to meet the demands of the analysis. For food control objectives, the most effective approach should be used based on the required level of ability of the personnel, accuracy, and speed of results. Methods that are acceptable to any enforcement authority or that are recognized globally should be employed whenever practical. Every analytical plan must always include technique checks to guarantee reproducibility, repeatability, and operator independence.

Labs for chemical, biological, and microbiological research should be kept apart from one another and from production areas. To protect delicate equipment from vibration, electrical interference, humidity, etc., separate rooms could be required. Reagents or items that might contaminate should preferably be stored in a separate facility. Care should be made to prevent contamination between labs and production areas in both directions. Waste items should be prepared for safe storage while they wait to be disposed of. Regulations relating to the control of dangerous chemicals must be carefully followed. The Control of Chemicals Hazardous to Health Regulations 1994, SI 1994 No. 3246 as revised by SI 1996 No. 3138, for instance, have an impact on the selection of safe laboratory working techniques in the UK. The risk associated with each of the chemicals used in the study should be evaluated for each approach, along with guidance on how to control any potential risks. Monitoring of exposure to dangerous compounds should be done as required.

Instruments and equipment used in control laboratories should be suitable for the tests being conducted. Equipment and instruments should be maintained and calibrated by a designated competent person, individuals, or organization at reasonable, stated intervals. Measuring instruments and test items used in the calibration procedure should be calibrated by authorized labs according to traceable national standards. Each instrument or piece of equipment should have a record of the calibration process and its outcomes. The date of the subsequent calibration or service must be noted in these records.

II. DISCUSSION

Future manufacturing techniques, traceability requirements, and facilities, changes in the acceptable level of protection required by legislators on behalf of society in various countries, and an increased ability of major retailers to impose strict quality standards on their suppliers are the factors most likely to have an impact on GMP.

Their goal is to determine whether flexible automated food processing lines can be constructed using a number of sealed units or modules that connect to one another via industry-standard interfaces. Each module would have its own processing environment that is sealed off and equipped with its own processing machinery. Barriers that stop contamination would connect the modules to one another. They could then be quickly and easily moved around using standard interfaces to reconfigure the "factory in a pipe" to meet various processing requirements. The researchers hope to invite additional industrial partners to advance the work into a full DEFRA Link project and build a demonstrator plant if the concept is found to be workable.

If the "factory in a pipe" idea is successful, there could be a host of advantages, including a reduction in the number of workers, lower energy costs, improved hygiene, and the ability to process food in unfriendly environments for people in order to extend shelf life and create novel new products. For instance, preparing chilled ready meals in such a system would greatly simplify hygiene control while only chilling the enclosed area rather than the entire factory building and its occupants [10]–[12].

III. CONCLUSION

Future traceability systems might make effective use of more recent technologies, like radio frequency identification, which is already being tested in retail and is likely to see increased use as costs decrease. However, there is still a problem with how manufacturers and retailers can use traceability "documentation," and this depends on better data management systems, perhaps with Internet use.

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A Brief Overview of the Standard Operating Procedures

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***Abstract*— Standard operating procedures should be developed and put into operation in a food processing and handling facility in addition to adhering to good manufacturing practises as outlined in Chapter 21. Specificity is the main distinction between SOPs and GMPs. SOPs are extremely specialised and concentrate on regular or repeated actions, operations, or functions inside the facility or system, in contrast to GMPs, which are general practices used across the facility or system.**

***Keywordss*— Food Safety, Monitoring System, Monitoring Record, Sop Monitoring, Stander Operating.**

I. INTRODUCTION

For people to carry out these tasks efficiently, they provide them with information and instructions that are very detailed and targeted. An essential component of the entire food handling or processing operation is the creation and use of SOPs for important tasks. They could talk about the organization's administrative and/or technical operating duties. Good SOPs encourage uniformity in the application of processes or procedures and might boost productivity by reducing staff workload. They lessen the likelihood of misunderstanding and faulty communication while also providing a foundation for staff training. Moreover, increased data comparability, believability, and legal defensibility are benefits of well-written SOPs [1]–[3].

Federal regulatory organisations in the US need certain SOPs for a range of tasks throughout the industrial sector. Some employees in the food business may already be knowledgeable about the laboratory SOPs needed by the Environmental. SOPs are a tool used by the US Army Veterinary Corps to assess a facility producing food for the US Department of Défense. As part of this programme, military auditors demand and assess SOPs for process controls, food sanitation, control of food safety hazards, and quality systems against the Military Standard to determine compliance. SOPs are necessary to confirm that a facility is operating within the defined limits as part of their quality management system when a facility is being audited for conformity with Military Standard 3006A.

SOPs must be properly developed such that they are useable and adhered to in order to be effective. SOPs that are too generic and poorly drafted are obviously not very useful. However, even well-written SOPs lose their effectiveness if they are not implemented. As a well-executed SOP programme offers a summary of compliance with GMPs and other practices, it requires careful planning to include a documentation and tracking system. Moreover, SOPs should be easily identifiable and available for employees carrying out the duties to refer to in the particular work area. The SOPs that describe the work processes and provide a framework for documentation for those actions related to the manufacture of safe food items are the most useful in terms of food hygiene and sanitation. Sanitation SOPs are often used to refer to SOPs that explicitly handle sanitation issues.

A. The essential elements of SOP programmes and SOPs

To guarantee that sanitation operations in a food processing facility are successful, valid SOPs are crucial. The usage of SOPs is a great technique to show mastery of duties or capabilities, such as process controls, daily hygiene, or sanitation systems. An auditor can tell that a company has control over its processes if it has well-documented SOPs. The essential elements of these SOPs may, however, change somewhat depending on the specific demands of independent auditors, the military, and regulatory bodies.

SOPs should be prepared as a group or team effort with participation from all concerned personnel with appropriate knowledge and expertise about the procedures and processes involved. The processes and system analysis and assessment should be given enough time. Attention should be given to the number of SOPs necessary, a description of the primary duties, and the overall sequence or procedures. Consideration should also be paid to training requirements and needs. Before examining the essential components of SOPs, it is crucial to highlight that each SOP is prepared as part of an overall sanitation programme for particular sanitation conditions and practices. This curriculum also includes monitoring essential SOP conditions and procedures. Rectification of those SOP circumstances and procedures not in conformity; and Documents to document the monitoring and adjustments.

B. General SOP components

The general main components of an SOP include the following.

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C. Identification

SOPs should be properly recognised as follows: The title should be descriptive and clearly explain the activity or procedures. Facilities with many SOPs for various operations should use an identifying numbering scheme for proper retrieval and referencing. The date of issuance, as well as the date of any amendment, should be explicitly mentioned. Identification of accountable person. The signature requirements for SOPs may vary but should contain the signatures of the person who wrote and authorised the SOP, as well as of individuals responsible for daily implementation and their superiors. An area for regulatory signatures may also be relevant for certain SOPs mandated by legislation.

D. Table of contents

A table of contents is optional and may not be essential for each SOP, depending upon its complexity. If SOPs are collectively preserved in a single document, however, a table of contents should be employed and is handy as a fast reference for accessing information.

E. Purpose and Scope

Different terms may be used for this section. This should be a brief description of the precise aim of the SOP. A concise explanation of the scope of the SOP should be supplied. Which is particularly covered by the SOP.

F. Regulatory Requirements and Implications

If the SOP is a component of a preparatory programme needed under a HACCP. If relevant, a table of definitions of specific terminology, abbreviations, acronyms, etc. may be supplied for each SOP. If SOPs are collected and preserved in a single document, the definitions might all be merged into one part of the overall document.

G. Special Precautions and Procedures

If appropriate, SOPs should include a written warning of any risk of personal injury involved with performing the tasks. The procedures section of an SOP is the framework and fabric of the document. Since wordy and lengthy procedural statements and SOP documents are difficult to implement, the format should be concise, step-by-step, and easy to read. The following should be considered in writing the procedures section. Each step should define one action or task. Combining steps should be avoided. As employees generally tend to ignore long SOPs, it is often recommended that SOPs contain no more than 10±12 procedural items or steps. If an SOP goes beyond this number of steps, it may be appropriate to break it up into sub-SOPs or two SOPs. SOPs should be written in the language appropriate to the ethnic background of the workforce. For example, an SOP written in English cannot be effectively followed by employees who do not read English. The most effective SOPs are those written in active voice and present verb tense. Active voice/ present verb tense usually provides stronger directive statements to the person performing the task while using a few words.

Procedural steps should be written with sufficient detail such that someone with limited experience, but with a basic understanding, of the procedures can adequately follow the procedures without supervision. However, care should be taken when providing highly specific data in procedural steps, unless it is necessary. The provision of precise data implies that these values will be precisely monitored and documented. For example, providing a precise temperature for the detergent solution used to clean a piece of equipment implies that this temperature is precisely monitored and maintained at that temperature. Depending upon the procedure or condition and how it is to be monitored, it may be advisable to provide a minimum value, a maximum value, or a range of values. The use of general descriptive terminology may be used, but only when precise monitoring is not appropriate or necessary. However, if monitoring is necessary to determine the effectiveness of the procedure, these descriptive terms should not be used, as they do not provide enough information for consistent day-to-day monitoring operations [4]–[6].

Use of phrases such as see manufacturer's recommendations or according to manufacturer's recommendations should be avoided in SOPs. An SOP should be a stand-alone document to be adequately followed by employees. The manufacturer's recommended procedures may or may not be readily available to the employee performing the tasks. Thus, it is more appropriate to list these recommended procedures as steps in the SOP. Revisions of SOPs. SOPS must be kept current and up to date. Whenever significant changes in the processes and/or practises occur, the SOPs should be revised accordingly. SOP monitoring and record keeping

The adage, `if you did not write it down, you did not do it', definitely applies to SOPs. This is especially true where SOPs are required by commercial or regulatory entities. The monitoring and record-keeping programme should be formatted in such a way that it is easily implemented. A wide variety of monitoring procedures are used. Monitoring of SOPs is usually subjective and periodic but could involve continuous monitoring using instrumental devices. For example, typical monitoring procedures used to evaluate an SOP for cleaning and sanitising a food contact surface may include the visual observation that the tasks are completed, a visual inspection that the surface is clean, chemical testing of solutions used, or a verification check.

As much as is practical and practicable, an SOP monitoring programme should be designed with the specific SOP and the procedures and practises listed therein in mind. However, it is not necessary and may be redundant to repeat all the SOP steps on the monitoring record. The individual responsible for monitoring May, in some instances, be the same individual as performed the tasks, the supervisor, or both. The monitoring frequency also varies with the requirements of the SOP. For example, an SOP established for the condition and maintenance of food equipment may

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International Journal of Science, Engineering and Management (IJSEM)
Vol 10, Issue 2S, February 2023

require monthly monitoring, while monitoring for an SOP established for cleaning and sanitising equipment would be daily or more frequently.

SOP monitoring records should be structured similarly to the SOPs themselves: succinctly, plainly, and intuitively. An SOP monitoring record should include the following details. Minimum requirements or objectives for the work being monitored. Information about surveillance and the participants' job descriptions and duties. An explanation of the necessary remedial activities. A declaration of remedial measures, and the day and time of the observation. The individual doing the monitoring's signature or initials; and the supervisor's initials or signature.

An employee replies to a series of questions by inserting a checkmark in the relevant box as either yes or no, which is a popular structure for an SOP monitoring record. Another option is to ask the person in charge of monitoring to sign their name and the date in a box on the table to indicate that certain duties have been completed. It should be reminded that SOP monitoring records and forms are not intended for inspection or auditing purposes. So, it is often inappropriate to seek for subjective assessment from others. For instance, using judgement language or a rating or scoring system in an SOP record would not be suitable.

SOP documentation which should be current with the actual practises being carried out provides evidence of ongoing daily procedures. As a result, SOP monitoring forms may undergo periodic revisions as judged necessary to offer the most accurate representation of current procedures. When the SOPs themselves are amended, it can also be essential to update the monitoring forms. An archival record should be maintained on file whenever the monitoring form or an SOP is amended, together with a note explaining why the changes were made. Depending on the kind of product being made, as well as on the demands of regulatory bodies or consumers, different SOP records should be maintained on file for different amounts of time. SOP records should generally be retained for a minimum amount of time that is at least equal to the anticipated shelf-life of the product.

II. DISCUSSION

The goal of an SOP program's verification is to show that the procedures and SOPs properly describe the standards and requirements for good sanitation and that they are being followed to the letter. An SOP should be verified via suitable assessment techniques if it is being used as a control measure for a food hazard to show that it is successful in containing the risk.

Verification and review should be carried out by someone with the necessary education and expertise. The verification should ideally be carried out by a different person from the SOP's author. Verification should be carried out from the beginning before the SOP is finalised, and anytime major changes to the procedures and methods call for a modification of the SOP. SOPs must be maintained current; hence a yearly verification is necessary. As previously mentioned for SOP monitoring records, a file should be maintained with a record of verification actions [7]–[9].

SOP requirements for HACCP programmes that are regulated the US Department of Health and Human Services/Food and Drug Administration and US Department of Agriculture/Food Safety and Inspection Service include SSOPs as prerequisite programmes as part of their regulatory HACCP systems. While these agencies' requirements for regulations varied significantly, their fundamental goals in relation to SSOPs are the same.

A. FDA HACCP guidelines

For juice made from fruits and vegetables as well as fish, the FDA has issued HACCP requirements. The National Conference on Interstate Milk Shipments programme also includes an optional HACCP programme for Grade A fluid milk and fluid milk products. Some HACCP programmes have similarities to SSOPs and precondition programmes, but there are also some minor variances, which are covered in the following.

Regulations of HACCP for FDA seafood in 1995. In addition to mandating the HACCP system's application for domestically and internationally traded fish, fisheries products, and molluscan shellfish, these laws place a strong emphasis on adherence to precursor programmes like current best practices for manufacturing; and Sanitation management techniques.

B. Juice FDA HACCP guidelines

FDA HACCP standards for domestic and imported fruit and vegetable juice and juice products were first published in 2001.10,11 These requirements are fairly similar to those for fish and fishery goods. The need of written SSOPs as opposed to their recommendation, as is the case with the seafood HACCP rule, is a remarkable exception. The eight essential sanitation procedures and circumstances must be followed before, during, and after processing, according to these SSOPS. Similar requirements to those for the seafood HACCP rule apply to monitoring, record keeping, and record retention. If shared equipment is used to process both milk and juice, the FDA advises using strict SSOP controls to prevent cross-contamination of milk allergens into juice. These SSOPs should include sufficient logging and documentation to ensure that such equipment has been cleaned properly before it is used to process juice.

C. Management and Personnel Concerns

According to the authors' experience, management and people difficulties are the most frequent obstacles when it comes to successfully adopting SOPs. The following are some typical obstacles that might prevent SOPs from being implemented smoothly.

ISSN (Online) 2456 -1304
International Journal of Science, Engineering and Management (IJSEM)
Vol 10, Issue 2S, February 2023

D. Insufficient teambuilding

Too often, one person is responsible for drafting SOPs. The SOP is often monitored by the same person who also does pre-operational inspections, audits, and SOP monitoring. This puts this person and others who are expected to carry out the duties in a "we vs. them" scenario and causes trust to erode, which impedes successful implementation. It is essential to take a team approach and get the support of all staff engaged. This also refers to the participation of the workers themselves. The usefulness of an SOP that was created by someone who has never performed the job is restricted.

E. Inadequate backing from senior managers

An efficient SOP implementation programme cannot be carried out without the backing of high management. Every employee, from the supervisor to the line worker, needs to feel empowered to apply SOPs with the help of effective incentive systems and people management. Implementing SOPs ineffectively might result in a highly prescriptive, top-down management style.

F. Inadequate working hours

Another often occurring issue with employees is how understaffed and production-focused many facilities are. As a result, cleanliness and SOP execution may not be seen as being as vital as they need to be. SOP development and implementation demand a significant time investment to be successful. The SOP programme will not succeed if there is not enough support and time allocated.

G. Inadequate instruction

Effective SOP implementation requires a strong training programme. SOPs that have been carefully crafted may really be utilised to support staff training. The effectiveness of SOP implementation will suffer if training is not given enough attention.

H. Functional concerns with SOP

Inadequate monitoring and documentation systems

The monitoring and record-keeping programme may be burdensome, poorly designed, or inadequate, which is a functional issue that often prevents the successful implementation of SOPs. It should be kept in mind that not all workers find SOPs fascinating, and there are those who may not strictly adhere to the monitoring frequency and instead fill out the forms at the end of the day or less often than required. For implementation to be successful, supervision and the proper chain of responsibility checks are essential.

Incorrect information

As mentioned above, choosing the right level of information is a significant difficulty when developing SOPs. SOPs that are too wordy and detailed cannot be applied to daily operations. SOPs with too little specificity, on the other hand, are ineffective and just partially useful. The amount of detail must be assessed during verification and review.

I. Regulation's effect and third-party audit requirements

While the HACCP and SOP standards, as well as the customer audit requirements, have generally had a beneficial objective and effect, there could be some drawbacks to these programmes. The efficacy is closely correlated with how well the auditor and food handling entity work together. One error that results from a lack of trust or collaboration is to intentionally draught extremely bare-bones SOPs with few specific descriptive phrases rather than giving information for parameters. This is being done out of concern that if the monitoring and record-keeping programme failed to show compliance with the stringent mandated details, a third-party auditor or regulatory authority may invalidate the SOP. The wrong and naive idea at work in this situation is that if you withhold the precise facts, the person doing the audit will have less to look into and will be less likely to fail you. Whether such information is required within the SOP's aim must be determined via discussion with the team and the auditors [10]–[12]

III. CONCLUSION

Lastly, regulatory standards' strict prescriptiveness may lessen. Individuality and inventiveness. For a wide range of applications, excellent regulatory guidance materials and model SOPs are available. These may not, however, be appropriate for everyone. Industry people may take the easy route by concentrating more on the minimal regulatory requirements and these sample papers rather than exerting the necessary effort to create customised SOPs for their own operations. As a consequence, the team-building and development processes required to create customised SOPs that may be successfully executed in their particular operation are lacking among the staff.

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Methods of the Managing Risks from Allergenic Residues

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***Abstract*— With numerous reports in the medical literature from the 20th century, food allergy has long been recognized as a clinical phenomenon.13 Even though it was known that patients could experience extremely severe and occasionally fatal reactions after ingesting very small amounts of the offending food, food allergy was only thought to be a problem for specific sufferers. Nevertheless, this perspective has evolved since 1985, and food allergy is now acknowledged as a significant public health issue.**

***Keywordss*— Allergenic Residences, Cross Contact, Food Allergy, Risk Management, Residual Allergen..**

I. INTRODUCTION

The growth in the prevalence of atopic disease, a symptom of which it might be regarded, is likely a significant contributor to this growing worry. While there is a dearth of reliable baseline epidemiological data that allows for clear conclusions, the prevalence and incidence of food allergy as well as the number of severe reactions5 may be rising. The shift in how people see food allergies has been followed by an understanding that the issue can only be solved via cooperation between all the interested parties, including patients and those who care for them, physicians, government agencies, and the food sector [1]–[3].

The ultimate goal for all parties involved is to prevent people who have food allergies from responding to the allergens to which they are sensitive. There are two methods to do this. One is to ensure accurate allergen declaration through labelling, and the other is to ensure that, in cases where a particular allergen is not declared, the product does not contain it in a quantity that would put consumers at risk and lead them to believe it is safe for them despite the absence of a declaration. Only a thorough understanding of product composition may satisfy both of these conditions. The procedures used to manufacture food are quite complicated. Its complexity results from several variables, including the source of materials, their processing, the effective use of equipment, and other resources, and the creation of products. An integrated strategy that considers all these aspects throughout the supply chain, from ingredient suppliers to retailers and, finally, the customer, is necessary to manage allergy concerns.

It is sometimes difficult to completely exclude cross-contact, which would result in the removal of certain allergens from goods when they are not a component of the formulation. In such cases, it is necessary to analyze the danger posed by the residual allergen and then conduct a quantitative risk assessment. The amount of an allergen in a product is a crucial factor in this evaluation and the subsequent control of the allergy risk, even if information on the lowest triggering dosages for many allergens is lacking. Many stages in the examination of this risk might include the use of allergen detection techniques. They include the preliminary analysis stage, during which the present risk is identified, and the verification of certain risk management practices, such as line cleaning. Analytical techniques may be utilized upstream of the food maker as a part of the supplier audit procedure. The identification of allergens is important for incident investigations and process standard adherence. The function of allergen detection techniques will be covered in this chapter, however, specifics of each approach will not be covered until they may have an impact on how they are used in a certain situation [4]–[6].

A. Product safety and food allergy

It is helpful to look at food allergy as a safety concern more broadly before discussing the function of detection technologies in maintaining the safety of customers who are allergic to certain foods. The fact that the danger of food allergies is different from that of other toxicants is the first thing to take into account. Food allergy affects only a specific segment of the population, and food allergens pose no risk to non-allergic people, regardless of the level of intake. In fact, schemes for the classification of adverse effects of food usually distinguish them from toxic reactions, which may affect anyone who eats the food. Yet, even if risk assessment in food allergy must concentrate on the unique population at risk, it is still beneficial to analyze it using the widely known methodology of hazard identification, hazard characterization, exposure assessment, and risk characterization.

The characterization of the issue, namely food allergy, includes the first phase, hazard identification. Every immune system-mediated response to food is considered to be hazardous, albeit for practical reasons this only applies to reactions that include antibodies of the IgE class. Clinical reactivity is a notion that is fundamental to the recognized definition of allergy. Hence, it eliminates circumstances in

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Vol 10, Issue 2S, February 2023

which individuals are only sensitized, as determined by skin prick testing or measurement of certain IgE, but otherwise do not respond upon contact with the meal.

The process of characterizing risk involves determining how the dosage of a substance and the effect it has. This is often accomplished in traditional toxicology by tests on the appropriate animal species. They help to define a no-observed adverse effect threshold from which a safe dosage for persons may be established. They also give information on dose-response correlations. Food allergy hazard characterization differs from this scenario in two ways: firstly, there is no need for animal experiments and secondly, it may be examined at both an individual and community level. The individual component is most useful to the doctor counseling a patient on condition treatment, while the population dimension is most significant from the perspective of public health, and as a result, for the food producer.

B. Information regarding this is particularly difficult to get by due to ethical considerations.

Individual receptivity to various allergen dosages. Only when the dosage increment utilized turns out to be too great may full characterization, up to the point of the most severe response, occur accidentally. Yet, it is practical and moral to characterize how people react to dietary allergies in order to support patients in managing their condition. In trials utilizing a double-blind, placebo-controlled food challenge, allergen dosages are increased until the lowest level produces an objective response. These studies include details on how often the group being studied responds to certain dosages. Unfortunately, these studies have a number of shortcomings as instruments for determining an exact NOAEL. First off, they can only be carried out logistically on very few allergic people, which reduces their statistical power. A typical clinical trial might test 29 or 58 participants, and it can be shown that statistically, such numbers provide 95% confidence that less than

An additional drawback is that some doctors remove participants who have had a severe response to the allergen of interest from the trials. These patients make up about 10% or 5%, respectively, of the population from which they are taken. Recently, a modeling strategy to solve these issues was put forth. while this strategy is showing promise, significant validation work must be done before it can be used to risk management.

Exposure evaluation is necessary when the hazard has been identified and a NOAEL has been established. Acute intake of often very tiny quantities of an allergen poses a concern to those who have food allergies rather than chronic ingestion. The quantity of allergen that could be present in a serving of food is often taken into account for risk assessment considerations. Yet, there is a significant unsolved problem about the time frame during which the intake of allergen should be added, as well as the potential impact on the provoking dosage of exposure to tiny quantities, incapable of eliciting an allergic response on their own. In fact, exposure to such dosages through routes other than the oral one has been linked in certain papers to enhanced reactivity.

C. The goals of managing food allergies

Protecting customers who have food allergies should be the first priority of food allergy management, without needlessly restricting their meal options. This implies the above-described risk assessment since, in certain cases, the alternative would be to mark practically all items with cautious language. Indeed, a risk-based strategy for managing food allergens during food processing is the basis of the function of allergen residue detection technologies. Methods to identify leftover allergens wouldn't be necessary if allergens were always stated, regardless of the harm they provide. The allergic customer would only be made aware of certain allergens' presence and allowed to take personal risk management measures. Yet, allergic customers perceive this strategy as a dereliction of duty and strongly disapprove of it.

Moreover, it may mislead customers about the safety of items, putting them at greater risk rather than protecting allergic people. From the standpoint of the manufacturer, managing allergens on a risk basis entail effectively forming an opinion about what portion of the allergic population it is practical to protect, based on knowledge of NOAEL for specific allergens along with an evaluation of achievable residual allergen content for specific products.

The objectives of allergy management must be clearly defined in order to create process control goals and to provide a foundation for clear communication with stakeholders, such as allergic customers and the medical professionals they contact for guidance. For instance, choices must be taken on whether the policy tries to prevent all allergic people's reactions or simply the most severe ones. It's important to consider the ramifications of reaching this goal in a broader socioeconomic environment. For example, more extensive cleaning techniques can have negative environmental effects, or adding water to dry systems might create a microbiological threat. Those that are allergic have a very broad range of responses, and some of them respond to very low amounts. Only by telling these customers not to eat produced foods can their protection be ensured.

II. DISCUSSION

Modern strategies for managing allergen risk in the food business take into account the fact that it must be incorporated throughout the whole life cycle of the product, starting with its design and ending when the customer consumes it. The function of allergen detection techniques must be compatible with that integrated strategy. Large food producers have created detailed corporate policies for managing allergies, which are complemented by guidelines that provide helpful guidance to particular production units. By using these techniques, the organisation is guaranteed to handle allergies to a high minimum level. For instance,

ISSN (Online) 2456 -1304
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Vol 10, Issue 2S, February 2023

Unilever's allergen policy requires the company to disclose the presence of any allergen that often causes allergic responses in its products. Any allergy that must be disclosed by local laws will at the very least be present. Nonetheless, if clinical or epidemiological evidence suggests it is necessary, the allergic risk from foods that are not typically recognized to be allergenic may be examined. This food ingredient would be disclosed on labels and included in HACCP plans if it were later shown to be a frequent cause of allergic reactions. Also, Unilever promises to let any customer know if any particular items have rare allergies upon request [7]–[9].

Allergen management rules must make sure that allergens are accurately and clearly stated in goods while also making sure that they are not unintentionally present at levels that might have a negative impact on health. These particular criteria must cover every phase of the product life cycle, from design to ingredient procurement to manufacturing, labelling, and distribution. It must specifically address the following:

A. Innovation

Is the allergic component required for the product's functioning, or might a comparable non-allergenic ingredient work just as well

B. Supply chain

In order to regulate allergies throughout the supply chain, suppliers must have a good working connection with us in order to comprehend and satisfy our demands. A questionnaire describing the allergens handled and the safeguards in place to prevent cross-contact, including if a HACCP plan is in place, would often serve as the starting point of the supplier evaluation. Periodic inspections of the suppliers' facilities serve as support for this. Also, suppliers must get permission before changing the composition of a component they provide.

C. Manufacturing procedures

Manufacturing procedures are still another essential component. Common allergens should be included in HACCP plans, production should be scheduled to minimize cross-contact, cleaning methods should be verified, and particular allergenic substances should be clearly labelled and separated within the factory. Processes must cover rework, in which sound product is "recycled" rather than packed. Employee education on the significance of allergen control measures is essential and strengthens support for what may be extra production-related processes. Lastly, both the company's own production plant and those of co-packers need the same level of care. Packaging, advertising, and promotion: packaging includes a label.

D. The information on allergens

To guarantee that information stays with the product until it reaches the customer, care must be taken. Warnings should be included if the formulation has changed and now contains a component that was previously absent and is allergenic.

E. Retailers

Often, the allergy information provided by the manufacturer will be enough. But, it's important to take caution to make sure the customer is fully aware in instances like in-store promotions. When a good product falls short of all requirements for public sale, it may still be repackaged and sold at specialty stores or even in a new market. The producer must make sure that the right allergy information is stored and made accessible to the final customer.

F. Food professionals

The majority of food allergies happen outside the house, where products are often not labelled, and even when questioned, food professionals fail to provide accurate information. The manufacturer has a duty to make sure that proper allergy information is given and communicated to the consumer in cases when pre-prepared food is offered to that sector.

G. Allergen detection's function in the comprehensive strategy

There are many instances when the identification of allergenic residues is important, as shown by a consideration of the different stages of the product life cycle. These will all be the areas where it is unclear if allergens are present or what level they are at. By definition, detection only applies to allergens that could unintentionally be present, hence it will also apply to any steps prior to those in the production process. During the invention stage, the detection of allergenic residues will play a very little role, however, it could be helpful when choosing between ingredient suppliers. As was said, determining the risk of unintentional allergen presence starts with the component suppliers, and it is evident that measuring residual allergen levels might provide useful data.

As previously stated, the goals of the policy must serve as a guide when using detection methods in allergy risk management. It is uncommon, if ever, feasible to completely eliminate the allergen risk, which is to say a guarantee that no allergic person will be harmed, regardless of their sensitivity or the degree of responses they suffer, unless certain allergens are prohibited from production facilities. The smallest dosage that causes a response in those people is a crucial factor in determining what has to be done in order to provide a certain degree of protection to the allergic population. Even in the case of the most prevalent food allergies, information on such dosages is regrettably still limited and the topic of considerable discussion. These may be challenging to utilize with confidence in the management of risk allergies, especially given how challenging it is to quantify the uncertainties associated with their derivation. The level below which residual allergenic protein in a food must be kept in order to protect a specified proportion of the

allergic population has recently been attempted to be estimated by mathematical modeling. As work progresses on defining such levels, they will provide more effective ways of monitoring the success of risk management measures. Techniques for the

As a result, the relevance of residue detection will rise in tasks like verifying that materials and goods adhere to guidelines and validating risk management practices like cleaning. Therefore, they will also serve as the foundation for the authorities' evaluation of conformity. There are several applications for methods for the detection of allergenic substances. In the business world, this will comprise what is essentially the risk assessment's exposure assessment component. Assessing the degree of cross-contact at various sites as part of a HACCP study and then validating the controls put in place to limit the degree of low-level homogenous cross-contact are typical tasks.

As part of the audit of suppliers' processes, these techniques could be used to verify suppliers' claims about their ingredients further up the supply chain. Downstream, product analysis could be considered in cases where incidents have occurred or there is a suspicion that allergenic residues may exceed the allowable limit. Similarly, confirming the presence of residues and their quantity would be a crucial first step in any event inquiry. Yet, other possible users of detection techniques exist besides industry. Demonstrating the existence of residual allergens in items that are not intended to have them may be a significant component of the evidence that public authorities use to justify compliance operations. While none of them are now appropriate for this kind of application, allergic consumers may also be future users of such approaches.

In terms of detection limits, quantitation, robustness, and usability, various users presumably need different approaches with distinct features. Activities involving risk assessment need quantitative assessments, thus it's necessary to use measurement techniques that can detect important residues even in complicated matrices. While preferred, it is generally not necessary for the procedure in HACCP investigations to be simple to use. On the other hand, enforcement agencies won't really be concerned about quantitation unless the applicable rules have an action level. It would probably be sufficient for a technique to have a sufficient detection limit and to be known not to create false positives if no threshold was given. No false negatives and a sufficient limit of detection are essential for prospective allergic users.

It has been demonstrated numerous times that an allergenic food's allergenic activity is typically dependent on a variety of proteins, and it has also been demonstrated more recently in allergic patients and laboratory animals that the overall response to an allergenic food is a summation of the responses to the individual proteins. These findings have the consequence that immunoassays for food allergens should primarily be thought of as methods of quantifying the relevant protein, as opposed to evaluating the allergenic activity in the meal, which will vary for each allergic patient. Another implication is that quantifying individual allergenic proteins may be useful for observing how processing affects these proteins, but it may produce wildly inaccurate results when used in an assay for determining, for example, the extent of cross-contact or whether a product contains more allergenic material than is allowed. The test's intended use should thus be the primary factor taken into account while developing the assay. While being the apparent selection, the allergenic protein may not always be the best option. Nonetheless, as protein detection is most likely the most widely used method, it is important to go through the alternatives.

Monoclonal and polyclonal antibody technology are the two major options for an approach for creating an experiment based on protein detection. Both have benefits and shortcomings. If the antibodies have been properly screened, this approach often produces a highly specific test with a reasonably low frequency of cross-reactivity, even with closely related proteins. Monoclonal antibodies recognize single epitopes on proteins. Theoretically, there is an unlimited supply of antibodies that operate identically to the original antibody. The monoclonal antibody's limited specificity, meanwhile, may also be its downfall, since the protein of interest may only be detected if the antibody binding site is still present and accessible in the numerous dietary matrices in which it may be found. Depending on the food preparation, polyclonal antibody technology depends on the creation of a variety of antibodies, either to a particular protein of interest or to all the proteins in the meal. In the event that processing changes the relative quantities of the various immunochemically active proteins in a meal, this offers a detection approach that is less likely to entirely fail to identify the presence of proteins of interest, albeit quantification may still pose problems. To ensure specificity and the absence of unwanted cross-reactivity, as well as the need to develop procedures to ensure batch-to-batch reproducibility, extensive purification procedures that may need to be applied to the protein of interest, as well as to the resulting antiserum, are the main drawbacks of polyclonal technology.

There are various options when the technology has been chosen related to the creation of protein-based immunoassays. As previously mentioned, monoclonal technology produces a highly specific detection system, but it may still be expanded by combining detecting antibodies against other protein or protein-related epitopes. Beyond a few proteins, optimising this gets difficult. The substance against which the antiserum may be developed can be chosen in polyclonal technology. As a result, it may be as broad as an extract of the protein from the whole diet or as specialised as a highly purified protein.

When looking for allergenic residues, it may not always be required or even the best strategy to identify the protein, or

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International Journal of Science, Engineering and Management (IJSEM)
Vol 10, Issue 2S, February 2023

proteins, in question. Instead, a marker molecule that can be consistently detected in a known ratio to the proteins and for which an accurate and sensitive analytical technique exists may be utilised. As an example, lactose in milk may be used as a tracer to determine how much milk protein was left on a line after cross-contact. A marking substance could also be used during supplier audits. An allergic person, however, could only determine if a certain food is safe to consume by measuring the protein. Similar to this, food safety authorities will probably demand that compliance actions directly show the presence of the offending allergen rather than using a marker substance.

The reverse transcriptase polymerase chain reaction test, which is covered elsewhere in this book, has lately attracted a great deal of attention. It makes use of the amplification of any relevant DNA that may be present in the target meal to the point of detection. Moreover, it may be used in a semi-quantitative fashion. Yet when it comes to allergies, it makes the unstated assumption that the presence of DNA in a processed meal indicates the presence of protein, which calls for scientific support.

H. Capacity for detection

Every assay's limit of detection is a crucial metric, but it must be taken into account together with the other factors that make up the test. Along with the other factors, the assay's goal should determine this one as well. It would be reasonable for the detection limit to be set so that the assay could detect allergenic material in a portion of food that was close to the lowest amount shown to cause some reaction under controlled clinical conditions for the majority of purposes, such as monitoring the effectiveness of allergen control measures or verifying compliance with set limits. This naturally raises the issue of what such levels are and the degree to which any ambiguity in estimating the minimum provoking dosages should also be taken into account. In the group of allergic patients, Bindslev-Jensen et al. recently presented their cumulative frequency versus log-normal dosage as a sigmoidal log-normal plot. Minimum provoking doses differ significantly across individuals. The upshot of this distribution is that a tiny percentage of people will react to allergens at extremely low concentrations. Even putting aside potential technological concerns with signal to noise ratio, it is debatable whether assays with this level of sensitivity are genuinely necessary, except from forensic uses. According to a recent suggestion1 that was based on clinical data, efforts should be made to shield 95% of the population who are allergic from allergens that are unintentionally present in industrial food production. Thus, the lowest amounts of residual allergen that should not be exceeded were on the order of 5 ppm protein, a criterion that is met by the majority of the existing commercial tests, assuming minimum extraction losses. The idea of a legitimate lower detection limit should also be kept in mind since it only applies to assays designed to identify a representative range of proteins in food products. In these situations, for the previously mentioned reasons, it may be exceedingly challenging to interpret assays designed to detect a single protein.

I. The optimum allergen detection assay's characteristics

After examining several test parameters for the detection of allergenic residues, it is necessary to look at what a perfect assay may include. But, by posing such a question, one is compelled to wonder whether there can ever be a single "perfect test" that is equally appropriate for all uses. So, a few of the several scenarios in which the "ideal assay" notion may be used will be studied.

For example, a common use of such an experiment would be to evaluate how well various line cleaning techniques work. A key criterion would be that it has sufficient sensitivity to identify significant allergen concentrations and appropriate accuracy to provide an accurate measurement of the analyte. Nevertheless, accuracy is more crucial than high levels of precision. High specificity is also necessary since food items often include a variety of proteins from various sources. When irrelevant proteins are found, it may be required to take more drastic steps than necessary to control allergens or, if the analysis indicates that the issue cannot be solved, to use defensive labelling. Nevertheless, the assay must also be created with the main users in mind in addition to the proper scientific criteria. They won't always be individuals with specialised laboratory expertise in an industrial setting. Hence, the assay design must be sufficiently reliable for use by employees outside of the laboratory; formats like calibrated test strips, for example, are worthwhile to look into. Similar to this, there may be important lessons to be learned from the experience of developing at-home diagnostic tests used for clinical monitoring.

While using assays to measure residual allergen in final goods is uncommon, there are times when it is important. This could include instances when a process error leads to the judgement that a residual allergen is very likely to be present at a level that might risk allergic people or where there have been product reaction complaints, for example. Although many of the characteristics listed for monitoring assays are required for this sort of application, the test is likely to be done by laboratory staff rather than in a factory, thus "user-friendliness," while always desired, is of a lesser importance.

J. Tests for evaluating conformity

The test must adhere to more strict parameters than in past cases where limitations have been placed on the residual allergen levels in food items. Given the possible legal repercussions of the test finding an allergen, accuracy is more crucial than for other assays while sensitivity and specificity remain essential components. In particular, there shouldn't be many false positive results from the test.

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K. Tests for determining individual allergenic proteins

Single allergenic protein tests have been created in large numbers. Although they may sometimes be used for the aforementioned goals, as was already said, they have a number of drawbacks. Nonetheless, they could be useful in assessing the impact of processing, for example, on the targeted protein. In essence, these assays will be very specific and possibly also sensitive. Nevertheless, as they will be used nearly exclusively in laboratories, ease of use will not be a top priority while designing them.

L. Common restrictions

The majority of the assays covered above have a variety of restrictions, some of which are brought on by the technique itself, while others are the consequence of specific combinations of the methodology and the substrate the analyte is being sought for. The three main drawbacks of the technology include changes in the analyte that make it harder for the method to detect them, interference from other matrix elements that cannot be easily separated, and extraction of the analyte from the meal for analysis.

The majority of standard techniques, such as many for total protein analysis, and enzyme-linked immunosorbent assay techniques, work in an aqueous environment and need protein extraction before analysis. The solubility of the target protein in the aqueous extraction buffer will determine how effective this extraction is. Lipids are a common ingredient in meals and food products, and many proteins, including allergens, are linked to the lipid component in these foods and goods.

Based on a comparison with the content assessed by excited nitrogen analysis, which does not need an extraction, we consistently recovered only 50% of the total residual protein by extraction into phosphate-buffered saline in studies to evaluate the content of edible oils. It could be challenging to notice this impact. The recovery of protein injected into oils in the cited case was essentially quantifiable, likely due to variations in their physicochemical characteristics when compared to the proteins still present in the oils after refining. In a separate situation, Keck-Gassenmeier et al. discovered that the peanut protein added to chocolate goods had extremely poor recovery rates. Nevertheless, they were able to increase this to a nearly quantitative recovery rate by adding fish gelatine to the extraction buffer. These experiences suggest that to get accurate findings, one must have a good understanding of the physicochemical properties of both the matrix and the target protein.

M. Interference in a matrix

The food matrix, or some of its components, may actually interfere with the following analysis, preventing the recovery of the desired analyte, if those components are co-extracted in sufficient quantities. As an example, we discovered that sometimes, solutions with a very high sugar content significantly decreased the recovery of -lactoglobulin. Depending on how they fare during extraction, other substances often found in meals, such as colors, may potentially impair the performance of tests based on colorimetric endpoints.

N. Processing-related modifications to proteins

When it comes to allergen detection, food processing undoubtedly presents the most obstacles, especially for the most used kind of assay, immunoassays. Processing may modify a protein's immunoreactivity, the way it interacts with the food matrix, or perhaps both. This might change a protein's allergenicity or affect how easily it can be recognized in the food matrix. As a result, when milk is fermented with certain strains of lactobacilli, the product has less potential to bind IgE than unfermented milk, which suggests that it has less of an effect on the body. Under these conditions, the discovery of reduced levels of milk protein would accurately indicate a decrease in risk to the allergic person. The apple allergen, which is known to be heat-labile, presents a similar problem.

As a total protein test produced a complete recovery, it must be inferred that the changed identification of the protein analyte causes assays to considerably underestimate the quantity of heat-treated milk proteins. For proteins from roasted peanuts, Koch et al. obtained similar results. According to clinical evidence on reactions to the heated milk and peanut proteins, the apparent drop in protein concentration under such conditions does not signal a decrease in risk for the allergic individual. These instances highlight the need of thoroughly comprehend an assay's potential flaws before using it to provide data for risk assessment

III. DISCUSSION

Since the significance of food allergy as a public health issue has grown, the need for the detection of allergenic residues has been established. There are many current developments that might have an impact on how allergy detection is developed and used. One is the evolving legal landscape, which will eventually result in specified action levels. Another is figuring out NOAELs for several of the primary foods that cause allergies. A third issue might be the need for methods of monitoring the allergenicity of certain foods when they are changed to make them less allergenic. Lastly, even if it is not presently possible, pressure from allergy sufferers and their support organizations may result in the development of certain fast tests for checking foods for the presence of cross-contact allergens. We'll look at each of these trends' potential effects independently.

The legal framework around food allergens is quickly evolving as countries like Switzerland, Japan, Australia/New Zealand, and the European Union pass laws defining which items must be labeled as allergic. The lists often expand on the Codex General Standard on Labelling’s list of allergies to include those with more regional significance, such as celery

and mustard in the European Union. As a result of this law, it is expected that food producers would employ test kits considerably more often to support the validity of their allergy risk management practices. The enforcement authorities will definitely try to utilize allergy testing to buttress other evidence, even if it hasn't consistently served as the main enforcement method in other jurisdictions where it has a longer history, like the USA. The problem of allergen presence via cross-contact is not currently addressed by regulation, except Switzerland, and no action thresholds have been established. Yet, as the usage of allergy test kits increases, pressure—particularly from manufacturers—is expected to increase for clearly defined action limits, below which the presence of the allergen would not be illegal. Case law, which is perhaps not the best vehicle for this kind of problem, will likely establish action thresholds if they are not determined by the agencies or the lawmakers.

Manufacturers will have clear objectives for their allergen management plans thanks to the determination of NOAELs and their utilisation, in terms of what concentrations pose a danger to what percentage of people who suffer from food allergies. Also, they will provide producers with knowledge to better manage allergy dangers. Yet, for them to exercise such control, they must be aware of the quantity of allergenic residues in their goods. This information may be obtained by measuring allergenic residues at opportune times throughout the production process, and as a result, its application may grow significantly from what it is now, which is still very restricted.

Another area where the identification of allergic residues may become more important is in the monitoring of the allergenicity of certain foods or food products as producers work to make foods that are less allergenic. While investigating for residual allergenicity by protein quantification is only one stage in identifying decreased allergenicity, this area is probably less significant than the first two. Food allergies drastically reduce a person's quality of life [10]–[12].

An expansion of the measurement of allergenic residues to this whole new region might be prompted by a need for the tools to do so. Given the need for strong and easy-to-use procedures, this scenario is probably still fairly far off. The extent of the test manufacturer's legal obligation in the event that an allergen is not discovered and causes a response in a patient will be a crucial concern.

IV. CONCLUSION

Allergies are a severe public health issue. Although there are medications that can alleviate allergy symptoms, the only way to cure allergies is through immunotherapy, which alters the patient's response to the allergen. Allergen Management is a documented system that restaurants and other food enterprises must build in order to detect and regulate food allergens in their recipes, educate personnel on handling allergenic materials, and convey to consumers the risk and presence of food allergens in meals. An allergy risk assessment is used to identify the dangers associated with the inadvertent presence of allergens. You may determine whether or not allergy warning labelling is necessary based on the results of the risk assessment.

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