ISSN (Online) 2456 -1304

International Journal of Science, Engineering and Management (IJSEM)

Vol 11, Issue 4, April 2024

Edible Coating on Fruits and Vegetables Using Chitosan

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Abstract*— Use of Eco Friendly and user friendly attributes and the materials derived from marine food processing industry waste have wide range of application. Freshness and aesthetic appeal are two elements that influence the customer to buy the products from a market. The fresh quality of fruits, vegetables, dairy products and meat can be increased by composite coating over a mixture of two or more substances that provide antimicrobial protection against microbial activity and oxidation property. This coating prevent ability of microorganisms to grow on surface of fruits, vegetables, dairy products and meat. Compound suggested are AloeVera Gel, Green tea extract, leaf extract, pomegranate peel, date pit oil, Essential oils possess a high antioxidant capacity, a total flavonoid content, a total polyphenol content, and may aid in protecting food from the harmful effects of oxidants. They are widely known for having high antioxidant and antimicrobial volatile compounds. This Composite coating increases aesthetic appearance of food .The chitosan film are able to carry food additives such as antioxidants and antimicrobial agents allowing food to increase its overall quality by improving microbiological and nutritional qualities. Emerging research shows polysaccharides, bacteriocins, Essential oil, leaf extract have realized potential in enhancing shelf life of food. This study compares the effectiveness of composite coatings consisting of chitosan and aloe vera, chitosan and green tea extract on the coated surface. The comparison involves assessing fungal decay, weight loss, color, phenolic compounds, as well as similar evaluations with leaf extract, pomegranate peel, date pit oil, and essential oil. This project illustrates how the quality and shelf life of fruits, vegetables, dairy goods, and meat are affected by a new biodegradable edible coating. This coating assures that there is no need for costly packaging with in and protective atmosphere. Additionally, in order to extend the shelf life of the items, the most active extracts were utilized in this process to create an edible coating based on chitosan. It is safe and good alternative to preserve food.

***Index Terms*— EDIBLE, CHITOSAN, CHITIN, SHELF LIFE, ANTI OXIDANT.**

I. INTRODUCTION

In recent years, the food industry has been under increasing pressure to develop sustainable solutions that not only enhance the safety and quality of food products but also reduce the environmental footprint of food packaging. One promising avenue of research in this domain is the development of edible and biodegradable coatings for fruits and vegetables. These coatings increase the longevity of perishable produce but also address the challenges associate with traditional packaging materials, which often contribute to plastic waste and environmental pollution [2].

Chitosan, a biopolymer derived from chitin, the main component of crustacean shells, has emerged as a valuable candidate for creating such innovative coatings. With its natural abundance, biocompatibility, and biodegradability, chitosan offers a compelling solution to the demand for sustainable food packaging. This paper explores the utilization of chitosan-based coatings to protect fruits and vegetables, providing an overview of the advantages and potential applications of this technology. A modified biopolymer called chitosan is produced when chitin undergoes partial deacetylation. It is made up of units of glucosamine and (1 → 4) connected N-acetyl glucosamine that alternate. [1]It is a white, hard, inelastic and nitrogenous polysaccharide.

Chitosan finds multifaceted applications due to its nontoxicity, biodegradability and antimicrobial properties. It is used in biomedical industries, agriculture, genetic engineering, food industry, environmental pollution control, water treatment, paper manufacture, photography and so on. Chitosan nanoparticles (ChNP) possess the qualities of nanoparticles, including small size and quantum size effects, surface and interface effects, and chitosan-like features. . Because of ChNP's immense potential, this paper receive particular attention.[3] Combination of chitosan and green tea extract is one kind of edible coating that frequently serves as a food preservative, chosen because of its high antioxidant contents. The purpose of this study is to create a food coating film using a composite of chitosan and green tea extract and to investigate the effects of varying the concentration to the phenolic contents and antioxidant activity of the film. The primary goal of this research is to present a comprehensive understanding of the benefits that edible and biodegradable chitosan coatings can offer to the food industry. By investigating the development, application, and impact of chitosan coatings on fresh produce, we aim to contribute to the ongoing efforts in creating eco- friendly and effective food preservation methods. Additionally, we will highlight key findings and discuss the implications of this technology for both the industry and consumers, emphasizing its potential to revolutionize how we protect and package fruits and vegetables.

II. MATERIALS AND METHODS

A. Coating Materials

Persimmon (Diospyros) and capsicum (Capsicum annuum) with uniform maturity and size having no wounds were washed with water and air dried [1]. Dried shells of prawns were collected from market and pomegranate peel, Aloevera gel, date seeds, green tea powder were also collected from different house hold in a bulk amount.

B. Preparation of Chitosan Solution

Raw dried shells were gathered and mixed with a 2 wt% of sodium hydroxide. The mixture underwent a two-hour treatment at 60°C, followed by washing and drying.

Subsequently, the treated shells were introduced into a beaker containing a 7% weight of hydrochloric acid (HCl) and left for 4 hours at room temperature. The mixture was agitated on an orbital shaker during this period. Afterward, the shells were thoroughly washed and dried. In the next step, the shells were immersed in a solution consisting of 50 wt %of NaoH oil at 120°C for two hours [10]. Subsequent to the oil treatment, the shells underwent a washing process with water until reaching neutrality, followed by drying and powdering. This multistep procedure involving alkaline and acidic treatments, along with oil immersion, aims to modify and prepare the shells for various applications. The sequential steps of treatment and washing contribute to the extraction and refinement of desired properties from the shells, ultimately yielding a powdered form suitable for further utilization.

C. Preparation of Antioxidant Extracts

The extraction process for preparing date seed extract, green tea extract, pomegranate peel extract, and aloe vera extract involves a series of steps to obtain bioactive compounds from each source

1. Preparation of Date Seed Extract:

Roasting and Powdering: - Date seeds are subjected to roasting to enhance flavor and aroma. Once roasted, the seeds are powdered to increase the surface area for efficient extraction.

Ethanol Extraction: - 15 g of date seed powder are mixed with 250 ml of ethanol. The mixture is then boiled at 80°C. Ethanol acts as a solvent, extracting bioactive compounds from the date seed powder during the boiling process [11].

2. Preparation of Green Tea Extract:

Powdering: - Green tea leaves are ground into a fine powder to facilitate the extraction of bioactive compounds.

Water Extraction: - Fifteen grams of green tea powder are combined with 250 ml of water and boiled at 80°C. Water serves as a solvent to extract various compounds, including polyphenols and catechins, from the green tea powder [6].

3. Preparation of Pomegranate Peel Extract: Pomegranate peels are dried and ground into a powder to maximize the surface area for extraction

Water Extraction: - Fifteen grams of pomegranate peel powder are mixed with 250 ml of water and boiled at 80°C.Water is utilized as a solvent to extract bioactive compounds present in the pomegranate peels [14].

4. Preparation of Aloe Vera Extract:

Gel Extraction: - Aloe vera leaves are processed to extract the gel, which contains various bioactive compounds. Then it is subjected to water extraction [14].

D. Determination of Weight Loss and Physical Appearance of Persimmon

100 mL of chitosan solution was added to five separate beakers. Subsequently, 20 mL of various extracts were introduced into each respective beaker. The resulting solutions underwent thorough mixing using an orbital shaker for a duration of approximately 30 minutes. Following this, persimmons were individually immersed in the chitosan solution for coating and were then kept at a consistent temperature of 30 °C. Observations pertaining to weight loss and alterations in physical appearance were diligently recorded. After a period of seven days, the coated persimmons were carefully inspected. Weight loss measurements were also conducted at this juncture, enabling a comparative analysis between coated and non-coated persimmons. This detailed process aimed to assess the impact of chitosan coating and various extracts on the persimmons ; weight and physical attributes, providing valuable insights in potential applications of the coating in preserving fruit quality.

E. Determination of Weight Loss and Physical Appearance of Capsicum

Chitosan solutions of varying concentrations, namely 0.5%,

1 %, and 2%, were meticulously prepared through a standardized procedure. In the formulation of each solution, 5g of chitosan powder was amalgamated with 250 ml of 2% acetic acid .This acetic acid solution was precisely concocted by incorporating 15ml of acetic Acid into 750 ml of water, ensuring a consistent 2% concentration. To this varying Concentration of chitosan solution 20ml of green tea extract is added and mix it Thoroughly. These beakers were placed in an orbital shaker for 24 hours. Following Thorough mixing, three capsicum were selected for each chitosan concentration, with One capsicum serving as a control. The weight of each capsicum was measured on the first, fourth, and sixth days, providing a basis for the determination of weight loss Over

time. Furthermore, the physical appearance of these capsicum was observed Throughout the experiment. The integrated approach aimed to assess the impact of Different chitosan concentrations on the weight, physical attributes, and potential Preservation properties of capsicum, offering valuable insights into the application of chitosan in agriculture and food preservation.

F. Microbiological Analysis of Chitosan Solution

In the realm of microbiology analysis, the examination of the microbiological characteristics of a 10 ml chitosan solution is a meticulous process. Initially, a 0.1% peptone solution was meticulously prepared by dissolving 2.85 gm of peptone powder in 300ml of water. From this solution, 90ml of peptone was measured and added to a conical flask.

Subsequently, 10 ml of 0.5% chitosan was introduced to the flask, creating a blend that was subjected to an orbital shaker to ensure thorough mixing. This marked the creation of the stock solution. Replicating this method stock solutions of 1% and 2% chitosan were also prepared.

For the actual microbiological analysis, three test tubes were employed, each containing 9ml of varying concentrations of the chitosan stock solution (0.5%, 1%, and 2%). The next step involved the careful pouring of 15 ml of plate count agar into petri dishes, followed by the addition of 1ml of the prepared sample to each petri dish as a doublet. These prepared petri dishes were then subjected to the pour plate method on plate count agar, facilitating the determination of the number of colonies present, expressed as colony-forming units per milliliter (CFU/ml). This detailed procedure ensures a comprehensive assessment of the microbiological composition of the chitosan solution at different concentrations.

G. ICP-OES for Chitosan Solution

The methodological approach presented herein exhibits absolute detection limits reaching the picogram level, surpassing those reported for inductively coupled plasma atomic emission spectrometry by 10- to 1000-fold. Additionally, it achieves detection sensitivity 10-fold superior to that attained by nebulization with inductively coupled plasma mass spectrometry. The relative standard deviations observed range from 2 to 13%, indicating a satisfactory level of precision and reproducibility [13].

III. RESULT

A. Coating Materials

Approximate uniform weight of Persimmon and Capsicum were collected. Initial weight was observed. Chitosan was extracted from crustaceans shell and was processed. extracts were prepared using pomegranate peel, aloe vera gel, dates seed, green tea powder.

B. Chitosan Solution

2 (w%) chitosan solution was prepared having a gelly like texture which forms a glassy appearance on coating. which is known for its antimicrobial property and ability to form protective barrier, making them valuable in different industries [10].

C. Determination of Weight Loss and Physical Appearance of Persimmon

Color degrade swiftly during storage, but the application of chitosan coating proves beneficial. This coating effectively slows down the decline in sensory attributes, thereby extending the fruit shelf life. Notably, both the control group and chitosan-coated, persimmons remain commercially viable even after seven days of storage. However, after fourteen days, the control group becomes unsuitable for the market, contrasting with the chitosan-coated slices that maintain their high quality.

Additionally, persimmons coated with green tea extract exhibit a pleasing appearance even after seven days, emphasizing the positive impact of such coatings on fruit preservation. Research indicates that chitosan coating plays a pivotal role in enhancing fruit quality and prolonging shelf life. In this study, the application of chitosan on persimmons not only improved overall quality but also prevented issues like surface cracking and juice leakage, contributing to an extended preservation period. Overall, these findings underscore the efficacy of chitosan coatings in preserving the visual appeal and taste of persimmons, providing valuable insights for the fruit storage industry.

Table. 1: Weight loss analysis of persimmon

COATING	DAY 1	DAY 2	DAY 7
CHITOSAN	300g	300g	89g
CONTROL	300g	250g	179g
CHITOSAN + GREEN TEA EXTRACT	300g	300g	210g
CHITOSAN + POMEGRANATE PEEL EXTRACT	300g	300g	183g
CHITOSAN + DATE SEED EXTRACT	300g	300g	188g
CHITOSAN + ALOE VERA EXTRACT	300g	300g	200g

Fig. 1: Physical appearance of persimmon on Day

D. Determination of Weight Loss and Physical Appearance of Capsicum

The color scores of capsicum exhibit a gradual decline during storage, but the introduction of chitosan coating proves to be a mitigating factor. This coating effectively delays the decrease in sensory quality, extending the shelf life of the capsicum.

Fig. 2: Phyical appearance of Capsicum on Day 7

Both the control group and chitosan-coated capsicum maintain commercial viability after six days of storage. However, beyond a certain storage duration, the Control group becomes unsuitable for the market, while the chitosan-coated capsicum retain their good quality.

Interestingly, the sensory quality after three days shows no significant difference among tomatoes treated with 0.5%, 1%, and 2% chitosan. Yet, the disparity Becomes notable between those treated with 1% and 2% chitosan after seven days, As indicated in" Table .2" Notably previously reported that chitosan coating has a Positive impact on vegetable quality and shelf life.

Table. 2: Weight Loss Analysis of Capsicum

COATING	DAY 1	DAY 2	DAY 7
CONTROL	130g	97g	81g
0.5%CHITOSAN + GREEN TEA EXTRACT	135g	118g	106g
1% CHITOSAN +GREEN TEA EXTRACT	135g	110g	98g
2% CHITOSAN +GREEN TEA EXTRACT	135g	126g	113g

In this study, the application of chitosan coating on capsicum not only enhances overall quality but also serves as a preventive measure against surface cracking and

Juice leakage. These findings highlight the efficacy of chitosan coatings in preserving capsicum quality during storage, aligning with previous research on the positive effects of chitosan on vegetables.

E. Microbiological Analysis of Chitosan Solution

Table 3 focuses on the chitosan solution microbiological analysis. The results indicate that the chitosan coating, when applied to both persimmons and capsicum,serves as an effective inhibitor of microorganism growth. Notably, as the concentration of chitosan increases from 0.5% to 2%, there is a discernible impact on restraining microbial growth, as detailed in "Table 3".This observation suggests that the antimicrobial properties of the chitosan coating exhibit a concentration-dependent effect[14].

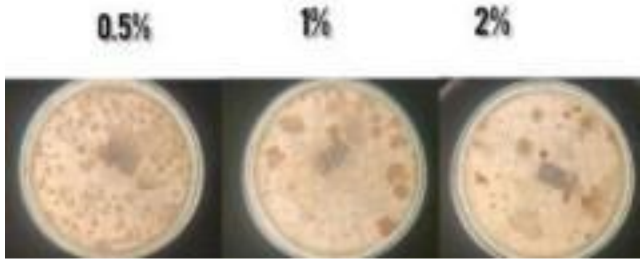

Fig. 3: Microbial analysis of chitosan solution on Day 3

The data underscores the significance of chitosan in impeding the proliferation of microorganisms on both persimmons and capsicum, with higher concentrations demonstrating increased efficacy. This aligns with the broader understanding that chitosan possesses antimicrobial attributes, making it a valuable element in preserving the microbiological integrity of fruits. The findings in "Table 3" contribute valuable insights into the concentration-dependent relationship between chitosan and its inhibitory effect on microbial growth, further emphasizing its potential role in enhancing food safety during storage.

Table. 3: Microbiological analysis of chitosan solution

CONCENTRATION	DAY 1 Avg Colony count (CF U/ml)	DAY 3 Avg colony count (CFU/ml)
0.5%	198 *10 CFU/ml	268*10 CFU/ml
1%	168 *10 CFU/ml	204*10 CFU/ml
2%	35 *10 CFU/ml	73.5*10 CFU/ml

F. ICP-OES for Chitosan Solution

Method of Analysis: Inductively Coupled Plasma Optical Emission Spectrometer.

Table.4: ICPOES analysis result

Sl.No.	Component Name	Sample
1	Arsenic (As)	ND
2	Cadmium (Cd)	0.020
3	Calcium(Ca)	27.400
4	Cobalt (Co)	ND
5	Copper(Cu)	0.390
6	Chromium (Cr)	0.150
7	Iron (Fe)	2.040
8	Lead (Pb)	0.400
9	Lithium (Li)	ND
10	Magnesium (Mg)	13.070
11	Molebdenum (Mo)	ND
12	Manganese (Mn)	0.140
13	Nickel (Ni)	ND
14	Selinium(Se)	ND
15	Antimony (Sb)	ND
16	Stroncium (Sr)	0.121
17	Zinc (Zn)	0.760

Units of measurement=microgram/Litre ND:not detected

This outcome demonstrates that the coating solution is edible and has no negative physiological effects.

IV. CONCLUSION

In conclusion, the research on the effect of edible coatings on fruits and vegetables has revealed a promising and practical approach to enhance the quality, safety and shelf life of these perishable products. The application of edible coatings, for- mulated with various ingredients such as antioxidants, and antimicrobial agents, has been shown to offer several key benefits. First and foremost, edible coatings have proven effective in preserving the compositional integrity of fruits and vegetables. By acting as protective barriers, these coatings inhibit moisture loss, flavor degradation, and nutrient loss during storage, resulting in products that retain their original characteristics. Furthermore, the use of edible coatings has been found to enhance the nutritional and biological value of fruits and vegetables. By incorporating essential nutrients, fortifying with antioxidants, and reducing the impact of enzymatic browning, these coatings contribute to the overall nutritional quality of the produce. The maintenance of food quality during storage is a critical outcome of edible coating application. By creating a shield against external factors such as oxygen, moisture, and microbial contamination, these coatings significantly extend the shelf life of the products, ensuring that they remain safe and appealing for consumption. Edible coatings contribute to the visual quality and surface smoothness of fruits and vegetables, which is particularly significant for fresh produce and confectionery items. Moreover, the use of edible coatings can lead to a reduction in the need for synthetic preservatives and excessive packaging materials, contributing to environmental sustainability by minimizing the use of chemicals and plastic waste in the food industry. Edible coatings reduce weight loss and firmness loss in fruits and vegetables, ensuring that these products remain fresh and appealing throughout their shelf life. As research continues in this field, the potential for even more effective and diverse edible coatings offers a promising outlook for the future of food preservation and quality enhancement.

Acknowledgments

Authors greatly thank the Department of Biotechnology, Sahrdaya College of Engineering and Technology for providing the labs and resources to conduct the experiments.

REFERENCES

[1] Dutta, P. K., Dutta, J., & Tripathi, V. S. (2004). Chitin and chitosan: Chemistry, properties and applications.

[2] Adiletta, G., Di Matteo, M., & Petriccione, M. (2021). Multifunctional role of chitosan edible coatings on antioxidant systems in fruit crops: A review. *International Journal of Molecular Sciences*, *22*(5), 2633.

[3] Kumar, N., Petkoska, A. T., AL-Hilifi, S. A., & Fawole, O. A. (2021). Effect of chitosan–pullulan composite edible coating functionalized with pomegranate peel extract on the shelf life of mango (Mangiferaindica). *Coatings*, *11*(7), 764.

[4] Yuan, G., Chen, X., & Li, D. (2016). Chitosan films and coatings containing essential oils: The antioxidant and antimicrobial activity, and application in food systems. *Food Research International*, *89*, 117-128.

[5] Basumatary, I. B., Mukherjee, A., Katiyar, V., Kumar, S., & Dutta, J. (2021). Chitosan-based antimicrobial coating for improving postharvest shelf life of pineapple. *Coatings*, *11*(11), 1366.

[6] Sabaghi, M., Maghsoudlou, Y., Khomeiri, M., & Ziaiifar, A. M. (2015). Active edible coating from chitosan incorporating green tea extract as an antioxidant and antifungal on fresh walnut kernel. *Postharvest biology and technology*, *110*, 224-228.

[7] Verdeguer, M., Roselló, J., Castell, V., Llorens, J. A., & Santamarina, M. P. (2020). Cherry tomato and persimmon kaki conservation with a natural and biodegradable film. *Current research in food science*, *2*, 33-40.

[8] Saleem, M. S., Ejaz, S., Anjum, M. A., Nawaz, A., Naz, S., Hussain, S., ... & Canan, İ. (2020). Postharvest application of gum arabic edible coating delays ripening and maintains quality of persimmon fruits during storage. *Journal of Food Processing and Preservation*, *44*(8), e14583.

[9] Sucharitha, K. V., Beulah, A. M., & Ravikiran, K. (2018). Effect of chitosan coating on storage stability of tomatoes (Lycopersicon esculentum Mill). *International Food Research Journal*, *25*(1), 93-99.

[10] Srinivasa, P. C., & Tharanathan, R. N. (2007). Chitin/chitosan—Safe, ecofriendly packaging materials with multiple potential uses. *Food reviews international*, *23*(1), 53-72.

[11] Ali, M. A., Al-Hattab, T. A., & Al-Hydary, I. A. (2015). Extraction of date palm seed oil (Phoenix dactylifera) by soxhlet apparatus. *International Journal of Advances in ring & Technology*, *8*(3), 261.

[12] Dong, H., Cheng, L., Tan, J., Zheng, K., & Jiang, Y. (2004). Effects of chitosan coating on quality and shelf life of peeled litchi fruit. *Journal of food engineering*, *64*(3), 355-358.

[13] Olesik, J. W. (1991). Elemental analysis using icp-oes and icp/ms. *Analytical Chemistry*, *63*(1), 12A-21A.

[14] Chien, P. J., Sheu, F., & Yang, F. H. (2007). Effects of edible chitosan coating on quality and shelf life of sliced mango fruit. *Journal of food engineering*, *78*(1), 225-229.