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Development of Golden Millet Milk: A Protein-Enriched Plant-Based Beverage Using Proso Millet Protein Nanoemulsion

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Abstract*— The increasing awareness of health and nutrition has led to a growing interest in plant-based functional beverages that offer enhanced nutritional value and improved stability. Traditional cereal-based drinks are commonly consumed in various regions; however, they often lack sufficient protein content to meet daily nutritional requirements. The present study aims to develop "Golden Millet Milk," a protein-enriched beverage prepared using proso millet protein nano emulsion as a fortification approach. Proso millet, a nutrient-rich and underutilized cereal, was selected due to its high protein content and functional properties. Protein was extracted using alkaline extraction followed by isoelectric precipitation and further processed through lyophilization to obtain a stable powder. A protein-based nano emulsion was then prepared using suitable homogenization techniques to enhance dispersion and stability. The nano emulsion was incorporated into the beverage at different concentrations to improve its nutritional content. The developed product was evaluated for physicochemical properties such as pH, viscosity, particle size, and colour, along with nutritional composition and sensory acceptability using a 9-point hedonic scale. The results are expected to indicate improved protein content, better stability, and have a good consumer acceptability. This study highlights the potential of proso millet protein nano emulsion in developing innovative, nutritious, and functional plant-based beverages.

Index Terms: *Proso millet, Nano emulsion, Golden millet milk, Protein fortification, Functional foods.*

I. INTRODUCTION

In recent years, there has been an increasing demand for plant-based milk alternative and many people are shifting away from dairy milk due to lactose intolerance, milk allergy, vegan lifestyle choices, environmental concerns, and increasing awareness about health and sustainability [1],[2]. One such cereal-based beverage is corn milk, which is prepared from yellow maize kernels and is naturally rich in carbohydrates, energy, dietary fibre, vitamins, and carotenoid pigments that contribute to its attractive yellow colour [1]. However, many cereal-based beverages such as corn milk face challenges especially related to low protein content and poor stability. Fortification using proso millet protein through nano emulsion technology provides one such promising solution to these issues. This study aims to develop a protein-enriched corn milk beverage with improved nutritional quality, stability, and functional properties, contributing to the development of a sustainable plant-based milk alternative.

II. NEED OF THE STUDY

Cereal-based beverages like corn milk have a good nutritive value especially carotenoids like zeaxanthin but it is low in protein and may show poor stability, which can limit their overall quality and acceptance. With the increasing demand for plant-based beverages, there is a need to develop and improve such products. Incorporating proso millet protein using nano emulsion technology may help enhance both nutritional value and stability, making the product a more acceptable plant-based one.

III. OBJECTIVES OF THE STUDY

- To develop a protein-enriched corn milk beverage using proso millet protein.
- To prepare and incorporate proso millet protein nano emulsion to improve stability and uniform distribution in the beverage.
- To evaluate the nutritional composition, physicochemical properties, and sensory acceptability of the developed fortified corn milk beverage.

IV. REVIEW OF LITERATURE

Proso millet (Panicum miliaceum L.) is one of the oldest cultivated cereal grains and belongs to the group of small millets. Unlike major cereals such as rice and wheat, proso millet is considered a climate-resilient crop, making it highly important in global food security and sustainable agriculture. Proso millet requires significantly less water and fewer agricultural inputs, making it a sustainable crop for resource-limited regions [3]. Its high fibre content contributes to weight management and improved gut health, while the presence of antioxidants supports the prevention of lifestyle-related diseases such as cardiovascular disorders and obesity [4].

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In millet, proteins are naturally present along with starch, fiber, and fats, so they need to be separated properly to obtain them in a pure and useful form. A commonly used method is alkaline extraction followed by isoelectric precipitation because it is simple, cost-effective, and gives a good yield [5]. Studies have reported that proso millet proteins have good emulsifying capacity and stability, which helps improve the overall stability of food systems [6]. Overall, millet proteins play a dual role in food systems by enhancing both nutrition and functionality, making them suitable for use in protein-enriched beverages and nano emulsion-based systems as explored in the present study [5],[6].

Nano emulsions are systems made by mixing two liquids that normally do not mix, such as oil and water, where one is dispersed in the other as very tiny droplets ranging from 20 to 200 (nm) in size. Because of this extremely small droplet size, nano emulsions show special properties such as high stability, better appearance (clear or slightly cloudy), large surface area, and improved absorption of nutrients [2],[7]. Unlike normal emulsions, which tend to separate over time, nano emulsions are more stable because the small droplet size reduces problems like creaming, coalescence, and phase separation [7]. These systems are widely used in the food industry as delivery systems for bioactive compounds like vitamins, antioxidants, and fat-soluble nutrients, since their increased surface area helps improve digestion and bioavailability [2] [8].

Proteins play an important role as natural emulsifiers in food systems because they help mix and stabilize liquids like oil and water that normally do not combine. In food products, proteins are preferred over synthetic emulsifiers since they are safe, natural, and also add nutritional value [9], [10]. When added to an oil–water mixture, proteins move to the boundary between the two phases, where the oil-loving part attaches to oil and the water-loving part interacts with water, forming a protective layer around the droplets [9]. This layer reduces the tension between oil and water and prevents droplets from joining together, which improves the stability of the system [10]. Overall, proteins act as both stabilizing agents and nutritional enhancers, making them highly suitable for use in nano emulsion-based, protein-enriched beverages like the fortified corn milk developed in this study [6], [10].

Nano emulsions are very small emulsions with droplet sizes between 20 and 200 (nm), made using oil, water, and surfactants. Because of their tiny size, they have special properties such as better stability, improved appearance (clear or slightly cloudy), and enhanced absorption of nutrients, which makes them very useful in beverage applications [2], [11]. One of the main advantages of nano emulsions is their ability to carry and deliver bioactive compounds, especially fat-soluble nutrients like vitamins A, D, E, and K, carotenoids such as β carotene and lycopene, polyphenols, and omega-3 fatty acids, which are normally difficult to mix in water-based drinks. Studies have shown that nano emulsion-based beverages containing lycopene have better stability against light, heat, and oxygen, and also improve nutrient absorption in the body [12]. Overall, nano emulsions offer a highly effective way to improve the stability, nutrition, and quality of beverages, making them an important tool in the development of modern functional and fortified drinks.

Plant-based beverages such as soy, oat, almond, rice, and coconut drinks have become very popular due to increased health awareness, lactose intolerance, and the rise of plant-based diets. However, many of these beverages are not nutritionally complete, as they are often low in protein, vitamins, and minerals. To improve their nutritional value, fortification is commonly used [1],[2]. Protein fortification is especially important because proteins are needed for growth, repair, and body functions, and many plant-based drinks, particularly cereal- and nut-based ones, contain low amounts of protein. Studies have shown that adding protein sources like soy protein hydrolysates to oat beverages can increase protein content, improve antioxidant activity, and enhance functional properties such as solubility and emulsifying ability [13]. Nano emulsion technology has emerged as an advanced method for fortification because it helps improve the distribution, stability, and absorption of nutrients. Nano emulsions allow fat-soluble nutrients like vitamins A, D, E, and omega-3 fatty acids to be evenly spread throughout the beverage, preventing separation and settling. They also protect sensitive nutrients from damage caused by heat, light, and oxygen, thereby improving shelf life [2], [11]. Overall, with advancements in nano emulsion technology and the use of plant-based protein sources, it is possible to develop improved functional beverages that are nutritious, stable, and suitable for a wide range of consumers, including vegans and health-conscious individuals [1],[2].

Two important factors that determine the effectiveness of Nano emulsion technology are stability and bioavailability. Stability refers to how well the nano emulsion resists changes like separation, aggregation, or chemical breakdown during storage. Nano emulsions also improve bioavailability, which means how well nutrients are absorbed and used in the body. Their small droplet size increases the surface area, allowing better interaction with digestive enzymes and improving the formation of micelles that help absorb fat-soluble nutrients like vitamins A, D, E, and K, carotenoids, and polyphenols [14]. They also protect sensitive compounds from damage caused by light, oxygen, or changes in pH, ensuring that more nutrients remain active during digestion [15]. Overall, nano emulsions provide an effective way to improve both the stability and bioavailability of nutrients, making them highly suitable for developing advanced functional food and beverage products.

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V. METHODOLOGY

The methodology for the present study is presented as follows:

a) Procurement and processing of raw materials
b) Isolation of Protein
   i) Extraction of proso millet protein
   ii) Centrifugation
   iii) Isoelectric precipitation of protein
   iv) Recovery and washing of protein pellet
   v) Lyophilization of protein
c) Characterization of protein pellet
   i) Moisture content
   ii) Protein content
   iii) Bulk density
   iv) Solubility
   v) Water absorption capacity
   vi) Oil absorption capacity
   vii) Emulsifying capacity
d) Preparation of protein nano emulsion
e) Characterization of nano emulsion
   i) pH stability test
   ii) Viscosity
   iii) pH and titratable acidity
   iv) Colour analysis (CIELAB values)
f) Preparation of corn milk
g) Characterization of corn milk
   i) pH
   ii) Viscosity
   iii) Colour
   iv) Total solids
   v) Protein content
h) Fortification of corn-based beverage
i) Sensory evaluation
j) Nutritional analysis
   i) Moisture content
   ii) Ash content
   iii) Protein content
   iv) Fat content
   v) Calcium content
   vi) Carbohydrate content
k) Cost calculation
   i) Statistical analysis (ANOVA)

VI. RESULTS & DISCUSSION

The present study was aimed at the development of a protein-enriched corn-based beverage using proso millet protein nano emulsion and its evaluation in terms of yield, physicochemical, nutritional, and sensory properties. The results obtained were analysed and discussed as follows:

A. Yield of Corn Milk, Defatted Proso Millet Powder and Lyophilized Millet Powder

Table 1 shows that 242 g of corn cob produced 600 mL of corn milk, while the proso millet processing processes produced 2.1 g of lyophilized millet protein powder and 67.5 g of defatted millet powder. These results demonstrate that the millet protein extraction process—which included soaking, grinding, filtering, defatting, alkaline extraction, centrifugation, isoelectric precipitation, washing, and lyophilization—was effective in transforming the raw material into a concentrated protein ingredient as well as a beverage base. Because isolation eliminates non-protein components and keeps just the concentrated recovered protein fraction, the low final yield of lyophilized powder in comparison to the initial millet fraction is anticipated.

This result is important because it shows that the protein-enrichment method can be used even in cases when only a small amount of the final protein isolate is obtained. Although millet proteins are being investigated more and more as alternative food proteins, cultivation, extraction pH, fraction recovered, and downstream drying technique all have a significant impact on the extraction yield. A small isolate yield is common in such systems because recovery and maximum performance vary significantly with extraction methods and protein fraction composition, according to literature on proso millet proteins.

Table 1: Yield of Corn Milk, Defatted Proso millet powder and lyophilized millet powder

Parameters	**Average Yield**
Corn cob (g)	242
Corn milk (ml)	600
Defatted millet powder (g)	67.5
Lyophilized millet powder (g)	2.5

B. Functional properties of protein pellet

Table 2 displays the protein pellet's moisture content of 6.25 ± 0.07%, bulk density of 0.625 ± 0.005 g/mL, solubility of 69.67 ± 0.75%, water absorption capacity of 1.86 ± 0.04 g/g, oil absorption capacity of 22.00 ± 0.36%, and emulsifying capacity of 4.40 ± 0.20. Following the extracted protein pellet's lyophilization and functional characterisation, these values were acquired.

Table 2: Functional Properties of Protein pellet

Functional characteristics	Mean ± SD
Moisture content (%)	6.25 ± 0.07
Bulk density (g/ml)	0.625 ± 0.005
Solubility (%)	69.67 ± 0.75
Water absorption capacity (g/g)	1.86 ± 0.04
Oil absorption capacity (%)	22.00 ± 0.36
Emulsifying capacity	4.40 ± 0.20

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In order to determine if the pellet could serve as a suitable component in a beverage nano emulsion system, it was carefully assessed for moisture, bulk density, solubility, water absorption, oil absorption, and emulsifying capacity. Because it shows improved drying efficiency and storage stability, the low moisture value is favored. A powder with less moisture is typically more stable on the shelf and is less prone to microbiological growth and caking. It should be noted that the powder itself had a relatively low bulk density, which makes it easy to manipulate, blend, and reconstitute. In the case of use at a low level of inclusion, powders with moderate bulk density tend to be distributed much better than compact dense ones in beverages.

The solubility is undoubtedly one of the main properties defining whether protein can be effectively utilized in a fluid food system. The solubility of approximately 70%, thus, is the most important value from the table provided. More soluble proteins are more evenly distributed, minimize sedimentation, and are more efficiently involved in emulsification processes. According to proso millet proteins research. Despite the assertion by Wang et al. and Ren et al. that solubility plays an important role in influencing emulsification capability and the application potential in food science, the work of Akharume et al. indicated that there were significant differences in the level of solubility among various fractions of proso millet protein.

The binding capability of the protein with water and its contribution in creating body and mouthfeel as well as hydration in beverages can be seen through its water holding capacity. The ability of the oil holding value indicates that it can interact with lipid materials, hence useful in flavor interaction and emulsion formation, despite being lower compared to values in other literature regarding other millet protein fractions. The reason is that the protein was used in nano-emulsion formation, and therefore, its emulsifying capacity is very crucial. Plant proteins have been well recognized in creating structural stability through maintaining oil water interface in food. Their efficiency, however, depends on solubility, molecular flexibility, and hydrophobic hydrophilic balance.

C. Quantitative characterization of nano emulsion

The pH of the nano emulsion was 6.60 ± 0.05, which is nearly neutral and appropriate for use in beverage systems. In general, a pH close to neutrality is favourable since it lowers the possibility of protein precipitation and promotes stability. The line spread test showed a viscosity of 7.60 ± 0.20. The addition of protein and emulsified droplets may have contributed to the nano emulsion's comparatively thicker consistency, as shown by its lower spread value as compared to corn milk.

Table 3: Quantitative characterization of nanoemulsion

Parameter	Trial 1	Trial 2	Trial 3	Mean ± SD
pH	6.55	6.60	6.65	6.60 ± 0.05
Viscosity (Line spread test)	7.4	7.6	7.8	7.60 ± 0.20
Titratable acidity (mL)	0.70	0.72	0.69	0.70 ± 0.02

In Table 3, the nano emulsion showed a pH of 6.60 ± 0.05, viscosity of 7.60 ± 0.20 by line spread test, and titratable acidity of 0.70 ± 0.02 mL. Based on the line spread test, the nano emulsion had a pH of 6.60 ± 0.05, a viscosity of 7.60 ± 0.20, and a titratable acidity of 0.70 ± 0.02 mL.

Table 4 demonstrates that in acidic, mildly acidic, neutral, or alkaline environments, no discernible phase separation was seen.

Table 4: pH stability test of nanoemulsion

pH condition tested	Observation
Acidic pH	No visible phase separation
Slightly acidic pH	No visible phase separation
Neutral pH	No visible phase separation
Alkaline pH	No visible phase separation

The resulting nano emulsion showed good physical stability because there was not a significant phase separation under various pH settings. This is important for a fortified beverage since instability would cause apparent layer formation, flocculation, creaming, or coalescence, all of which lower consumer acceptability. Because of their small droplet size and stabilized interfaces, which enhance kinetic stability as compared to traditional emulsions, nano emulsions are highly desired. These systems can enhance the dispersibility, stability, and delivery of bioactives and other functional components in aqueous foods, according to reviews of food-grade nano emulsions.

A pH of about 6.6 is also good. The pH of this solution is not low enough to cause substantial protein precipitation under isoelectric conditions, but the value is sufficiently near neutral for it to work well with the cereal beverage. In beverage applications, the effect of pH on the stability of a formulation cannot be overemphasized since pH is a critical factor in determining the stability of emulsions when proteins are the interfacial materials.

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In comparison with just corn milk, the viscosity measured using the line-spread technique indicates a comparatively viscous dispersion system. As such, this result is anticipated as a consequence of the presence of both protein and dispersed droplets. According to emulsion theory, higher viscosity tends to provide greater stability by limiting droplet motions, thus reducing the number of collisions.

D. Colour analysis of nano emulsion

Table 5: Colour analysis of nanoemulsion

Colour parameter	Value
L*	51.95
a*	-0.35
b*	2.31
C*	2.34
h°	98.73

- L* = 51.95 indicates the sample had moderate lightness
- a* = -0.35 indicates a slight greenish tone
- b* = 2.31 indicates a slight yellowish tone

Table 5 showed the colour analysis of nanoemulsion. The measured L*, a*, b*, C* and h° were 51.95, -0.35, 2.31, 2.34 and 98.73°, respectively. Such results indicate that this sample was rather light and had some green yellow undertones. Color measurement by using an instrumental color measurement in accordance with CIELAB system is a common method for the evaluation of attractiveness of food products.

The fact that nano-emulsion had weak colors made its chances of dominating over natural colors of the maize milk drink lower. Since consumers do not like products that seem overly artificial, grey or phase-separable, it is important to keep the color attractive and recognizable.

E. Functional characterization of corn milk

Table 6: Functional characterization of corn milk

Parameter	Mean ± SD
pH	7.60 ± 0.05
Viscosity (Line spread test)	16.10 ± 0.20
Total solids (%)	72.21 ± 0.30

The prepared corn milk as shown in Table 6 had a pH of 7.60 ± 0.05, a viscosity of 16.10 ± 0.20 based on the line spread test, and a total solid of 72.21 ± 0.30%.

Since neutral pH systems are typically easier to fortify with protein than extremely acidic ones, the pH indicates that the corn milk was close to neutral. Protein-rich emulsions can be added with more flexibility in a nearly pure matrix without causing severe flavour distortion or precipitation right away. This is consistent with current trends in the development of plant-based beverages, where formulation frequently aims to achieve a balance between acceptable pH, flavour, and colloidal stability and protein addition.

From the viscosity result, plain corn milk had a much higher line spread value than the nano emulsion, indicating that it was less rigid and more fluid. This may be because the nano emulsion has more interface-active material and dispersed lipid-protein structures, whereas the corn milk has suspended and soluble cereal components. This distinction is helpful in the formulation process because it allows for the improvement of mouthfeel and body without making the system overly thick by incorporating a more structured nano emulsion into a thinner beverage base.

Higher solids can also enhance body, opacity, and sensory fullness, but if the matrix is not sufficiently homogenized, they may also have an impact on sedimentation and shelf stability.

F. Colour analysis of corn milk

In Table 7, the corn milk colour values were L = 59.64, a = -0.01, and b* = 37.09**. A strong yellow tone is confirmed by the high positive b* value, a close to neutral red-green balance is shown by the a* value, and moderate to high lightness is shown by the L* value.

Table 7: Colour analysis of corn milk

L*	a*	b*
59.64	-0.01	37.09

L* = 59.64 shows the sample had moderate to high lightness
a* = -0.01 indicates a neutral tone
b* = 37.09 indicates a strong yellow colour

This is important since color has a significant impact on beverage acceptance at first. Since consumers typically link yellow cereal-based drinks with maize, sweetness, and natural plant origin, the strong yellow tone can be seen as a positive quality indicator. The maize milk was significantly more yellow and lighter than the nano emulsion, indicating that the base beverage had a distinct visual character.

G. Nutritional properties of corn milk after fortification

The fortified beverage's moisture content was 88.99 ± 0.15%, ash was 0.81 ± 0.02%, protein was 3.88 ± 0.07%, fat was 2.00 ± 0.02%, calcium was 52.6 ± 1.1 mg/100 mL, iron was 1.76 ± 0.04 mg/100 mL, and carbohydrate was 2.756 ±

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0.063%, according to Table 8. After fortification and proximate/mineral analysis, these values were determined.

Table 8: Nutritional properties of corn milk after fortification

Nutritional properties	Mean ± SD
Moisture content (%)	88.99 ± 0.15
Ash content (%)	0.81 ± 0.02
Protein content (%)	3.88 ± 0.07
Fat content (%)	2.00 ± 0.02
Calcium (mg/100 mL)	52.6 ± 1.1
Iron (mg/100 mL)	1.76 ± 0.04
Carbohydrate (%)	2.756 ± 0.063

This table makes it quite clear that the finished product was a nutritionally enhanced beverage rather than merely a modified one. One of the biggest problems with plant-based drinks is that many products, particularly those made from cereal, are rather low in protein, thus the protein value becomes important. Reviews of plant-based drinks note that, aside from soy-based drinks, the majority of substitutes frequently have poor protein densities and might need to be fortified.

The idea that fortification increased mineral contribution is further supported by the ash and calcium levels. This is helpful because another known downside of plant-based beverages, especially when paired with dairy, is nutritional deficiencies. Walther et al. shown that the nutritional richness of various plant-based beverages differs significantly from that of milk and frequently requires better fortification techniques. The beverage can be utilized as a functional beverage, according to the data, which reveal an increase in calcium.

H. Difference in macro and micronutrient content of control and variation corn milk

In Table 9, Protein increased from 1.22 ± 0.04% to 3.88 ± 0.07%, fat increased from 1.05 ± 0.03% to 2.00 ± 0.02%, calcium increased from 28.4 ± 1.0 to 52.6 ± 0.85 mg/100 mL, and iron increased from 0.85 to 1.76 mg/100 mL. The percentage of carbohydrates decreased from 2.93 ± 0.06% to 2.76 ± 0.06%. Based on ANOVA, all of these changes were statistically significant, with p-values less than 0.05. The table shows that the protein content increased. This promotes the use of proso millet protein nano emulsion as an effective enrichment technique compared to only an additive with minimal nutritional impact. Increasing the amount of protein in the plant-based beverage while maintaining acceptance and dispersion is a difficulty.

Table 9: Difference in macro and micro nutrient content of control and variation corn milk

Parameters	Sample (value ± SD)		p-value
	Control	Variation	
Protein (%)	1.22 ± 0.04	3.88 ± 0.07	0.001*
Fat (%)	1.05 ± 0.03	2.00 ± 0.02	0.006*
Calcium (mg/100 mL)	28.4 ± 1.0	52.6 ± 0.85	0.003*
Iron (mg/100 mL)	0.85 ± 0.8	1.76 ± 1.1	0.007*
Carbohydrate (%)	2.93 ± 0.06	2.76 ± 0.06	0.042*

*Control: corn milk, Variation: corn milk with protein nano-emulsion, *Indicates p<0.05, significant difference, NS indicates no significant difference*

An effective preparation of the variation in maize milk can be observed by the increases in fat, calcium, and iron. Because nano emulsions have a dispersed lipid phase, which can further enhance mouthfeel and energy density, the increased fat value is expected. The gains in minerals show that the fortified system provided more than just protein. This is significant since recent evaluations highlight the need for future plant-based beverages to increase their protein content and nutrient density in order to become more effective functional alternatives. The small decrease in carbohydrates may be a sign of compositional redistribution following fortification: the proportion of carbohydrates in the beverage decreased slightly as protein, minerals, and lipid-associated components increased.

I. Difference in protein content of lyophilized protein powder, corn milk and fortified beverage

In Table 10, the protein content of the lyophilized protein powder was 62.40 ± 0.80%, compared with 1.22 ± 0.04% in corn milk and 3.88 ± 0.07% in the fortified beverage, with $p < 0.001$.

Table 10: Difference in macro nutrient content(protein) of control and variation corn milk

Nutritional Property	Lyophilized Protein Powder (Mean ± SD)	Corn Milk (Mean ± SD)	Fortified Beverage (Mean ± SD)	p-value
Protein (%)	62.40 ± 0.80	1.22 ± 0.04	3.88 ± 0.07	< 0.001*

**Indicates p<0.05, significant difference, NS indicates no significant difference*

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This result clearly shows that the lyophilized powder was a concentrated protein-rich ingredient and that adding it to maize milk effectively raised the completed beverage's protein content. The rise from 1.22% to 3.88% is nutritionally significant for a beverage product, even if the fortified drink did not match the protein percentage of the separated powder. This demonstrates the useful potential of proso millet protein isolate for enhancing the protein content of plant-based drinks.

Reviews of plant-based beverages reveal that, unless they are enriched, the majority of cereal and nut-based beverages continue to be poor sources of protein, while protein rich or fortified systems stay complete and supply nutrients in according with human needs.

J. Sensory evaluation

In Table 11, the control sample (CM) received the greatest overall values in the sensory table. FM2 (10%) exceeded the other fortified samples, though. FM2 received scores of 8.20 for overall acceptability, 8.00 for consistency, 8.30 for aroma, 8.10 for flavor, 8.20 for mouthfeel, 7.90 for aftertaste, 8.30 for color, and 8.20 for appearance. All sensory qualities had p-values between 0.001 to 0.006, indicating statistically significant differences between the samples. The sensory data clearly reveal a significant trend. Although FM1's scores were lower than FM2's, it was still acceptable with a 5% nano emulsion. This implies that the 5% level might not have been sufficient to improve the beverage's body, taste, texture, and overall mouthfeel. FM3, which contained 15% nano emulsion, had least favourable ratings across all of the samples, particularly in terms of flavour, mouthfeel, aftertaste, and general acceptability. This suggests that an excessive amount of nano emulsion may have contributed to the drink's thicker texture, unpleasant flavour, and aftertaste. The medium level produced the best outcome, a small quantity produced less improvement, and an excessive amount decreased acceptability.

Table 11: Sensory analysis score

Sensory Attribute	CM (Mean ± SD)	FM1 (Mean ± SD)	FM2 (Mean ± SD)	FM3 (Mean ± SD)	p-value
Appearance	8.60 ± 0.50	7.40 ± 0.56	8.20 ± 0.48	7.10 ± 0.62	0.003*
Consistency	8.30 ± 0.47	7.20 ± 0.63	8.00 ± 0.52	6.90 ± 0.58	0.005*
Aroma	8.50 ± 0.51	7.50 ± 0.54	8.30 ± 0.46	7.20 ± 0.60	0.004*
Flavour	8.40 ± 0.50	7.30 ± 0.58	8.10 ± 0.49	6.80 ± 0.67	0.002*
Mouthfeel	8.50 ± 0.51	7.40 ± 0.55	8.20 ± 0.47	6.90 ± 0.61	0.003*
Aftertaste	8.20 ± 0.56	7.10 ± 0.60	7.90 ± 0.51	6.70 ± 0.65	0.006*
Colour	8.60 ± 0.49	7.50 ± 0.52	8.30 ± 0.45	7.00 ± 0.59	0.004*
Overall acceptability	8.50 ± 0.50	7.40 ± 0.57	8.20 ± 0.48	6.90 ± 0.63	0.001*

*CM – control milk, FM1 – Formulated milk 1(5%), FM2 – Formulated milk (10%), FM3 – Formulated milk (15%), All values are Means of triplicate determinants ± Standard deviation (S.D.), *indicates p-value is <0.05 by ANOVA, NS indicates no significant difference*

The FM2 (10%) result is important because it shows that the beverage might be made healthier without decreasing customer acceptability. A lot of plant-based drinks have issues like weak mouthfeel, unstable texture, and bad flavor. The 10% nano emulsion level in this study appears to have enhanced the nutritional value while maintaining the drink's palatability and panelists' acceptance. As a result, of the fortified samples, FM2 is the most appropriate formulation.

VII. BENEFITS

The developed corn milk beverage has improved protein content, making it more nutritious. It also provides more

calcium and iron, which are important for health. Being plant-based, it is suitable for lactose-intolerant individuals and vegans. The nanoemulsion helps improve stability and texture, and the product remains acceptable in taste, especially at the 10% level. Overall, it is a healthy and functional beverage with good consumer appeal.

VIII. LIMITATIONS

- Advanced analysis (particle size, zeta potential) was not performed.
- Limited sensory panel size.
- No shelf-life study conducted.

IX. RECOMMENDATIONS

- Conduct shelf-life studies to check stability and safety.
- Perform advanced nano emulsion analysis (particle size, zeta potential).
- Carry out scale-up and larger consumer studies

X. CONCLUSION

From the result obtained in the study, maize milk may be considered useful as a base for making beverages using plant proteins; however, the nutritional benefits have to be enhanced through protein fortification. Proso millet was observed to be a good source of plant protein and that the protein obtained after processing may be easily made into an isolate with excellent functional properties to make it fit for use in foods. Since there was no phase separation under different pH values, the nanoemulsion from the protein demonstrated good stability. Maize milk was highly enriched nutritionally by adding the protein nanoemulsion to enhance its protein content, fat, calcium, and iron. From all the formulations tested, FM2, which had 10% of the nanoemulsion, was found to be the best in achieving the appropriate balance of nutritional benefits and sensorial characteristics. However, an increase in the level to 15% decreased its sensory quality, indicating the importance of optimization in the process. Therefore, proso millet protein nanoemulsion may be considered a suitable option for making beverages that are stable, nutritious, and delicious.

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