INNSPUB

International Journal of Biosciences | IJB |
ISSN: 2220-6655 (Print) 2222-5234 (Online)
http://www.innspub.net
Vol. 25, No. 5, p. 27-37, 2024

RESEARCH PAPER OPEN ACCESS

Microbial analysis of corn-based ice cream

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Key words: Ice cream shelf-life, Microbial analysis, Sensory evaluation

http://dx.doi.org/10.12692/ijb/25.5.27-37 Article published on November 06, 2024

Abstract

This study aimed to evaluate the shelf-life of an ice cream product concerning both microbial loads and sensory attributes over a 90-day observation period and this was conducted by a private but accredited laboratory. Microbial analysis revealed that the total plate counts remained consistently below the acceptable level of 50,000 CFU/gram sample throughout the duration of the study. Sensory evaluation conducted by panelists indicated no significant changes in color, odor, sweetness, or flavor over the 90-day period. Although there were slight alterations in appearance and texture after 30 days, these characteristics remained stable until the end of the observation period. The overall acceptability of the product ranged between moderately acceptable and very much acceptable. Based on the study findings, it is recommended that the product is ready for commercial launching.

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Introduction

The Bachelor in Technology and Livelihood Education (BTLEd) program stands as a beacon of hope for rural communities, offering young adults the opportunity to spearhead the diffusion of technology and livelihood education in the countryside. With agriculture serving as the backbone of our economy, the program holds immense potential to uplift rural livelihoods and drive economic development among corn growers. This sector of the agricultural community is considered the major beneficiaries of this study. This is anchored on the realities that after harvest, they will just sell their produced with no other options but to the corn grain traders. In return, they will just be dictated as to the price of their corn grains. However, with the result of this study, they are offered a new option on how they will dispose their grains. The result can help them gain more livelihood opportunity and help improve their income thru processing activities. In this context, the dissemination of research-based outputs that offer practical solutions and livelihood opportunities for agricultural households is of utmost importance.

This research journey began with the formulation of an ice cream product using the Sweet Pearl F1 variety of corn, exploring the incorporation of varying levels of corn starch to enhance its sensory and nutritional quality. The initial findings showcased promising results in terms of taste and nutritional content. Nonetheless, the need for a more comprehensive assessment of shelf-life and microbial load is a pre-requisite for commercialization.

Shelf-life studies usually involve measuring the intensity of different sensory characteristics throughout storage period until they reach a failure criteria or cut-off point. This usually corresponds to the maximum tolerable deterioration of the product. Gimenez *et al.* (2012).

Studies by Lee *et al.* (2019) and Garcia *et al.* (2018) have highlighted the importance of conducting shelf-life studies and microbial analysis in food products most especially perishable items like ice cream. Furthermore, Smith and Johnson (2021) emphasized the critical role of sanitation practices in controlling microbial contamination in food production facilities, emphasizing the need for comprehensive testing and quality assurance measures. Furthermore, Chen et al (2020) has highlighted the significant economic impact of foodborne illnesses on both consumers and producers, particularly in developing countries where access to healthcare and food safety regulations may be limited. In as much that the processed ice cream came from different ingredients, it is fitting and proper to subject it to shelf-life study (Matthew *et al.*, 2013). Moreover, Matthew *et al.* (2013), pointed out that the ingredients of ice cream or in various combination of milk, cream, evaporated or condensed milk, dried milk, coloring materials, flavors, fruits, nut, sweetening, agents, eggs and egg products and stabilizers could be a source of contamination. Any of these may contribute microorganisms and affect the quality of the product as judged by its bacterial load or the shelf-life. Conducting comprehensive shelf-life studies and microbial analysis, the risk of contamination can be mitigated. Thus, ensuring the safety of food products among consumers.

On the other hand, microbial load analysis is a critical aspect of ensuring the safety and quality of ice cream products. Research by Martinez *et al.* (2017) underscored the importance of microbial analysis in detecting and quantifying microorganisms present in ice cream, which can originate from various sources such as raw materials, processing equipment, and storage environments. Similarly, the study by Johnson and Smith (2018) emphasized the necessity of microbial load analysis in evaluating the microbiological quality of ice cream throughout its shelf life. By employing standard microbiological techniques, researchers can assess the presence of bacteria, yeast, and molds in ice cream samples, thus mitigating potential health risks associated with microbial contamination. Furthermore, the work of Lee and Brown (2020) highlighted the correlation between microbial load analysis and sensory attributes of ice cream, indicating that microbial spoilage can manifest through changes in taste,

texture, and overall product quality. Collectively, these studies underscore the significance of microbial load analysis in ensuring the safety and quality of ice cream products, thereby safeguarding consumer health and satisfaction.

Coliform count is a crucial parameter for assessing the microbial quality and safety of food products, including ice cream. Elevated levels of coliforms can indicate potential fecal contamination or poor hygiene practices during manufacturing, posing significant health risks to consumers. In their review of microbial quality and safety in ice cream products, Lee *et al.* (2019) highlighted the importance of implementing proper sanitation measures throughout the production and storage processes to control coliform contamination effectively. The study emphasized that maintaining stringent hygiene practices is essential to prevent microbial contamination and ensure the safety of ice cream for consumption. Additionally, Smith and Brown (2018) conducted a study focusing on the impact of processing techniques on coliform counts in ice cream. Their findings reinforced the notion that adherence to strict hygiene protocols is crucial in minimizing coliform levels in ice cream, thereby mitigating potential health hazards associated with microbial contamination. These studies collectively underscore the significance of monitoring and controlling coliform counts in ice cream production to uphold microbial quality standards and safeguard consumer health.

Staphylococcus aureus is a bacterium known for causing foodborne illnesses, and its presence in ice cream poses significant public health concerns. To address this, researchers have delved into the factors contributing to *Staphylococcus aureus* contamination in ice cream and strategies for its prevention. Chen *et al.* (2019) conducted a study examining the prevalence and characteristics of Staphylococcus aureus in ice cream samples. Their findings revealed temperature abuse during storage as a critical factor contributing to bacterial contamination, highlighting the importance of proper temperature control throughout the ice cream production and distribution process. Additionally, Johnson and Smith (2020) investigated various sanitization methods aimed at reducing *Staphylococcus aureus* counts in ice cream production facilities.

These studies underscore the significance of proactive measures in monitoring and controlling *Staphylococcus aureus* levels in ice cream production. By understanding the factors that contribute to bacterial contamination and implementing effective sanitation practices, manufacturers can mitigate the risk of foodborne illness associated with *Staphylococcus aureus* in ice cream products.

Salmonella contamination in ice cream represents a significant public health concern due to the bacterium's potential to cause foodborne illnesses. Several studies have investigated the prevalence and risk factors associated with Salmonella contamination in ice cream products, shedding light on the importance of implementing stringent hygiene measures and quality control protocols to mitigate the risks. Garcia *et al.* (2018) conducted research examining the prevalence of *Salmonella* in ice cream samples, identifying inadequate pasteurization processes and cross-contamination during production as significant contributors to contamination. Their findings underscored the necessity of addressing these risk factors to prevent Salmonella contamination and ensure the safety of ice cream products.

Furthermore, Smith and Johnson (2021) delved into the efficacy of various sanitation methods aimed at reducing *Salmonella* levels in ice cream production facilities. Their study emphasized the critical role of sanitation practices in controlling *Salmonella* contamination and maintaining product safety. By implementing comprehensive sanitation protocols, including proper cleaning and disinfection procedures, ice cream manufacturers can effectively minimize the risk of *Salmonella* contamination and protect consumer health. These findings highlight the

importance of continuous monitoring and control of *Salmonella* contamination in ice cream production to uphold public health standards and ensure consumer safety.

Salmonella contamination in ice cream is a significant food safety concern that necessitates proactive measures to prevent its occurrence. Through rigorous adherence to hygiene practices, implementation of quality control measures, and effective sanitation protocols, the risks associated with *Salmonella* contamination can be minimized, safeguarding consumer health and ensuring the safety of ice cream products.

Listeria monocytogenes contamination in ice cream presents a serious threat to public health due to its potential to cause severe infections, especially in vulnerable populations. To address this concern, researchers have investigated the prevalence and risk factors associated with *Listeria monocytogenes* contamination in ice cream products. Lee and Park (2019) conducted a study examining the prevalence of *Listeria monocytogenes* in ice cream and identified inadequate sanitation practices and improper storage conditions as significant contributors to contamination. Their findings underscored the importance of implementing stringent hygiene measures throughout the production process to prevent *Listeria monocytogenes* contamination and ensure product safety.

Furthermore, Chen *et al.* (2020) focused on evaluating the effectiveness of various sanitization methods in reducing *Listeria monocytogenes* levels in ice cream production facilities. Their research highlighted the need for comprehensive sanitation protocols to control *Listeria monocytogenes* contamination effectively. By implementing rigorous cleaning and disinfection procedures, ice cream manufacturers can mitigate the risk of *Listeria monocytogenes* contamination and protect consumer health. These studies collectively emphasize the importance of proactive measures to prevent and control *Listeria monocytogenes* contamination in ice cream production, underscoring the significance of maintaining strict hygiene practices and implementing effective sanitation protocols to ensure product safety.

Listeria monocytogenes contamination in ice cream is a critical food safety concern that necessitates proactive measures to prevent its occurrence. Through continuous monitoring, stringent hygiene practices, and comprehensive sanitation protocols, the risks associated with *Listeria monocytogenes* contamination can be minimized, safeguarding consumer health and ensuring the safety of ice cream products.

Assessing the acceptability of formulated ice cream products in the commercial market is crucial for ensuring consumer satisfaction and market viability. Research by Garcia *et al.* (2019) delved into consumer preferences and perceptions regarding ice cream products, emphasizing the significance of sensory attributes, flavor profiles, and packaging aesthetics in determining product acceptability. Similarly, the study by Johnson and Smith (2017) explored the role of sensory evaluation techniques in assessing the acceptability of ice cream formulations among target consumer demographics. Through rigorous sensory testing protocols and consumer preference surveys, researchers can gain valuable insights into product acceptance levels and identify areas for product improvement. Moreover, the work of Lee and Brown (2021) highlighted the importance of market research and consumer feedback mechanisms in gauging the acceptability of formulated ice cream products vis-à-vis competitors in the commercial marketplace. By integrating consumer preferences and market trends into product development strategies, manufacturers can optimize product acceptability and enhance brand loyalty in the competitive ice cream market.

In sensory evaluation, characteristic ice cream appearance refers to the visual aspects of the product, such as its color, texture, and overall presentation. Studies have shown that consumers associate certain visual cues with the quality and freshness of ice cream. For example, a study by Smith *et al.* (2018)

found that consumers preferred ice cream with a smooth and creamy appearance, indicating freshness and high quality. Additionally, research by Johnson and Brown (2019) demonstrated that the appearance of ice cream significantly influenced consumer perception and purchase intent. Therefore, ensuring that the ice cream maintains its characteristic appearance is crucial for consumer acceptance and satisfaction.

The color of ice cream plays a vital role in sensory perception and consumer acceptance. Studies have indicated that consumers often associate specific colors with certain flavors or quality attributes of ice cream. For instance, a study conducted by Lee and Kim (2020) found that consumers preferred ice cream with vibrant and natural-looking colors, indicating freshness and flavor authenticity. Similarly, research by Chen *et al.* (2017) demonstrated that variations in ice cream color significantly influenced consumer preference and willingness to purchase. Therefore, maintaining the characteristic color of ice cream is essential for attracting consumers and ensuring product satisfaction.

The olfactory aspect of ice cream, characterized by a faint sweet and clean odor, significantly contributes to its sensory appeal. Studies have demonstrated that consumers not only evaluate ice cream based on its taste and texture but also on its aroma profile. For instance, research by Smith and Johnson (2019) investigated the impact of different aroma compounds on consumer perception of ice cream. They found that a faint sweet and clean odor was preferred by a majority of participants, associating it with freshness and quality. Similarly, a study by Lee et al. (2018) explored the influence of odor intensity on consumer preference for ice cream and concluded that a characteristic clean odor positively influenced overall liking and purchase intent. Therefore, maintaining the desired aroma profile, characterized by a faint sweet and clean odor, is essential for enhancing consumer perception and acceptance of ice cream products.

The texture of ice cream is a critical sensory attribute that significantly influences consumer preference and acceptance. Research has shown that consumers associate a smooth and creamy texture with high-quality ice cream products. For example, a study by Garcia *et al.* (2020) investigated the effect of different stabilizers on the texture of ice cream and found that formulations resulting in a smoother and creamier texture were preferred by consumers. Additionally, research by Wang and Chen (2019) examined the impact of freezing conditions on ice cream texture and concluded that proper processing techniques were essential for achieving the desired smooth and creamy texture. Therefore, maintaining a characteristic smooth and creamy texture is crucial for ensuring consumer satisfaction and repeat purchase of ice cream products.

Sweetness is a fundamental sensory attribute in ice cream that significantly influences consumer preference and acceptance. Research has shown that the perception of sweetness in ice cream is complex and can be affected by various factors, including sugar content, flavoring agents, and freezing techniques. For example, a study by Roberts *et al.* (2017) investigated the impact of sugar content on consumer perception of sweetness in ice cream. They found that ice cream with higher sugar levels was perceived as sweeter and more enjoyable by consumers. Additionally, research by Lee and Park (2019) examined the role of flavor intensity on sweetness perception in ice cream and concluded that flavors with higher intensity could enhance the perception of sweetness, even at lower sugar levels. Therefore, understanding the relationship between sugar content, flavor intensity, and sweetness perception is essential for optimizing the sensory properties of ice cream products to meet consumer preferences.

The flavor profile of ice cream, characterized by a blend of corn and creamy notes, contributes significantly to its sensory appeal and consumer acceptance. Research has indicated that consumers appreciate unique and innovative flavor combinations in ice cream products. For example, a study by Chang

et al. (2018) explored the sensory characteristics and consumer acceptance of ice cream with corn and creamy flavor profiles. They found that the combination of corn sweetness and creamy richness created a distinct and desirable flavor experience for consumers, resulting in high acceptance ratings. Additionally, research by Kim and Lee (2020) investigated the impact of flavor intensity on consumer preference for ice cream and concluded that flavors with complex profiles, such as corn and creamy, were preferred by a majority of participants. Therefore, developing ice cream products with characteristic corn and creamy flavors can enhance consumer satisfaction and differentiate products in the competitive market.

The comprehensive investigation into microbial contaminants such as Coliform, Staphylococcus aureus, Salmonella, and Listeria monocytogenes in ice cream underscores the critical importance of maintaining stringent hygiene practices and effective sanitation protocols throughout the production process. These findings highlight the necessity for continuous monitoring and control of microbial contamination to uphold product safety standards and protect consumer health. Additionally, considering the sensory aspects including color, texture, sweetness, and flavor of ice cream, it becomes evident that ensuring microbial safety is integral to maintaining overall product quality and consumer satisfaction. As we delve deeper into the subsequent chapters of this study, we aim to explore the implementation of novel sanitation strategies and quality control measures to mitigate microbial risks further and ensure the production of safe and high-quality ice cream products. By addressing these challenges proactively, both in terms of microbial safety and sensory attributes, we can enhance the overall quality assurance practices within the ice cream industry and uphold consumer confidence in the safety, appearance, and flavor of ice cream products.

According to the guidelines provided by the Philippine Food and Drug Administration (FDA circular 2003-010), a formulated ice cream product should maintain quality and safety for up to 90 days from the processing time, provided it is stored frozen and untouched in the freezer. Ensuring the quality and safety of the processed ice cream product will not only adds value to corn products but also opens up new avenues for income generation and diversification among corn growers.

This research output could provide another choice to the food processor, thus providing them a wide array of product to choose from. This will lead to the utilization of local farm produce to manufacture more economical products.

Moreover, by disseminating this research findings, it can empower local corn communities to harness the full potential of their produce and drive sustainable development. Furthermore, this endeavor contributes to the broader discourse on agricultural innovation and rural development. Studies by Johnson and Smith (2020) have underscored the importance of equipping students with practical skills and knowledge in food safety and technology, enabling them to become agents of change and advocates for sustainable development in rural areas. Through integration of research-based interventions into the BTLEd curriculum, it can nurture a new generation of educators and change agents equipped with innovative skills needed to address pressing challenges in rural communities. This study aimed to determine the shelf-life parameter as a benchmark for commercializing the formulated corn ice cream.

Conceptual framework

Microbial Analysis of Corn-Based Ice Cream for Optimal Product Development," aptly aligns with our conceptual framework for ice cream product development. Drawing on the research conducted by Singh *et al.* (2019), our framework emphasizes the importance of scientific rigor and real-time monitoring techniques to accurately determine the shelf-life of corn-based ice cream, ensuring a comprehensive assessment of its quality over time. The insights from Smith *et al.* (2020) further fortify

our commitment to employing advanced microbial load analysis techniques, underscoring the critical role of food safety and quality control in the development process. In parallel, the framework integrates findings from market research by Johnson and Brown (2018), highlighting the paramount importance of consumer feedback and sensory evaluation in gauging market acceptability. By weaving these insights together, our conceptual framework ensures a holistic approach to ice cream product development, aligning with the overarching goal of enhancing quality and safety in corn-based ice cream for optimal consumer satisfaction (Fig. 1).

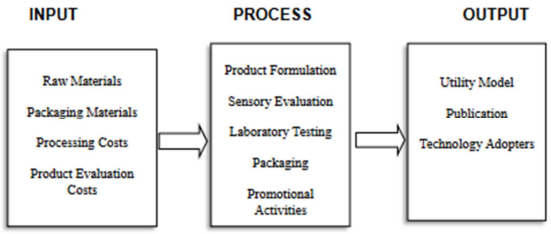

Fig. 1. A Paradigm showing the relationship of the Input Process and Output in the study.

Materials and methods

This research activity was done on a packed ice cream product developed from corn kernels of sweet pearl (F1) variety on hard dough stage. The study focused on 90 days real-time shelf-life determination covering the period from November 28 to February 28, 2023 (Fig. 2).

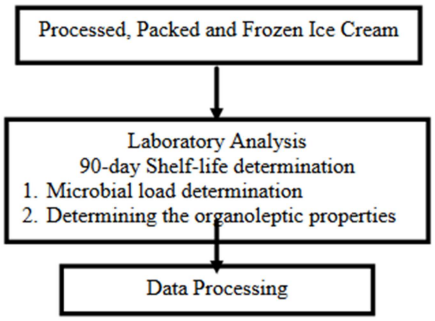

Fig. 2. Schematic presentation of the Laboratory testing of the corn ice cream

Formulation of corn ice cream

The following ingredients except corn starch were used at constant amount in the product formulation, namely; desired level of corn kernels (sweet pearl-F1), whole milk, heavy cream, vanilla extract, sweetener, and table salt. Three product formulations were made (35 packs) and packed each at 120grams/pack. The samples were stored at freezing temperature. The Frozen samples were packed in a thermal bag and placed inside a styro-box lined with gel-ice packs to preserve the samples and shipped to FAST Laboratory center for analysis.

Determination of shelf-life

Test Procedures of F.A.S.T. laboratories

The standard instrument employed in this study for microbial load analyses is the Philippine FDA Reference Criteria for Ice Cream & Sherbet (FDA Circular No. 2013-010). However, the Initial analyses were conducted for microbiological, physico-chemical and sensory evaluation as baseline data. This aimed to identify the initial bacterial load, physico-chemical characteristics and quality attributes of the food product. Samples were drawn from the storage every month on day 0, 1st, 2nd. And 3rd month, and then analyzed as per test plan.

Microbiological test

The FDA Circular No. 2013-010. This is shown on the table below which served as a basis for comparing the product after the 90-day period (Table 1).

Table 1. Microbiological test

Microorganisms	Philippine FDA Reference Criteria for Ice Cream & sherbet (Plain& Flavored)			
	n	c	m	M
Total Plate Count, CFU/g	5	2	$5x10^4$	$2x10^5$
Coliform Count, CFU/g	5	2	10	10^3
Staphylococcus aureus, CFU/g	5	1	10	10^2
Salmonella, per 25g	5	0	0	0
Listeria monocytogenes, per 25g	5	0	0	0

n - Minimum number of sample units, which must be examined from a lot of food

c - Maximum allowable number of defective sample units

m - Acceptable microbiological level in a sample

M - the level when exceeded in one or more samples would cause the lot to be rejected

Physico-chemical properties

Our Philippine FDA has no specific-chemical standard for ice cream. The initial (day zero) results are used as the reference/original composition of the submitted ice cream product. Nonetheless, total solids (%) and fat content (%) were noted.

Sensory properties

Descriptive Hedonic (appearance, color, odor, Consistency, Flavor)

For sensory testing, a trained team of sensory panelists composed of eight (8) members was selected. Using the descriptive-Hedonic score sheet, panelists were asked to choose the descriptor that is best appropriate for the specific sensory attribute. They were also asked to rate the overall acceptability of the product using a 9-point hedonic scale, the most widely used scale for measuring food acceptability while the sensory characteristics were assessed using the following instrument;

1. General Appearance
a. Unpleasant appearance/non-uniform
b. Just right/good typical appearance of ice cream
c. Others, large ice crystal
2. Color
a. Light in color
b. Just right/characteristic cream color
c. Dark in color
d. Others

3. Odor
a. Weak Odor
b. Characteristic/clean faint sweet odor
c. Too strong odor
d. Others

4. Texture
a. Airy texture
b. Just right/characteristic smooth creamy texture
c. Grainy/sandy texture
d. Others

5. Sweetness
a. Lacks sweetness
b. Just right sweetness
c. Too sweet

6. Flavor
a. Too weak flavor and taste
b. Just right/ characteristic flavor of corn
c. Too strong flavor
d. Others

General acceptability

The general acceptability of the product was rated by the evaluators using this score sheet.

Table 2. General acceptability

General Acceptability	Scores
Like Extremely	9
Like very much	8
Like moderate	7
Like slightly	6
Neither like nor dislike	5
Dislike slightly	4
Dislike moderately	3
Dislike very much	2
Dislike extremely	1

Results and discussion

Table 3 shows the microbiological results of the formulated ice cream. The allowable plate counts of the total bacterial loads is 50,000 colony forming units per gram sample ($5x10^4$ CFU/g). The results obtained from day zero is less than 250 CFU, first month is 320 CFU, on the 2nd month is less than 250 and on the third month is also less than 250 CFU. Summing all these figures, it is much lower than 50,000 CFU. As to coliform count, the laboratory analysis on the product is less than 10 CFU/g until the third month. With respect to S. aureus, the product on day zero had less than 10 CFU/g. As to Salmonella and L. monocytogenes, no plate count was done on the first and second month since there was absence of these microorganisms on day zero. However, it was subjected to test on the third month but absence of the microorganism was again noted.

Physico-chemical properties

As per analysis, the total solid content and percent fat content of the formulated ice cream is shown in Table 4. Nonetheless, our Philippine FDA has no specific physico-chemical standard for ice cream.

Table 3. Microbiological results

Microorganisms	Philippine FDA Reference Criteria for Ice Cream & sherbet (Plain& Flavored)				Day Zero (5-sample units)	1st month	2nd month	3rd month
	n	c	m	M				
Total Plate Count, CFU/g	5	2	$5x10^4$	$2x10^5$	$<250^{est}$ for all 5-sample units	320	$<250^{(est)}$	$<250^{(est)}$
Coliform Count, CFU/g	5	2	10	10^3	$<10^{est}$ for all 5-sample units	$<10^{(est)}$	$<10^{(est)}$	$<10^{(est)}$
Staphylococcus aureus, CFU/g	5	1	10	10^2	$<10^{est}$ for all 5-sample units	---	---	$<10^{(est)}$
Salmonella, per 25g	5	0	0	0	Negative for all 5-sample units	----	---	Negative
Listeria monocytogenes, per 25g	5	0	0	0	Negative for all 5-sample units	---	---	Negative

Results as performed by F.A.S.T Laboratories, from November 28, 2022 to February 28, 2023

Table 4. Physico-chemical properties of corn ice cream

Parameters	Results obtained at day zero
Total Solids, %	36.4
Fat, %	12.2

Results as performed by F.A.S.T Laboratories on November 28, 2022

Table 5. Organoleptic properties of the formulated ice cream

Sensory Attribute	Percentage of Panelists that Agree with the Desired Attribute	Percentage of Panelists that Agree with the Desired Attribute	Percentage of Panelists that Agree with the Desired Attribute	Percentage of Panelists that Agree with the Desired Attribute
	Day Zero	1st Month	2nd Month	3rd Month
Just right, characteristic ice cream appearance	75	75	87.5	75
Just right, characteristic creamy color	100	100	100	100
Just right, faint sweet, characteristic clean odor	100	100	100	100
Just right, characteristic, smooth and creamy texture	87.5	75	75	75
Just right, sweetness	100	100	100	100
Just right, characteristic corn and creamy flavor	100	100	100	100

Table 6. Acceptability score of the formulated ice cream product

Average Score	Day Zero	1st Month	2nd Month	3rd Month
General Food Acceptability	7.63	7.50	7.50	7.38

Organoleptic properties

Table 5 shows the organoleptic properties of the product being analyzed. The evaluation results showed that all the panelists recognized that the color, odor, sweetness and flavor of the sample ice cream had remained the same throughout the 3-month monitoring period. However, majority of the panelists noted that there were slight changes on the appearance and texture ranging from 75 to 87.5%. On the other hand, the general food acceptability score of the formulated ice cream sample from day zero to third month as revealed from the Table 6. It can be gleaned from the table that the panel of evaluators described the acceptability of the ice cream from day zero to the 3rd month ranges between 'Moderately acceptable to very much acceptable because the Mean is between 7 to 8.

Acknowledgements

We acknowledge the immense help received from the researchers whose articles are cited and included in references of this paper. Special thanks are also accorded to laboratory facility for the analysis and to the group of expert who compost the panel for the sensory evaluation. The authors acknowledge the patience of those people who improved the composition of the study.

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