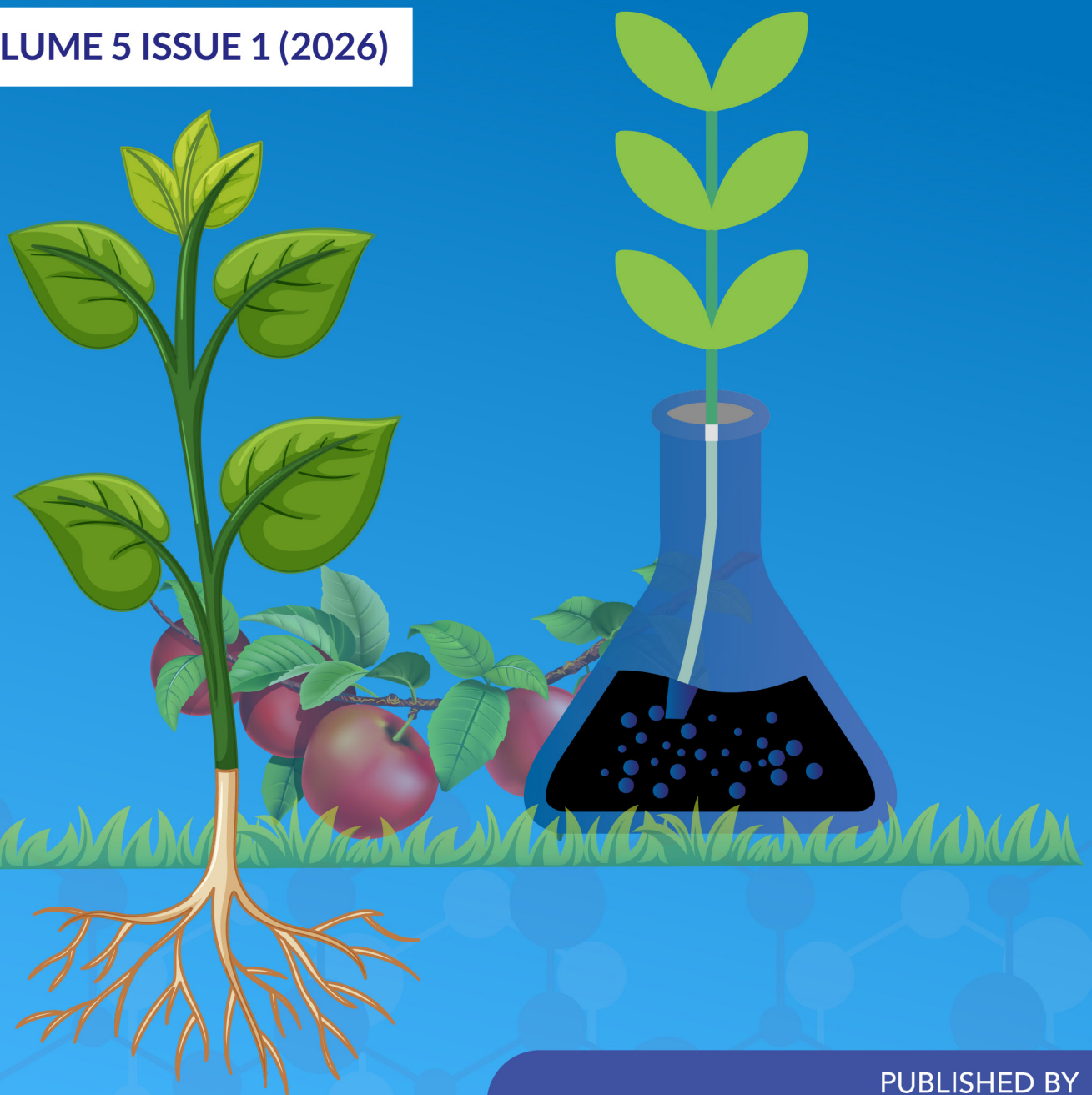




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PHYSICOCHEMICAL, PROXIMATE AND SENSORY CHARACTERISTICS OF SELECTED PLANT BASED ICE CREAM

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ABSTRACT

The aim of this study was to evaluate and compare the physicochemical properties, proximate composition, and sensory attributes of plant-based ice creams produced from soybean, tigernut, and coconut milks. The different plant milks were extracted by blending each base with water at a 1:3 ratio for 5 minutes, followed by filtration through muslin cloth. Ice cream mixes were prepared, and homogenized, pasteurized at 85°C for 30 minutes, and cooled to 4°C. The mixes were frozen at -5°C for 30 minutes to obtain the respective ice creams. The samples were labeled A (coconut milk ice cream), B (soy milk ice cream), and C (tigernut ice cream), while cow milk ice cream (sample D) served as the control. Physicochemical properties, proximate composition and sensory properties analysis of the samples were determined using standard methods. The pH, overrun, viscosity and sugar content ranged from 4.28-5.12, 37.93-42.86%, 2.71-2.90 Pa.s, and 21.00-26.01 °Brix, respectively. The melting rate of the samples ranged from 1.60-5.18% at 10 minutes, 1.68-75.70% at 20 minutes, and 67.20-100.00% at 30 minutes, with soybean ice cream showing the least melting rate. There was a significant difference ($p < 0.05$) in the proximate composition of the samples, except for the total carbohydrate content. Moisture content, crude protein, crude fat, ash, and total carbohydrate contents of the ice cream samples ranged from 56.00-65.40%, 0.148-0.481%, 1.09-5.99%, 1.55-5.20%, and 18.47-18.62%, respectively. Sensory evaluation results showed no significant differences ($p > 0.05$) in colour (6.80-7.70), flavour (6.40-7.90), thickness (6.40-7.70) and aftertaste (6.30-7.20) between plant-based ice creams and the control. This study showed that soybean, tigernut, and coconut milks are suitable for producing high-quality plant-based ice creams with favourable sensory and nutritional profiles. These products are particularly recommended for lactose-intolerant consumers and those seeking reduced-cholesterol dessert options.

INTRODUCTION

Ice cream is a globally consumed dessert. It is a sweetened frozen dairy product preferred as snacks or desert made of milk and milk products that is often added with fruits along with other essential ingredients like flavours and colors. It is classified based on their ingredients and flavour used. Ice cream contains high sugars and fat, and other compositions like minerals, vitamins (Legassa, 2020). It is a suitable carrier for all functional ingredients due to its low storage temperature, ingredient stabilization, and consumer popularity. This concept flips the idea of ice-cream being unhealthy, and turns ice-cream into a positive and an essential healthy treat (Ramesh *et al.*, 2023).

Cow milk is the primary ingredient of dairy based ice cream which are not suitable for the population with cow milk allergy, lactose intolerant patients and people who are following a vegan lifestyle (Amirtha *et al.*, 2021). Cow's milk contains a wide variety of high-quality nutrients for human health, such as protein, vitamins, and minerals; however, milk lipids have been associated with an increase of cholesterol levels in the blood (Meneses *et al.*, 2020). It is considered a staple in many diets due to its high nutritional value, and contains almost every nutrient that the human body needs (Ramon *et al.*, 2022). However, some people can not consume ice cream

because of their inability to digest the lactose content in cow's milk in their body (Andreas & Bayu, 2021). The demand for plant-based foods to meet the vegan public and /or individuals allergic to milk protein has increased, leading to the development of new products for this market (Tomczyńska-Mleko *et al.*, 2024).

Plant based milk refers to a variety of milk alternatives made from plants, nuts, seeds, or grains. plant milk, are produced from the breakage of the interesting raw material, reducing its size, with subsequent extraction in water and homogenization (Silva *et al.*, 2022). The development of plant-based alternatives is driven by the need for nutrient-dense options; for instance non-dairy milks have been shown to compare favourably with or even exceed, the protein content of cow milk (Chud, 2023). This mirrors a broader movement in Food Science to incorporate nutrient-rich plant sources into traditional staples to combat dietary deficiencies (Gonzales *et al.*, 2026). Plant milk ice cream contains enzymes and substances that make digestion easier as they stimulate digestive juice and speed up the intestinal tract and so prevent constipation (Ekumankama, 2022). These milks are designed to mimic the taste, texture and nutritional profile of dairy milk but are derived from plant-based sources. Plant-based milk products are rich sources

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of health-promoting bio-actives and are devoid of cholesterol and ecologically require less energy input per unit of milk production and thus are much appreciated (Ramesh *et al.*, 2022).

Tigernut (*Cyperus esculentus*) is an underutilized tuber rich in many essential nutrients including proteins, carbohydrates, vitamins, minerals, the tuber is reported to have numerous nutritional and health benefits (Obinna-Echem *et al.*, 2024). It can be consumed raw, due to its unique sweet taste, as well as a valuable source for vegetable oils. It is used as high added value compound such as starch, glucose, protein, and minerals (potassium, phosphorus, vitamin E and C) (Bazine & Arslanoglu, 2020).

Coconut (*Cocos nucifera*) has long been recognised as a rich source of plant-based nutrition, offering a composition that complements tiger nut and dairy-free formulations. Coconut milk is also widely used as an alternative to cow's milk, particularly with individuals with lactose-intolerance, milk allergies, or those following a vegan diet (Hatice *et al.*, 2022). An important benefit of coconut milk to the human body is its heart-friendly properties. Despite its relatively high-fat content, studies suggest that the specific fats found in coconut milk may contribute to a healthier cholesterol profile by raising good HDL cholesterol while potentially reducing bad LDL cholesterol (Reyes-Jurado *et al.*, 2021). Additionally, coconut milk contains potassium and magnesium, both of which play essential roles in regulating blood pressure and maintaining cardiovascular health (Amirtha *et al.*, 2021).

Soybean (*Glycine max*) is a widely cultivated leguminous crop known for its high protein content and versatile application in the food industry. As a plant-based milk alternative, soy bean milk has gained prominence in on-dairy ice-cream formulation due to its nutritional benefits, functional properties and suitability for individuals with lactose-intolerance or those following a vegan diet (Hatice *et al.*, 2022). The increasing demand for dairy alternative has made soy milk one of the most researched and utilized basis for plant-based ice cream. It has been widely studied as an alternative to cow milk due to its ability to provide sufficient protein and essential nutrients while being naturally free from cholesterol and lactose (Collard & Cormick, 2021). Soy protein is one of the most significant attributes of soy milk. It contains all nine essential amino acids, making it a complete protein source similar to animal-based proteins (Reyes-Jurado *et al.*, 2021). This is particularly important in ice-cream production because proteins play a crucial role in emulsification, aeration, and the overall stability of the product.

Lactose intolerance affects a significant portion of the global population, leading to digestive discomfort when consuming traditional dairy products (Andreas and Bayu, 2021). Some consumers have avoided the consumption of dairy products as a result of lactose intolerance due to cow milk allergy. More individual struggle with allergies and intolerance, which makes it mandatory to provide

alternatives. One of the primary reasons for the increased use of plant-based milk in ice-cream production is its lactose free nature. However, there is need to ascertain which one is preferable or rated best in terms of sensory and nutritional profiling.

MATERIALS AND METHODS

Sample Collection

The ingredients used in this study were tigernut, coconut, and soybean milks, which served as the base ingredients for the plant-based ice cream formulations. These were sourced from Mile 3 market, Port Harcourt, Rivers State, Nigeria, and prepared under hygienic conditions. Other ingredients included sugar, vegetable fat, carboxymethylcellulose (CMC), egg yolk, and vanilla flavour. Distilled water was used where necessary during the extraction of milk from the plant sources. Conventional dairy milk was used as a control sample for comparative analysis, and purchased from same market.

Chemical/ Reagent

The chemicals, reagents and equipment that was used were of analytical grade and were obtained from the Food Analytical/ Food Chemistry and Microbiological Laboratory, Department of Food Science and Technology, Rivers State University, Nkpolu-Oroworukwo, Port Harcourt, Rivers State, Nigeria.

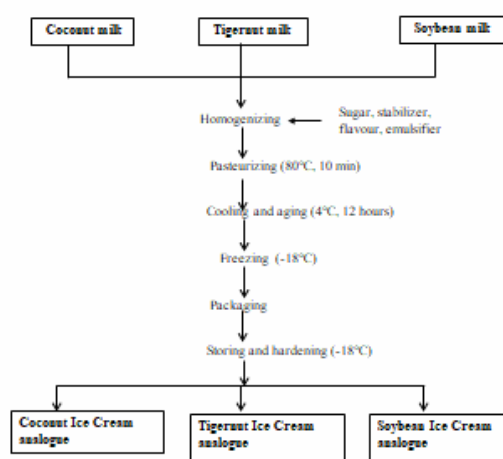
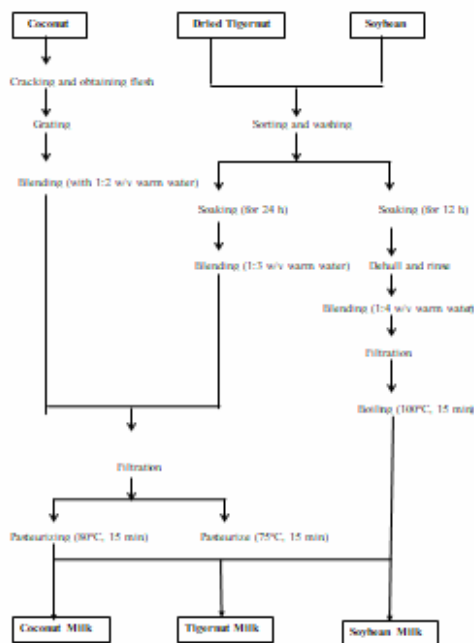
Processing of the Plant-based Milk

The processing of the tigernut, coconut and soybean milks is shown in Fig.1.0

Tigernut Milk Extraction: Dried tigernuts were cleaned, sorted, and soaked in clean water for 24 hours to soften the tubers. The softened tigernuts were blended with distilled water in a ratio of 1:3 (tigernut to water) using a high-speed blender. The resulting slurry was filtered through a muslin cloth to separate the fibrous residue from the liquid. The extracted tigernut milk was pasteurized at 75°C for 15 minutes to eliminate microbial contaminants and stored at 4°C before use.

Coconut Milk Extract: Matured coconuts was cracked open, and the flesh were manually separated from the shell using a clean stainless knife. The coconut flesh was grated and blended with warm water at a ratio of 1:2. The mixture was pressed through a muslin cloth to extract coconut milk. The extracted milk was heated at 80°C for 10 minutes for pasteurization and stored at 4°C before use.

Soybean Milk Extraction: Dry soybeans was sorted and soaked in water for 12 hours to facilitate the removal of anti-nutritional factors such as phytic acid. The soaked beans was dehulled, rinsed, and blended with water in a ratio of 1:4 (soybean to water). The slurry obtained was boiled at 100°C for 15 minutes to eliminate off-flavors and deactivate enzyme inhibitors. The mixture was filtered using a muslin cloth to separate the soybean milk from the residue. The extracted milk was cooled and refrigerated at 4°C before use.



Ice Cream Formulation and Production

The ice creams were formulated using different plant-based milk as substitutes for dairy milk. A standardized formulation consisting of milk (70%), sugar (15%), vegetable fat (8%), stabilizers (1.5%), emulsifiers (1%), and flavour (4.5%) was used for each sample as described by Codex Alimentarius Commission (CAC, 2011). The ingredients were mixed thoroughly and pasteurized at 85°C for 30 minutes to ensure microbial safety. The mixture was then homogenized using a homogenizer at 3000 rpm for 5 minutes to achieve a uniform emulsion. The homogenized mix was aged at 4°C for 12 hours to enhance texture and stability. The ice cream will be frozen at -18°C and hardened before evaluation.

Table 1: Recipe for Ice Cream production

Ingredients	Quantity (g)
Milk (ml)	600
Sugar	129
Vegetable fat	69
Egg yolk	3.5
CMC	4.6
Vanilla flavour	39

Source: CAC (2011)

Determination of Physicochemical properties of the ice creams

The pH, Total titratable acidity (TTA), sugar content, viscosity, melting rate and overrun was determined as described by Association of Official Analytical Chemists (AOAC, 2012). The pH of the ice cream was determined using a digital pH meter (pHs-2F, Harris, England). Exactly 50 ml of the sample was transferred into a beaker and the pH was determined after the meter was calibrated using

standard buffer solutions of pH 4.0 and 7.0. Sufficient time was allowed for equilibration before readings were taken. Thereafter, 3 drops of phenolphthalein were added as the indicator and the mixture was titrated against 0.1 M NaOH, to determine the TTA. Acidity was expressed as % lactic acid with each ml of the 0.1 M NaOH equivalent to 0.0908 of lactic acid. The hand-held sugar refractometer was used to determine the sugar content. The prism of the refractometer was cleaned and a drop of the sample was placed on the prism and closed. The total sugar content (°Brix) was read off the scale of the refractometer when held close to the eye. Viscosity of the of the sample (100 mL) was determined using Rotary Viscometer (NDJ-85, China). To determine the melting rate, the ice cream samples ere kept at -18°C overnight. The samples was then put on a stainless-steel sieve (No.25) at room temperature. At regular time intervals of 10 minutes, the weight of the melted sample was recorded. The volumes of mix and ice cream was weighed, and the percentage overrun were calculated as volume of mix subtracted from the volume of ice cream divided by the volume of mix. This was multiplied by 100.

Determination of Proximate composition of the ice cream samples

The moisture, crude protein, crude fat, ash and total carbohydrate contents of the samples were analysed using the standard analytical method described by AOAC (2012). Moisture was obtained gravimetrically after drying to a constant weight at 70oC in a hot air oven (DHG 9140A). Fat was determined using soxhlet extraction method with ethyl ether. Kjeldahl method and a nitrogen conversion factor of 6.25 was used for crude protein determination. Ash content was determined gravimetrically after the incineration of the samples in a muffle Furnace (Model SXL) at 550oC for 2 h. Total carbohydrate was determined using the Anthrone method.

Determination of Sensory properties of the samples

Sensory evaluation of the ice cream produced was carried out using the 9-point hedonic scale as described

by Iwe (2010). Sensory parameters assessed were colour, flavour, taste, thickness, mouthfeel, aftertaste and overall acceptability. The products were assessed by a panel of 20 individuals who were familiar with ice cream.

Statistical analysis

All the analysis were carried out in duplicate. Statistical analysis was performed using Statistical Package for Service Solution (SPSS), version 26. Data obtained were subjected to Analysis of Variance (ANOVA) and difference between means were compared using Turkey's Multiple comparison tests with 95% confidence level.

RESULTS AND DISCUSSION

Physicochemical properties of ice cream from selected plant-based milk

The pH, viscosity, TSS and overrun of ice cream produced from soy bean, coconut, cow and tiger-nut milk is presented in Table 2.0 below, while the melting rate is presented in Fig. 3.0.

The pH of the samples ranged from 4.28-5.12. Sample A (coconut ice cream) recorded the lowest value, while the highest value was recorded in sample D (cow milk ice cream). There was significant difference ($p < 0.05$) between the control (cow milk ice cream) and the plant-based ice cream. The plant-based ice cream recorded lower PH values (4.28–4.82) when compared with the cow milk ice cream (5.12). This observation agrees with findings by Taesuk *et al.* (2025), who reported that plant-based milk alternatives generally have lower pH values than cow milk products due to their organic acid content. Similarly, Akarca *et al.* (2023) also noted that ice creams made with non-dairy milk exhibited lower pH, possibly due to fermentation by natural lactic acid bacteria present during processing.

The sugar content of the samples ranged from 21.00-

26.01 °Brix with sample A and B (coconut and soybean ice cream) having the lowest value, and sample D (cow milk ice cream) recording the highest. There was significant difference ($P < 0.05$) between the plant-based ice creams and the control. Cow milk ice cream recorded the highest sugar content (26.01 °Brix). Plant-based milk tends to contain less natural sugar unless fortified, explaining the lower values in coconut and soybean ice creams. Tiger nut milk ice cream (24.00 °Brix) shows moderate sugar content, likely due to its natural sweetness. According to Marchyshyn *et al.* (2021), tigernut extract contains high levels of natural sugars like sucrose and fructose, which contributes to its sweetness.

The viscosity of the yoghurt samples ranged from 2.71-2.90 Pa.s, with sample B (soybean ice cream) having the lowest, and sample D (cow milk ice cream) recording the highest. Viscosity is an important factor influencing mouth feel and body of ice cream. There was no significant difference ($P > 0.05$) between the samples. The low viscosity in soybean milk ice cream is consistent with findings of Bricarello *et al.* (2004), who stated that soy milk has a thinner consistency compared to cow milk due to lower fat and solids-not-fat content.

The overrun of the samples ranged from 37.93-42.86%, with sample B and D (soybean and cow milk ice cream) having the lowest, and sample C (Tigernut ice cream) recording the highest. Overrun (incorporation of air) influences texture, lightness, and profitability. There was no significant difference ($P > 0.05$) between samples. Higher overrun values mean more air and lighter ice cream. Soy milk-based frozen desserts studied by Haque *et al.* (2023) exhibited overrun values of approximately 50–65%, this was higher than 37.93% in this study. Tigernut contains a significant amount of starch and fibre which improves air retention (Yu *et al.*, 2022). This explains its high overrun among the plant based- ice cream.

Table 2: Physicochemical properties of ice cream from selected plant-based milks

Sample	pH	Viscosity (Pa.s)	Sugar (°Brix)	Overrun (%)
A	4.28 ^c ±0.03	2.81 ^a ±0.14	21.00 ^c ±0.00	40.85 ^a ±0.00
B	4.71 ^b ±0.01	2.71 ^a ±0.22	21.00 ^c ±0.00	37.93 ^a ±0.00
C	4.82 ^b ±0.06	2.85 ^a ±0.06	24.00 ^b ±0.00	42.86 ^a ±0.00
D	5.12 ^a ±0.01	2.90 ^a ±0.01	26.01 ^a ±0.01	37.93 ^a ±0.00

Values are means ± Standard Deviation of duplicate determinations. Means in the same column with different superscript are significantly different at $p < 0.05$

Keys:

A = Coconut milk ice cream

B = Soy milk ice cream

C = Tigernut ice cream

D = Cow milk ice cream (control)

The melting rate of the ice cream samples is presented in figure 3.0 below. At 10 minutes sample A recorded 5.18% melting rate, C recorded 1.60% while B and D did not melt, while the melting rate in 20 minutes was 55.79%, 1.68%, 75.70% and 70.84% for sample A, B, C and D respectively. At 30 minutes sample A recorded

100% melting rate, B recorded 67.20% while C and D did not record any melting. Coconut ice cream had the fastest melting rate, reaching 100% melt by 30 minutes. Rezaei *et al.* (2020) reported that even when coconut milk ice cream was fortified with dietary fibre its melting rate remained relatively high, recording 60 to 80% melt within 20 to 25 minutes at room temperature which is higher than 55.79% reported in this study.

Soybean ice cream showed very slow melting in the first 20 minutes but reached 67.2% by 30 minutes. This indicates good initial resistance, possibly due to higher

protein content that creates a more stable network, delaying structural breakdown. According to Hasan *et al.* (2024), soy proteins help form strong emulsions in frozen desserts, enhancing melting resistance.

Tigernut ice cream had a high melting rate at 20 minutes (75.7%) but no melting at 30 minutes. Oladipo *et al.* (2021) examined tigernut milk ice cream and reported that the formulations began melting earlier than dairy controls, with substantial melt occurring within 20 to 25 minutes at ambient temperature. Tigernut milk is rich in natural sugars and starch, which can influence melting behaviour. However, its fibre and starch might form a gel-like barrier on the surface, delaying further melting, as reported by Ismail *et al.* (2024).

Cow milk ice cream did not melt at all at 10 or 30 minutes but showed significant melting at 20 minutes (70.84%). Marshall *et al.* (2013) reported that standard cow milk ice creams begin to drip between 8 and 10 minutes under room temperature conditions and achieve about 50 to 60% melting by 20 minutes, progressing to near complete melting around 30 to 35 minutes. According to Afifa and Kurnia (2024), cow milk-based ice creams exhibit slow, steady melt due to superior protein-fiber interactions, especially when high total solids are present.

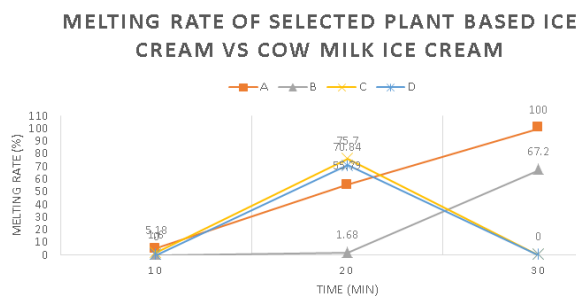


Figure 3: Melting rate of ice cream from selected plant-based milks

Keys:

A = Coconut milk ice cream

B = Soy milk ice cream

C = Tigernut ice cream

D = Cow milk ice cream (control)

Proximate Composition of ice cream from selected Plant-based milk

Table 3.0 shows the proximate composition of ice cream from tiger-nut, coconut, soy bean and cow milks.

The moisture content of the samples ranged from 56.00-65.40%. Sample A recorded the lowest value while the highest value was recorded in sample B. Moisture content determines the sample's water content and, indirectly, its dry matter content. Moisture level more than 14% according to Airaodion *et al.* (2019) makes substances susceptible to microbial growth; hence have a lower storage period. The moisture content of the Ice cream samples in the study (56.00 – 65.40%) was higher than

the 14% threshold, and this explain why ice cream are susceptible to spoilage if not well stored.

Sample B recorded the lowest fat content (1.09%), while the highest fat content (5.99%) was observed in sample A. Fat content varied widely across samples, there was significant difference ($P < 0.05$) between the control (sample D) and the plant-based ice cream. Soy milk ice cream had the lowest fat content (1.09%), a factor which likely influenced its melting behaviour and sensory smoothness as reported by Devalekar and Udachan (2025). Coconut milk ice creams often contain 6–10% fat because of coconut's high natural fat content (Sarsaiya *et al.*, 2022) which is the same with the coconut ice cream (5.99%) in this study.

Crude protein content of the samples ranged from 0.148% in sample A to 0.481% in sample B. Soy milk ice cream recorded the highest crude protein content. This difference is expected, given the naturally high protein content of soybeans. Bricarello *et al.* (2004) emphasized that plant-based proteins, particularly from soy, improve the emulsion stability of ice cream, leading to better texture, viscosity, and melting resistance. This also supports the observed superior performance of the soy milk sample in sensory evaluations.

The ash content of the sample ranged from 1.55-5.20%. Sample A recorded the lowest ash content, while the highest ash content was observed in sample C. The ash content is an indicator of mineral presence. There was no significant difference ($P > 0.05$) between the control (sample D) and the tigernut (sample C) and soy milk ice cream (sample B) but there was significant difference in the coconut ice cream (sample A). Tigernut is known to contain significant levels of potassium, magnesium, and calcium, which may be the reason for the high ash content of the ice cream. Sarsaiya *et al.* (2022) reported ash content between 0.9% and 1.5% for coconut milk ice cream, and this aligns with the ash content of coconut (1.55%) in this study.

Sample A and D recorded the lowest total carbohydrate content (18.47%), while the highest (18.62%) was observed in sample B. Slight differences in carbohydrate content can influence the sweetness, freezing point, and melting behavior of ice cream. Hasan *et al.* (2024) noted that sugars impact both the sensory properties and shelf stability of plant-based ice creams, especially when not countered with protein or fiber-rich components.

Sensory properties of ice cream from selected plant-based milks

The sensory properties result of ice cream produced from coconut, tiger-nut, cow, and soy bean milks is presented on Table 4.0 below. Sensory analysis as reported by Obinna-Echem (2023), is an important criterion for assessing quality in the development of new products and for meeting consumers requirements. The taste score ranged from 6.00-7.80. Sample A was scored lowest while sample B was rated the highest. Colour score of the samples ranged from 6.80-7.70 with sample a having

Table 3: Proximate composition (%) of ice cream from selected plant-based milks

Sample	Moisture	Crude Protein	Crude Fat	Ash	Total Carbohydrate
A	56.00 ^c ±0.71	0.148 ^d ±0.00	5.99 ^a ±0.04	1.55 ^b ±0.07	18.47 ^a ±0.01
B	65.40 ^a ±0.57	0.481 ^a ±0.00	1.09 ^c ±0.14	4.90 ^a ±0.14	18.62 ^a ±0.00
C	61.75 ^b ±1.06	0.306 ^c ±0.00	5.90 ^a ±0.03	5.20 ^a ±0.00	18.57 ^a ±0.01
D	56.70 ^c ±0.14	0.313 ^b ±0.00	2.80 ^b ±0.00	4.90 ^a ±0.10	18.47 ^a ±0.09

Values are means ± Standard Deviation of duplicate determinations. Means in the same column with different superscript are significantly different at $p < 0.05$

the lowest, while sample B and D was scored the highest. There was no significant difference ($P > 0.05$) between samples in their colour scores. Samples B (soy ice cream) and D (cow ice cream) recorded same colour scores (7.70), indicating there were liked moderately (Iwe, 2010). Flavour score of the ice cream samples ranged from 6.40-7.90. Sample A was scored the lowest, while samples B was rated the highest. There was no significant difference ($p > 0.05$) between samples. The smoothness score of the samples ranged from 5.90-7.90. Sample A (tigernut ice cream) was scored the lowest, while the highest was observed in sample B (soy milk ice cream) recorded the highest score. The protein and emulsifier properties in soy help stabilize air cells and prevent iciness, supporting the observations by Devalekar and Udachan (2025) that protein-rich formulations result in smoother ice cream. Sample A was scored the lowest for thickness, while the highest was observed in sample B. There was however no significant difference ($p > 0.05$) among samples. Dairy ice

creams, according to Marshall *et al.* (2013) and Aboulfazli *et al.* (2014), generally achieve higher body scores, often 8.0 and above, due to their balanced fat-protein structure and stable air incorporation during freezing. The aftertaste of the samples ranged from 6.30-7.20, with sample a scoring the lowest, and the highest being observed in sample B and D. The overall acceptability of the samples ranged from 6.30-7.70, sample A was scored the lowest, while sample B was rated the highest. Soy and almond-based frozen desserts by Haque *et al.* (2023) reported overall acceptability scores ranging from 6.5 to 7.8, this aligns to the overall acceptability of soy milk ice cream (7.70) recorded in this study. These findings reinforce that soy milk is a suitable base for plant-based ice cream due to its good nutritional composition and high consumer acceptability, as concluded by Hasan *et al.* (2024).

CONCLUSION

The study demonstrates that plant-based ice creams produced from soybean, coconut and tigernut milks vary

Table 4: Sensory properties of ice cream from selected plant-based milks

Sample	Colour	Taste	Flavour	Smoothness	Thickness	Aftertaste	Overall Acceptability
A	6.80 ^a ±1.03	6.00 ^b ±1.49	6.40 ^a ±1.96	5.90 ^b ±1.37	6.40 ^a ±1.58	6.30 ^a ±1.83	6.30 ^b ±1.14
B	7.70 ^a ±1.06	7.80 ^a ±0.79	7.90 ^a ±0.88	7.90 ^a ±1.20	7.70 ^a ±0.82	7.20 ^a ±1.14	7.70 ^a ±0.76
C	7.00 ^a ±1.70	6.80 ^{ab} ±1.87	7.60 ^a ±1.07	6.70 ^{ab} ±1.42	6.50 ^a ±2.12	7.10 ^a ±1.37	6.95 ^{ab} ±1.39
D	7.70 ^a ±1.34	7.50 ^{ab} ±1.26	7.60 ^a ±0.97	7.40 ^{ab} ±1.35	6.80 ^a ±1.40	7.20 ^a ±1.14	7.37 ^{ab} ±1.07

Values are means ± Standard Deviation of duplicate determinations. Means in the same column with different superscript are significantly different at $p < 0.05$

significantly in physicochemical and sensory properties when compared to cow milk ice cream. Soy milk ice cream showed superior structural stability with slower melting and higher viscosity, while coconut milk ice cream had the fastest melting rate due to its high fat but low protein content. Tigernut milk ice cream exhibited moderate performance, influenced by its starch and sugar content. Sensory evaluation revealed that soy and cow milk ice creams were most liked overall, while coconut and tigernut variants required formulation adjustments to improve flavour and texture. These results confirm that plant-based ice creams can achieve properties close to dairy products but require optimization of protein and stabilizer content to enhance melt resistance, overrun, and acceptability.

REFERENCES

Aboulfazli, F., Baba, A. S., & Misran, M. (2014). Effect of vegetable milks on the physical and rheological properties of ice cream. *Food Science and Technology Research*, 20(5), 987–996.

Afifa, S.I., & Kurnia, P. (2024). Test of total solids and melting rate of coconut milk-based ice cream combined with cashew milk. *Journal La Lifesci*, 5(3), 250-260.

Airaodion A.I., Airaodion E.O., Ewa O., Ogbuagu E.O. & Ogbuagu U. (2019). Nutritional and anti-nutritional evaluation of garri processed by traditional and instant mechanical methods. *Asian Food Science Journal*, 9(4),1-13.

Akarca, G., Kiliç, M., & Denizkara, A. J. (2023). Quality specification of ice creams produced with different homofermentative lactic acid bacteria. *Food science &*

- nutrition*, 12(1), 192–203. <https://doi.org/10.1002/fsn3.3762>
- Amirtha, G., Vijaya, V.R., & Sarah, P. C. (2021). Formation and proximate evaluation of barnyard millet-based ice cream. *Int. J. Multidiscip. Res. Arts Sci.* 12, 59-66.
- Andreas, R., & Bayu, M. (2021). Effect of dairy and non-dairy ingredient in the physical characteristic of ice cream. IOP conference series: *Earth and Environmental Science*, 794(1), 012145.
- AOAC (2012). Official Method of Analysis: Association of Analytical Chemists. 19th Edition, *Washington DC*, 121-130.
- Bazine, T., & F. Arslanoglu, F. (2020). Tiger nut (*Cyperus esculentus*): morphology, products, uses and health benefits. *Black Sea Journal of Agriculture*, 3(4), 324-328.
- Bricarello, L. P., Kasinski, N., Bertolami, M. C., Faludi, A., Pinto, L. A., Relvas, W. G., Izar, M. C., Ihara, S. S., Tufik, S., & Fonseca, F. A. (2004). Comparison between the effects of soy milk and non-fat cow milk on lipid profile and lipid peroxidation in patients with primary hypercholesterolemia. *Nutrition (Burbank, Los Angeles County, Calif.)*, 20(2), 200–204. <https://doi.org/10.1016/j.nut.2003.10.005>
- Codex Alimentarius Commission (2011). Milk and milk products. Second Edition. World Health Organization Food and Agriculture Organization of The United Nations. Rome, 2011.
- Collard, K.M., & Cormick, M.C. (2021). A nutritional comparison of cow milk and alternative milk product. *Academic Pediatrics*, 21 (6), 1067-1069.
- Chude, C.O. (2023). Microbial lactic acid fermentation improves nutritional and organoleptic profile of non-dairy milk made from Bambara groundnut. *American Journal of Food Science and Technology*, 2(1), 5-15.
- Devalekar, S.K., & Udachan, I.S. (2025). Process optimization of vegan prebiotic ice cream by response surface methodology. *Discov Food* 5, 13 (2025). <https://doi.org/10.1007/s44187-025-00282-0>
- Ekumankama, I.O.O. (2022). Photochemical composition of ice cream from tiger nut (*Cyperus esculentus*) milk and coconut (*Cocos nucifera*) milk. *Nigerian Journal of Nutritional Science*, 43(2), 18-26.
- Gonzales, M.J.B, Amor, J.G.C., Pescuela, A.M., & Monares, L.T. (2026). From garden to table: Incorporating organic lettuce into pandesal. *American Journal of Food Science and Technology*, 5(1), 25-31.
- Haque, M., Rahman, T., Akter, S., & Karim, R. (2023). Quality parameters of plant-based frozen desserts: A comparative study of almond and soy formulations. *Journal of Dairy Science*, 106(4): 2154–2166. <https://doi.org/10.3168/jds.2023-23011>
- Hasan, T., Thoo, Y. Y., & Siow, L. F. (2024). Influence of Brown Rice, Pea, and Soy Proteins on the Physicochemical Properties and Sensory Acceptance of Dairy-Free Frozen Dessert. *Food science & nutrition*, 12(11), 9391–9402. <https://doi.org/10.1002/fsn3.4494>
- Hatice, B., Hamza, G., Dila, K., Faith, B., & Osman, S. (2022). Determination of theological, melting and sensorial properties and volatile compounds of vegan ice cream produced with fresh and dried walnut milk. *International Journal of Gastronomy and Food Science* 28 (3), 100521.
- Ismail, S. A., Adeola, A. A., & Bamidele, O. P. (2024). Physicochemical and sensory properties of ice creams produced with tigernut and cow milk blends. *Journal of Food Science and Technology*, 2: 32-39 <https://doi.org/10.1007/s13197-024-06125-7>
- Iwe, M.O. (2010). Handbook of Sensory Methods and Analysis. Nigeria Rejoint Communication Science Ltd., Enugu. Pp 75-78
- Legassa, O. (2020). Ice Cream Nutrition and Its Health Impacts. *J. Food Nutritional Science*, 7(1), 19-27.
- Marchyshyn, S., Budniak, L., Slobodianiuk, L., & Ivasiuk, I. (2021). Determination of carbohydrates and fructans content in *Cyperus esculentus* L. *Pharmacia*, 68(1), 211–216. <https://doi.org/10.3897/pharmacia.68.e54762>
- Marshall, R. T., Goff, H. D., & Hartel, R. W. (2013). Ice Cream (7th ed.). Springer. 28-32.
- Meneses, R.B., Silva, M.S., Monteiro, M.L.G., Rochaleao, M.H.M., & Conte-Junior, C.A. (2020). Effect of dairy by-products as milk replacers on quality attributes of ice cream. *Journal of Dairy Science* 103(11), 10022-10035.
- Nawas, T., Yousuf, N. B., Azam, M. S., Ramadhan, A. H., Xu, Y., & Xia, W. (2017). Physiological properties and sensory attributes of ice cream fortified with microencapsulated silver carp (*Hypophthalmichthys molitrix*) oil. *American Journal of Food Science and Nutrition Research*, 4(3), 79–86.
- Obinna-Echem, P. C., Enente, U. J., Amadi, A. O & Fyne-Akah, H. (2023). Effect of Processing Methods on the Quality Characteristics of Ogi from two Varieties of Millet. *Research Journal of Food Science and Quality Control (R/JFSQC)*, 9 (3), 1-18.
- Obinna-Echem, P. C., Amadi, A. O., Ekuma, C. C., & Fyne-Akah, H. (2024). Quality Attributes of Wheat-Tigernut Flour Blends and Chin-Chin Produced from the Blends. *IPS Journal of Nutrition and Food Science*, 3(1), 102–109. <https://doi.org/10.54117/ijnfs.v3i1.39>
- Oladipo, I. C., Akinoso, R., & Adebo, O. A. (2021). Nutritional and functional properties of tigernut milk-based ice creams. *Journal of Food Science and Technology*, 58(3), 1075–1084. <https://doi.org/10.1007/s13197-020-04609-3>
- Ramesh, F.C., Rahul, R.S., & Bhagwan, K.S. (2023). Functional Ice Cream: Chemistry, Characteristics, and Technology. The chemistry of milk and milk products, 87-106.
- Ramon, B., & Eric, K.S. (2022). Innovative technologies for manufacturing plant based non-dairy alternative milk and their impact on nutritional, sensory and safety aspects. *Future foods*, 5(21), 100098.
- Reyes-Jurado, F., Soto-Reyes, N., Davila- Rodriguez, M., Lorenzo-Leal, A.C., Jimenez- Munquía, M.T.,

- Mani-Lopez, E., & Lopez-Malo, A. (2021). Plant based milk alternatives: types, processes, benefits and characteristics. *Food Reviews international*, 39(4), 2320-2351.
- Rezaei, F., Alihosseini, F., & Ziaee, E. (2020). Effect of dietary fiber fortification on physical and melting properties of coconut milk ice cream. *Journal of Food Processing and Preservation*, 44(9), e14632. <https://doi.org/10.1111/jfpp.14632>
- Sanjana, K., Vincent H., & Sinija, V.R. (2022). Development of plant based milk beverage from coconut and cashew nut milk. *The Pharma Innovation Journal 2022*, 11(7), 3743-3748
- Sarsaiya, S., Awasthi, S., & Kumar, V. (2022). Development and evaluation of cashew and coconut milk-based ice creams. *International Journal of Food Science*, 2022, Article 9206936. <https://doi.org/10.1155/2022/9206936>
- Silva, A.R.A., Silva, M.M.N., & Ribeiro, B.D. (2022). Chapter 12- Plant based milk products. In: *Future foods*, ed. R. Bhat, London, United Kingdom: Academic Press, 233-249.
- Taesuk, N., Wang, A., Srikaew, M., Chumroenphat, T., Barile, D., Siriamornpun, S., & Bunyatratchata, A. (2025). Phytochemical profiling of Thai plant-based milk alternatives: Insights into bioactive compounds, antioxidant activities, prebiotics, and amino acid abundance. *Food chemistry: X*, 27, 102402. <https://doi.org/10.1016/j.fochx.2025.102402>
- Tomczyńska-Mleko, M., Mykhalevych, A., Sapiga, V., Polishchuk, G.; Terpilowski, K., Mleko, S., Solowiej, B.G., & Pérez-Huertas, S. (2024). Influence of Plant-Based Structuring Ingredients on Physicochemical Properties of Whey Ice Creams. *Appl. Sci.*, 14, 2465. <https://doi.org/10.3390/app14062465>
- Yakum, K. N., Ariaahu, C. C., Ariaahu, E. C., & Igoli, J. O. (2024). Physicochemical properties of fortified coconut milk-based chocolate-like drinks as influenced by cocoa powder and sugar levels. *International Journal of Food Science and Technology*, 3(1), 1-19.
- Yu, Y., Lu, X., Zhang, T., Zhao, C., Guan, S., Pu, Y., & Gao, F. (2022). Tiger Nut (*Cyperus esculentus* L.): Nutrition, Processing, Function and Applications. *Foods (Basel, Switzerland)*, 11(4), 601. <https://doi.org/10.3390/foods11040601>