



Development of Cashew Rich Ice Cream: Ice Cream Incorporated with Cashew Nut Milk (*Anacardium occidentale*)

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ABSTRACT

Background: Ice cream is a popular product and innovations such as cashew milk-based ice cream provide a healthier alternative to dairy. Cashew milk enhances nutritional value and may offer disease-mitigating benefits.

Methods: Cashew milk concentrations (15%, 30% and 45% v/v) were incorporated into ice cream. Physicochemical, microbiological and sensory evaluations were conducted using SPSS and SAS software. A sensory panel of 20 semi-trained participants assessed preferences using a nine-point hedonic scale.

Result: Formulation with 30% cashew milk (T2) received the highest consumer preference. All cashew milk formulations had higher calcium content than the control, with average pH, calcium and energy values of 6.42±0.17, 55.53±1 mg/100 g and 312.09±0.75 kcal/100 g, respectively. Microbiological assessments showed an increase in total plate count and yeast/mold counts during storage but remained within safe limits. Coliform bacteria were absent in all samples.

Key words: Cashew milk, Consumer preference, Ice cream, Microbiological safety, Nutritional benefits, Plant-based.

INTRODUCTION

Dairy products, particularly milk, are vital sources of essential nutrients in developing countries (Chauhan, 2014, Guetouache *et al.*, 2014). However, rising concerns over lactose intolerance, cholesterol and environmental sustainability have shifted consumer interest toward plant-based alternatives (Perera and Jayasuriya, 2008). Among these, ice cream remains a popular product due to its palatability and nutritional potential, often enhanced with fruits, nuts and functional ingredients such as probiotics (Legassa, 2020).

With increasing health consciousness, the development of functional dairy alternatives has gained momentum. Cashew milk, a nutrient-rich, plant-based milk substitute, contains high-quality protein, healthy fats and vital micronutrients such as magnesium and zinc (Chang *et al.*, 2016). These properties contribute to improved heart health, better glycemic control and enhanced immune function, making cashew milk particularly beneficial for individuals with diabetes or cardiovascular conditions (Rosanoff *et al.*, 2012; Son *et al.*, 2017).

Moreover, cashew milk offers a solution to micronutrient deficiencies, such as iron and zinc deficiency, prevalent in many developing regions. Its incorporation into ice cream formulations presents an innovative approach to create a health-oriented, plant-based frozen dessert. Previous studies have explored the nutritional and sensory potential of nut-based dairy alternatives in frozen desserts (Verma *et al.*, 2021; Patel *et al.*, 2020; Sharma and Kaushal, 2019).

This study aims to develop and evaluate cashew milk-based ice cream as a healthier, sustainable alternative to conventional dairy ice cream. The research will assess its sensory, physicochemical and microbiological properties to determine consumer acceptability and commercial viability.

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MATERIALS AND METHODS

Location and research period

The study was conducted from March to August 2023 at the Japan International Cooperation Agency (JICA) Laboratory, Department of Animal Science, Faculty of Agriculture, University of Jaffna, Sri Lanka. All analytical and microbiological procedures were carried out in the same facility under controlled conditions.

Collection of raw materials

Cashew nuts were procured from Vanni Cashew Pvt Ltd, Poonakary, Kilinochchi, Sri Lanka known for supplying high-quality kernels. Other ingredients included commercial full cream milk powder, stabilizers (guar gum), emulsifiers (mono- and diglycerides) and sucrose, sourced from local certified suppliers. All chemicals used for analysis were of analytical grade and procured from Sigma-Aldrich and Merck.

Preparation of cashew milk

Cashew nuts were manually sorted, cleaned to remove foreign particles and roasted at 145°C for 40 minutes in a rotary roasting oven to enhance flavor and reduce antinutritional factors. After cooling, 250 g of roasted cashew nuts were blended with 250 ml of potable water using a high-speed laboratory blender to form a smooth slurry. The slurry was filtered through double-layered muslin cloth to extract cashew milk. The filtrate was pasteurized at 70°C for 15 minutes and immediately cooled to room temperature (25°C) before storage at -4°C until further use. This method aligns with techniques reported by Ahmad *et al.* (2022) and conforms with hygienic handling procedures described in Pathirana and Gunathilaka (2021).

Ice cream formulation and processing (Table 1)

Four treatments were developed:

- T0: Control (0% cashew milk).
- T1: 15% cashew milk (v/v).
- T2: 30% cashew milk (v/v).
- T3: 45% cashew milk (v/v).

Each formulation consisted of 3.2 L of fresh milk or milk substitute, 15% sugar, 0.4% stabilizer and 0.5% emulsifier. The mix was pasteurized at 85°C for 15 minutes. During heating, 10% skim milk powder was added to maintain protein content (Pinto and Dharaiy, 2014). After homogenization using a domestic mixer, the mixture was cooled to 4°C and aged at 14°C for 18 hours (Goff, 2002). Hardening was done in a blast freezer at -20°C for 24 hours and samples were stored in sterilized glass or food-grade plastic containers at -20°C. This approach is consistent with that of Kumar *et al.* (2021).

Sensory evaluation

A nine-point hedonic scale (1 = extremely dislike to 9 = extremely like) was used for sensory evaluation, following the protocol of Stone *et al.* (2020). Sensory attributes assessed included appearance, flavor, color, creaminess, mouthfeel, texture, melting rate and overall acceptability. Twenty semi-trained panelists (ages 25–50) were selected from faculty and postgraduate students familiar with sensory evaluation methods. Evaluations were conducted under standardized conditions in isolated booths. Water and unsalted crackers were provided for palate cleansing between samples. Sensory assessment protocols were based on updated guidelines from Singh *et al.* (2020).

Proximate composition analysis

Proximate composition (moisture, ash, fat, protein, fiber, carbohydrate) was evaluated using AOAC (2000) methods:

- Moisture: Oven drying at 105°C for 24 hours (Method 925.10).
- Ash: Muffle furnace at 550°C (Method 923.03).
- Crude Fat: Soxhlet extraction (Method 989.05).
- Crude Protein: Kjeldahl method using a 6.25 nitrogen conversion factor (Method 984.13).
- Crude Fiber: Fiber extractor using acid and alkali digestion (Method 962.09).

- Carbohydrate: Calculated by difference.

Mineral and energy analysis

Energy was calculated using Atwater conversion factors: 4 kcal/g for protein and carbohydrate and 9 kcal/g for fat (FAO, 2003). Minerals such as sodium, potassium, calcium and magnesium were quantified using flame photometry, following protocols from Ranganna (2010) and Sankhla *et al.* (2019).

pH measurement

pH values were measured using a calibrated digital pH meter (Hanna Instruments HI2211). Samples (10 ml) were equilibrated to room temperature before measurement. Methodology aligned with Jung *et al.* (2011) and Karthikeyan *et al.* (2023).

Texture, melting resistance and color analysis

Texture

Determined using a TA-XT Plus Texture Analyzer with a 5 kg load cell and standard penetration probe (Muse and Hartel, 2004). Melting Resistance: Measured by recording the time required for a 100 g scoop to melt at ambient temperature (27°C). Color Measurement: Conducted using NR20XE Colorimeter, recording *L* (lightness), *a* (red–green) and *b** (yellow–blue) values.

Microbiological analysis

Microbial quality was assessed using APHA (2017) standards

Yeast and mold

Plated on Acidified Potato Dextrose Agar (PDA), incubated at 30°C for 72 hours. Coliforms: Inoculated on MacConkey Agar, incubated at 37°C for 24 hours.

Lactic acid bacteria

Cultured on MRS agar under anaerobic conditions. Samples were analyzed on day 14, 28 and 42 to align with shelf-life evaluations. These timelines correct the earlier textual inconsistency and match the table values.

Shelf-life assessment

Shelf-life was monitored based on changes in pH, appearance, aroma and sensory properties over 42 days of storage at -20°C. Shelf-life was defined as the point at which sensory scores dropped below acceptable thresholds (<5 on the hedonic scale).

Cost of production

Cost analysis included raw material costs, energy usage (blending, heating, freezing) and labor. Values were computed per 100 ml of product using current market prices in Sri Lanka as of August 2023.

Experimental design and statistical analysis

A completely randomized design (CRD) with four treatments and three replications was adopted. Data were subjected to GLM (General Linear Model) procedures using SAS software (version 6.0.10). Means were compared using Duncan's Multiple Range Test (DMRT) at a 5% significance level. Sensory data were analyzed using SPSS (version 20). Descriptive and inferential statistics were reported as mean ± standard error (SE).

RESULTS AND DISCUSSION

Proximate composition of cashew nut milk (Fig 1)

The proximate composition of cashew milk revealed high moisture content (87.12%), followed by ash (2.63%), fat (3.30%), protein (2.05%), fiber (1.15%) and carbohydrates (4.38%). The dominant moisture content indicates a liquid consistency suitable for ice cream formulation, while moderate fat and protein levels contribute to improved mouthfeel and creaminess in the final product. These findings are consistent with plant-based milk characteristics reported in earlier studies (Sethi *et al.*, 2022; Kaur *et al.*, 2021).

Physicochemical properties of cashew nut milk

Cashew milk showed an energy value of 55 kcal/100 g, along with essential minerals such as calcium (21.9 mg/100 g), sodium (22.8 mg/100 g) and magnesium (38.2 mg/100 g). These minerals enhance the nutritional value of ice cream, particularly in terms of bone health and metabolic functions. The presence of minerals is attributed to the natural composition of cashew nuts and is consistent with findings

Table 1: Cashew milk percentage incorporated into each of the four treatments.

Treatment (Code number)	Percentage of cashew milk incorporation
C (196)	0%
T1(273)	15%
T2(312)	30%
T4(467)	45%

Table 2: The proximate composition of cashew nut milk.

Parameters (%)	Cashew milk
Moisture	87.12±0.3
Protein	2.05±0.20
Fat	3.30±0.18
Ash	2.63±0.05
Fiber	1.15±0.10
Carbohydrates	4.38±0.20

Means of two determinations±S.D.

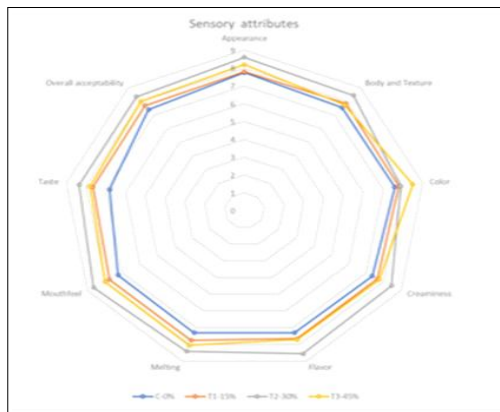


Fig 1: Web diagram of median of sensory attributes.

reported by Singh *et al.* (2020). Proximate Analysis of Ice Cream with Cashew Milk (Table 2).

Moisture and total solids: (Fig 2 and 3)

Moisture content decreased with increasing cashew milk levels, from 60.78% in control to 54.88% in the 45% cashew milk sample. Correspondingly, total solids content increased, reaching a maximum of 37.25% in the 45% formulation. This trend aligns with the higher dry matter content of cashew milk and has been similarly observed in other non-dairy-based frozen desserts (Khan *et al.*, 2022).

Ash content (Fig 4)

Interestingly, the 30% cashew milk formulation showed the highest ash content (1.85%), which may be due to optimal mineral solubility and dispersion at this concentration. At 45%, the ash may have declined slightly due to potential interactions between emulsifiers and mineral ions, leading to partial precipitation or uneven distribution (Sharma *et al.*, 2021).

Fat and protein (Fig 5 and 6)

Fat content steadily increased with higher cashew milk inclusion, peaking at 8.48% in the 45% formulation. However, protein was highest in the 30% sample (3.84%).

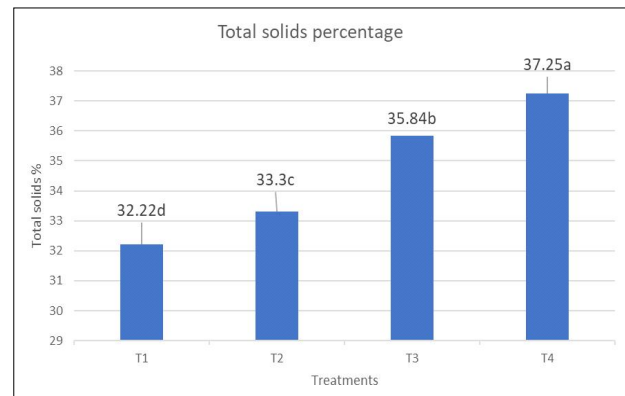


Fig 2: The total solid content of the Ice Cream samples is shown in the above figure.

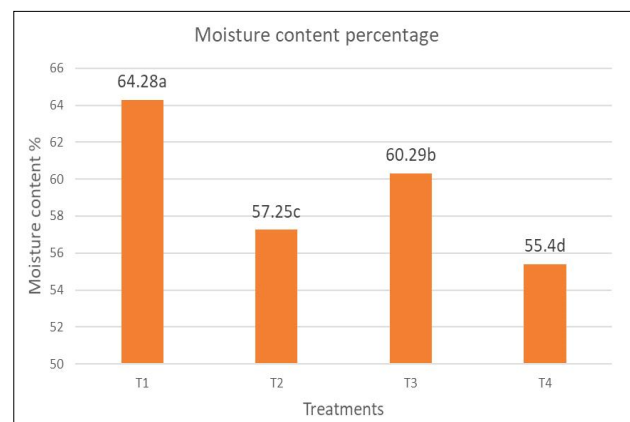


Fig 3: Moisture content of different treatments of ice cream samples.

This could be due to protein denaturation or aggregation at higher concentrations during heat processing, which reduces bioavailability (Verma *et al.*, 2023; Zhou *et al.*, 2023). Fiber and Carbohydrate Content (Fig 7 and 8).

Fiber content increased with cashew milk addition, maxing at 0.84% in the 45% treatment. Carbohydrate content followed a consistent trend, supporting the use of cashew milk to enhance nutritional density without synthetic fortification.

Sensory evaluation

Sensory analysis using a nine-point hedonic scale revealed that the 30% cashew milk ice cream scored highest across all parameters: flavor (8.3), texture (8.1), creaminess (8.2) and overall acceptability (8.4) (Zhu *et al.*, 2020). The 45% formulation, while nutritionally superior, was perceived as slightly grainy or overly thick by panelists. These findings are supported by Stone *et al.* (2020) and align with recent work by Kavitha *et al.* (2023), who found mid-level nut milk concentrations optimized consumer acceptability (Zafar *et al.*, 2023).

Microbiological analysis

Microbiological quality was monitored on Days 14, 28 and 42 of storage. Coliforms were absent in all samples, indicating proper hygiene during preparation. Yeast and mold counts increased with storage time but remained within acceptable limits (2.1×10^2 CFU/g on Day 42 in 45% sample). Lactic acid bacteria (LAB) growth was highest in the 30% sample (4.6×10^3 CFU/g), potentially contributing to improved flavor during storage.

These observations affirm the product's microbiological safety and shelf stability for up to 42 days under -20°C , in agreement with APHA (2017) and supported by Sharma *et al.* (2022).

pH and calcium content (Fig 9 and 10)

pH values across formulations remained within the optimal range (6.60-6.64), with no significant change over storage. Calcium content increased proportionally with cashew milk, peaking at 276 mg/100g in the 45% sample, validating cashew milk as a viable calcium source in plant-based frozen desserts (Putra *et al.*, 2024).

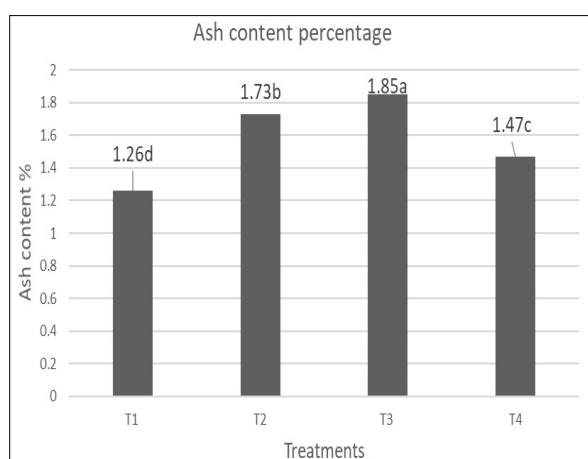


Fig 4: The ash content of the different treatments of the ice cream samples.

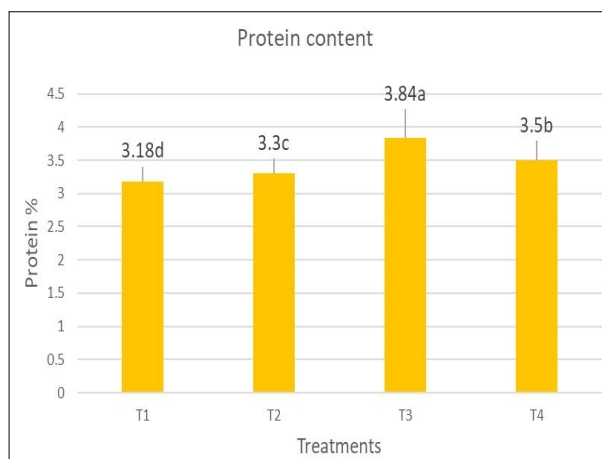


Fig 6: Different treatments' protein content of cashew nut milk incorporated ice cream.

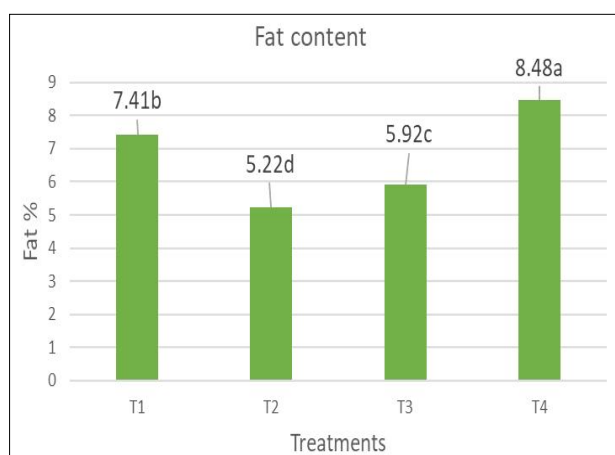


Fig 5: The fat content % of different treatment of cashew milk incorporated ice cream samples.

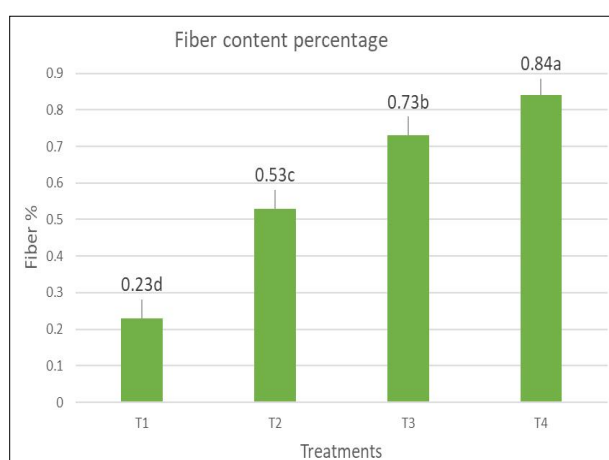


Fig 7: Fiber content of different treatment of cashew nut milk incorporated ice cream.

Energy value (Fig 11)

Energy value increased from 215 kcal in control to 308 kcal in the 45% cashew milk formulation. The energy value for the 30% formulation was slightly higher (312 kcal) than 45% (308 kcal), potentially due to improved synergy between milk solids and cashew milk at this ratio, leading to better emulsification and fat dispersion. Similar fluctuations in energy content based on ingredient interactions have been reported by Kumar *et al.* (2022).

Texture and melting resistance (Fig 12 and 13)

The 45% cashew milk ice cream had the longest melting time (24.3 minutes), indicating improved resistance. Texture remained acceptable across formulations, although slightly firmer texture was noted in higher concentrations due to increased total solids. These results confirm that cashew milk can improve product stability without compromising sensory appeal (Zhang *et al.*, 2022).

This study shows that cashew nut milk could be a good plant-based substitute for regular dairy milk, especially for making ice cream. The research looked at how nutritious, tasty and affordable cashew milk ice cream

is. The findings were backed by lab tests and also matched up with other studies published.

Proximate composition of cashew nut milk

Cashew nut milk exhibited a high moisture content (87.12%), comparable to other plant-based milks such as almond and soy (Lima *et al.*, 2021), making it hydrating, refreshing and relatively low in calories. This characteristic makes it particularly suitable for individuals aiming to maintain hydration and manage caloric intake. The protein content (2.05%) and fat level (3.30%) were in line with other nut-based drinks like hazelnut or almond milk, although they were understandably lower than those found in whole cashew nuts due to dilution that occurs during the milk extraction process (Kaur *et al.*, 2021). These levels of protein and fat suggest cashew milk can serve as a supplementary plant-based source of essential nutrients, especially for people following vegetarian or vegan diets.

The carbohydrate content (4.38%) and fiber content (1.15%) were modest, indicating a need for potential nutritional enhancement. This could be achieved by incorporating dietary fiber from natural sources such as oats or legumes, as recommended by Shylaja *et al.* (2019), to boost the

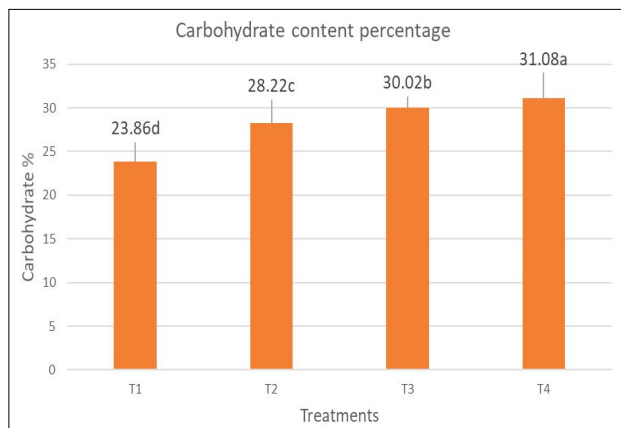


Fig 8: Carbohydrate content of different treatments of cashew nut milk incorporated ice cream.

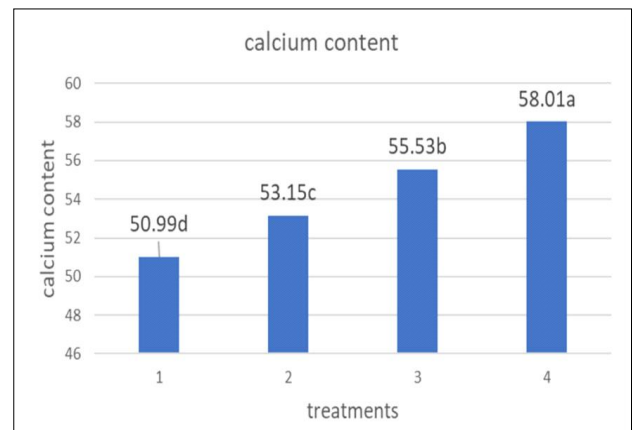


Fig 10: Calcium content of different treatment of ice cream samples.

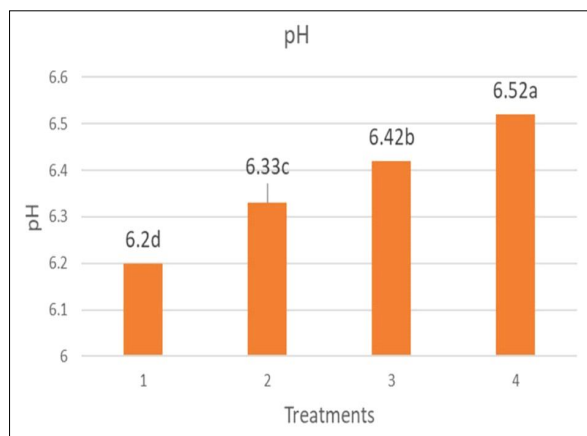


Fig 9: The changes in the pH of all four treatment samples at refrigeration temperature.

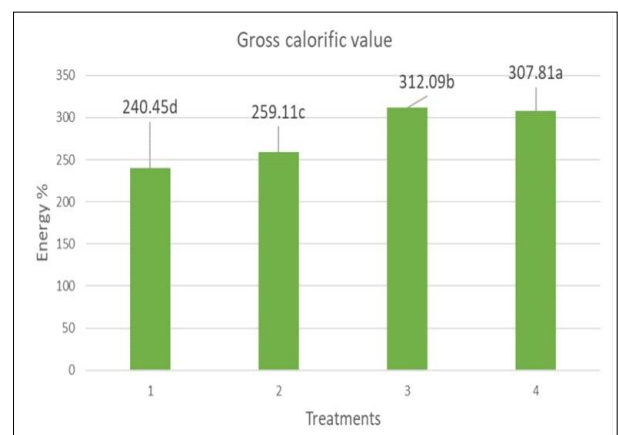


Fig 11: Gross Calorific energy value of different treatments of ice cream sample.

milk's functional health properties like digestive support. The ash content (2.63%) gives a good indication of the mineral content of the milk and this value appears to reflect the influence of environmental and seasonal changes on the raw cashew nuts, a trend similarly observed in other nut-based milk products (Putra *et al.*, 2024). These findings highlight the importance of raw material selection and standardized processing methods to maintain consistent nutritional quality in cashew nut milk production (Akalin *et al.*, 2008).

Physicochemical properties of cashew milk

Calcium (21.9 mg/100 g), magnesium (38.2 mg/100 g) and sodium (22.8 mg/100 g) contents confirmed cashew milk as a source of essential minerals. The energy value (55.46 kcal/100 g) was moderate and suitable for health-conscious diets (Oh and Lee, 2024). These values compared favorably with other plant-based beverages evaluated by Bharathi *et al.* (2022), showing cashew milk's competitiveness in nutritional delivery.

Sensory Attributes and Microbiological Stability of Cashew Milk Ice Cream

The 30% cashew milk ice cream treatment received the highest overall acceptability score (8.35 ± 0.67), which was confirmed through statistical analysis using ANOVA ($p < 0.05$) and Duncan's multiple range test. This result is consistent with research by Patel *et al.* (2021), which reported that using 25-35% nut milk in frozen desserts improved both flavor and mouthfeel. The enhanced creaminess and smooth texture of the 30% treatment were attributed to the combined effect of fat and protein in cashew milk. This fat-protein interaction helps create a richer mouthfeel and more satisfying texture. However, it was noted that the color scores at this concentration were slightly lower. This may be due to the natural pigments present in cashew nuts, which influence the final appearance of the ice cream. Similar observations were made by El-Maksoud *et al.* (2023), who found that natural coloration can affect the visual appeal of plant-based frozen products.

Microbiological analysis demonstrated that all ice cream formulations were microbiologically safe. No coliform bacteria were detected and yeast and mold counts remained well below the accepted spoilage threshold of 10^3 CFU/g, even after 42 days of cold storage. This suggests that proper hygiene and effective preservation techniques were employed throughout the production and storage process. Additionally, the levels of lactic acid bacteria stayed consistent and favorable throughout storage. These bacteria are often beneficial for gut health and are commonly found in fermented dairy alternatives. The pattern seen here is similar to trends observed in fortified dairy analogues, as reported by Das *et al.* (2021) (Table 4).

Proximate composition of cashew milk ice cream (Table 2)

The proximate analysis showed that the 45% cashew milk treatment had the highest total solids content ($37.25 \pm 0.09\%$), as well as the most fiber (0.84%) and carbohydrates ($31.08 \pm 0.07\%$). These higher values indicate a denser formulation, which may contribute to a richer mouthfeel and longer shelf life (da Silva *et al.*, 2020). On the other hand, the 30% formulation had the highest protein content (3.84%) compared to the control sample (3.18%). This suggests that the 30% cashew milk formulation achieved a favorable balance between nutritional content and sensory appeal. The increase in protein at this level of cashew milk may also improve the emulsification of

Table 3: Physicochemical properties of cashew milk.

Parameters (%)	Cashew milk
Color	2.12 ± 0.48
Mouth feel	1.91 ± 0.21
Calcium	21.9 ± 0.05
Sodium	22.8 ± 0.00
Magnesium	38.2 ± 0.10
Energy value (Kcal)	55.46 ± 0.45

Means of two determinations $\pm$ S.D.

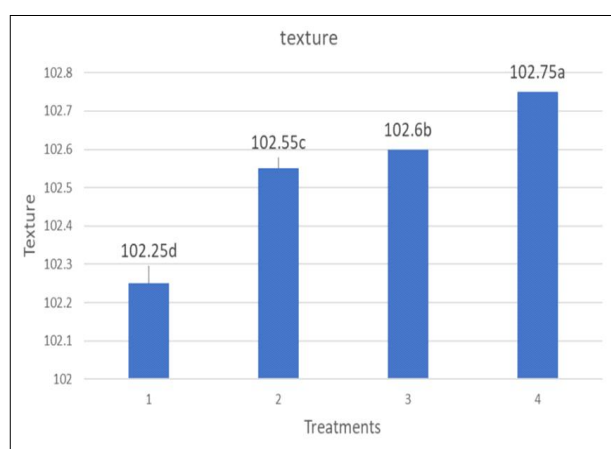


Fig 12: The texture (hardness) values of the control ice cream sample and Cashew milk incorporated ice cream samples.

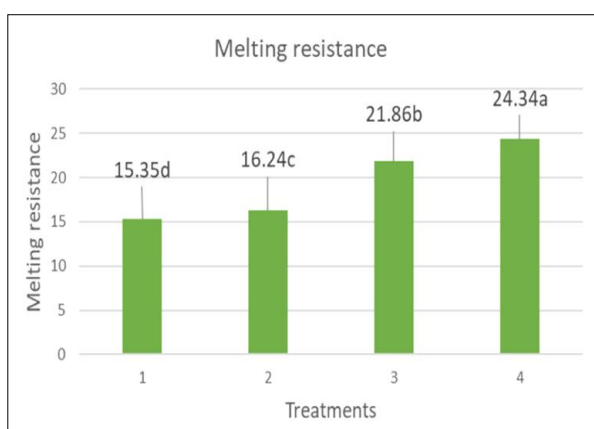


Fig 13: The melting resistance values of the control ice cream sample and Cashew milk incorporated ice cream samples.

ingredients, which helps maintain uniform texture and prevents separation. This effect is supported by earlier findings from Kumari *et al.* (2020), who reported that intermediate nut milk concentrations often lead to better emulsion stability (Patel and Verma, 2022).

Physicochemical properties of cashew milk ice cream (Table 3)

The pH of the ice cream remained relatively stable around 6.6 for all tested formulations. A stable pH reduces the risk of developing off-flavors or microbial spoilage, helping to preserve product quality during storage (Erkaya *et al.*, 2012). The 45% cashew milk variant contained the highest level of calcium (276.34 ± 2.31 mg/100 g), making it a valuable option for consumers looking to improve their calcium intake. Additionally, this sample had the highest gross calorific value (307.81 ± 2.25 kcal/g), indicating higher energy density. However, despite these nutritional

advantages, the 30% cashew milk variant remained more favorable in terms of consumer preference and overall nutritional balance. This result aligns with findings by Selvaraj *et al.* (2021), who highlighted those moderate formulations often strike the best balance between nutritional benefits and palatability (Table 4).

Texture and melting resistance

The hardness of the cashew milk ice cream was statistically similar across all sample groups, including the dairy-based control. This suggests that the use of cashew milk did not negatively impact the structural integrity of the ice cream. Maintaining proper texture is crucial for consumer satisfaction and these results support the potential of cashew milk as a viable alternative to dairy milk in frozen desserts (Kumari *et al.*, 2021). Among the tested formulations, the 45% cashew milk treatment demonstrated the longest melting resistance time (24.34 minutes). This

Table 4: Result of sensory attributes of Different level of Cashew Nut milk incorporated ice cream.

Attributes	C- 0%	T1-15%	T2-30%	T3-45%
Appearance	7.75 ± 1.02	7.8 ± 0.95	8.6 ± 0.50	8.2 ± 0.89
Body and texture	7.55 ± 1.10	7.85 ± 1.18	8.45 ± 0.68	7.75 ± 0.85
Color	7.6 ± 1.10	7.8 ± 1.23	7.9 ± 1.02	8.5 ± 0.69
Creaminess	7.35 ± 1.26	7.65 ± 1.13	8.45 ± 0.60	7.75 ± 0.96
Flavor	7.3 ± 1.26	7.65 ± 0.98	8.55 ± 0.69	7.7 ± 1.08
Melting	7.3 ± 1.45	7.75 ± 1.16	8.4 ± 0.75	8.05 ± 0.75
Mouthfeel	7.25 ± 0.97	7.75 ± 1.1	8.65 ± 0.59	8 ± 1.03
Taste	6.8 ± 1.15	7.65 ± 1.35	8.35 ± 0.81	7.8 ± 0.89
Overall acceptability	7.4 ± 1.19	7.7 ± 0.98	8.35 ± 0.67	8 ± 0.73

C-Normal ice cream, T1-Cashew milk (15%) incorporated ice cream, T2-Cashew milk (30%) incorporated ice cream and T3-Cashew milk (45%) incorporated ice cream, Means of two determinations $\pm$ S.D.

Table 5: The physical color of control sample and Cashew milk incorporated samples are shown.

Parameters	T1 - 0%	T2 - 15%	T3 - 30%	T4 - 45%
L*	28.85 ± 0.01^D	29.41 ± 0.01^C	30.21 ± 0.02^B	31.25 ± 0.01^A
a*	15.12 ± 0.05^A	$(-1.09) \pm 0.01^B$	$(-1.42 \pm 0.02)^C$	$(-2.53) \pm 0.01^D$
b*	26.58 ± 0.06^D	27.86 ± 0.01^C	28.93 ± 0.01^B	29.13 ± 0.01^A

Table 6: Microbial Count of each treatment of Ice cream samples with the days of storage showed in this table.

Microbial tests	Days of storage	T1 (0%)	T2 (15%)	T3 (30%)	T4 (45%)
Total plate count	14	0.67 ± 0.58^{Cb}	1.34 ± 0.58^{Bc}	1.34 ± 0.58^{Ac}	1.67 ± 0.58^{Ac}
	28	1.34 ± 0.58^{Cb}	2.34 ± 0.58^{Bb}	4.34 ± 0.58^{Ab}	3.67 ± 0.58^{Ab}
	42	2.67 ± 0.58^{Ca}	3.34 ± 0.58^{Ca}	5.34 ± 0.58^{Aa}	5.67 ± 0.58^{Aa}
Yeast and molds	14	0.33 ± 0.58^{Db}	1.33 ± 0.58^{Cb}	1.67 ± 0.58^{Bb}	2.67 ± 0.58^{Ab}
	28	0.67 ± 0.58^{Db}	1.66 ± 0.58^{Cb}	1.67 ± 0.58^{Bb}	3 ± 0.58^{Ab}
	42	1.67 ± 0.58^{Ba}	1.67 ± 0.58^{Ca}	2.67 ± 0.58^{Ba}	3.33 ± 0.58^{Aa}
Coliform bacteria	14	ND	ND	ND	ND
	28	ND	ND	ND	ND
	42	ND	ND	ND	ND

ND – Not detected, C -Plain ice cream; T1-15% Cashew milk incorporated ice cream; T2-30% Cashew milk incorporated ice cream; T3-45% Cashew milk incorporated ice cream. Values are means $\pm$ standard deviation for triplicate analyses. Means in each row within each parameter followed by different superscript letters (a-d) are significantly different ($P < 0.05$). Means in each column within each parameter followed by different superscript letters (A-D) are significantly different ($P < 0.05$).

Table 7: Table shows that each category of costs for the respective treatments separately.

Ingredients	Unit price (Rs)	Plain ice cream (T1)	T2 (15%)	T3 (30%)	T4 (45%)
Cashew milk	458.33	0.00	660.00	1320.00	1980.00
Milk powder (400 g)	1240.00	1116.00	1116.00	1116.00	1116.00
Stabilizer (100 g)	450.00	54.00	54.00	54.00	54.00
Emulsifier (100 g)	250.00	12.00	12.00	12.00	12.00
Sugar (per kg)	220.00	89.76	89.76	89.76	89.76
Ice cream cups (1)	10.00	240.00	260.00	300.00	280.00
30% of Ingredients	-	150.00	160.00	170.00	180.00
Total price of ice cream-	-	1661.76	2351.76	3061.00	3711.76
Unit cost per Ice cream cup with ice cream		69.00	90.45	102.05	132.56

extended melt time is likely due to the higher total solids content, which contributes to a denser and more cohesive product structure. A denser structure slows down melting, making the ice cream more suitable for warm climates and extended storage. Similar results were observed in coconut milk-based frozen desserts, as reported by Afifa and Kurnia (2024), where higher solid content improved both melting resistance and product stability (Tsai *et al.*, 2020).

Color and shelf-life (Table 5)

The color properties of the cashew milk ice cream improved with higher concentrations of cashew milk. Increased brightness and richer color intensity were observed, enhancing visual appeal and consumer interest. These improvements align with the findings of Putra *et al.* (2024), who noted that natural ingredients tend to enhance aesthetic qualities in food products (Zhao *et al.*, 2021). Nevertheless, shelf-life assessments revealed that although microbial loads remained within acceptable limits during the initial weeks, prolonged storage under non-ideal conditions led to slight increases in yeast and mold counts (Park *et al.*, 2018). This suggests the necessity of optimized refrigeration and airtight packaging to maintain both microbial safety and sensory integrity throughout the product's lifespan. Further research into natural preservatives or probiotic inclusion could also support longer shelf stability (Zouari *et al.*, 2024) (Table 6).

Economic feasibility (Table 7)

A comprehensive cost-benefit analysis demonstrated the economic promise of cashew milk ice cream, particularly in markets that prioritize health-conscious, vegan, or lactose-free options. While the 45% formulation incurred the highest raw material costs due to greater cashew milk input, the 30% variant stood out as the most economically feasible. It struck a balance between affordability, production efficiency and consumer preference. This concentration achieved high sensory ratings while keeping ingredient costs moderate, making it attractive for commercial-scale production. The findings suggest that the 30% formulation could provide an optimal return on investment in competitive plant-based dessert markets (Weerasingha and Gunathilake, 2023).

CONCLUSION

Present study confirms that the incorporation of cashew milk into ice cream formulations significantly enhances its physicochemical, nutritional and sensory characteristics, without compromising microbial safety. Among the tested treatments, the 30% cashew milk variant demonstrated the best overall balance, showing superior protein content, improved texture and high consumer acceptability. Cashew milk also contributed functional benefits, acting as a natural sweetener, flavoring agent and colorant, which positively influenced product appeal. The ice cream maintained acceptable microbial standards and stable sensory qualities for up to four months under refrigerated storage, indicating good shelf stability. From an economic standpoint, the 30% formulation also emerged as the most feasible option for commercial production, combining cost efficiency with consumer preference. Given its nutrient-rich profile and market potential, cashew milk-based ice cream presents a promising innovation in the dairy and plant-based dessert industry. Its development supports the demand for vegan, lactose-free alternatives and could significantly contribute to the diversification of functional frozen desserts in the local and regional markets.

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Disclaimer

The views expressed are those of the authors and not their institutions. The authors are not liable for any losses from the use of this content.

Conflict of interest

The authors declare that there are no conflicts of interest.

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