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RESEARCH ARTICLE

Development and Evaluation of Sensory Characteristics of Peanut Milk-Based Ice Cream

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ABSTRACT

Ice cream is a widely consumed dairy product enjoyed by all age groups. There has been a growing trend in developing plant-based ice-creams by substituting cow milk with alternatives derived from nuts, legumes, and grains, as these alternatives have enhanced nutritional and functional benefits compared to conventional dairy-based ice cream. The objective of the current study was to develop a nutritionally enhanced ice cream by partially replacing cow milk with peanut milk and to evaluate its sensory and physicochemical properties. Three different combinations of ice creams were formulated by incorporating peanut milk at varying levels (30%, 40%, and 50%). Sensory evaluation was conducted for the three ice cream samples, and the formulation containing 50% peanut milk was significantly preferred by the panelists ($p<0.05$). Rheological and physicochemical analysis were performed on the ice cream sample which was selected from the sensory analysis. The overrun, total solids, moisture, carbohydrates, protein, fat, and ash percentages of the selected sample were 29.63±0.01, 42.78±0.02, 57.16±0.25, 30.59±0.25, 3.46±0.25, 7.07±0.03 and 1.73±0.02, respectively. According to these results 50% peanut milk ice cream had desirable physicochemical properties and high sensory acceptability. Therefore, it can be considered a nutritious and consumer-acceptable alternative to conventional ice cream.

Keywords*: Ice cream, Milk, Peanut milk, Physicochemical analysis, Sensory evaluation*

INTRODUCTION

Ice cream is a sweetened frozen food mostly eaten as a snack or dessert. It is usually made up of dairy products, such as milk and milk cream and is also often combined with fruits or other ingredients for flavour and colour. It is typically sweetened with sugar or sugar alternatives (Campidelli *et al.*, 2022). Flavorings and colorings are added in combination with stabilizers and emulsifiers. Because of the increasing number of people with metabolic disorders, there is a corresponding increase in demand for low-calorie foods (Turck *et al.,* 2013), which is the motivation for this alternative in ice cream formulation. In 2020, the U.S. National Library of Medicine indicated that approximately 65% of individuals globally have impaired lactose digestion. In East Asia, 70-100% of people are lactose intolerant (Beegum *et al.*, 2022). Plant-based ice cream alters the nutritional composition of the ice cream in addition to minimizing the negative effects associated with lactose intolerance (Vanga *et al.,* 2018). The accurate selection of the milk base is critical in ice cream making. Peanuts are a plant source abundant in protein, minerals, and essential fatty acids such as linoleic and oleic acids which are considered highly beneficial for human nutrition (Jones *et al.*, 2014). Furthermore, the use of plant source reduces the demand for dairy ice cream, making non-dairy frozen desserts an ideal choice for individuals following vegan or vegetarian diets (Petersen *et al.*, 2017). A number of dietary requirements brought on by health conditions including food allergies and lactose intolerance, as well as lifestyle modifications, and rising environmental consciousness, have led to a recent surge in consumer demand for more plant-based meals (Paul *et al.*, 2020). Accordingly, healthy sustainable alternative food sources are needed to meet the nutritional needs of the growing world population. In addition to incorporating the nutritional benefits and health-promoting effects of plant compounds into ice cream, the use of plant-based milk as a source of plant proteins and lipids also produces novel products with particular characteristics, like lactose-free products, which may appeal to and benefit consumers plant-based milk is cholesterol-free and contains unsaturated fats, which benefit the cardiovascular system (Trubnikova *et al.*, 2023). These products are nutritious alternatives to animal milk and are also rapidly digestible. Some people, such as vegans or those who are allergic to lactose or casein, have completely eliminated dairy products from their diet (Mäkinen *et al.*, 2016).

Vegan ice cream is a type of ice cream made from non-animal based raw materials, usually non-dairy milk, such as soy milk, coconut milk, almond milk, cashew milk, etc. (Nistor *et al.*, 2020). Nowadays, there is an increasing trend for plant-based or non-dairy milks in the food industry. Cow milk allergy and lactose intolerance are some of the reasons for the consumers to choose vegan diet as an alternative (Sethi *et al.*, 2016). Plant-based milk alternatives are a crucial element in a variety of vegan foods, including plant-based ice cream, yogurt, cheese, kefir, and butter (Anwar *et al.*, 2022). Peanuts are a low-cost, nutrient-dense dietary source for people globally (Legassa *et al.*, 2020). Peanuts are consumed whole, roasted, and in a variety of products including peanut butter, peanut oil, and other substances (Arslan *et al.*, 2018). Peanuts belong to the Fabaceae family of beans and legumes, and their main components are protein, fats, and fiber (Chang *et al.*, 2013). According to Arya *et al.* (2015), peanuts are a rich source of oleic and linoleic acids, and a typical peanut contains approximately 50% fat, of which about 80% is unsaturated, and the majority of these unsaturated fatty acids are oleic and linoleic acids. The linoleic acid is necessary for human metabolism, and since people lack the enzyme to synthesize it, omega-6 fatty acids must be consumed with food (Toomer *et al.*, 2018). The oleic acid guarantees health benefits and offers an advantage for a long shelf life in addition to oxidizable polyunsaturated fatty acids (Saini *et al.*, 2021). Additionally, peanuts contain vitamins, minerals, polyphenols, antioxidants, phytosterols (which prevent the body from absorbing cholesterol from food), flavonoids, resveratrol, and phenolic acids, among other significant substances (Bernat *et al.*, 2014). According to research, peanuts contain all 20 amino acids, with the highest concentration of arginine, along with the co-enzyme Q10 (Settaluri *et al.*, 2012). These bioactive substances are believed to promote longevity and have a preventative effect against certain diseases (Arya *et al.*, 2015). Protein, fat, vital amino acids, minerals, and vitamins are all present in peanut milk, and as it contains no cholesterol and unsaturated fatty acids, it lowers the risk of heart disease (Bernat *et al.*, 2014). In contrast, the issue of lactose intolerance will be resolved by utilizing this milk. Peanut milk can be made by soaking and crushing full-fat raw peanuts in water, then filtering (Syed *et al.*, 2018). Peanut milk and its products are nutritionally beneficial to both young and elderly individuals due to their high protein, mineral, and essential fatty acid content (Yadav *et al.*, 2010). Over time, peanut milk has been effectively transformed into low-cost edible items with good nutritional content (Diarra *et al.*, 2005). This study aims to develop a peanut milk–based ice cream by partially replacing cow milk with peanut milk and to evaluate its sensory acceptability and physicochemical properties as a nutritious plant-based alternative to conventional ice cream.

MATERIALS AND METHODS

The required raw materials were obtained from a local grocery store and the research was conducted at the Food Production Laboratory of Faculty of Technology, University of Jaffna. The preparation of peanut milk was the initial step of the study, followed by ice cream formulation and subsequent analyses. Initially, the sorted peanut seeds were roasted at 130°C for 20 min, de-skinned, and weighed. They were then soaked for at least 12 h in a $NaHCO_3$ solution (0.5 g per 100 mL), following the method of Schmidt (2004). The kernels were washed with water, and blended with water at a 1:6 ratio [peanuts (g): water (mL)]. The resulting slurry was then filtered through a clean cloth to obtain peanut milk, following the method described by Goff (2016). All ingredients were accurately weighed according to the formulation requirements for each of the three treatments. Milk powder and stabilizer were pre-mixed with a small amount of water. All components were then combined, stirred while heating to 45–50°C, and blended for 3 min. The mixture was pasteurized at 80°C for 25 sec, homogenized, and immediately cooled to 5°C. It was then aged for 3 h at 4–5°C. Subsequently, the mixture was frozen in a batch ice cream maker for 20 min, following the procedure of Deosarkar *et al.* (2016), and filled into coded plastic containers before being stored at -18°C for a minimum of 24 h. The resulting ice cream mix was then added into a batch ice cream maker and frozen for 20 min. Finally, the samples were poured into plastic containers, coded, and stored at -18°C for at least 24 h, following the storage procedure of Smith *et al.* (2008). Three distinct peanut milk ice cream samples were made by adding peanut milk in varying ratios, as shown in Table 1. A conventional ice cream sample was produced using cow milk, utilizinging the same ingredients and processing conditions for comparison.

All experiments were conducted in triplicate, and the results are presented as mean ± standard deviation (SD). Sensory evaluation data obtained from 30 untrained panelists and physicochemical parameters were analyzed using one-way analysis of variance (ANOVA). Significant differences among treatment means were determined at a 95% confidence level ($p<0.05$)

Table 1: Formulations of peanut milk ice cream (% w/w)

Ingredients	Treatment 1 (%)	Treatment 2 (%)	Treatment 3 (%)
Peanut milk	30	40	50
Milk powder	15	15	15
Sugar	15	15	15
Stabilizer	0.5	0.5	0.5
Lecithin	0.2	0.2	0.2
Vanilla	0.2	0.2	0.2
Water	35	25	15

The analyses included rheological properties, physicochemical properties, sensory evaluation, and microbial quality assessment. Rheological properties such as overrun and melting resistance, and physical properties including texture and color, were evaluated (Bisla *et al.,* 2012). Sensory evaluation was conducted using 30 untrained panelists, and the most acceptable formulation was selected. Moisture, fat, ash, and protein contents were determined using oven drying, manual extraction, a muffle furnace, and the Kjeldahl method, respectively. Carbohydrate content was calculated by difference. The selected sample was further subjected to physicochemical, rheological, and microbial analyses (Aboulfazli *et al.,* 2014). Microbial quality was assessed by determining total plate count, yeast, and mold counts. For yeast and mold analysis, Acidified Potato Dextrose Agar (PDA) was used. Diluted samples were inoculated into sterile Petri dishes using the pour plate method and incubated at 30°C for 72 h. Colony-forming units (CFU) were enumerated using a colony counter (SLS 393, 1990). The PDA medium was prepared by dissolving 40 g of dehydrated powder in 1 L of distilled water, allowing it to soak for 10 min, and stirring using a magnetic stirrer. The medium was dispensed into conical flasks and sterilized by autoclaving at 121°C for 15 min. Physicochemical parameters of the ice cream samples were analyzed according to the official methods of AOAC International (2000), including fat, pH, protein, ash, moisture, total solids, and carbohydrate content.

RESULTS AND DISCUSSION

The formulated peanut milk ice cream samples were evaluated for sensory, physicochemical, rheological, and microbial properties. Sensory evaluation was conducted using 30 untrained panelists to identify the most acceptable formulation. Among the three treatments, the ice cream containing 50% peanut milk (T3) received the highest scores for appearance, taste, aroma, texture, and overall acceptability, indicating a significant preference among panelists ($p<0.05$).

The selected formulation (T3) was further subjected to physicochemical and rheological analyses. The moisture, fat, protein, ash, carbohydrate, total solids, and pH values were determined according to AOAC (2000) standard methods. The results demonstrated that the incorporation of peanut milk contributed to a nutritionally enriched product with acceptable physicochemical characteristics. The overrun and melting resistance values indicated satisfactory structural stability and desirable quality attributes of the developed ice cream.

Microbial quality assessment of the selected formulation revealed no detectable microbial growth during the storage period. Total plate count, yeast, and mold counts remained within acceptable limits, confirming the microbiological safety and stability of the product. These findings suggest that peanut milk can be successfully utilized as a partial substitute for cow milk in ice cream production without adversely affecting product quality or consumer acceptability.

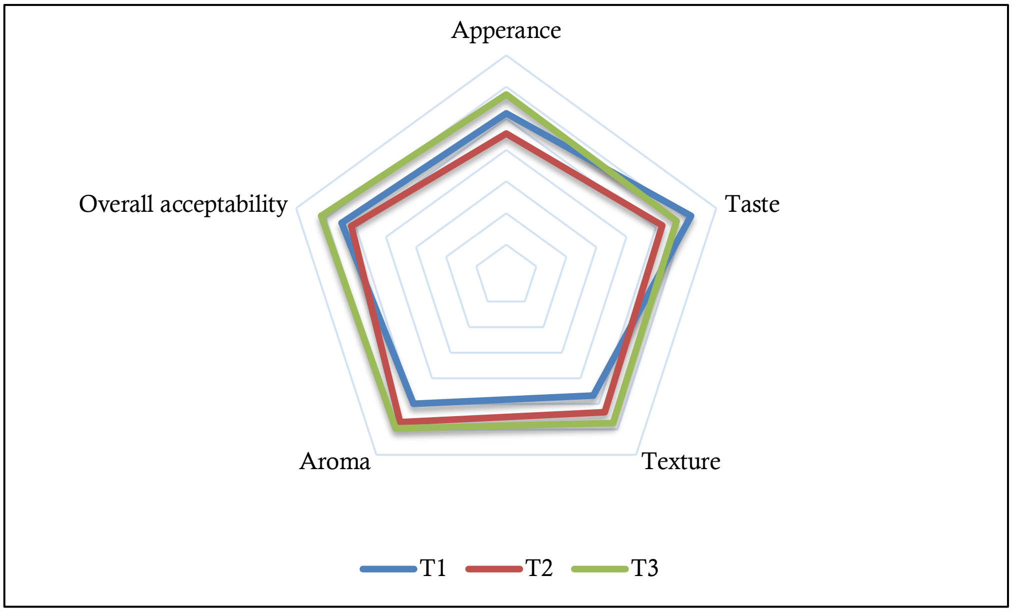

Figure 1: Radar graph of median of sensory attributes

The proximate composition was analyzed for the developed and selected peanut milk ice cream sample (T3–incorporating 50% peanut milk), as identified through sensory evaluation (Figure 2). There was a significant difference ($p<0.05$) between the fat content, protein content, total solids, and ash content of the peanut milk ice cream when compared to the typical cow milk ice cream. The

moisture, fat, protein, carbohydrates and ash content of cow milk ice cream is 61.7%, 12.0%, 4.1%, 20.7%, and 1.4%, respectively. The moisture, fat, protein, carbohydrates and ash content of peanut milk ice cream is 57.16%, 7.07%, 3.45%, 30.59%, and 1.73%, respectively. Compared to the typical cow milk ice cream, these study findings indicate that there were some similarities and a few contrasts in the outcomes for physicochemical properties and chemical properties of peanut milk ice cream; however, the results will help to improve this finding to comply with the recommended limits for ice cream of Sri Lankan standards.
The pH value of all three treatments were increased with increasing of storage period (Figure 3). T1 and T3 exhibited statistically similar pH values with no significant difference observed, whereas the remaining treatments demonstrated either significantly higher or lower pH levels. In this case, T1 and T3 had significantly higher pH values than did T2. According to Erkaya *et al.* (2012), the pH of ice cream samples incorporated with 5%, 10%, and 15% Cape gooseberry (*Physalis peruviana* L.) syrup decreased during the storage period.

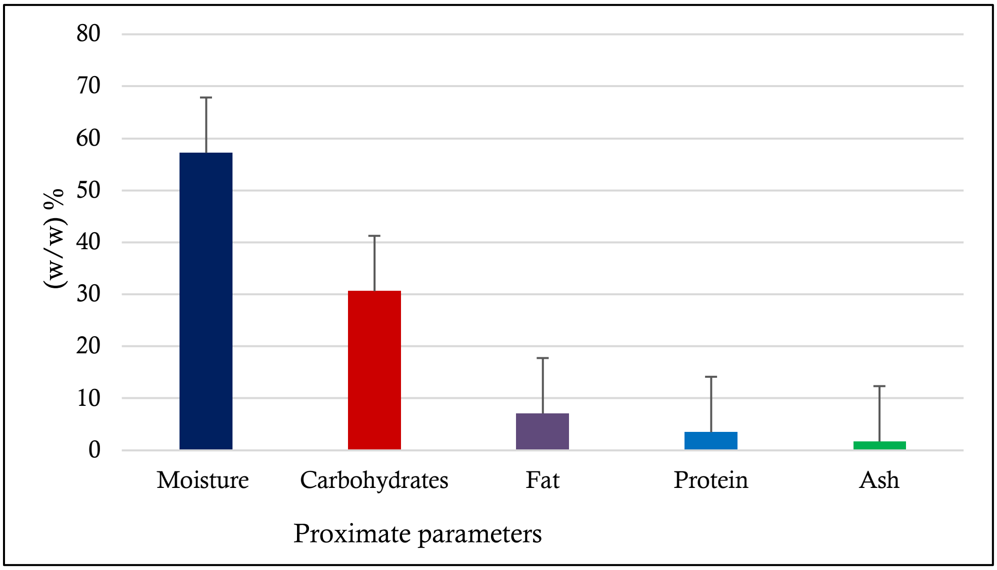

Figure 2: Proximate composition of selected ice cream sample (T3) from sensory evaluation

Their pH values were 6.30, 6.13, 5.98, and 5.83 for the control, 5%, 10%, and 15% syrup-incorporated samples, respectively. According to the Sri Lanka Standards Institution (SLS 731), the recommended pH value for ice cream is 6.62±0.02 (SLS, 1990).The results revealed that pH of peanut milk ice cream was lower than that of normal cow milk ice cream (6.38±0.02) due to the inherent compositional differences between peanut milk and cow milk. The substitution of cow milk with peanut milk, which may possess higher acidity or lower buffering capacity, could have contributed to the reduced pH. The pH of peanut milk ice cream was lower than the pH of normal cow milk ice cream (6.38±0.02) due to the inherent compositional differences between peanut milk and cow milk. The substitution of cow milk with peanut milk, which may possess higher acidity or lower buffering capacity, could have contributed to the reduced pH.

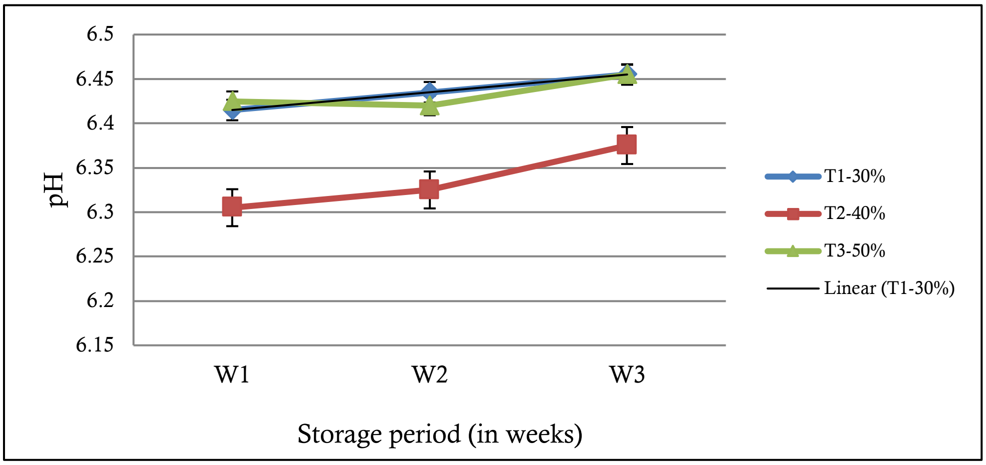

Figure 3: Changes in pH of all three formulated ice cream samples with storage period

The melting rate of T1, T2 and T3 is 12.5 mins/g, 11.52 mins/g and 10.48 mins/g respectively. Among all the treatments, 30% peanut milk incorporated ice cream sample registered with highest melting resistance (12.5 min). From the melt down graphs (Figure 4), it can be observed that the melting rate of selected peanut milk ice cream T3 was higher than that of other ice cream sample T1 and T2. The melting point of fatty acids significantly affects the melting behavior of ice cream, and this differs notably between dairy and non-dairy ice creams due to differences in fat composition. Many plant fats are either too hard (high melting point) or too soft (low melting point).

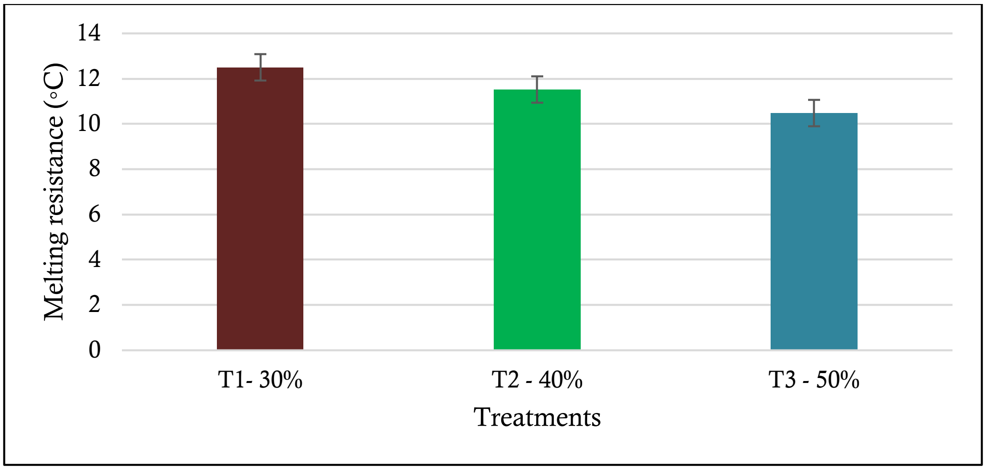

Figure 4: Melting resistance values of ice cream samples

A low freezing point is the primary cause of rapid melting whilst a high amount of air and fat incorporation (overrun) tends to slow down the melting (Perera, and Perera, 2021). The variation in melting behaviour among the ice cream samples could be influenced by the percentage of peanut milk incorporated as a non-dairy milk source.

The melting rates of T1, T2, and T3 were 12.5 min/g, 11.52 min/g, and 10.48 min/g, respectively. Among all the treatments, 30% peanut milk incorporated ice cream sample had the highest melting resistance (12.5 min). From the melt down graphs (Figure 4), it can be observed that the melting rate of the selected peanut milk ice cream T3 was higher than that of other ice cream samples. The melting point of fatty acids significantly affects the melting behavior of ice cream, and this differs notably between dairy and non-dairy ice creams due to differences in fat composition. Acccording to Freire (2020), many plant fats are either too hard (high melting point) or too soft (low melting point).

Table 2: Color scores of all three treatments of ice cream sample

Storage period (in weeks)	Treatments	L*	a*	b*
W1	T1	31.315±0.01	0.320±0.01	9.475±0.01
	T2	26.965±0.01	1.055±0.01	9.250±0.01
	T3	25.805±0.01	0.565±0.01	9.165±0.01
W2	T1	24.025±0.01	0.505±0.01	4.835±0.01
	T2	23.925±0.01	0.255±0.01	3.575±0.01
	T3	20.985±0.01	0.470±0.01	4.020±0.01
W3	T1	18.815±0.01	0.625±0.02	1.035±0.02
	T2	19.925±0.01	0.530±0.01	0.980±0.03
	T3	16.715±0.01	0.225±0.01	1.205±0.01

According to the results, the percentage of total solids of peanut milk ice cream differed from the total solid percentage of normal cow milk ice cream because a different fat source was used in the ice cream mix. Ice cream with a fat content of 12–15% usually consisted of 32–40% of total solid content. Based on the formulations of ice cream mix, the peanut milk ice cream sample which was selected from sensory evaluation contained 42.78% of the total solid content, and this value did not fall within the recommended range. The variation between the total solid content of selected treatment sample and normal cow milk ice cream was due to higher solid content in peanut milk, however the texture and melting quality was made satisfied consumer preference towards selected ice cream sample (T3) in sensory evaluation.

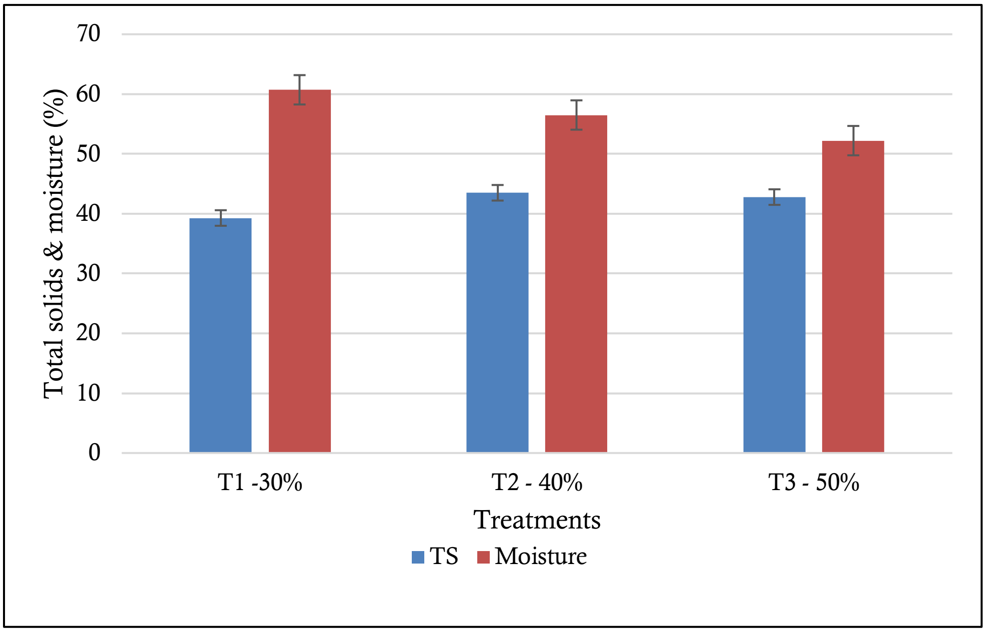

Figure 5: Comparison of total solids (TS) and moisture percentage of different treatments

The microbial analysis was conducted for the ice cream sample selected based on sensory evaluation. Under the microbial analysis, total plate count and yeast and mold counts were performed for a 3-week storage period. No microbial growth was detected in any of the ice cream samples during the storage period. These results revealed that the ice cream samples remained microbiologically safe for consumption for up to 3rd week.

CONCLUSION

The findings of this study confirm that partial replacement of cow milk with peanut milk is a promising approach for developing plant-based ice cream with enhanced nutritional and functional properties.The formulation containing 50% peanut milk exhibited the highest sensory acceptability, along with satisfactory physicochemical and rheological characteristics. Although slight variations from standard values were observed, the product maintained desirable quality attributes and remained microbiologically safe throughout storage. Therefore, peanut milk can be effectively utilized as a cost-effective, nutritious, and lactose-free alternative in ice cream production, catering to health-conscious and lactose-intolerant consumers while supporting the growing demand for plant-based dairy alternatives.

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