

# Development of Plant Based Ice cream from Cottonseed Milk

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**Abstract** - The growing demand for plant-based dairy alternatives has driven innovation in traditional and novel food products. Cottonseed milk is a nutrient-rich plant-based milk alternative, considered as a 'triple nutrient' due to its high content of protein, essential fatty acids and sugars. This study focuses on the formulation, standardization, and evaluation of frozen dessert (ice-cream) prepared using cottonseed milk (CSM) as a primary ingredient. Cottonseed milk was extracted and optimized for use as a dairy substitute, with emphasis on improving flavor, texture, and nutritional quality. Various formulations were developed by adjusting sweeteners, and coconut cream to achieve desirable sensory properties. The final products was subjected to comprehensive evaluations including physicochemical analysis, microbial safety assessment, and sensory evaluation. Nutrient analysis revealed notable differences in composition between dairy and cottonseed milk (CSM) ice cream. CSM ice cream was found to have relatable levels of protein (3.25 %) to dairy based ice cream (3.50 % protein). In contrast, CSM had lower fat content (5.19 %), compared to dairy ice cream (9.08 %). Sensory analysis revealed a comparable consumer acceptability for CSM ice cream, with a sensory score of 8.2 and 8.5 for dairy ice cream. CSM ice cream exhibited a slightly faster meltdown rate (1.08 g/min) and lower overrun (43.6 %) than dairy ice cream (0.78 g/min and 55.26 %, respectively). The results demonstrate the potential of cottonseed milk as a viable plant-based ingredient for frozen desserts, offering a nutritious and acceptable alternative for consumers.

**Key Words:** Cottonseed milk, Plant Based, Ice cream

## 1. INTRODUCTION

In recent years, there has been a significant shift in consumer preferences toward healthier and more sustainable food options. This change is driven by increased awareness of environmental concerns, animal welfare, lactose intolerance, and dietary restrictions. One area witnessing rapid innovation is the development of plant-based alternatives to traditional dairy products, particularly ice cream.

### 1.1. PLANT BASED ICE CREAM

Plant-based ice cream refers to frozen desserts made without any dairy ingredients. Plant-based milk substitutes,

derived from sources like soy, cashew, and almond as base ingredient enable the creation of dairy-free ice cream. These alternatives aim to replicate the creamy texture, rich flavour, and overall sensory appeal of conventional ice cream while offering additional health benefits. These plant-based milks offer cholesterol-free, unsaturated fat-rich alternatives, containing vitamins, minerals, and antioxidants, classifying them as functional foods and nutraceuticals. Leahu, A. et al., (2022).

## 1.2 COTTONSEED MILK

Cottonseed milk, traditionally referred to as Paruthi Paal in Tamil (where "Paruthi" means cottonseed and "Paal" means milk), is a common household beverage in South India, often served as welcome drink. Celebrated for its nutritional value, it is considered a source of essential nutrients such as protein and fat. Praveena, M., & Subaratinam, R. (2021). The common ingredients needed to make this nutritious beverage, which include cottonseeds (Paruthi), cardamom powder, coconut milk, grated coconut, dried ginger powder, rice or kudu millet, jaggery Kumar, M (2019). Cotton seed milk has a pH between 6.5 and 7.1, total solids content between 11.8 % and 13 %, and acidity between 0.17% and 0.19 % and viscosity between 2.8 and 3.4 cP. Amudha, J. (2018).

## 2. MATERIALS AND METHODS

This chapter deals with the materials and methods used for the preparation of cottonseed milk and various steps involved in the manufacturing of cottonseed milk ice cream.

### 2.1 MATERIALS

Cottonseed was purchased from a local shop in Melur, Madurai. Sugar, Jaggery, Flavors, Non-Dairy whipping cream, Coconut Cream, Essence were purchased from various stores in Chennai.

**Table -1:** Cottonseed Milk ice cream ingredients and functions

Ingredients	Function
Cottonseed	Dairy-free base for the ice cream
Sugar	Adds sweetness Enhance flavour and palatability
Jaggery	Act as a natural sweetener, alternative to refined sugar. Imparts a unique, earthy and slightly caramelized flavor.
Full cream milk	Base ingredient for Dairy ice cream. Contributes to smooth, creamy texture and rich flavor.
Non-dairy whipping cream	Vegetable fat source Adds a creamy texture and improves overrun
Coconut cream	Adds a rich flavour, creamy texture
Essence	Provides a distinct flavour profile

## 2.2. PREPARATION OF COTTONSEED MILK

For the preparation of cottonseed milk, 500 g of cottonseed was used to prepare 1 liter of milk. Cottonseed was soaked for 12 hours and then thoroughly ground in a mixer grinder with a water ratio of 1:2 to prepare a cottonseed slurry. The collected cottonseed slurry was then strained through a muslin cloth into a bowl to obtain the cottonseed milk. The extracted cottonseed milk was stored in a clean glass jar in the refrigerator for use in product preparation and chemical analysis.

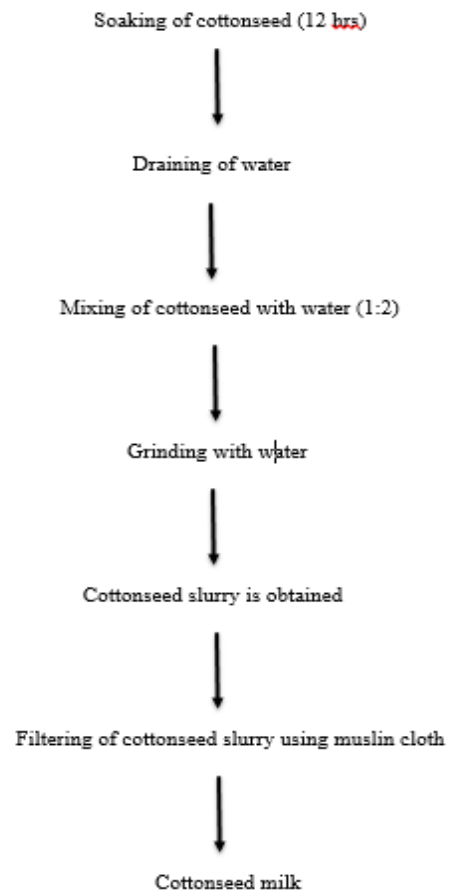


Fig 1: Process flowchart for cottonseedmilk preparation

## 2.3. PREPARATION OF COTTONSEED MILK ICE CREAM

To prepare cottonseed milk, several trials were conducted to optimize the levels of sugar and coconut cream. Cottonseed milk formulated with jaggery syrup as the sugar base exhibited a slightly bitter taste and a melting rate of 1.65 g/min. In contrast, ice cream prepared with sugar syrup demonstrated better palatability and melting rate. After multiple trials with varying proportions of sugar syrup and coconut cream, the optimal formulation was determined to be 300 mL of sugar syrup and 120 mL of coconut cream.

To prepare 1 liter of cottonseed milk ice cream, begin by gently heating the cottonseed milk at 70 C for about 10-12 minutes. Add 300 mL of sugar syrup and stir until the mixture thickens. Once thickened, let it cool. In a separate bowl, whip together 200 mL of non-dairy whipping cream and 120 mL of coconut cream for about 10 minutes until the mixture turns light and fluffy. Combine the whipped cream with the cooled cottonseed milk mixture, then add 2 drops of essence. Finally, churn the mixture and freeze it at -18°C for 4 to 6 hours.

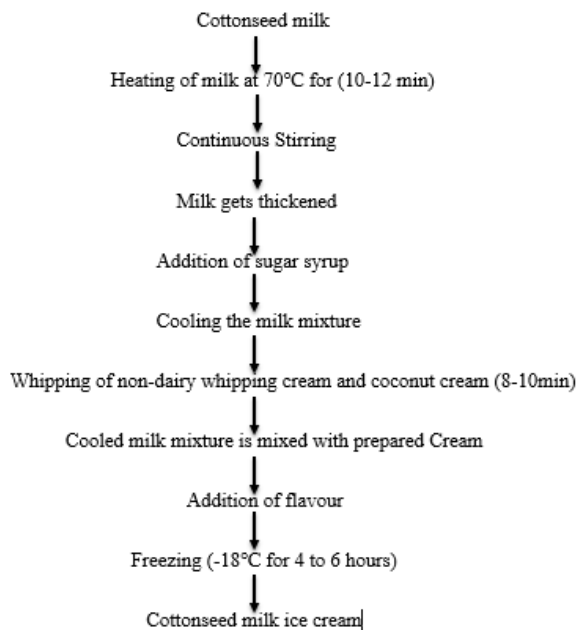


Fig 2: Flowchart for preparation of cottonseed milk ice cream

## 2.4. ANALYSIS

### 2.4.1 pH

The pH of the ice cream was measured directly using a calibrated pH meter (DELUXE pH meter).

### 2.4.2 Titratable Acidity

Titratable acidity was expressed as percent lactic acid, determined by titration against 0.1 N NaOH using phenolphthalein as an end point indicator. 5 ml of ice cream sample was diluted in 10 mL of distilled water in a beaker. To this 1 ml of phenolphthalein indicator was added and content was mixed with a glass rod. The sample was titrated against 0.01 N NaOH solution till a faint permanent pink colour appears.

Titratable acidity %

$$= \frac{\text{Titrate value} \times \text{Normality of NaOH} \times \text{Equi wt of lactic acid}}{\text{Volume of ice cream sample}}$$

### 2.4.3. Total Solids

Total solids is determined as described by Singo and Beswa, (2019).

$$\text{Total solids}(\%) = \frac{(\text{Weight dry pan plus sample} - \text{dry pan weight})}{\text{Weight of the sample}} \times 100$$

### 2.4.4. Moisture

10 g of samples was taken in a clean, dried and pre-weighed petri dish and put in dry oven at 100° C for 2 hours till a constant weight was obtained and cooled in desiccator. After cooling, the loss in weight was taken as moisture content and expressed in terms of g/100g.

$$\text{Moisture}(\%) = \frac{\text{Initial weight}(g) - \text{Final weight}(g)}{\text{Weight of the sample}} \times 100$$

### 2.4.5 Protein

The protein content is determined from the organic Nitrogen content by Kjeldahl method. The various nitrogenous compounds are converted into ammonium sulphate by boiling with concentrated sulphuric acid. The ammonium sulphate formed is decomposed with an alkali (NaOH) and the ammonia liberated is absorbed more than standard solution of acid and then back titrated with standard alkali. Raghuramulu et al., (2003).

$$\text{Nitrogen \%} = \frac{14.01 \times 0.1(TV - BV)}{W \times 100} \times 100$$

$$\text{Protein}(\%) = \text{Nitrogen \%} \times 6.25$$

### 2.4.6. Ash

5 g of sample was weighed in a crucible and charred over a burner. Then samples were ignited completely in a muffle furnace at 550°C for 4-5 hours to get a light grey ash result and subsequently cooled in a desiccator then weighed soon after reaching room temperature. Raghuramulu et al., (2003). The weight of the residue was then noted and the ash content was calculated as follows:

$$\text{Ash}(\%) = \frac{\text{Weight of the ash}(g)}{\text{Weight of the sample taken}(g)} \times 100$$

### 2.4.7. Carbohydrate

Carbohydrate content present in the sample was expressed as percent and determined by “difference” i.e. by calculated by subtracting a sum of values (per 100g) of moisture, protein, fat ash and crude fiber from 100.

### 2.4.8. Overrun

Overrun was measured as described by Daw and Hartel (2015). The measurements were based on the weight of a certain volume of ice cream mix and ice cream. A container was filled with either ice cream mix or ice cream and the weight was recorded. Overrun measurements were taken in triplicate and the calculations were done using the following equation:

$$\text{Overrun (\%)} = \frac{\text{Weight of mix} - \text{Weight of ice cream}}{\text{Weight of ice cream}} \times 100$$

### 2.4.9. Meltdown

Meltdown of the ice cream samples was determined as described by Pon et al., (2015). The sample (80.0 g) was placed on a wire mesh that drained into a graduated glass cylinder on top of a weighing balance at controlled temperature (25 ± 1°C). The dripped volume was measured at 10-min intervals for a total of 45 min. The first drop time was measured as the volume drip per minute. The data recorded were used to determine the melting rate (g/min).

$$\text{Melt down rate} \left( \frac{\text{g}}{\text{min}} \right) = \frac{\text{Weight of the melted ice cream (g)}}{\text{Time (min)}}$$

### 2.5.10 Texture Analysis

A 50-g sample of ice cream was used to determine the texture. Ice cream tubs were taken out of the freezer and left at room temperature for two minutes. The ice cream samples were analyzed texturally by using TA.XT Plus texture analyzer (Stable Micro System Ltd, Surrey, UK) with P/20 probe (20 mm diameter), a trigger force of 5 g, distance of 10 mm and a test speed of 5 mm/s.

### 2.5.11. Sensory Analysis

The acceptability of ice-cream prepared by using cottonseed milk and dairy full cream milk was assessed by 14 semi trained sensory panel members from College of Fish Nutrition and Food Technology. The appearance, taste, texture, mouthfeel and overall acceptability was assessed by using 9 point hedonic scale as per procedure described in Gaikwad et al., (2020).

## 3. RESULTS AND DISCUSSION

In the chapter, the results and discussion of the research study is presented. Physicochemical analysis was conducted for both the cottonseed milk and the ice cream developed from cottonseed milk. The prepared cottonseed milk ice cream was tested for moisture, protein, ash, carbohydrate, crude fiber, texture profile and sensory and comparisons was made to dairy-based ice cream.

### 3.1. Analysis of Cottonseed Milk

The physicochemical and proximate analysis of cottonseed milk for three trials was conducted and the results (Mean±SD) are provided in Table 2 and Table 3 below.

Table 2 Physicochemical analysis of Cottonseed Milk

Parameters	Values
pH	6.26 ± 0.02
Titrateable Acidity (%)	0.21 ± 0.01
Total Solids (%)	5.90 ± 0.02

Table 3 Proximate Analysis of Cottonseed Milk

Proximate composition	Values
Moisture (%)	90.35± 0.02
Protein (%)	2.58± 0.02
Crude fat (%)	1.9± 0.02
Ash (%)	0.98± 0.02
Carbohydrate (%)	4.19 ± 0.01
Energy (Kcal)	44.18 ± 0.01

### 3.2 Physicochemical Analysis of Cottonseed Milk Ice cream

The physicochemical analysis of dairy-based ice cream (T0) and cottonseed milk ice cream (T1) was conducted and compared, and the results are presented in Table 3.

Parameters	Dairy based ice cream (T0)	Cottonseed milk ice cream (T1)
pH	6.41 ± 0.02	6.54 ± 0.02
Titrateable Acidity (%)	0.19 ± 0.02	0.28 ± 0.04
Total Solids (%)	43.02 ± 0.02	48.70 ± 0.02
Meltdown rate(g/min)	0.78 ± 0.02	1.08 ± 0.02
Overrun (%)	55.26 ± 0.02	43.6 ± 0.02

@ Average of 3 trials ((Mean±SD)

#### 3.2.1 pH

The pH levels in dairy-based ice cream (T0) and cottonseed milk ice cream (T1) samples were found to be 6.41 ± 0.02 and 6.54 ± 0.02, respectively. Notably, T1 has a higher pH, indicating it is less acidic than T0. The values obtained for cottonseed milk ice cream were similar to those reported by Mendonça et al., (2022), who found the pH of soy extract ice cream to be 6.15 ± 0.05.

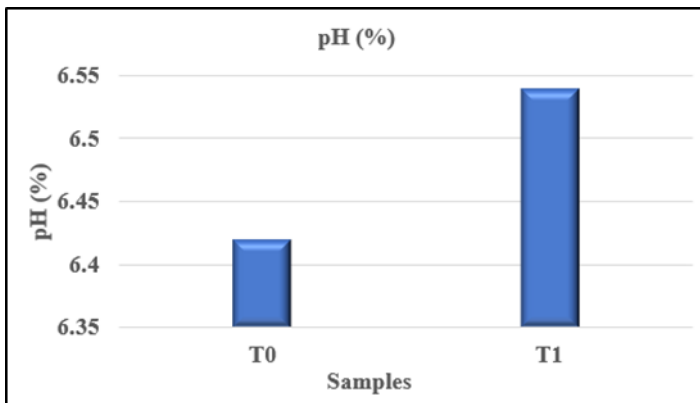


Chart 1: pH of Dairy ice cream (T0) and Cottonseed Milk Ice cream (T1)

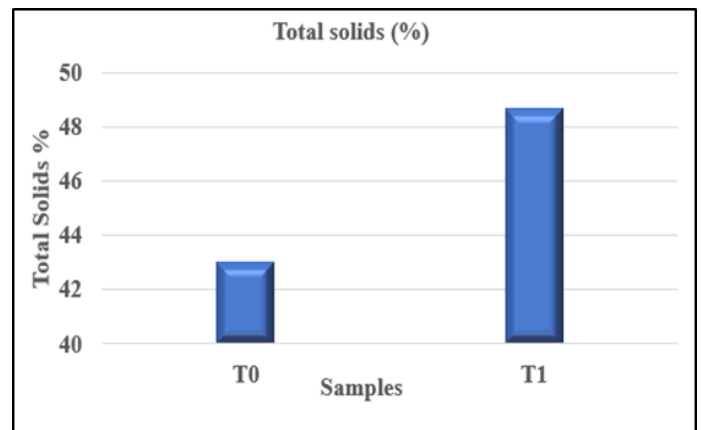


Chart 3: Total Solids of Dairy Ice cream (T0) and Cottonseed Milk Ice cream (T1)

### 3.2.2. Titratable Acidity (%)

The titratable acidity of dairy-based ice cream (T0) and cottonseed milk ice cream (T1) samples was calculated as  $0.19 \pm 0.02$  and  $0.28 \pm 0.04$ , respectively. These values obtained for cottonseed milk ice cream were similar to those reported by Leahu, A et al., (2022), who found the titratable acidity of almond milk ice cream to be  $0.17 \pm 0.01$ .

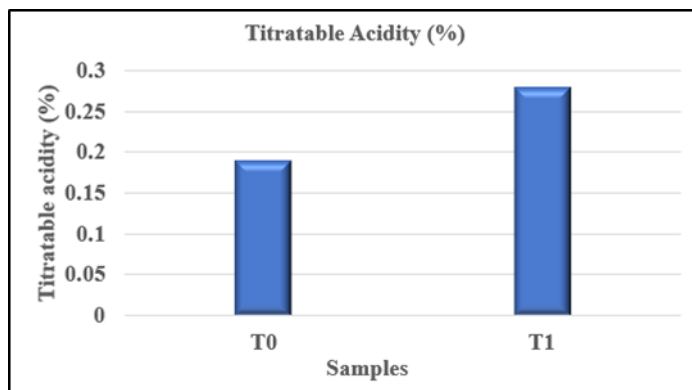


Chart 2: Titratable Acidity (%) of Dairy Ice cream (T0) and Cottonseed Milk Ice cream (T1)

### 3.2.3 Total Solids (%)

The total solids content of dairy-based ice cream (T0) and cottonseed milk ice cream (T1) samples was found to be  $43.02 \pm 0.02$  and  $48.70 \pm 0.02$ , respectively. The total solids of cottonseed milk ice cream were considerably higher than those of the dairy-based ice cream (control), which corresponded with the studies of Swarup, V. K., and Poonia, A. (2022), who reported that total solids in cereal-based ice cream ( $36.70 \pm 0.02$ ) were higher than those in dairy ice cream ( $30.40 \pm 0.05$ ).

### 3.2.4 Meltdown rate (g/min)

The melt-down rate of dairy-based ice cream (T0) and cottonseed milk ice cream (T1) samples was calculated as  $0.78 \pm 0.02$  and  $1.08 \pm 0.02$ , respectively. The value obtained for cottonseed milk ice cream was close to the value found by Srinu, D et al., (2022), who reported that ice cream made by incorporating spice had a melting rate of  $1.20 \pm 0.03$ .

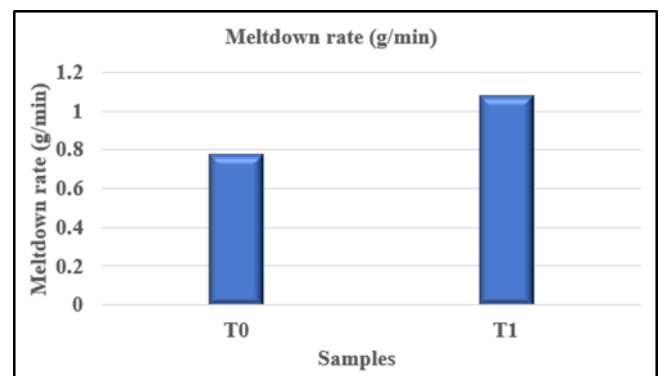


Chart 4: Meltdown rate of Dairy based ice cream and CSM ice cream

### 3.2.5 Overrun (%)

The overrun of dairy-based ice cream (T0) and cottonseed milk ice cream (T0) samples was calculated as 55.26% and 43.6%, respectively. T1 had a lower overrun value than T0. A similar decrease in value was reported by Afriana, N and Kurnia, P (2024), who found that ice cream made with a combination of coconut milk and cashew milk had an overrun of  $47.08 \pm 3.06\%$ .

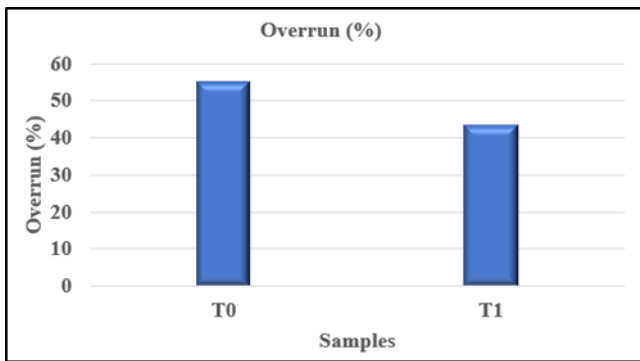


Chart 5 Overrun of dairy based ice cream and CSM ice cream

### 3.3. Proximate Analysis of Cottonseed Milk Ice cream

The proximate composition of dairy-based and cottonseed milk ice cream was determined and compared, with results shown in Table 4.

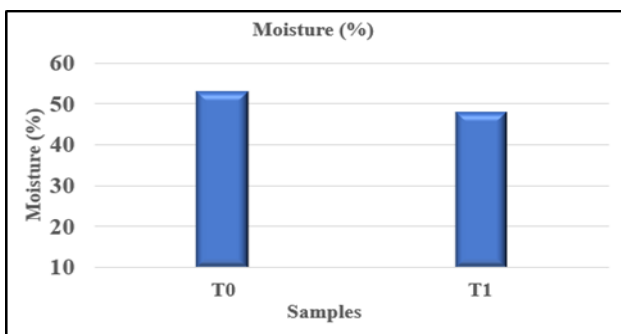
Table -4: Proximate analysis of dairy-based and cottonseed milk ice cream

Parameters	Dairy based ice cream (T0)	Cottonseed milk ice cream (T1)
Moisture (%)	53.08 ± 0.06	48.06 ± 0.06
Protein (%)	3.50 ± 0.02	3.25 ± 0.02
Fat (%)	9.08 ± 0.02	5.19 ± 0.02
Ash (%)	2.3 ± 0.02	1.0 ± 0.02
Carbohydrate (%)	32.04 ± 0.03	42.56 ± 0.03
Energy (Kcal)	223.88 ± 0.03	229.95 ± 0.03

@Average of 3 trials (Mean±SD)

#### 3.3.1. Moisture (%)

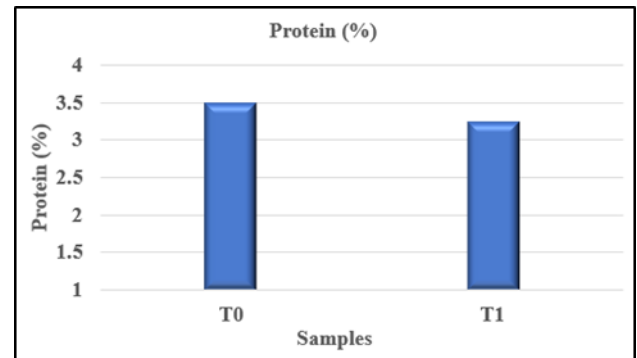
The moisture content of dairy-based ice cream (T0) was found to be 53.08 ± 0.06, whereas the moisture content in cottonseed milk ice cream (T1) was found to be 48.06 ± 0.06, which is in agreement with the values of peanut flavor vegan ice cream (54.24 ± 0.05) reported by Diniz, L. G. T. et al., (2022).



Moisture content of Dairy based ice cream (T0) and CSM ice cream (T1)

#### 3.3.2 Protein (%)

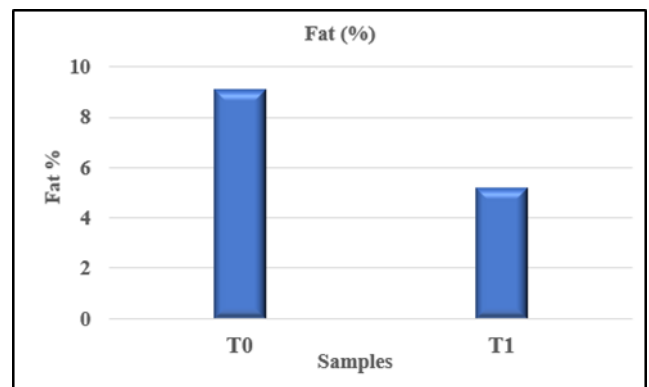
The protein content of dairy-based ice cream (T0) and cottonseed milk ice cream (T1) samples was found to be 3.50 ± 0.02 and 3.25 ± 0.02, respectively. T1 has a comparable protein value to T0. The value obtained for cottonseed milk ice cream is similar to the value obtained by Pontonio, E. et al., (2022) for plant-based YL (yogurt-like) ice cream, which had a protein content of 3.52 ± 0.15.



Protein content of Dairy based ice cream (T0) and CSM ice cream (T1)

#### 3.3.3 Fat (%)

The fat content of dairy-based ice cream (T0) and cottonseed milk ice cream (T1) samples was found to be 9.08 ± 0.02 and 5.19 ± 0.02, respectively. T0 had a higher fat content than T1. The value obtained for cottonseed milk ice cream was close to the value found by Diniz, L. G. T. et al., (2022), who reported that ice cream made from barnyard millet had a crude fat content of 6.05 ± 0.01.

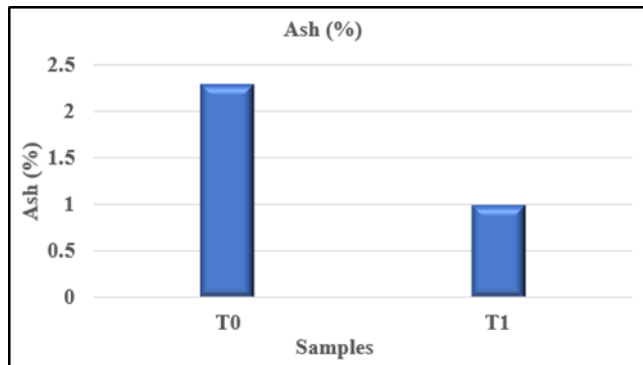


Fat content of dairy based ice cream and CSM ice cream

#### 3.3.4 Ash (%)

The ash content of dairy-based ice cream (T0) and cottonseed milk ice cream (T1) samples was found to be 2.3 ± 0.02 and 1.0 ± 0.02, respectively. The analysis results revealed a significant difference in the mineral content. The value obtained for cottonseed milk ice cream was close to the ash

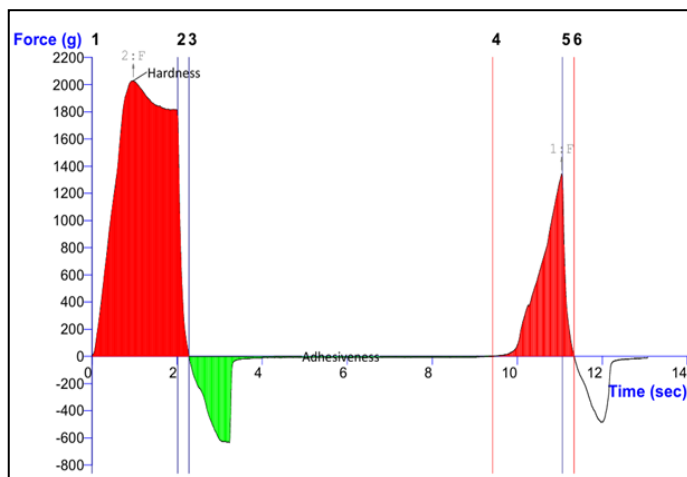
content of symbiotic ice cream from cottonseed milk, which was reported to be 0.89% by Pidathala Sahitya et al., (2024).



Ash content of dairy based ice cream and CSM ice cream

### 3.4. Texture Profile Analysis of Cottonseed Milk Ice cream

The textural parameters, namely hardness, adhesiveness, springiness, cohesiveness, gumminess, chewiness, and resilience, of the cottonseed milk ice cream (T<sub>1</sub>) were found to be 2027g, -463.085g, 0.812mm, 0.263, 532.436, 432.275, and 0.047, respectively. The values found for cottonseed milk ice cream were close to those reported by Srinu, D *et al.*, (2022), who found that ice cream made by incorporating spice had textural parameters of hardness 2280.77g, cohesiveness 0.288, and gumminess 516.05g.

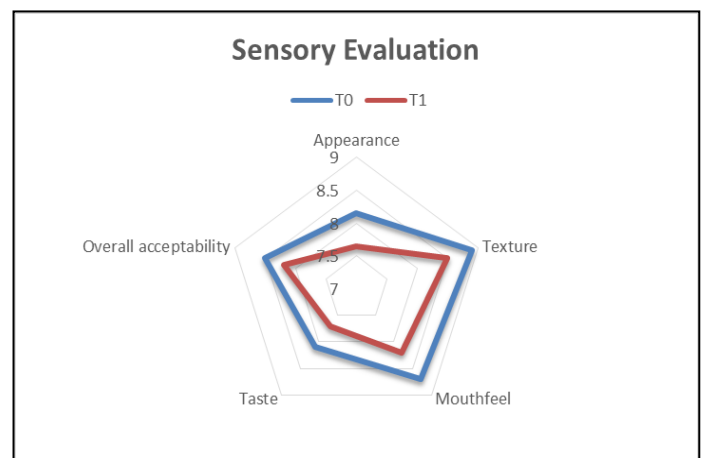


### 3.5. Sensory analysis of dairy based and cottonseed milk Ice cream

The formulated ice cream samples, dairy based ice cream (T<sub>0</sub>) and cottonseed milk ice cream (T<sub>1</sub>), were prepared and evaluated for their organoleptic characteristics, namely Appearance, Taste, Texture, Mouthfeel, and Overall Acceptability, by a panel of 20 non-trained members using a 9-point hedonic scale. The scores obtained for each attribute of sensory evaluation for the samples are shown in Table 5.

Table -5: Data obtained for sensory analysis of dairy-based and cottonseed milk ice cream (Mean±SD)

Sensory attributes	Dairy based ice cream (T <sub>0</sub> )	Cottonseed milk ice cream (T <sub>1</sub> )
Appearance	8.15 ± 0.06	7.65 ± 0.02
Taste	8.9 ± 0.02	8.5 ± 0.03
Texture	8.7 ± 0.01	8.2 ± 0.01
Mouth feel	8.1 ± 0.05	7.7 ± 0.02
Overall acceptability	8.5 ± 0.03	8.2 ± 0.02



Based on sensory evaluation, cottonseed milk ice cream exhibited a slight aftertaste but was comparably preferred to full cream milk ice cream. Although cottonseed milk ice cream scored lower in appearance, texture, and mouthfeel, likely due to faster melting and ice crystal formation, the addition of coconut cream and flavor may have contributed to its higher taste score.

### 3.6 Microbial analysis of dairy based and cottonseed milk ice cream

#### 3.6.1 Total plate count

The total plate count (TPC) for both dairy-based ice cream (T<sub>0</sub>) and cottonseed milk ice cream (T<sub>1</sub>) was determined using the pour plate method. A 1 mL aliquot of 10<sup>-4</sup> and 10<sup>-5</sup> dilutions of each ice cream were mixed with nutrient agar medium in Petri dishes and incubated at 37°C for 24 hours. After incubation, the number of colonies that developed was counted, and the results showed that both samples had a total viable bacterial count of less than 10 Colony-Forming Units per milliliter (CFU/mL).

#### 3.6.2 Coliform count

The total coliform count for both dairy-based ice cream (T<sub>0</sub>) and cottonseed milk ice cream (T<sub>1</sub>) samples was determined

using MacConkey agar, a selective medium for coliform bacteria. A 1 mL aliquot of  $10^{-4}$  and  $10^{-5}$  dilutions was inoculated onto MacConkey agar plates. Following incubation at 30°C for 48 hours, the results indicated the absence of detectable coliform bacteria in both samples, which was expressed as "NIL" Colony-Forming Units per milliliter (CFU/mL).

### 3.7 Cost analysis of developed cottonseed milk ice cream

The production cost of the developed cottonseed milk ice cream was calculated based on various expenses, including ingredients and materials, manufacturing costs such as electricity and LPG gas, labor costs, and operational expenses like packaging and logistics. Market rates were used to determine the prices of all components, and the cost of the developed cottonseed milk ice cream was calculated to be Rs. 257 per liter.

## 4. CONCLUSION

The development of ice cream using cottonseed milk presents a promising alternative to traditional dairy-based products, particularly in the context of increasing consumer demand for plant-based, sustainable, and lactose-free foods. This study successfully formulated and evaluated an ice cream using cottonseed milk, demonstrating its nutritional viability and sensory acceptability.

The cottonseed milk ice cream (T1) showed comparable protein content and consumer acceptability to conventional dairy ice cream (T0), while offering distinct advantages such as lower fat content and a plant-based composition. Although it exhibited a slightly higher meltdown rate and lower overrun, these differences were within acceptable sensory thresholds, especially with the addition of coconut cream. Physicochemical, microbial, and sensory analyses confirmed the nutritional adequacy, safety, and appeal of the product. This plant-based formulation could serve as a valuable product for lactose-intolerant individuals, vegans, and health-conscious consumers. Further research can focus on enhancing texture and shelf-life, incorporating functional additives, and scaling production for commercial viability.

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