

EFFECT OF SPROUTED PEARL MILLET EXTRACT AND SAPODILLA FRUIT PULP INCORPORATION ON THE PHYSICOCHEMICAL AND SENSORY PROPERTIES OF KULFI

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ABSTRACT

The present study was carried out to develop a value added functional kulfi using sprouted pearl millet extract incorporated with sapodilla (Manilkara zapota) fruit pulp and to evaluate its physicochemical, microbiological and sensory characteristics. Pearl millet is a nutrient rich cereal containing dietary fibre, minerals, and bioactive compounds; however, its utilization is limited by poor digestibility and anti-nutritional factors. Sprouting was employed to enhance nutrient bioavailability and improve functional properties. Sapodilla pulp was incorporated to provide natural sweetness, desirable flavour and additional nutrients. Kulfi formulations containing varying levels of sprouted pearl millet extract and 10% sapodilla pulp were prepared and evaluated. The optimized formulation (T3) exhibited the highest sensory acceptability. Proximate analysis revealed increased protein, fibre, carbohydrate and antioxidant activity, while fat content decreased compared to the control. The product showed acceptable physicochemical properties, with pH 6.75, titratable acidity 0.14 % of lactic acid and antioxidant activity of 15.47 %. Microbiological analysis confirmed product safety, with no coliforms detected during 30 days of frozen storage. The study demonstrated that sprouted pearl millet extract and sapodilla pulp can be successfully utilized to develop a nutritious, acceptable and functional frozen dessert.

Key words: Kulfi, sprouted pearl millet extract, sapodilla

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INTRODUCTION

Milk is a complete food, which is rich in all essential nutrients such as carbohydrate (lactose), fat, protein, minerals

and vitamins. It is directly consumed as liquid milk or converted into many value added dairy products like khoapeda, ice cream, kulfi, paneer, cheese, ghee, butter and fermented dairy products such as curd and yoghurt etc. Kulfi, often referred to as malaikulfi, is a native frozen dairy product with a consistency that is quite similar to ice cream. Kulfi is traditionally prepared by evaporating of milk by slow heating

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with continuous stirring to keep milk from sticking to the bottom of the vessel until the volume is reduced by a half, thus concentrating the milk (Yogeshwari *et al.*, 2022)

Customers prefer kulfi because it is a relatively inexpensive, delectable, and healthy frozen dairy delicacy. In comparison to ice cream, it is widely accepted and its demand is rising daily. Kulfi contains no air while ice cream is either overrun or whipped with air. Kulfi comes in a variety of flavours, including apple, orange, strawberry and peanut in addition to the more classic strawberry, rose, mango, saffron (Keshar) and pistachio. It is a common frozen treat sold in various regions of our country particularly during the summer, by tiny milk vendors, halwais, sweet manufacturers, etc. Hence, the kulfi can be considered as the poor man's ice cream (Ubale *et al.*, 2014). About 0.7% of the total milk in India is used to make kulfi, ice cream and other frozen desserts. India has a per capita consumption of these frozen desserts of roughly 300 ml/year, which is significantly less than the global average of 2.3 litre/year (Ramkumar *et al.*, 2025).

Kulfi is a traditional frozen dairy dessert widely consumed in India due to its rich taste, creamy texture and high sensory appeal. Conventionally, kulfi is prepared using cow or buffalo milk, sugar and flavoring agents. However, increasing awareness about nutrition, lactose intolerance and the need for diversified food products has led to growing interest in the development of alternative and value-added frozen desserts

using plant-based ingredients. Incorporation of nutritionally rich cereals and fruits into traditional products offers an effective approach to enhance their nutritional quality while maintaining consumer acceptability (Raju and Pal, 2014).

Pearl millet (*Pennisetum glaucum*) is one of the most important millets cultivated in India and is well known for its high nutritional value. It is a rich source of dietary fibre, protein and bioactive compounds with antioxidant properties. Despite these advantages, the utilization of pearl millet in food products is limited due to the presence of anti-nutritional factors such as phytates and tannins, which reduce mineral bioavailability and digestibility. Sprouting or germination is a simple and effective processing technique that improves the nutritional profile of millet by reducing anti-nutritional factors, enhancing mineral absorption and improving flavor and texture (Nalkar, 2012). Sprouted pearl millet extract serves as a suitable plant-based alternative to animal milk and can be effectively used in product development.

Sapodilla (*Manilkara zapota*) is a tropical fruit known for its pleasant sweetness, soft texture and high energy content. It contains natural sugars, dietary fibre, vitamins and minerals, making it a desirable ingredient for frozen dessert formulations. The incorporation of sapodilla pulp not only enhances the flavour and colour of kulfi but also improves its nutritional value and consumer appeal, while potentially reducing the requirement for added sugar (Naik and Londhe, 2011).

The development of kulfi using sprouted pearl millet extract and sapodilla fruit represents an innovative approach to value addition of millets and fruits. Such a product combines the nutritional benefits of pearl millet with the sensory attributes of sapodilla, resulting in a functional frozen dessert suitable for all age groups. Therefore, the present study aims to develop and evaluate sprouted pearl millet extract-based fruit kulfi with respect to its physicochemical characteristics, nutritional quality, microbiological safety and sensory acceptability, thereby promoting the utilization of millets in traditional food products.

The study was undertaken to develop kulfi by partially replacing standardized milk with sprouted pearl millet extract incorporated with sapodilla fruit pulp and to evaluate the physicochemical, nutritional, microbiological and sensory qualities of the developed product.

MATERIAL AND METHODS

Preparation of Sapodilla fruit pulp incorporated Kulfi

A total of 250 mL of standardized milk was heated at $85 \pm 2^\circ\text{C}$ with continuous stirring until its volume was reduced to half (2:1 concentration ratio). Subsequently, 75 mL of sprouted pearl millet milk was added, followed by the incorporation of 13% sugar and 1% khoa, and mixed thoroughly until completely dissolved. The temperature of the mixture was reduced to 65°C , and sodium alginate (0.2%) was gradually added

under continuous stirring to ensure uniform dispersion. Fresh sapodilla fruit pulp was prepared by washing, peeling, deseeding and blending ripe fruits into a smooth pulp. The pulp was incorporated into the kulfi mix at the desired treatment levels (0, 5, 10, 15 and 20%) after cooling the mixture to $40\text{--}45^\circ\text{C}$. The prepared mix was homogenized, poured into sterilized kulfi moulds and hardened at -20°C for 12–24 h. The detailed flowchart is shown in figure 1. The frozen kulfi samples were stored at -20°C until physicochemical and sensory analyses.

Physicochemical analysis

pH

The pH of sprouted pearl millet extract based fruit kulfi was measured using a digital pH meter (Systronics digital pH meter 335, India), following the (AOAC 2012) method.

Titrateable acidity

The titrateable acidity of a sample was found in triplicate by titrating 10 ml of sprouted pearl millet extract based fruit kulfi with 0.1 N sodium hydroxide and using phenolphthalein as an indicator (AOAC 2012).

Antioxidant Activity

Antioxidant activity (AOA) of the sprouted pearl millet extract based fruit kulfi was assessed using the DPPH (2, 2-diphenyl-1 picrylhydrazyl) radical-scavenging assay as given by Patra *et al.*, (2021). Initially, 0.05 mL aliquot of the

extract was mixed with 2 mL of a 0.06 mM DPPH methanol solution. After thorough mixing, the mixture was incubated in darkness for 30 minutes. Later, the samples were taken to read the absorbance at 517 nm with a UV-visible spectrophotometer (Perkin-Elmer-Lambda 35, Perkin Elmer Inc., USA). Equation was used to calculate the percentage of inhibition of the DPPH radical.

$$\text{AOA (\%)} = [(A_c - A_s)/A_c] \times 100$$

Where A_c is the absorbance of the DPPH solution, and A_s is the absorbance of the DPPH solution and extract.

Proximate composition

Moisture, crude protein, crude fat, dietary fibre, crude fiber, and total ash, of sprouted pearl millet extract based fruit kulfi were determined following AOAC (2012). Carbohydrate and energy were calculated as per Ramkumar *et al.* (2025).

Sensory evaluation

Sensory evaluation was conducted using a 9-point Hedonic scale by a semi-trained panel of 15 members, aged 20 to 50 years from the College of Food and Dairy Technology, Koduveli, Chennai, Tamil Nadu, India. All procedures involving participants were conducted in accordance with relevant guidelines as per Ramkumar *et al.* (2025) and sensory attributes such as color and appearance, taste, flavor, mouth feel and overall acceptability of sprouted pearl millet extract based fruit kulfi were assessed.

Microbial Analysis

Microbiological analysis viz., standard plate count and coliform count were performed for the sprouted pearl millet extract based fruit kulfi as per the standard protocol described in BIS: 1981, SP: 18 (Part XI).

Statistical analysis: The data generated from the present study was subjected to analysis of variance (ANOVA) as per the guidelines of Snedecor and Cochran (1989) using Statistical Analytical System (SPSS version 16.0).

RESULT AND DISCUSSION

Optimization of sprouted pearl millet extract based fruit kulfi

Sprouted pearl millet extract based fruit kulfi was prepared under different treatments and were evaluated on 9 point hedonic scale (Color and appearance, taste, flavor, mouth feel and overall acceptability) by a semi-trained panel. The results are given below in Table 1. The T_3 (75 ml) with sprouted pearl millet extract and fruit incorporation of kulfi has higher overall acceptability followed by T_1 (25 ml), T_2 (50 ml) and T_4 (100 ml) and sapodilla pulp (10 per cent). Hence, T_3 sample was taken as the optimized product and used for further studies. These observations were in accordance with the findings of Kedaree *et al.* (2021), who developed kulfi by adding pineapple (*Ananas comosus*) pulp at different levels.

Proximate analysis of sprouted pearl millet extract based fruit kulfi

The results of proximate composition, such as moisture, fat, protein, carbohydrate, fibre and ash were estimated for control and sprouted pearl millet extract based fruit kulfi and the same is presented in Table 2. The mean values of proximate composition such as moisture, fat, protein, carbohydrate, fibre and ash of the optimized product (T_3) were 54.43 ± 0.015 , 5.35 ± 0.011 , 3.95 ± 0.007 , 32.8 ± 0.216 , 3.15 ± 0.006 and 0.47 ± 0.015 respectively.

Moisture (%) of the optimized product (T_3) was less than the control sample (milk kulfi) due to the incorporation of sprouted pearl millet extract and sapodilla fruit. This reduction of moisture is due to low water binding capacity of sprouted millet. Rao and Poonia, (2024) reported similar results while studying the formulation of Kulfi enriched with malted quinoa flour.

The protein content of optimized product (T_3) kulfi tend to increase due to incorporation of sprouted pearl millet extract and sapodilla fruit. The results showed significantly higher protein content than the control sample. The results are similar to the findings of Ali *et al.* (2016); Ayar and Gurlin, (2014) were of the view that sprouting increased the protein content and improved digestibility by activating enzymes that break down proteins.

Inversely, fat content of optimized product (T_3) sample tends to decrease due to incorporation of sprouted pearl millet extract

and sapodilla fruit kulfi. Which has a lower fat content. Darade *et al.* (2016) concluded the fat content of the kulfi decreased from 9.32 to 8.75 per cent as the amount of fruit pulp in the mix increased.

The ash content of sprouted pearl millet extract and sapodilla fruit based kulfi has decreased. Similar effects were observed by Tiwari *et al.* (2015), who also reported that ash content of the control sample was 1.1 per cent, which had decreased to 1.0 per cent on raising the composition of inulin in low-fat ice cream. The reduction in the ash content may also result in a reduction of solutes and thus a greater proportion of ice being formed for a given temperature, which may contribute to the increased hardness as mentioned above and the incorporation of fruit pulp may also cause the reduction in ash content as observed by Susngi *et al.* (2019), who reported that despite the increase in different concentrations of peach pulp in kulfi samples, the ash content slightly decreased.

The prepared sprouted pearl millet extract and sapodilla fruit kulfi has increased fibre content. It offers increased fibre content due to the inherent fibre in pearl millet and the higher pulp content of sapodilla, which acts as a natural sweetener and thickener. Hamad *et al.* (2017) studied the effect of fortification with guava pulp on some properties of bio-rayeb milk made from goat's milk through the incorporation of guava pulp and found that the developed product had fibre content than control ranging from 0.0 to 0.25 per cent with increased addition of guava pulp ranging from 3 to 15 per cent.

The carbohydrate content in optimized product (T_3) increased eventually after the addition of sprouted pearl millet extract and sapodilla fruit. As reported by Susngi *et al.* (2019), the effect of the addition of peach pulp to supplemented kulfi by adding different levels of peach pulp at 5, 10, 15 and 20 per cent and they discovered that kulfi containing peach pulp resulted in a significant increase in carbohydrates, ranging from 24.39 to 24.53 per cent higher than the control

Physico - chemical analysis of sprouted pearl millet extract based fruit kulfi

The mean pH, titratable acidity and antioxidant values of control and optimized product (T_3) are shown in Table 3. The average pH and acidity values (% of LA) of the control and optimized product (T_3) were 6.72 ± 0.008 , 0.16 ± 0.004 , 1.20 ± 0.001 and 6.75 ± 0.008 , 0.14 ± 0.009 , 15.47 ± 0.184 respectively.

From the results, the pH value of the sprouted pearl millet extract and sapodilla pulp kulfi was found to be higher than the control. Similar results have been reported by (Yogeshwari *et al.* 2022) developed fibre enriched kulfi which showed a significant decrease in the pH value than control.

Acidity plays a very important role in flavor of the product as well as spoilage (Teferra, 2021). The acidity of the optimized product (T_3) showed very slight decrease than control from 0.16 to 0.14 per cent (Table 3). Yogeshwari *et al.* (2022) reported that acidity content of fibre enriched kulfi

slight decreased possibly due to the action of the lactic acid bacteria.

Table 3 shows the mean antioxidant activity of optimized product (T_3) and control at ambient temperature. The mean antioxidant values of the optimized product (T_3) and the control were 15.47 and 1.20 respectively. The results of the present study were comparable with the findings of (Rao and Poonia, 2024) who found that the antioxidant activity is increased from 0 to 68.10 per cent in the control and malted quinoa flour incorporated kulfi.

Microbial analysis of sprouted pearl millet extract based fruit kulfi

The microbial quality of control and optimized product (T_3) sample during a storage period of 0th, 10th, 20th and 30th days at -18°C shown in figure 2. The control and optimized product (T_3) sample were analysed for total plate count (TPC). The mean values for control and product over different storage period ranged from 4.65 to 4.80 $\log_{10}$ cfu/g and 4.72 to 4.94 $\log_{10}$ cfu/g respectively. Similar result was obtained by Patel *et al.* (2020) who observed that TPC of kulfi prepared using amaranthus and the control kulfi samples increased the range of TPC from 4.67 to 5.14 $\log_{10}$ cfu/g and from 4.60 to 5.11 $\log_{10}$ cfu/g, respectively, on 30th day of storage.

Coliform was not detected in control and optimized product (T_3) from 0th to 30th day of the storage period. The result was on par with the findings of Patel *et al.* (2020).

CONCLUSION

This findings indicate that sprouted pearl millet extract and sapodilla fruit pulp can be effectively utilized as functional ingredients in frozen dairy desserts, offering a nutritionally enriched product with

improved sensory properties and consumer acceptability. The developed kulfi represents a promising strategy for value addition and diversification of millet based dairy products.

Table.1. Sensory evaluation score (Mean±SE) @ of control and sprouted pearl millet extract based fruit kulfi samples

Parameters	Control	T1	T2	T3	T4	F value
Color and appearance	6.34 ±0.123 _a	6.23 ±0.111 _a	6.80 ± 0.185 _a	7.84 ±0.177 _b	6.50± 0.175 _{bc}	23.950**
Flavor	5.32 ±0.141 _a	6.21 ±0.120 _b	6.73 ±0.130 _b	7.46 ±0.168 _c	6.63± 0.206 _{cd}	38.841**
Taste	5.24 ±0.127 _a	6.25 ±0.135 _b	6.60±0.144 _b	7.38±0.146 _c	6.36± 0.254 _c	39.889**
Mouth feel	7.50 ± 0.178 _a	7.50 ± 0.142 _b	7.75±0.142 _b	8.80±0.121 _b	6.83 ± 0.205 _c	22.568**
Overall acceptability	5.54 ±0.160 _a	6.29 ±0.116 _b	7.10±0.152 _b	7.23 ±0.112 _c	6.57± 0.175 _{bc}	25.822**

C - 325:0:0 - Milk (ml)

T1- 300:25:10 - Milk (ml): Sprouted pearl millet extract (ml): fruit pulp

T2- 275:50:10 - Milk (ml): Sprouted pearl millet extract (ml): fruit pulp

T3- 250:75:10 - Milk (ml): Sprouted pearl millet extract (ml): fruit pulp

T4- 225:100:10- Milk (ml): Sprouted pearl millet extract (ml): fruit pulp

** Highly significant ($p \leq 0.01$); Means bearing different superscripts within the rows (a, b, c) differ significantly.

Table.2. Proximate analysis (Mean ±SE) @ of control and sprouted pearl millet extract based fruit kulfi samples

Parameters	Control	Optimized Product (T3)	t value
Moisture (%)	60.55±0.050	54.43±0.015	102.142**
Protein (%)	3.55±0.024	3.95±0.007	82.250**
Fat (%)	10.68±0.082	5.35±0.011	5.215**
Ash (%)	1.129±0.012	0.47±0.015	10.233**
Fibre (%)	0.09±0.01	3.15±0.006	149.685**
Carbohydrate (%)	24.052 ±0.216	32.8 ±0.216	580.932**

@- Average of six trials

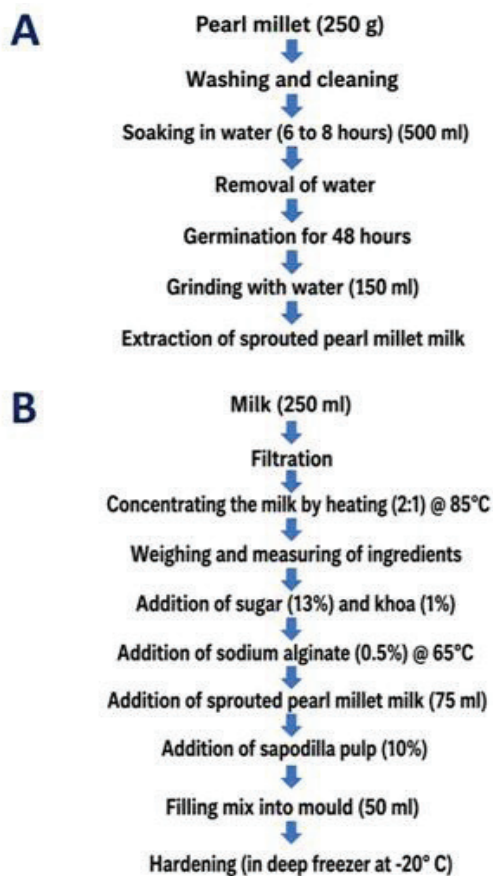
** - Highly significant ($P \leq 0.01$); * - significant ($P \leq 0.05$); Control – kulfi; Optimized Product – sprouted pearl millet extract based fruit kulfi

Table.3. Physico-chemical characteristics (Mean $\pm$ SE) @ of control and sprouted pearl millet extract based fruit kulfi

Parameters	Control	Optimized Product (T ₃)	t value
pH	6.72 $\pm$ 0.008	6.75 $\pm$ 0.008	5.320**
Titrateable acidity (% of lactic acid)	0.16 $\pm$ 0.004	0.14 $\pm$ 0.009	3.160**
Antioxidant activity(%)	1.20 $\pm$ 0.001	15.47 $\pm$ 0.184	15.318**

@- Average of six trials

** - Highly Significant ($P \leq 0.01$); * - significant ($P \leq 0.05$); Control – kulfi; Optimized Product – sprouted pearl millet extract based fruit kulfi.



**Fig.1. A) Flowchart for the preparation of sprouted millet extract and
B) Flowchart for the preparation of optimized product (T₃) kulfi**

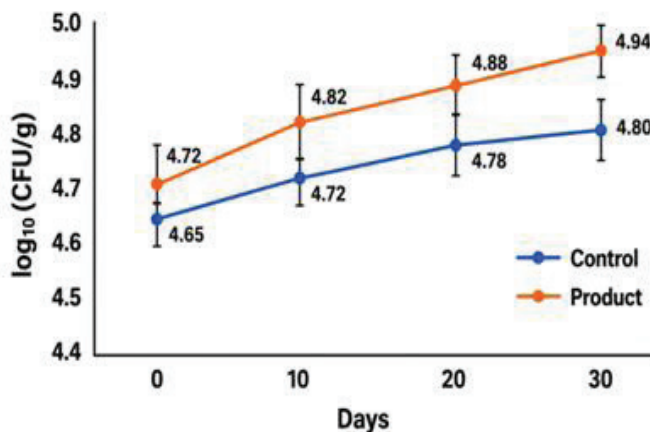


Fig.2. Total plate count of control and sprouted pearl millet extract based fruit kulfi (Product)

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