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Kulfi Unwrapped: Innovations in India's Classic Frozen Dessert

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Abstract

Numerous international communities and research entities have demonstrated considerable interest in the development of an enhanced kulfi formulation, enriched with elevated levels of nutrients and bioactive compounds. Experimental trials were conducted incorporating peach pulp, banana pulp, pistachio powder, probiotic strains, and mango-flavored camel milk powder to improve the color, flavor profile, and therapeutic properties of kulfi. Various formulations were evaluated, including banana pulp at concentrations of 5%, 10%, and 15%; pistachio powder at 2%; mango pulp at 10%, 15%, and 20%; probiotic cultures; peach pulp at 5%, 10%, 15%, and 20%; camel milk powder; and Amaranthus to skimmed milk powder (SMP) ratios of 25:75, 50:50, 75:25, 100:0, and 0:100. These variations were subjected to comprehensive physicochemical and sensory analyses across multiple research centers to identify the optimal formulation. The final optimized kulfi composition comprised 15% banana pulp, 15% peach pulp, 15% mango pulp, and 3% mixed probiotic cultures (*Lactobacillus acidophilus* and *Lactobacillus casei* in a 1:1 ratio), with an Amaranthus: SMP ratio of 25:75. This formulation exhibited superior performance relative to other variants. The integration of fortified ingredients, such as kulfi enhanced with antioxidant activity and total phenolic content, as well as malted quinoa-enriched kulfi with increased polyphenol and antioxidant levels, highlights the potential for creating nutritionally superior frozen desserts. The resultant products demonstrated significant improvements in nutritional quality while preserving the characteristic sensory attributes of traditional locally sourced kulfi.

Keywords: Kulfi, peach pulp, banana pulp, pistachio powder, probiotic mango kulfi, amaranthus, nutritional enhancement

Introduction

Kulfi, also referred to as Malai Kulfi or Malai-ka-burf, is a traditional Indian frozen dairy product primarily prepared using cow and/or buffalo milk. Although it shares compositional similarities with ice cream, kulfi is distinct in that it lacks incorporated air (Singh *et al.*, 2017; Nizam and Rai, 2018) [15, 11]. Conventionally, kulfi is produced by slowly concentrating sweetened and flavored milk through prolonged heating with continuous agitation until the volume is reduced by approximately 50%. It is available in a variety of flavors, including rose, mango, cardamom, saffron (kesar), strawberry, and pistachio, and is often enriched with fruit pulps such as mango, apple, orange, strawberry, and peanut. In India, approximately 0.7% of total milk production is utilized for manufacturing frozen desserts, including ice cream and kulfi. The compositional profile of kulfi typically comprises 8.53% fat, 34.18% total solids (TS), 3.43% protein, 11.02% solids-not-fat (SNF), 6.17% lactose, and 0.84% ash. Recent years have witnessed considerable research efforts focused on enhancing kulfi quality to better meet consumer demands. This review critically examines the recent advancements in kulfi production techniques, providing a comprehensive analysis of the methodologies and results associated with the development of nutritionally fortified and quality-improved kulfi formulations.

Enrichment of Kulfi

In the new millennium, there has been a marked increase in nutritional and health awareness, driving consumer demand for functional foods (Singh and David, 2018) [16]. The present study aimed to enhance kulfi by incorporating various flavors and supplements that not only

improve human health but also extend the product's shelf life. Singh and David (2018) ^[16] investigated the development of pistachio-flavored banana kulfi by partially substituting different levels of banana pulp and pistachio powder. Another study examined the incorporation of probiotics, specifically *Lactobacillus acidophilus* and *Lactobacillus casei*, into mango-based kulfi formulated with varying levels of Alphonso mango, the widely acclaimed "king of fruits" (Nalkar *et al.*, 2019) ^[10]. Susngi *et al.* (2019) ^[18] developed kulfi supplemented with peach pulp, with partial addition of various concentrations of peach pulp, yielding high consumer acceptance based on physicochemical and sensory attributes. Gupta *et al.* (2020) ^[7] evaluated kulfi supplemented with camel milk powder and concentrated milk, noting its therapeutic properties including antimicrobial, anti-inflammatory, antidiabetic, and anticancer effects. Patel *et al.* (2020) ^[12] focused on kulfi formulated with Amaranthus (Rajgara) incorporated at varying ratios with skimmed milk powder (SMP). Murthy *et al.* (2009) ^[4] explored the use of sunflower brand vanaspati (vegetable fat) as an alternative milk fat source for the preparation of filled kulfi. Kaur *et al.* (2021) ^[8] developed kulfi fortified with encapsulated betalains extracted from red beetroot (*Beta vulgaris* L.) pomace, which exhibited enhanced antioxidant activity and reduced microbial load compared to control samples. Amrita (2024) prepared a functional kulfi enriched with malted quinoa flour to increase protein and dietary fiber content; quinoa's gluten-free nature offers benefits for celiac disease and digestive health, while its low glycemic index makes it particularly suitable for diabetic individuals. Singh and Das (2019) ^[18] developed coconut milk-fortified kulfi with varying supplementation levels. Giri *et al.* (2014) ^[5] studied the impact of partial sugar replacement with stevia—a natural sweetener 100–300 times sweeter than sucrose known for health benefits such as improved digestion, diabetes prevention, weight management, and dental health—on kulfi quality. Sontakke *et al.* (2023) ^[17] examined buffalo milk kulfi with varying levels of strawberry pulp addition; strawberries are rich sources of manganese and vitamin C, and also provide potassium, folate, riboflavin, vitamin B5, omega-3 fatty acids, vitamin B6, vitamin K, magnesium, copper, dietary fiber, and iodine.

Method of preparation

After sourcing the ingredients, controlled experimental methodologies were implemented to perform the studies. The kulfi preparation followed the conventional protocol, including milk heating, blending of constituents, concentration, molding, and freezing for solidification. However, various research groups introduced modifications to the standard procedure to develop novel variations of the product. Different temperature conditions were applied in each experiment, as outlined in the following sections.

Development of pistachio flavoured banana kulfi

Singh and David (2018) ^[16] conducted an experiment involving the partial incorporation of banana pulp at varying concentrations (5%, 10%, and 15%) along with 2% pistachio powder. For the preparation of control kulfi samples, milk was standardized to contain 6% fat and 9% solids-not-fat (SNF) in a double-jacketed vat and subsequently concentrated to approximately 50% of its original volume. Following the concentration step, 14%

sugar was incorporated into the mixture. The resultant blend was cooled to 5 °C and then frozen in molds at –20°C overnight.

Suitability of incorporating probiotics in mango based kulfi

Nalkar *et al.* (2019) ^[10] investigated the feasibility of incorporating probiotics into mango-based kulfi by blending different concentrations of Alphonso mango pulp—10%, 15%, and 20%—with probiotic cultures of *Lactobacillus acidophilus* and *Lactobacillus casei* in varying proportions. Following probiotic inoculation, the kulfi mix was cooled, then incubated at 37 °C for 5 hours prior to the addition of mango pulp.

Development of kulfi supplemented with peach pulp

Susngi *et al.* (2019) ^[18] conducted experiments involving the partial incorporation of peach pulp at varying concentrations (5%, 10%, 15%, and 20%), alongside the preparation of a control sample for comparative evaluation.

Studies on Camel milk powder supplemented Kulfi

Gupta *et al.* (2020) ^[7] investigated formulations supplemented with camel milk powder, including blends of 95% concentrated milk with 5% camel milk powder (95% CM + 5% CMP), 90% concentrated milk with 10% camel milk powder (90% CM + 10% CMP), and 85% concentrated milk with 15% camel milk powder (85% CM + 15% CMP).

Development of Kulfi incorporated with Amaranthus (Rajgara)

In the study conducted by Patel *et al.* (2020) ^[12], the experimental design involved evaluating different ratios of Amaranthus to skimmed milk powder (SMP), specifically 25:75, 50:50, 75:25, 100:0.0, and 0.0:100. The formulated kulfi mix was pasteurized at 80 °C for 25 seconds and subsequently cooled to 4 °C. To enhance flavor, either artificial or natural mawa flavoring was incorporated at a concentration of 0.3%. The prepared mix was then filled into molds, sealed, and frozen in a candy-making machine at –20 °C. Once frozen, the kulfi was transferred to a deep freezer maintained at –18 ± 2 °C overnight to allow for hardening. The frozen product was stored under the same conditions until further analysis. The entire process was carefully standardized to obtain consistent and reproducible results as outlined in the study.

Preparation of filled kulfi by using vegetable fat

Murthy *et al.* (2009) ^[4] investigated the feasibility of substituting milk fat with vegetable fat in kulfi production. A control sample was prepared using skim milk and fresh cream. The kulfi mix was standardized to contain 5% fat and 8.5% solids-not-fat (SNF) by blending fresh skim milk, cream, and Sagar brand skim milk powder (SMP). The mix was preheated to 65 °C, followed by two-stage homogenization at 2500 psi (first stage) and 500 psi (second stage). It was then concentrated to 50% of its initial volume, after which stabilizer, emulsifier, and sugar were added at concentrations of 0.25% gelatin, 0.25% glycerol monostearate (GMS), and 15% of the condensed product, respectively, with gentle heating and thorough mixing. The prepared mix was aged at temperatures below 7 °C for 5 hours under stable conditions. Subsequently, color, flavoring agents, and crushed almonds were incorporated,

and the mixture was filled into 80 mL kulfi molds and hardened at -20 ± 2 °C for 12 hours. Experimental (filled) kulfi samples were prepared by replacing milk fat with vegetable fat at substitution levels of 60%, 70%, and 80%. Additionally, a dietetic variant of kulfi was developed by incorporating ash gourd pulp to assess its impact on product characteristics (David, 2014) [4].

Development of functional kulfi fortified with microencapsulated betalains

Kaur *et al.* (2021) [8] extracted betalains from red beetroot pomace following the procedure described by Singh *et al.* (2017) [15]. The extracted betalains were subsequently purified using the gel electrophoresis technique as outlined by Caldas-Cueva *et al.* (2016) [3]. Betalain content was quantified, and microcapsules were prepared using the freeze-drying method. The betalain content within the microcapsules was determined using the standard protocol described by Ravichandran *et al.* (2014) [13]. Kulfi was then formulated with slight modifications to the method proposed by Giri *et al.* (2014) [5]. For product development, the hot kulfi mix was supplemented with microencapsulated betalains at concentrations of 0.50% and 1%, freeze-dried betalain extract at 0.50% and 1%, and microcapsules without betalain (control, 0.50%) at 40 °C. The prepared mix was filled into molds and frozen at -20 °C for 24 hours to achieve complete hardening.

Preparation of malted quinoa flour enriched kulfi

Ji and A.P. (2024) developed a formulation of kulfi with specific objectives of producing a sugar-free, high-protein, and fiber-rich product. The experiment was conducted by incorporating malted quinoa flour at varying levels of 0%, 10%, 15%, and 20%.

Coconut milk fortified kulfi preparation

Singh and Das (2017) [18] formulated kulfi by fortifying it with coconut milk at concentrations of 10%, 20%, and 30%. The control sample, without coconut milk, contained 12% fat, 14% sugar, and 44% total solids.

Development of kulfi by adding stevia with partial replacement of sugar

Giri *et al.* (2014) [5] prepared kulfi by partially replacing sugar with stevia powder. Sugar was replaced at levels of 50%, 60%, and 70% using 0.05%, 0.06%, and 0.07% stevia powder, respectively.

Preparation of ash gourd pulp dietetic kulfi

David *et al.* (2014) [4] developed a dietetic version of kulfi by incorporating ash gourd pulp at different concentrations (5%, 10%, and 15%). The control formulation consisted of 10% milk fat, 15% sugar, 0.2% stabilizer, and 0% ash gourd pulp, yielding 37% total solids. Three treatment formulations were standardized as follows:

- T1: 10% milk fat, 15% sugar, 0.2% stabilizer, and 5% ash gourd pulp.
- T2: 10% milk fat, 15% sugar, 0.2% stabilizer, and 10% ash gourd pulp.
- T3: 10% milk fat, 15% sugar, 0.2% stabilizer, and 15% ash gourd pulp.

Production of strawberry pulp enriched kulfi: Sontakke *et al.* (2023) [17] investigated buffalo milk-based kulfi to

evaluate the sensory attributes after fortifying it with strawberry pulp at levels of 10%, 15%, 20%, and 25%.

Evaluation of physico-chemical, organoleptic and sensory properties of kulfi

The physicochemical parameters, including acidity, total solids (TS), protein content, and fat content, were analyzed according to standard AOAC methods (2005). The pH of the samples was measured using a calibrated pH meter, and melting resistance was assessed following the method described by Giri *et al.* (2012) [6]. The melting time of kulfi samples was also determined. Sensory evaluation was conducted to assess attributes such as color and appearance, body and texture, flavor, and overall acceptability using a nine-point hedonic scale (where 9 = “like extremely” and 1 = “dislike extremely”). A panel of trained and experienced judges carried out the evaluation (Nalkar *et al.*, 2019) [10]. Kulfi prepared with vegetable fat was specifically evaluated by a panel of 10 judges (Murthy *et al.*, 2009) [4].

Observation and results

In the investigation conducted by Singh and David (2018) on the development of pistachio-flavoured banana kulfi, a 15% inclusion level of banana pulp was identified as the most suitable among the tested combinations. This formulation was selected based on comprehensive organoleptic and sensory evaluations, in addition to the recognized nutritional benefits of banana and pistachio. Similarly, Nalkar *et al.* (2019) [10] demonstrated that incorporating 15% Alphonso mango pulp along with 3% mixed probiotic cultures (*Lactobacillus acidophilus* and *Lactobacillus casei* in a 50:50 ratio) resulted in a product of superior quality. This treatment exhibited higher probiotic viability counts of 8.75 and 8.20 log cfu/g for *L. acidophilus* and *L. casei*, respectively, after storage, compared to alternative formulations. Susngi *et al.* (2019) [18] reported that the addition of 15% peach pulp in kulfi yielded highly acceptable results, supported by both physicochemical and sensory analyses. In another study, Gupta *et al.* (2020) [7] explored the supplementation of kulfi with camel milk powder, using a formulation of 95% concentrated milk and 5% camel milk powder, and highlighted its potential therapeutic health properties, including antimicrobial, anti-inflammatory, antidiabetic, and anticancer activities. Patel *et al.* (2020) [12] investigated the incorporation of Amaranthus (Rajgara) into kulfi and observed that a 25:75 ratio of Amaranthus to skimmed milk powder (SMP) significantly improved flavor, body and texture, and color and appearance scores. These findings underscore the potential for developing innovative kulfi formulations that combine sensory appeal with health-promoting attributes. Murthy *et al.* (2009) [4] found that kulfi prepared exclusively with skim milk and cream exhibited the lowest acidity level (0.241% LA). Acidity and pH values increased with higher levels of vegetable fat substitution. Acidity values before aging ranged between 0.241–0.255% LA, while post-aging values ranged from 0.262–0.272% LA. Although color and appearance remained unaffected at all substitution levels, significant effects on body, texture, flavor, and overall acceptability were observed beyond a 70% substitution level, with panelists noting an oily taste. Kaur *et al.* (2021) [8] reported that fortified kulfi exhibited enhanced antioxidant activity and total phenolic content, along with reduced melting rate and lower microbial counts. Amrita

(2024) developed malted quinoa-enriched kulfi, which demonstrated high levels of polyphenols and antioxidants, as well as distinctive natural color and flavor, eliminating the need for artificial additives. The formulation containing 15% malted quinoa flour was optimized and stored for 35 days. Over the storage period, antioxidant activity remained high, acidity showed minimal changes, and microbial counts decreased significantly. Singh and Das (2017) [18] evaluated coconut milk-fortified kulfi through sensory analysis and identified 30% supplementation as optimal, with compositional values of 55.59% total solids, 22.73% fat, 24.28% carbohydrates, 7.57% protein, and 1.45% ash. Giri *et al.* (2014) [5] observed that increasing sugar replacement with stevia led to reductions in specific gravity, melting rate, total calorie content, and carbohydrate percentage, while freezing point, hardness, and fat, protein, ash, and moisture contents increased significantly. However, sugar replacement levels above 50% resulted in a bitter taste and icy texture. David (2014) [4] reported that T3 (containing 15% ash gourd pulp) received the highest organoleptic score, whereas T2 showed the most favorable results for microbiological counts based on standard plate count (SPC) and coliform count analyses. Overall acceptability was ranked in the order T0 > T1 > T2 > T3. Sontakke *et al.* (2023) [17] found that kulfi enriched with 15% strawberry pulp achieved the highest sensory acceptability, as evaluated using a nine-point hedonic scale.

Future Prospects

The future of kulfi innovation lies in exploring nutritionally enhanced and functional frozen desserts that cater to evolving consumer health preferences and market demands. There is substantial potential for developing fortified kulfi variants enriched with bioactive ingredients such as fruit pulps, plant-based proteins, probiotics, and natural antioxidants like betalains, which can improve the nutritional profile alongside sensory appeal. Advancements in microencapsulation technology promise enhanced stability and controlled release of sensitive nutrients, allowing kulfi to serve as a delivery vehicle for functional compounds targeting immunity, digestion, and chronic disease prevention.

Sugar replacement with natural, low-calorie sweeteners like stevia offers pathways to healthier products suitable for diabetic and calorie-conscious consumers, though further optimization is needed to overcome textural and flavor challenges. The integration of plant-based milk alternatives and vegetable fat substitutes can diversify product offerings, addressing lactose intolerance and vegetarian preferences without compromising quality.

Innovations in processing such as optimized heat treatments, homogenization, and freezing methods can improve texture, microbial safety, and shelf life. Moreover, clean-label development using natural colorants and flavoring agents aligns with consumer demand for additive-free foods. Finally, digitalization and automation in production could enable consistent quality control and scalability for both artisanal and commercial kulfi manufacturing, establishing kulfi as a competitive functional dessert in global markets.

Conclusion

Based on the findings of multiple experimental studies aimed at enhancing the color, flavor, and therapeutic value of kulfi, it can be concluded that the physicochemical,

sensory, and microbiological attributes of the developed formulations were highly acceptable. Kulfi enriched with various fruit pulps and functional powders demonstrated superior nutritional quality compared to conventional kulfi. As a rich source of high-quality animal protein, fat, minerals, and vitamins, kulfi has gained increasing consumer popularity in recent years. Banana and pistachio, both recognized for their diverse health-promoting properties in traditional medicine and supported by preclinical studies, can be effectively delivered through kulfi as a functional food matrix. The incorporation of fortified ingredients such as formulations with enhanced antioxidant activity and total phenolic content, as well as malted quinoa-enriched variants exhibiting increased polyphenol and antioxidant levels presents a promising strategy for developing nutritionally enhanced frozen desserts. The use of natural sources for imparting color and flavor in malted quinoa kulfi further highlights a shift toward clean-label and additive-free product development. Collectively, these innovative approaches underscore the potential of kulfi as a versatile platform for creating health-oriented, functional dessert products. These advancements not only enrich the traditional culinary landscape but also respond to the growing consumer demand for nutritious, natural, and sensorially appealing frozen desserts in the modern marketplace.

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