ISSN Print: 2664-844X
ISSN Online: 2664-8458
NAAS Rating (2025): 4.97
IJAFS 2025; 7(11): 120-124
www.agriculturaljournals.com
Received: 17-08-2025
Accepted: 20-09-2025

Amit M Kadam
Ph.D Scholar, Department of AHDS, Mahatma Phule Krishi Vidyapeeth, Rahuri, Maharashtra, India

Kaustubh R Kadam
M.Sc Scholar, Department of Agril. Extension Education, Mahatma Phule Krishi Vidyapeeth, Rahuri, Maharashtra, India

Akanksha D Chavan
Ph.D Scholar, Department of AHDS, Mahatma Phule Krishi Vidyapeeth, Rahuri, Maharashtra, India

Shrikrishna B Narale
M.Sc Scholar, Department of Biochemistry, Mahatma Phule Krishi Vidyapeeth, Rahuri, Maharashtra, India

Apeksha M Suryawanshi
M.Sc Scholar , Department of AHDS, Mahatma Phule Krishi Vidyapeeth, Rahuri, Maharashtra, India

Corresponding Author:
Amit M Kadam
Ph.D Scholar, Department of AHDS, Mahatma Phule Krishi Vidyapeeth, Rahuri, Maharashtra, India

Kulfi: A Traditional Indian Frozen Dessert with Nutritional Richness: A Comprehensive Review

Amit M Kadam, Kaustubh R Kadam, Akanksha D Chavan, Shrikrishna B Narale and Apeksha M Suryawanshi

DOI: https://www.doi.org/10.33545/2664844X.2025.v7.i11b.949

Abstract
Kulfi is popular Indian frozen dessert; it is produced by concentrating whole milk to about two folds followed by addition of sugar and freezing it in aluminium or plastic moulds, usually of conical shape. There are options of substituting sugar with artificial sweeteners like aspartame, sorbitol and maltodextrin. Addition of nutritive sweetening agents e.g. sugar, dextrose, fructose, liquid glucose, dried liquid glucose, maltodextrin, high maltose corn syrup, honey, fruit and fruit products, eggs and egg products, coffee, cocoa, ginger and nuts give significant improvement to the taste, texture and nutritive value.

Keywords: *kulfi*, milk, freezing, ice cream and frozen dessert

Introduction
This review depicts the current status of our knowledge regarding the technology of *kulfi*, difference between *kulfi* and ice cream, factors affecting on processing and preservation of *kulfi.*

Kulfi, a traditional Indian frozen dairy confection, has been consumed for over 500 years (Aneja, 1992) [1]. It occupies a prominent place among indigenous dairy-based desserts in India. The product is regionally known by various names, including qulfi, kulfa, and kulphy (Pandit, 2004) [19]. The term *kulfi* originates from the Hindustani word *kulaf*, meaning “lock” or “container,” which reflects the traditional method of its storage. Conventionally, the dessert is frozen in metallic conical molds that must be unlocked or opened to release the product for consumption (Aneja, 1992) [1].

Preparation of *kulfi*
Documentation on standardized methods for kulfi manufacturing remains limited in the available literature (Warner, 1951; Itzerott, 1960; Rao and Ghodeker, 1978; Salooja, 1979; Ghodeker and Rao, 1982; Ashokraju *et al*., 1989) [28, 15, 23, 24, 8, 3]. Conventionally, kulfi is prepared by concentrating whole milk to approximately double its original volume, followed by the addition of sugar. The mixture is then subjected to suitable heat treatment and subsequently frozen in conical aluminium or plastic moulds. The finished product is characterized by a distinctive pleasant aroma and flavour, a smooth and uniform texture, and the absence of large ice crystals or coagulated milk particles (Pal, 2006) [18].

The freezing step is generally carried out by immersing the moulds in an ice–salt or brine solution, or alternatively through extrusion freezing with very low overrun. Production and sale are mostly conducted on a small scale by traditional sweet makers (halwais), kulfi vendors, and street sellers who commonly use earthen pots (*matkas*), the size of which varies between producers (Vani, 1990) [27]. A process flow diagram describing different market-level methods of kulfi preparation was reported by Ghosh (1991) [11] (Fig. 1.1).

The dairy ingredients like Milk fat and MSNF and non-dairy ingredients like sweetness, stabilizers, flavours and other additives for formulation of *kulfi* mix (Yerriswami *et al*. 1983) [30] are determined by regulatory standards and the desired quality of frozen dessert, marketing strategy, consumer demand, relative price and availability of ingredients.

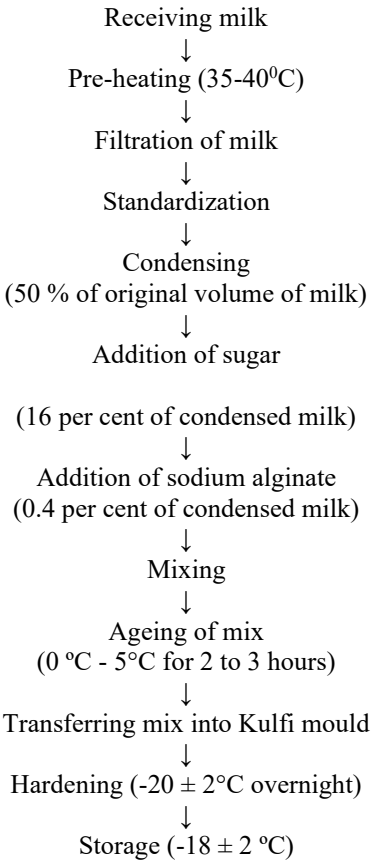

Fig 1.1: Process flow diagram for preparation of *kulfi* in different market (Ghosh, 1991) [11]

The Food Safety and Standards Authority of India (FSSAI) has not explicitly outlined specific standards for kulfi preparation. However, according to the Prevention of Food Adulteration (PFA) specifications, kulfi is defined as the product obtained by freezing a pasteurized mix prepared from milk and/or milk-derived products, with the incorporation of nutritive sweetening agents such as sugar, dextrose, fructose, liquid glucose, dried liquid glucose, maltodextrin, high maltose corn syrup, honey, fruits and fruit products, eggs and egg products, coffee, cocoa, ginger, and nuts. The formulation may also include chocolate and bakery products (e.g., cake or cookies) as a separate layer or coating.

The product may be frozen to a hard or soft consistency and must not contain artificial sweeteners. It should exhibit a pleasant and desirable flavour and aroma, and be free from any off-flavours or rancidity. The product must comply with the quality standards prescribed under IS 1050:1983 and IS 10974 (Part 4):1984 (Pal, 2006) [18].

According to the Bureau of Indian Standards (BIS) specifications (IS 10501:1983; Dharm Pal, 2006) [8], kulfi is defined as a frozen dairy product manufactured from cow milk, buffalo milk, a combination of both, or from cream and other milk-derived products. The formulation may include cane sugar, dextrose, liquid glucose, dried liquid glucose, eggs, fruits and fruit juices, nuts, chocolate, permitted edible flavours, and food-grade colouring agents.

The addition of starch is not permitted. However, approved stabilizers and emulsifiers may be incorporated in quantities not exceeding 0.5% by weight. The use of colouring and flavouring substances must comply with the permissible limits established under the Prevention of Food Adulteration (PFA) Rules, 1955.

Difference between *kulfi* and ice cream

Kulfi is a widely consumed frozen dairy dessert across various regions of the country, primarily due to its desirable sensory attributes and affordable price. Although its formulation and processing are broadly comparable to those of ice cream, a key distinction lies in its minimal or negligible air incorporation. Additionally, kulfi typically contains a higher concentration of total solids per unit volume than ice cream (Naik and Londhe, 2011) [16].

Initially, the Prevention of Food Adulteration (PFA) Act prescribed separate quality standards for ice cream and kulfi; however, these were subsequently harmonized to a single specification. Unlike ice cream, which is packaged after freezing, kulfi is generally frozen within its container, leading to less stringent sanitary requirements compared to ice cream manufacturing. The product exhibits a firmer body and texture, primarily attributed to its negligible overrun. Furthermore, there is limited documentation on the use of equipment and machinery in kulfi production (Naik and Londhe, 2011) [16].

Factors responsible for overall quality of *kulfi*

Multiple factors, including the quality and quantity of raw materials and ingredients, hygienic conditions maintained during mix preparation, processing parameters, type of flavouring agents used, freezing methods, and storage conditions, significantly influence the overall quality of kulfi (Aneja, 1992) [1].

Role of various components of *kulfi*

***Milk fat*:** Milk fat serves as an important source of fat-soluble vitamins and contributes significantly to the desirable creamy flavour, rich mouthfeel, improved body and texture, and enhanced melting resistance of kulfi (Aneja, 1992) [1]. When fruits and nuts are incorporated, the milk fat content may be proportionately reduced; however, it must not fall below 8.0% by weight (Naik and Londhe, 2011) [16].

Prakash developed a process technology for producing filled probiotic kulfi in which milk fat was substituted with vegetable fat to evaluate its impact on product quality. The kulfi mix was inoculated with *Lactobacillus acidophilus* and *Bifidobacterium bifidum*, and these probiotic strains remained viable in substantial numbers even after four weeks of storage, indicating good survival in the modified product.

Milk solids-not fat: Milk solids-not-fat (MSNF) serve as an important source of proteins, minerals, and vitamins, and play a critical role in determining the body and texture of kulfi. Inappropriate levels of MSNF have been associated with the development of a “sandiness” defect in the product (Aneja, 1992) [1]. Common sources of MSNF include dry milk, fluid whole milk, skim milk, condensed skim milk, and skim milk powder. Increasing consumer awareness regarding cholesterol and lactose content has encouraged the partial replacement of milk solids with plant-based alternatives, which are cost-effective and offer additional health benefits (Ramachandran *et al*., 2005) [22].

Bhadakawad *et al*. explored the use of a safflower milk and buffalo milk blend as the source of milk solids for producing golden kulfi. Safflower milk offers nutritional advantages, as it is cholesterol-free and rich in polyunsaturated fatty acids. The sensory evaluation of kulfi made from 80 parts

buffalo milk and 20 parts safflower milk showed overall acceptability comparable to the control, with a production cost reduction of approximately ₹4 per kg. Similarly, the incorporation of partially de-oiled groundnut meal in combination with milk or milk powders lowered the fat content of kulfi while offering potential health benefits, including a reduced risk of obesity, atherosclerosis, and cardiovascular diseases (Ramachandran *et al*., 2005) [22].

Rajor and Vani (1991) [21] attempted to formulate a kulfi-like product by substituting milk solids with soy solids at different ratios (50:50, 70:30, and 90:10, soy to milk solids). Among these, the 50:50 ratio yielded the best sensory scores for flavour, colour, and appearance, although the body and texture were found to be weak and icy. Yerriswamy *et al*. (1983) [29] prepared experimental kulfi by adjusting total solids through the addition of ingredients such as whole milk, cream, and skim milk powder, and compared the results with traditionally prepared samples. It was observed that commercial kulfi typically exhibited higher total solids due to uncontrolled evaporation, whereas experimental kulfi maintained a total solids content of 37–40%, with 13–14% milk fat and 10–12% SNF. This controlled formulation produced a more economical product with improved body, texture, and microbiological quality.

Sugar: Sugar is a critical ingredient in kulfi, widely used as a sweetener in the food industry due to its ability to impart sweetness and a pleasant taste. Its low cost and high energy content make it a preferred sweetening agent (Giri *et al*., 2012; Aneja, 1992) [9, 1]. Increasing sugar concentration in the kulfi mix raises the total soluble solids, which in turn alters the physicochemical properties of the product (Heldman, 2007) [12]. Giri *et al*. (2012) [9] reported that reducing sugar levels in the kulfi mix significantly increases freezing point, hardness, fat, protein, ash, and moisture content, while decreasing specific gravity, carbohydrate content, total caloric value, and melting rate. The reduced melting rate is attributed to higher sugar replacement levels, increased free moisture, and consequent formation of larger ice crystals. Tharp and Gottemoller noted that the freezing point of typical 10% fat ice cream is -2.61 °C, whereas removal of sweeteners elevates the freezing point to 0.78 °C.

Conventionally, sugar is derived from sources such as cane sugar and sugar beet. However, its consumption is limited for individuals with diabetes due to its high caloric content, contributing 20–30% of total calorie intake. Thus, low-calorie dietary alternatives substituting sugar with artificial sweeteners like aspartame, sorbitol, and maltodextrin may be beneficial for managing conditions such as obesity, diabetes, and dental caries (Arora *et al*., 2011) [2]. Researchers including Giri *et al*. (2012) [9], Naik and Londhe (2011) [16], and Pandit (2004) [19] have developed kulfi formulations utilizing various artificial sweeteners and natural sweeteners like stevia.

Pandit (2004) [19] formulated kulfi using a combination of artificial sweeteners and bulking agents (maltodextrin, sorbitol, and aspartame). The study concluded that maltodextrin and sorbitol were essential to achieve the desired body and texture, while aspartame provided the necessary sweetness. Giri *et al*. (2012) [9] optimized sugar replacement levels with stevia to produce dietetic kulfi without compromising the physicochemical and sensory attributes of the product. Similarly, Naik and Londhe (2011) [16] optimized artificial sweetener concentrations for the preparation of sugar-free kulfi.

Stabiliser/Emulsifier: Stabilizers and emulsifiers play a crucial role in determining the body and consistency of kulfi by enhancing the mechanical strength of the mix and improving its resistance to melting. The product's resistance to heat shock is influenced by the type and concentration of the stabilizer/emulsifier system employed (Aneja, 1992) [1]. Raju *et al*. (1989) [21] observed that increasing milk concentration under varying stabilizer conditions resulted in a decrease in the mean melt-down values, indicating enhanced melting resistance. Among the stabilizers tested, sodium alginate imparted greater melt-down resistance compared to starch. This improved resistance to melting is attributed to the stabilizing effect of sodium alginate, as previously reported by Glickman (1963) [10] and Broszkowsha *et al*. (1968) [5].

Effect of process parameter on *kulfi*

Various freezing methods for kulfi have been reported in the literature, with some differences among researchers. Early studies described freezing the kulfi mix in moulds placed inside large earthen vessels containing an ice and salt mixture in a 1:1 ratio. Raju *et al*. (1989) [21] recommended freezing kulfi mix moulds in an ice and salt mixture at a 4:1 ratio within an earthen pot. Yerriswamy *et al*. (1983) [2] reported that whipping the kulfi mix, followed by partial freezing in a refrigerator and subsequent hardening in an ice-salt mixture at –15 °C for 3 to 4 hours, produced a product with favorable organoleptic properties. Ghosh (1991) [11] concluded that kulfi frozen using traditional methods exhibited superior quality and proposed an industrial-scale method involving freezing the kulfi mix in a brine tank at –20 °C with continuous agitation.

Microbiological Quality of Kulfi

Monitoring the microbial quality of kulfi is essential to prevent foodborne illnesses and ensure consumer safety (Elango *et al*., 2010) [7]. Kulfi is highly susceptible to contamination by various microorganisms, including potential pathogens (Vani, 1990) [27]. Critical points for microbial contamination include inadequate milk heating, contaminated utensils, water, sugar, flavouring agents, and handling by personnel.

Kulfi prepared using traditional methods involving milk condensation in an open pan exhibited higher bacterial counts compared to kulfi prepared with the addition of various ingredients (Yerriswamy *et al*., 1983) [29]. Elango *et al*. (2010) [7] assessed total coliform and psychrotrophic bacterial counts to evaluate the microbiological quality of kulfi sold in Chennai. Twenty-four samples were collected from three sources: roadside stalls, small shops, and organized sectors. Psychrotrophic bacterial counts were highest in samples from roadside vendors (1.8×10^3 cfu/g), followed by small-scale producers (1.01×10^3 cfu/g), and lowest in branded samples from organized sectors (3.5×10^2 cfu/g). Roadside vendors accounted for 56.90% of the psychrotrophic organisms, small-scale producers 32.03%, and the organized sector 11.07%. Among the isolates, *Pseudomonas fluorescens* demonstrated greater proteolytic and lipolytic activity compared to *Pseudomonas aeruginosa* and *Pseudomonas putrefaciens*. The highest total bacterial

and coliform counts were also observed in roadside vendor samples, followed by small-scale producers.

In a microbial analysis conducted by Singh and Ranganathan (1974) [25] on ice cream and kulfi, enteropathogenic *Escherichia coli* serotypes were detected, indicating poor hygienic practices during production and handling of these frozen products. Ghosh (1970) [11] reported the presence of enterotoxigenic strains in 10.2% of ice cream samples and 6.7% of kulfi samples, underscoring the potential health risks associated with consumption of contaminated products.

Yerriswamy *et al.* developed a sterilized kulfi mix capable of being sealed in bottles for extended shelf life. Mixes containing 37%, 38%, 39%, or 40% total solids were prepared from milk, cream, skim milk powder, sugar, and stabilizer, then sterilized at 121°C for 10, 15, or 20 minutes. All sterilized samples were free of bacterial contamination and could be stored at room temperature for over three months, facilitating their availability in grocery stores. The mix with 39% total solids received the highest organoleptic scores after being frozen into kulfi.

Future Prospects

Future research on kulfi technology should focus on standardizing processing parameters and ingredient formulations to improve product consistency, safety, and shelf-life. Advanced freezing technologies, such as extrusion freezing with controlled overrun, could enhance textural uniformity and reduce ice crystal formation. Exploring natural stabilizers and emulsifiers aligned with clean-label trends may improve kulfi's melting resistance and sensory appeal. Given the rising demand for functional foods, incorporating probiotic strains and plant-based milk alternatives could diversify kulfi products while addressing health and dietary concerns. Improved microbiological control through better heat treatment protocols, hygienic processing environments, and packaging innovations will be essential to minimize contamination and extend shelf stability. The development of ready-to-freeze sterilized kulfi mixes presents promising avenues for commercial scaling and wider market penetration. Further, optimizing sugar substitutes and low-calorie sweeteners can cater to diabetic and health-conscious consumers without compromising quality. Digital technology-driven process monitoring and quality control could enhance production efficiency in small and large-scale operations. Ultimately, integrating traditional kulfi craftsmanship with modern food technology and stringent quality standards will advance kulfi's status as a nutritious, safe, and appealing frozen dessert in Indian and global markets.

Conclusion

Kulfi, a traditional Indian frozen dairy dessert, remains a popular indigenous delicacy with distinct sensory attributes such as a dense, creamy texture and rich flavor derived from concentrated milk solids and minimal air incorporation. Its manufacturing involves concentrating milk, sugar addition, heat treatment, and controlled freezing, largely carried out by small-scale artisans using traditional methods. Regulatory standards govern key ingredients like milk fat, milk solids-not-fat, sugar, stabilizers, and permissible additives, ensuring product safety and quality. Kulfi differs significantly from ice cream in terms of texture, overrun, and freezing processes. Numerous factors—including the composition of milk solids, sugar concentration, stabilizer type, freezing conditions, and hygiene practices—critically influence kulfi's sensory and microbiological quality. Microbial contamination risks in kulfi, especially from roadside vendors and small-scale producers, highlight the need for improved sanitary measures and processing controls. Innovations such as probiotic fortification and sterilized retail-ready mixes demonstrate potential for extending shelf life and enhancing functionality. Overall, kulfi's unique production techniques, compositional attributes, and market significance underscore the necessity for further standardization and research to optimize quality, safety, and scalability of this cherished frozen dessert.

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