EVALUATION OF SUITABILITY OF BETEL LEAF (*Piper betle* L.) EXTRACT FOR PREPARATION OF FUNCTIONAL *Kulfi*

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Abstract
The present investigation was undertaken to evaluate the suitability of betel leaf (Piper betle L.) extract for incorporation into Kulfi and to assess its effects on physicochemical, antioxidant, microbiological, sensory, and storage characteristics. Standardized Kulfi mix was prepared from buffalo milk and supplemented with aqueous betel leaf extract at levels of 0, 1, 2, 3, and 4%. The treatments were evaluated for compositional attributes, overrun, melting resistance, microbial quality, and sensory acceptability. Sensory evaluation indicated that Kulfi containing 2 per cent betel leaf extract exhibited the highest overall acceptability score (8.74 on a 9-point hedonic scale). Higher incorporation levels imparted excessive herbal flavor and slight astringency. Betel leaf extract improved oxidative stability and reduced microbial counts during storage. The findings demonstrated that betel leaf extract can be successfully utilized for development of functional Kulfi with enhanced nutraceutical value.
Keywords: *Betel leaf, Piper betle, Kulfi, Functional dairy foods, Frozen dairy dessert*

Introduction

Kulfi is a traditional Indian frozen dairy dessert widely consumed across the Indian subcontinent. Unlike conventional ice cream, *Kulfi* is prepared by concentrating milk through prolonged heating, resulting in a dense texture, rich flavor, and characteristic caramelized notes. Owing to its high consumer acceptance and nutritional value, *Kulfi* provides an attractive matrix for incorporation of functional ingredients. The increasing prevalence of lifestyle-related disorders and growing consumer awareness regarding health-promoting foods have stimulated interest in development of functional dairy products enriched with natural bioactive compounds. Plant-derived ingredients rich in antioxidants, polyphenols, flavonoids, and essential oils have gained considerable attention owing to their potential health benefits.

Betel leaf (*Piper betle* L.), belonging to the family Piperaceae, is an important medicinal plant extensively cultivated in India and Southeast Asia. The leaves contain a wide range of bioactive compounds including hydroxychavicol, chavibetol, eugenol, catechol, and various phenolic constituents that exhibit antioxidant, antimicrobial, anti-inflammatory, and digestive properties (Arambewela et al., 2005). Several studies have reported the antimicrobial and antioxidant potential of betel leaf extracts, suggesting their possible application as natural preservatives and functional ingredients in food systems (Pradhan et al., 2013). However, information regarding utilization of betel leaf extract in frozen dairy desserts remains limited. The present investigation was therefore undertaken to evaluate the suitability of betel leaf extract for preparation of functional *Kulfi* and to determine its optimum incorporation level.

Materials and Methods

Procurement of Raw Materials: Fresh buffalo milk was procured from the local vendors in the vicinity of the college of Dairy Technology, Warud(Pusad). Fresh betel leaves were obtained from a local market. Sugar, cardamom, and other ingredients were procured from commercial sources.

Preparation of Betel Leaf Extract: Fresh betel leaves were washed thoroughly, destalked, and shade-dried to remove surface moisture. Leaves were homogenized with distilled water (1:5 w/v) and extracted at 60°C for 30 min. The extract was filtered through muslin cloth followed by Whatman No. 1 filter paper and stored at 4°C until use.

Preparation of *Kulfi* Mix: Buffalo milk standardized to 6 per cent fat and 9 per cent solids-not-fat was concentrated to approximately two-thirds of its original volume by continuous heating. Sugar was added at 12% of the final mix. The mix was cooled to 40°C and supplemented with betel leaf extract according to treatment schedule.

Treatment Details

Treatment	Betel Leaf Extract (%)
T_0	0
T_1	1
T_2	2
T_3	3
T_4	4

The mixes were filled into *Kulfi* moulds and hardened at −18°C.

Analytical Methods: The products were analyzed for Total solids, Fat,Protein,Ash,Acidity,pH, Overrun,Melting resistance, Antioxidant activity (DPPH assay), Microbial quality Standard AOAC (2016) methods were employed.

Sensory Evaluation: *Kulfi* samples were evaluated by ten semi-trained panelists using a 9-point hedonic scale. The attributes assessed included Color and appearance, Flavor, Body and texture, Melting quality and Overall acceptability.

Statistical Analysis: The experiment was conducted using Completely Randomized Design (CRD). Data were analyzed using analysis of variance at a significance level of $P<0.05$.

Results and Discussion

Physicochemical Characteristics:

Table 1. Physicochemical Characteristics of Betel Leaf *Kulfi*

Treatment	Total Solids (%)	Fat (%)	Protein (%)	Acidity (%)	pH
T_0	38.4	10.8	6.82	0.21	6.52
T_1	38.6	10.8	6.84	0.22	6.48
T_2	38.8	10.7	6.86	0.23	6.44
T_3	39.0	10.7	6.88	0.24	6.40
T_4	39.2	10.6	6.90	0.25	6.36

Incorporation of betel leaf extract slightly increased total solids and acidity while reducing pH values.

Total Phenolic Content and Antioxidant Activity

Table 2. Bioactive Characteristics of Betel Leaf *Kulfi*

Treatment	Total Phenolics (mg GAE/100 g)	DPPH Scavenging Activity (%)
T_0	18.4	9.6
T_1	36.2	21.8
T_2	54.8	38.6
T_3	71.4	52.8
T_4	88.6	64.2

A significant increase in total phenolic content and antioxidant activity was observed with increasing levels of betel leaf extract. The enhancement may be attributed to the presence of hydroxychavicol, eugenol, and other phenolic compounds naturally occurring in betel leaves (Arambewela *et al.*, 2005).

Physical Characteristics:

Table 3. Overrun and Melting Resistance of *Kulfi*

Treatment	Overrun (%)	First Drip Time (min)
T_0	28.4	18.2
T_1	27.8	19.4
T_2	27.2	20.6
T_3	26.8	21.4
T_4	26.2	22.0

Betel leaf extract improved melting resistance, possibly due to increased solids and water-binding capacity.

Sensory Evaluation

Table 4. Sensory Scores of Betel Leaf *Kulfi*

Treatment	Flavor	Body & Texture	Color & Appearance	Overall Acceptability
T_0	8.24	8.30	8.18	8.24
T_1	8.46	8.52	8.48	8.48
T_2	8.76	8.82	8.64	8.74
T_3	8.28	8.46	8.52	8.42
T_4	7.62	8.08	8.40	7.96

Kulfi containing 2 per cent betel leaf extract exhibited the highest overall acceptability. Higher concentrations imparted pronounced herbal flavor and slight bitterness.

Microbiological Quality

Table 5. Total Plate Count During Storage at −18°C

Treatment	Day 0 (log cfu/g)	Day 30 (log cfu/g)
T_0	2.84	3.42
T_2	2.60	2.94

The optimized treatment exhibited lower microbial counts compared to control, indicating antimicrobial effects of betel leaf phytochemicals.

Discussion

The present investigation demonstrated that betel leaf extract can be effectively utilized in *Kulfi* manufacture to enhance functional attributes without compromising sensory quality. The increase in total phenolic content and antioxidant activity observed in treated samples is consistent with reports describing betel leaf as a rich source of bioactive compounds, including hydroxychavicol and eugenol (Arambewela et al., 2005; Pradhan et al., 2013). Improved melting resistance may be attributed to increased total solids and interactions between phenolic compounds and milk proteins. The antimicrobial properties of betel leaf extract contributed to reduced microbial counts during storage.

The highest consumer acceptability was observed at 2 per cent incorporation level, suggesting that moderate addition provides a desirable balance between functional enhancement and sensory characteristics.

Industrial Significance

Functional *Kulfi* enriched with betel leaf extract offers opportunities for Development of innovative dairy desserts, Utilization of indigenous medicinal plants, Enhancement of antioxidant intake, Diversification of traditional dairy products and Creation of premium functional food products,

Conclusion

The study demonstrated successful incorporation of betel leaf extract into *Kulfi*. Addition of betel leaf extract significantly enhanced antioxidant activity and improved microbial stability. *Kulfi* containing

2% betel leaf extract exhibited optimum physicochemical, sensory, and functional characteristics and was identified as the most acceptable formulation. The findings indicate considerable potential for commercialization of betel leaf-enriched functional *Kulfi* as a novel value-added dairy product.

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