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Study on Physico-chemical changes in crushed dried Mahua (*Madhuca longifolia)* flower kulfi during storage

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Abstract
The present investigation entitled ‘‘Keeping quality of crushed dried Mahua flower (*Madhuca longifolia*) kulfi prepared by traditional method” was undertaken in the Section of Animal Husbandry and Dairy Science and Section of Plant Pathology, College of Agriculture, Nagpur. The cow milk was standardized to 4% fat and the kulfi was prepared by addition of crushed dried Mahua flowers in the proportion of 100:0 (T_1) and 86:14 (T_5) with 13 per cent sugar was added. The objectives of the present investigations were to study the sensory, physiochemical, microbiological changes during storage of control treatment i.e. T_1 (100% condensed milk: 00% crushed dried mahua flower) and selected treatment i.e. T_5 (86% condensed milk: 14% crushed dried Mahua flower) at the interval of 0, 7, 14, 21, 28, 35 days.

Keywords: Cow milk, condensed milk, Mahua flowers, Kulfi, Physicochemical, chemical composition

Introduction
India is the highest milk producer and ranks first position in the world contributing 25% of global milk production. The milk production of India has registered 58% increase during the last nine years i.e., during the year 2014-15 and 2022-23 and increased to 230.58 Mn Tonnes in the year 2022-23. The milk production has increased at CAGR 6% over the past decade. The top 5 milk-producing states are: Rajasthan (15.05%), Uttar Pradesh (14.93%), Madhya Pradesh (8.6%), Gujarat (7.56%) and Andhra Pradesh (6.97%). They together contribute 53.11% of total Milk production in the country. India's Export of Dairy products was 63,738.47 MT to the world for the worth $272.64 Mn during the year 2023-24. (investindia.gov.in 2024) The chief difference between ice cream and kulfi is that the former is whipped with air or over run, while the latter is not and hence, comprises no air (Kumar *et al.*2017) [5].

Traditionally, kulfi is prepared using sweetened milk (containing 20-25% added sugar and concentrated to about half of its volume) and malai/cream, crushed nuts (almonds and pistachios) as well as flavouring ingredients (vanilla and/or rose essence. Subsequently, the prepared mix is poured and frozen in small conical shaped containers till consumption (Siva et al. 2019). At industrial level, a kulfi mix is composed of milk fat (10-16%), milk solids-not-fat (9-12%), sucrose (9-12%), corn syrup solids (4-6%), stabilizers/ emulsifiers (0-0.5%), total solids 36-45%, and water 55-64% (Kumar *et al.* 2017) [5].

Frozen dessert (Kulfi) is a dairy product, which closely resembles like ice cream in composition. In recent years, the consumption of ice cream in India has increased considerably in big cities and town. Every north Indian city is selling frozen Product to quench scorching heat of summer season. In India about 0.7% of the total milk produced is converted into frozen desserts. Whey protein is one of the major proteins found in cow milk comprising about 20% of total milk protein. It has the highest biological value and protein efficiency as compared to other protein, which makes it suitable for wide range of nutraceuticals and functional food system (David, 2015) [2].

Mahua (*Madhuca longifolia*) is a tropical tree mostly seen widely in the central and north Indian plane forest. It is known as the warehouse of no of phytochemicals and mostly used by the tribal people. It has numerous benefits in pharmaceutical and food industry. In Ayurveda, the flowers have application in medicines with cooling properties. Mahua flowers are edible and consumed by the tribal mostly.

It is rich in antioxidant and antimicrobial properties and used as food in tribal area. It is also used as an exchange of buying goods. The fruits of Mahua are utilized as vegetable and mostly prepared curries by rural tribal peoples. However, the Mahua tree is considered as medicinal tree and very useful for curing diseases like piles, skin diseases, headache, ulcer, constipation and many more. Mahua flower is not only used for the production of liquor but also used as an ingredient for the making of biscuit, cake, jam, jelly and sauces etc. The tree is considered as gold in forest dwellers and measured as fortunate thing for tribal. Oil is extracted from the flower used in cosmetic industry as well as for the purpose of cooking (Anubhuti Dwivedi *et al.* 2021) [1].

Methodology

Fresh, clean, whole cow milk was used for kulfi preparation. Cow milk was procured for every trial from Livestock Instructional Farm of Section of Animal Husbandry and Dairy Science, College of Agriculture, Nagpur. Mahua flowers, clean crystalline cane sugar, salt and ice was procured from local market. The muslin cloth and few glassware were also used during the experiment.

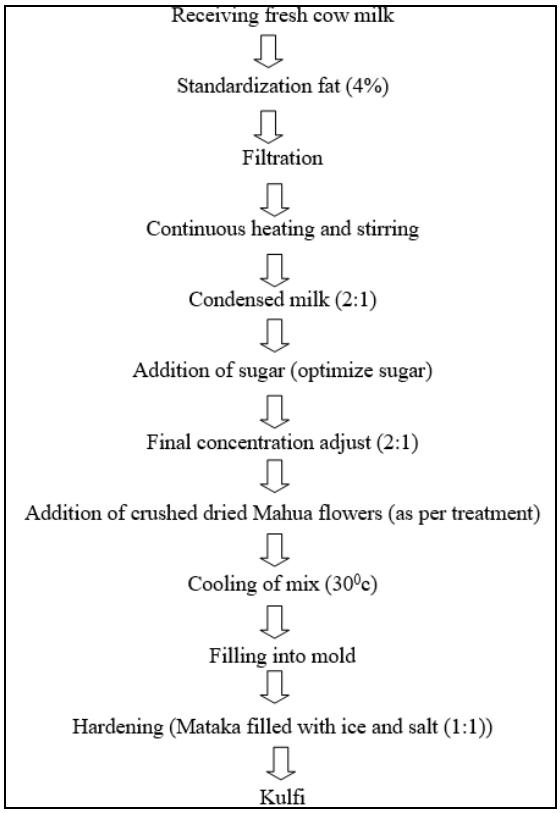

Fig 1: Flow chart for preparation Crushed dried mahua (*Madhuca longifolia*) flower kulfi prepared by traditional method

Physicochemical analysis of kulfi

The fat was determined by Gerber method as per procedure in SP: 18 (Part XI), 1981. Protein percentage of kulfi was determined as per the semi- micro Kjeldahl method as recommended in IS: 1479 part II (1961). The total solids percentage in Kulfi was determined by using gravimetric method as per the procedure of IS: 1479 (Part II) (1961). Moisture content in the sample was determined by subtracting the total solids content from 100 in the sample. SNF was obtained by substracting the percentage of fat from percentage of total solids. The acidity of milk expressed on per cent lactic acid will be determined by method described in IS: 1479 (Part II) 1961.

Results and Discussion

Physicochemical analysis during storage period

The physicochemical analysis of control treatment (T_1) and selected treatment (T_5) in takes place at the interval of 7 days and changes in properties is as below.

Fat content

Control treatment i.e. (100% condensed milk: 0% crushed dried mahua) and Selected treatment i.e. (84% condensed milk :14% crushed dried mahua was stored at refrigerated temperature (- 20 $c^{o)}$ up to 35 days and the fat content was determined at the interval of 0, 7, 14, 21, 28 and 35 days. The data obtained in respect of changes in fat content of kulfi during storage are tabulated and presented in Table 2.

Table 2: Changes in fat content of Mahuakulfi in the storage interval (%).

Treatments	Storage interval in days						Individual effect (Mean)
	0	7	14	21	28	35	
Control(T_1)	10.5	10.75	10.98	11.32	11.60	11.78	11.16
Selected (T5)	8.40	8.68	8.96	9.25	9.44	9.78	9.08
Individual effect (Mean)	9.45	9.72	9.97	10.28	10.52	10.78	10.12
	Treatments		**Storage interval**				**Interaction**
F test	Sig		Sig				Sig
SE (m)±	0.22		0.385				0.54
CD (p=0.05)	0.667		1.155				1.633

The mean values of fat content (%) of control kulfi T_1 for 0^{th} 7^{th} 14^{th} 21^{st} 28^{th} and 35^{th} day was 10.5, 10.75, 10.98, 11.32, 11.60 and 11.78 respectively and that of selected kulfi T_5 for 0^{th} 7^{th} 14^{th} 21^{st} 28^{th} and 35^{th} day was 8.40, 8.68, 8.96, 9.25, 9.44 and 9.78 respectively. This might be due to the losses in moisture content of kulfi during storage. The Bureau of Indian Standards (IS: 5550) has set a limit of at least 10 per cent for the fat content of kulfi for control and 8 percent for value addition kulfi. Based on the table, both the samples T_1 and T5 meet this standards. It was further revealed that fat content was significantly increased in both treatments at storage interval. The difference between the storage interval and treatments was observed significant. Kadam (2021) [4] reported that the fat content of kulfi samples significantly ($P < 0.05$) influenced during storage. The fat content of kulfi samples were ranged from 9.68 (T0) to 8.57(T_3), 9.61(T_0) to 8.52 (T_3), 9.47 (T_0) to 8.35 (T_3) and 9.34 (T_0) to 8.23(T_3) per cent, respectively. The fat content of kulfi samples significantly declined due to addition of piper betel leaves extract. As storage period increase, the fat content of kulfi samples significantly declined.

Moisture content

Control treatment (100% condensed milk: 0% crushed dried mahua) and Selected treatment i.e. T_5 (86% condensed milk: 14% crushed dried Mahua flower) was stored at refrigerated temperature i.e. (-20$c^{o)}$ up to 35 days and the moisture content was determined at the interval of 0, 7, 14, 21, 28 and 35 days. The data obtained in respect of changes in moisture content of kulfi during storage are tabulated and presented in Table 3.

From the table 10, it revealed that, the mean of moisture percentage of control kulfi T_1 for 0^{th} 7^{th} 14^{th} 21^{st} 28^{th} and 35^{th} day was .62.59, 62.50, 62.44, 62.39, 62.33 and respectively and that of selected kulfiT_5 for 0^{th} 7^{th} 14^{th} 21^{st} 28^{th} and 35^{th} day was 64.33, 64.30, 64.25, 64.19, 64.15 and 64.05 respectively. It was further observed from that moisture

content was significantly decreased in both the treatments individually and interaction of treatment at storage interval.

Table 3: Changes in moisture content of Mahuakulfi in the storage interval (%)

Treatments	Storage interval in days						Individual effect (Mean)
	0	7	14	21	28	35	
Control (T_1)	62.59	62.50	62.44	62.39	62.33	62.28	62.42
Selected (T5)	64.33	64.30	64.25	64.19	64.15	64.05	64.21
Individual effect (Mean)	63.46	63.40	63.35	63.29	63.24	63.16	63.31
	Treatments		Storage interval				Interaction
F test	Sig		Sig				Sig
SE (m)±	0.239		0.415				0.587
CD (p=0.05)	0.719		1.246				1.762

Dushyant Siddhu (2019) [3] reported that the average moisture content in Kulfi samples of different treatments is presented in. From the perusal of data on moisture percent in Kulfi samples of different treatments and control the highest mean moisture percent was recorded in the Value added Kulfi sample of To3 (57.81) followed by Tpg3 (57.75), Tp2 (57.70), Tp3 (57.60), T0 (57.52), Tpg2 (57.51), To1 (57.50), To2 (57.44), Tp1 (57.40) and Tpg1 (57.33).

Protein content

Control treatment T_1 i.e. (100% condensed milk: 0% crushed dried mahua) and Selected treatment i.e. T_5 (86% condensed milk: 14% crushed dried Mahua flower) refrigerated temperature up to 35 days and the protein content was determined at the interval of 0, 7, 14, 21, 28 and 35 days. The data obtained in respect of changes in protein content of kulfi during storage are tabulated and presented in Table 4.

Table 4: Changes in protein content of Mahua kulfi in the storage interval (%)

Treatments	Storage interval in days						Individual effect (Mean)
	0	7	14	21	28	35	
Control(T_1)	3.45	3.49	3.54	3.59	3.68	3.74	3.58
Selected (T5)	3.64	3.75	3.84	3.90	3.98	4.04	3.86
Individual effect (Mean)	3.54	3.62	3.69	3.75	3.83	3.89	3.72
	Treatments		Storage interval				Interaction
F test	Sig		Sig				Sig
SE (m)±	0.207		0.362				0.512
CD (p=0.05)	0.627		1.086				1.536

The mean of protein percentage of control treatment T_1 for 0^{th} 7^{th} 14^{th} 21^{st} 28^{th} and 35^{th} was 3.45, 3.49, respectively and that of selected treatment T_5 for 0^{th} 7^{th} 14^{th} 21^{st} 28^{th} and 35^{th} day was 3.64, 3.75, 3.84, 3.90, 3.98 and 4.04 respectively. The protein content values were increased significantly in both treatments individually at different storage days interaction between two treatments storage was also significant. Kadam (2021) [4] reported that the protein content of kulfi samples were ranged from 7.04(T0) to 7.58(T3), 6.96(T0) to 7.52(T3), 6.91(T0) to 7.36 (T3) and 6.81(T0) to 7.28(T3) per cent, respectively during storage.

Ash content

Control treatment i.e. (100% condensed milk: 0% crushed dried mahua) Selected treatment i.e. T_5 (86% condensed milk: 14% crushed dried Mahua flower) was stored refrigerated temperature i.e. (-20 °C) to 35 days and the ash content was determined at the interval of 0, 7, 14, 21, 28 and 35 days. The data obtained in respect of changes in ash content of kulfi during storage are tabulated and presented in Table 5 and graphically represented in Fig. 4. The mean of ash percentage of control treatment T_1 for 0^{th} 7^{th} 14^{th} 21^{st} 28^{th} and 35^{th} day was 0.53, 0.57, 0.63, 0.68, 0.74 and 0.8 respectively and that of T_5 for 0^{th} 7^{th} 14^{th} 21^{st} 28^{th} and 35^{th} day was 0.60, 0.66, 0.76, 0.84, 0.90 and 0.98 respectively

It is revealed that, ash content of kulfi was significantly increased in both the treatment. Prasad *et al.* (2017) reported that the ash content was increasing from 2.95 to 3.09 per cent in burfi during storage.

Table 5: Changes in ash content of Mahua kulfi in the storage interval (%)

Treatments	Storage interval in days						Individual effect (Mean)
	0	7	14	21	28	35	
Control (T_1)	0.53	0.57	0.63	0.68	0.74	0.8	0.66
Selected (T5)	0.60	0.66	0.76	0.84	0.90	0.98	0.79
Individual effect (Mean)	0.56	0.61	0.69	0.76	0.82	0.89	0.72
	Treatments		Storage interval				Interaction
F test	Sig		Sig				Sig
SE (m)±	0.013		0.023				0.032
CD (p=0.05)	0.040		0.069				0.098

Total solids

Control treatment T_1 (100% condensed milk:0% crushed dried mahua flower) i.e. Selected treatment i.e. T_5 (86% khoa: 20% crushed dried Mahua flower) was stored at refrigerated temperature i.e. (-20 ºC) up to 35 days and the total solids content was determined at the interval of 0, 7, 14, 21, 28 and 35 days. The data obtained in respect of changes in total solids content of kulfi during storage are tabulated and presented in Table 6.

Table 6: Changes in total solids content of Mahua Kulfi in the storage interval (%)

Treatments	Storage interval in days						Individual effect (Mean)
	0	7	14	21	28	35	
Control(T_1)	35.68	35.79	35.92	36.18	36.31	36.45	36.05
Selected (T5)	37.68	37.84	37.98	38.24	38.44	38.54	38.12
Individual effect (Mean)	36.68	36.81	36.95	37.21	37.37	37.49	37.08
	Treatments		Storage interval				Interaction
F test	Sig		Sig				Sig
SE (m)±	0.179		0.310				0.439
CD (p=0.05)	0.538		0.932				1.318

The mean value of total solids percent of control treatment T_1 for 0^{th} 7^{th} 14^{th} 21^{st} 28^{th} and 35^{th} day was 35.68, 35.79, 35.92, 36.18, 36.31 and 36.45 respectively and that of selected treatment T_5 for 0^{th} 7^{th} 14^{th} 21^{st} 28^{th} and 35^{th} day was 37.68, 37.84, 37.98, 38.24, 38.44 and 38.54 respectively. Total solids content of crushed dried Mahua flower kulfi was significantly increased in both the treatment, individually and the result on interaction of both treatments at storage interval was also found significant.

Solid Not Fat

Control treatment T_1 (100% condensed milk:0% crushed dried mahua flower) Selected treatment i.e. T_5 (86% condensed milk: 14% crushed dried Mahua flower) was stored at refrigerated temperature i.e. (-20 °C) up to 35 days and the Solids Not Fat content was determined at the interval of 0, 7, 14, 21, 28 and 35 days. The data obtained in respect of

changes in Solids Not Fat content of kulfi during storage are tabulated and presented in Table 7.

Table 7: Changes in Solids Not Fat content of MahuaKulfi in storage interval (%)

Treatments	Storage interval in days						Individual effect (Mean)
	0	7	14	21	28	35	
Control(T_1)	27.18	27.09	27.0	26.92	26.84	26.76	26.96
Selected (T5)	27.28	27.11	26.96	26.93	26.87	26.67	26.97
Individual effect (Mean)	27.23	27.10	26.98	26.92	26.85	26.71	26.965
	Treatments		Storage interval		Interaction		
F test	Sig		Sig		Sig		
SE (m)±	0.24		0.417		0.589		
CD (p=0.05)	0.722		1.251		1.769		

The mean of solids not fat percent of Control treatment (T_1) for 0^{th} 7^{th} 14^{th} 21^{st} 28^{th} and 35^{th} days was 27.18, 27.09, 27, 26.92, 26.84 and 26.76 respectively and that of Selected treatment (T_5) for 0^{th} 7^{th} 14^{th} 21^{st} 28^{th} and 35^{th} days was 27.23, 27.13, 26.98, 26.92, 26.85 and 26.71 respectively. Solids not fat content of crushed dried Mahua flower kulfi was significantly decreased in both the treatment, individually and the result on interaction of both treatments at storage interval was also observed significant.

Titratable acidity

Control treatment T_1 i.e. (100% condensed milk:0% crushed dried mahua flower) Selected treatment i.e. T_5 (86% condensed: 14% crushed dried Mahua flower) was stored at refrigerated temperature i.e. (-20 °C) up to 35 days and the titratable acidity content was determined at the interval of 0, 7, 14, 21, 28 and 35 days. The data obtained in respect of changes in titratable acidity content of kulfi during storage are tabulated and presented in Table 8 and graphically represented in Fig. 7.

The mean of titratable acidity per cent of control treatment (T_1) for 0^{th} 7^{th} 14^{th} 21^{st} 28^{th} and 35^{th} days was 0.22, 0.24, 0.25 0.27, 0.29 0.31 respectively and that of selected treatment (T_5) was 0.17, 0.20, 0.22, 0.25 and 0.26 respectively. According to the BIS (IS: 5550), the acidity content of kulfi should not exceed 0.30 per cent. The both samples meet these standards till 35 days.

Titratable acidity content of crushed dried Mahua flower kulfi was significantly increased in both treatments, individually and the result on interaction of both treatments at storage interval was also showed significant.

Table 8: Changes in titratable acidity content of Mahuakulfi in storage interval (%)

Treatments	Storage interval in days						Individual effect (Mean)
	0	7	14	21	28	35	
Control (T_1)	0.22	0.24	0.25	0.27	0.29	0.31	0.26
Selected (T5)	0.17	0.20	0.22	0.23	0.25	0.26	0.22
Individual effect (Mean)	0.19	0.22	0.235	0.25	0.27	0.29	0.24
	Treatments		Storage interval		Interaction		
F test	Sig		Sig		Sig		
SE (m)±	0.003		0.006		0.008		
CD (p=0.05)	0.010		0.018		0.025		

Conclusion

Fat, protein, total sugar, ash, total solids, titratable acidity content of kulfi T_1 prepared with 86% condensed milk and 14% crushed dried Mahua flower as well as T_1 prepared with 100% condensed milk was increased from 7^{th} day to 35^{th} day. While, moisture and snf was decreased in both T_1 and T_5.

Conflict of Interest

Not available

Financial Support

Not available

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