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Process Optimization and Effect of Jaggery on Nutritional and Rheological Behaviour of Burfi

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ABSTRACT: Jaggery, a traditional Indian sweetener, offers a unique flavor and nutritional profile. This research focuses on optimizing the process for manufacturing jaggery-based burfi, a popular Indian sweet. Process parameters such as jaggery concentration, Rheological and proximate composition were investigated to determine the effect of jaggery. On sensory basis, the 24% jaggery was optimized as suitable for making burfi. The jaggery addition leads to moisture reduction while the fat and protein content was increased in jaggery added burfi. The moisture reduction affects the hardness of the jaggery based burfi. Although it modifies the textural behaviour of burfi, it increases the mineral profile and palatable taste of burfi. The jaggery addition will be beneficial when compared to the control burfi sample.

Keywords: jaggery, burfi, process optimization, rheology.

INTRODUCTION

Milk is an almost complete food available in nature and serve as the primary source of active nutrients for all age groups of the human population. As a result of the white revolution, India accomplished self-sufficiency in milk and milk products through the Operation Flood programme (1970-1996). India currently produces approximately 221.1 MT of annual milk (NDDB, 2021), accounting for around 23 percent of total global milk production. Indian producers of buffalo milk have propelled the country to the top of the milk production rankings. India is the second-largest producer of cow's milk after the United States. It is estimated that nearly 50-55 percent of total milk production is converted into a variety of traditional milk products through processes such as heat desiccation, heat and acid coagulation, and fermentation, with approximately 7.0 percent of total milk production used for Khoa production in India (Rao *et al.,* 2020).

Traditional Indian dairy products and sweets are an essential element of an Indian culture, with significant social, religious, cultural, medical, and economic value (Nobrega *et al*., 2023). Milk and milk products have been the foundation of Indian cuisine since Vedic times. Sweets were made from evaporated milk with the addition of honey or jaggery as a natural sweetener or sugar during the Maurya period (75-300 A.D.). They are widely accepted and demanded by consumers. Each of these goods is distinguished by its distinct flavor, texture, and appearance (Giovanazzi *et al.,* 2023).

Khoa is a popular heat-desiccated milk product that serves as a base for various Indian delicacies such as burfi, peda, kalakand, gulabjamun, and so on a large proportion of India's total milk production converted into khoa. Buffalo milk is favored over cow and goat milk when making dairy products like paneer, basundi, khoa, and khoa-based desserts (peda, burfi, kalakand, gulabjamun, etc.) as because it provides the final product a soft, uniform body with a smooth, compact, and homogenous texture. It is made by continuously heating, stirring, and scraping in an open pan until it reaches a semisolid consistency. An Inclined Scraped Surface Heat Exchanger (ISSHE) was created by the National Dairy Development Board in Anand, India, for continuous khoa production (Amruthakala, 2012).

Browning reactions, such as Maillard (an interaction between reducing sugars and amino acids) and caramelization, are created in milk during the manufacture of khoa. Khoa has a two to four day shelf life at room temperature and a three week shelf life at refrigeration temperature (Sonika *et al.,* 2015).

Burfi, the most recognized delicacy made from heat-desiccated milk (khoa), has a special place in both festive and everyday diets on the Indian subcontinent. Depending on the additions used, such as coconut, besan, fruits, chocolate, nuts, palm, groundnut, saffron, soy, reduced calorie, and probiotics, several types of burfi could be created. A mixture of condensed milk solids (khoa) and sugar is heated until nearly homogeneous, then cooled and sliced into tiny cuboids to make burfi. Before cooling, beating and whipping techniques are occasionally used to create products with a smooth texture and tightly knit body (Badola *et al.,* 2018).

Jaggery (Gur) is defined as the product formed by concentrating the sweet juices of sugarcane or palm trees to a solid or semi-solid state. It is a natural sweetener with a sweet, winy taste and aroma. It has a strong scent and a delightful flavor that is midway between brown sugar and molasses (Kumar and Kumar 2021). India ranks first globally in consumption and second in production of sugar. Maharashtra and Uttar Pradesh produce 60% of all the sugar produced in India (Da Cruz and Machado 2023).

In terms of nutrient content, it is also a superior product among natural sweeteners. It is an energy food that is supposed to cleanse the blood, regulate liver function, and keep the body healthy (Sharifi-Rad *et al.,* 2023). As a type of sugar, it is an important part of the diet and is either taken directly or used as a sweetening factor in sweet dishes. Jaggery contains proteins, minerals, and vitamins. It is also a good source of minerals, with higher iron and copper contents than refined sugar (Rao and Singh 2022).

The replacement of cane sugar by jaggery in burfi acquires depth and a distinct flavor from the rich, nuanced flavor of jaggery, which has a sense similar of caramel, lends the burfi a cozy, golden-brown tint that enhances its attractive, natural appearance and Burfi's texture, which combines well with the richness of the milk and grain base.

MATERIALS AND METHODS

The work related to this research topic was completed in the PG laboratory of the Department of Dairy science and Food Technology, Institute of Agricultural Sciences, Banaras Hindu University, Varanasi, India and this experiment covers the study on the development of technology for Burfi.

Buffalo milk was procured from the Dairy Farm, BHU, Varanasi and was standardized to 6.0 per cent fat and 9.0 per cent SNF. Good quality cane sugar of commercial grade was obtained from the local market of Varanasi. Good quality natural GI tagged jaggery was obtained from the local market of Kolhapur (MH).

For the preparation of jaggery burfi, Buffalo milk (6% fat & 9% SNF) was standardized. After preparing a khoa, jaggery was added to it in different proportions to study the changes in different parameters of jaggery burfi.

Flow Chart of Jaggery *Burfi.* The preparation of jaggery burfi was present in Figure 1. The Treatment Detail of jaggery burfi was depicted in Table 1.

Sensory Evaluation. For the organoleptic evaluation of jaggery *Burfi*, 10 judges were selected.Burfi was carried out using 9-point Hedonic scale given in IS: 6273, Part - I and II (1971) for various sensory attributes. The judges were also requested to give criticism for each attributed of the samples.

Yield estimation of jaggery *burfi.* The yield was estimated by the ratio of weight of the final product to the weight of raw materials taken. In case of jaggery *burfi* raw materials used are milk and jaggery.

$$\% \text{ Yield} = \frac{\text{Wt. of jaggery burfi}}{\text{Wt. of raw material}} \times 100$$

Rheological analysis of jaggery *burfi.* Rheological properties were tested by a "texture analyzer" (Brookfield Texture Analyzer) Rheological properties of *burfi* which were tested are hardness, cohesiveness, gumminess, chewiness, adhesiveness, and springiness. The test speed was 10 mm/s, distance from the sample was 5.0 mm/s with 25g trigger force in texture analyzer.

Analysis of *Burfi.* Jaggery *Burfi* samples were subjected to compositional analysis

Moisture. The moisture of the Jaggery *Burfi* samples was determined by standard procedure of AOAC (2012) The per cent moisture in Jaggery *Burfi* sample was calculated by using the following formula:

$$\text{Moisture (\% by weight)} = \frac{\text{Loss in weight of sample}}{\text{weight of sample taken}} \times 100$$

Fat. Fat extraction of Jaggery *Burfi* was determined as per the procedure described in IS: 2311-(1963).

$$\text{Fat (\% by weight)} = \frac{\text{Weight of residue}}{\text{Weight of sample}} \times 100$$

Protein. The protein content in the Jaggery *Burfi* was estimated by the protocol of AOAC (2000) using Kjeldahl method in which digestion, distillation and titration are basic process to get protein content.

Calculations

$$\% \text{ Nitrogen} = \frac{14.01 \times 0.1\text{N} \times (\text{TV} - \text{BV})}{W \times 1000} \times 100$$

% Protein = %N ×6.25 (for food samples)

Where,

TV= Titer value

BV= Blank value

W= Sample weights

Total carbohydrate (By difference). Total carbohydrate content of GR was determined by subtracting fat, proteins and ash content from the total solids content.

% Total Carbohydrates = 100 - (% Fat + % Protein + % Ash + % Moisture)

Ash. Ash content of all the samples was determined by procedure described in BIS (IS: 1547-1985). Two to three grams of homogenous sample was weighed in a silica crucible. The sample in crucible was heated on naked-flame till it was completely reduced to ash. The sample was then transferred to muffle furnace and held for 3.5 hr at 550±20°C.

$$\text{Total ash (\% by weight)} = \frac{\text{W2} - \text{W}}{\text{W1} - \text{W}} \times 100$$

Where,

W = Weight in g of the empty crucible

W1 = Weight in g of the crucible with sample

W2 = Weight in g of the crucible with ash

RESULT AND DISCUSSION

Sensory evaluation. The data collected during experiment was statically evaluated and explained in this chapter. The sensory attributes of control and optimized jaggery burfi was depicted in Table 2. Each observation yielded a mean average of two repetitions of data.The T2 sample was scored comparable score with the control sample. The lower and and higher amount of jaggery affects the sensory quality. Based on sensory evaluation, Jaggery *burfi* (T0), Sample T2 jaggery@24% were discussed and presented. Fig. 2 and 3illustrates the prepared control sample (T0) and optimized jaggery burfi (T2). Kokani and Padwal (2021) found that the similar type of results that more than 20% of jaggery was suitable for ragi based burfi.

Effect of rate of addition of jaggery on compositional properties of jaggery *burfi*

Moisture. The effect rate of addition of jaggery on moisture showed in Table 3. Average moisture content of the control *burfi* sample (T0) was 24.2 percent that was more than the average moisture content from the experimental sample T2 that moisture content was 23.6 percent.Understanding the moisture level of a product can help anticipate its quality, stability, and shelf life during packaging and storage (Vilades *et al.*, 1995). Fatima *et al.* (2019) reported that the moisture was reduced when external product replaced with sugar in burfi.

Fat. Effect of addition of jaggery on fat content showed in Table 4. Average fat content of the control *burfi* sample (T0) was 21.2 percent that was less than the average fat content from the experimental sample T2 that fat content was 21.4 percent. Brown Peda, the average fat content ranged from 18.58 (T2) to 19.59 (T6) percent. Comparable fat content values discovered for Peda, ranging from 14.78 to 17.04 percent (Dhobale, 2016). This might be due to the moisture reduction and increase the nutritional concentration of burfi.

Protein. Effect of addition of jaggery on protein content showed in Table 5. Average protein content of the control *burfi* sample (T0) was 13.2 percent that was less than the average protein content from the experimental sample T2 that protein content was 14.3 percent. Fatima *et al.* (2019) reported that the protein was increased when burfi subjected to the oat's addition. Three different levels of wood apple pulp *burfi* had protein content between 13.50 to 10.42 % in which protein content continuous decreased with addition of wood apple pulp (Asati *et al.,* 2019).

Ash. Effect of addition of jaggery on ash content showed in Table 6.Ash content was higher in jaggery burfi because it jaggery have more mineral content than sugar. Ash content of *burfi* with the addition of 15 parts of finger millet flour is 3.7 (Mohod *et al.,* 2020).

Carbohydrate. Effect of addition of jaggery on carbohydrate content showed in Table 7.Carbohydrate was lessin treatment T2 than T0 because addition of cane sugar that have more purity of sucrose than jaggery.The overall carbohydrate content in Peda ranged between 35.31 - 47.02 percent (Dhobale, 2016). Based on the findings, the carbohydrate content was slightly reduced due to the carbohydrate source reduction.

Effect of rate of addition of jaggery on texture of jaggery *burfi.* Texture analysis of control and optimized burfi showed in Table 8.

Hardness (N). The average value of hardness of control sample (T0) was 37.08 N and the average value of hardness of *burfi* sample (T2) was 40.36 N. When the rate of jaggery addition increased, it was discovered that the hardness of experimental jaggery *burfi* significantly increased in all samples. According to Londhe (2006), the hardness of brown Peda had similar results, with values ranging from 35.11 to 43.23N. Similar type of phenomenon was observed by Shinde *et al.* (2024) in jaggery added kajukatli.

Chewiness (N). The average value of chewiness of control sample (T0) was 0.73 N and the average value of chewiness of *burfi* sample (T2) was 0.83 N. When the rate of jaggery addition increased, it was discovered that the chewiness of experimental jaggery *burfi* significantly increased in all samples. According to Londhe (2006), chewiness of jaggery *burfi* had similar results, with values ranging from 0.65 to 0.85 N. The chewiness was increased and reported by Shinde *et al.* (2024) in jaggery added kajukatli.

Cohesiveness (mm). The average value of cohesiveness of control sample (T0) was 0.11 mm and the average value of cohesiveness of *burfi* sample (T2) was 0.20 mm. According to Londhe (2006), cohesiveness of jaggery *burfi* had similar results, with values ranging from 0.1 to 0.3 mm. In comparison to control, T2 and T3 cohesiveness values of aloe vera *burfi* were marginally greater. Due to a minor increase in fiber content in T2 and T3 compared to T1, this increased trend in cohesiveness in T2 and T3 was the result (Keerthi *et al*., 2016).

Adhesiveness (N mm). The average value of adhesiveness of control sample (T0) was 0.71 N mm and the average value of adhesiveness of *burfi* sample (T2) was 0.83 N mm.According to Londhe (2006), adhesiveness of jaggery *burfi* had similar results, with values ranging from 0.7 N mm to 1.0 N mm. In comparison to control, T2 and T3 adhesiveness values of aloe Vera *burfi* was marginally greater. Due to a minor increase in fiber content in T2 and T3 compared to T1, this increased trend in adhesiveness in T2 and T3 was the result (Keerthi *et al*., 2016).

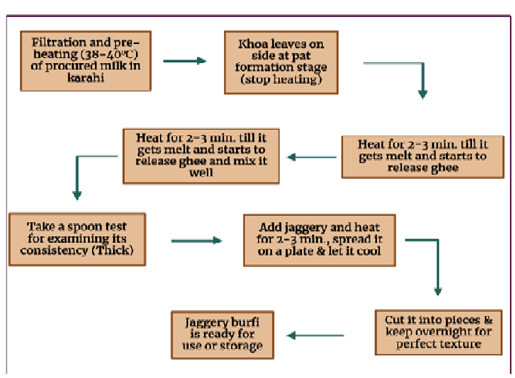

Fig. 1. Preparation of jaggery based burfi.

Fig. 2. Control burfi

Fig. 3. Optimized burfi sample (T2).

Table 1: Jaggery (% w/w of khoa) at selected level.

Designation of the experimental sample(s)	Khoa (g/100g)	Jaggery (g/100g)	Sugar (g/100g)
T0 (control)	76	-	24
T1	70	30	-
T2	76	24	-
T3	80	20	-

Table 2: Effect of various levels of jaggery on the sensory attributes of *burfi.*

Treatments	Colour and Apperance	Body and texture	Flavour	Taste	Overall acceptability
T0	7.6±0.43	7.4±0.62	7.7±0.23	7.4±0.45	7.5±0.52
T1	6.7±0.35	7.8±0.26	6.9±0.56	6.6±0.34	7.0±0.35
T2	7.3±0.56	8.2±0.63	8.5±0.45	8.0±0.54	8.0±0.57
T3	7.5±0.54	7.4±0.55	7.5±0.45	7.6±0.34	7.5±0.46

Table 3: Effect of addition of jaggery on moisture content.

Moisture				
Treatment	**Replication**			**Mean±SD**
	R1	**R2**	**R3**	
T0	24.6	23.9	24.2	24.2±0.35
T2	23.2	23.7	24.1	23.6±0.45

Table 4. Effect of addition of jaggery on fat content.

Fat				
Treatment	**Replication**			**Mean±SD**
	R1	**R2**	**R3**	
T0	21.2	20.9	21.7	21.2±0.40
T2	21.8	21.4	21.0	21.4±0.4

Table 5: Effect of addition of jaggery on protein content.

Protein				
Treatment	**Replication**			**Mean±SD**
	R1	**R2**	**R3**	
T0	13.6	12.9	13.2	13.2±0.35
T2	14.1	13.9	14.9	14.3±0.52

Table 6: Effect of addition of jaggery on ash content.

Ash				
Treatment	**Replication**			**Mean±SD**
	R1	**R2**	**R3**	
T0	**2.1**	**2.2**	**1.9**	**2.06±0.15**
T2	**2.7**	**3.1**	**2.9**	**2.9±0.2**

Table 7: Effect of addition of jaggery on carbohydrate content

Carbohydrate				
Treatment	**Replication**			**Mean±SD**
	R1	**R2**	**R3**	
T0	38.5	37.5	38.9	38.3±0.72
T2	37.3	37.1	38.1	37.5±0.52

Table 8: Texture analysis of control and optimized burfi.

TPA Profile	T0	T2	Mean±SD T0	Mean±SD T2
Hardness(N)	36.24	39.74	37.08±0.75	40.36±0.72
	37.31	40.20		
	37.69	41.16		
Chewiness(N)	0.74	0.84	0.73±0.35	0.83±0.30
	0.77	0.80		
	0.70	0.86		
Cohesiveness(mm)	0.09	0.18	0.11±0.02	0.2±0.02
	0.11	0.20		
	0.14	0.22		
Adhesiveness (N mm)	0.69	0.84	0.71±0.025	0.83±0.035

CONCLUSIONS

The jaggery addition was beneficial to preparethe burfi as shown in results.The sensory evaluation revealed that the 24% of jaggery was optimal. The higher concentration of jaggery addition leads to visible color change and affects the flavor of the burfi. The 20% of jaggery addition was not created any sensory benefits in burfi. The ash content and protein profile of jaggery based burfi was more when compared to the control burfi sample. The jaggery affects the water content, it makes slightly hardness appearance. The texture didn't affect the flavor of burfi. Despite the textural modifications, the jaggery based burfi was better when we focused on nutritional, sensory point of view. Furthermore, the physicochemical, microbial and storage studies of jaggery based burfi needs to be evaluated.

FUTURE SCOPE

The prepared burfi will be more nutritional and alternative to the commercial burfi available in the market with same cost of production. It will be more attractive and reach among the consumers.

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Conflict of Interest. None.

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