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Mechanization and optimization of parameters for the preparation of Burfi in Multipurpose Scraped Surface Heat Exchanger

I A Chauhan* AG Bhadania
[1] Dairy Engineering Department, SMC College of Dairy Science, AAU, Anand, Gujarat, India

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Abstract
Indian sweet-Burfi is very popular khoa based confection with added sugar as well as flavoring and taste imparting ingredients which is very popular all over India. In India mostly the product is manufactured manually in open pan by manual scraping. The quality of product is not uniform due to human intervention and batch to batch variation is also there. The throughput of the product is also low as it done manually. The multipurpose scraped surface heat exchanger has been designed and developed at Dairy engineering department of SMC College of Dairy Science, AAU, Anand. The optimization of process parameters for mechanized production of burfi in the multipurpose scraped surface heat exchanger has been studied. Load size, scrapper speed and steam pressure varied in different trials. The quality of the product was analyzed in terms of sensory analysis. The steam and electrical power consumption was estimated during the manufacture of burfi. The operating conditions of the SSHE required are 2.5 kg/cm^2 steam pressure, 30 rpm scraper speed and 30 kg loading. The steam and electrical power requirements for the manufacture of Burfi are 1.45 kg per kg of water evaporated and 0.12 kWh per kg of product respectively.

1. Introduction

Burfi is a khoa based confectionary with added sugar as well as flavoring and taste imparting ingredients. It occupies the prominence place in indigenous dairy product of India. A lot of variation can be observed in physical attributes of Burfi sample collected from market. Good quality Burfi is characterized by moderately sweet taste, soft and slightly greasy body and smooth texture with very fine grains. Color of Burfi varies in different varieties. The traditional method employed for the preparation of Burfi is very labor and energy intensive as well as quality of product varies considerably. There is a need to mechanize the manufacture of Burfi for commercial application to achieve uniform quality of the product. The scraped surface heat exchangers (SSHE) have been successfully used for concentration of milk specially for the processing of viscous product. The various types of SSHEs are available depending on processing requirement of the product. It is possible to use SSHE having suitably designed product tube and scrapper assembly for preparation of Burfi. Many small and medium size entrepreneurs are interested for mechanized production of Burfi. However, they are not in position to mechanize the traditional method of Burfi making due to the lack of suitable technology for mechanized production of Burfi. Therefore, the present work is undertaken to offer technology for mechanized manufacture of Burfi.

The objectives of the study are:

1. To optimize the parameters for preparation of Burfi in the SSHE.
2. To evaluate the heat transfer performance of the SSHE during manufacture of Burfi.
3. To evaluate the energy requirement and energy analysis of the SSHE during production of Burfi.
4. To evaluate the quality of the product prepared in the SSHE.

2. Material and Method

2.1Experimental set up

Experimental set up for mechanized production of *Burfi* is shown in figure 1. The multipurpose Scraped Surface Heat Exchanger (SSHE) was used for the experiment. The SSHE consists of Jacketed product tube, Spring loaded scraper assembly, Vapor hood with exhaust fan, Drive arrangement for the scraper assembly and Measuring and control instruments. These components of the SSHE have been mounted on stainless steel frame and provision has been made to supply steam and removal of condensate from the jacket.

***Corresponding Author,**
E-mail address:istiyakhusen@gmail.com
Phone No.: +91-9924023097

2.2 Selection of raw material

2.1.1Milk: The standardized pasteurized milk having 6.0 % milk fat and 9.0 % SNF was used in preparation of *Burfi* during all experimental trials.

2.1.2 Sugar: A fine crystalline sugar (sucrose) of commercial grade was obtained from the local market of Anand.

2.1.3 Additives: Good quality green cardamom and almonds were obtained from the local market of Anand.

2.2 Method of manufacture of Burfi

2.2.1Control product:

Control samples of Burfi were prepared in the laboratory by the conventional method. The pasteurized whole milk (6% Fat and 9% SNF) [1], [2] weighing 2.0 kg was taken in the S.S. karahi and it was put on LPG stove for the preparation of Khoa. The milk was continuously stirred using ladle during heating of milk to evaporate the water. When Semisolid mass obtained, add pre-weighed (5 % of milk) white crystalline sugar and mix properly. Mix continuously until desired consistency obtained. The container was then removed from the burner of the stove and cardamom (at the rate of 0.3%) added. Collection of homogenous mixture of final product in well-greased plates and spreading into uniform thick layer. Cooling at room temperature and cut into uniform pieces. Apply almond half on each piece of burfi. Evaluation of quality of the Burfi.In preparation of the control product, all ingredients and their rate of addition was kept same as that of experimental method followed in the SSHE.

2.2.2Experimental product in SSHE

Standardization of Buffalo milk is done at 6% Fat, 9% SNF and 0.17 % LA [1], [2]. Concentration of milk in multipurpose SSHE at different loading size, steam pressure and scrapper rpm is followed. Addition of sugar at the rate of 5% of milk when semisolid mass obtained. Concentration continued with sugar at different steam pressure and scrapper rpm till desired consistency was obtained. Add cardamom powder and mix properly. Collection of homogenous mixture of final product in well-greased plates and spreading into uniform thick layer. Cooling at room temperature and cut into uniform pieces. Apply almond half on each piece of burfi. Evaluation of quality of the Burfi.

2.3 Measurement of operating variables Speed of scraper assembly

The scraper speed was varied by using the Variable Frequency Drive and correlation between frequency of power supply and scraper speed was established under the operating conditions of the machine. The scraper speed was confirmed by using a non-contact type digital tachometer (ASAHI, Nagasima Keiki, Japan) and for low speed, visual counting was carried out.

Fig. 1: Multi purpose SSHE

2.4 Analytical procedures

2.4.1 Analysis of milk: The milk used for making the Burfi was analyzed for milk fat and total solids (TS) as per the methods given in "Ist Handbook of Food Analysis Part XI Dairy Products". Acidity was determined by the procedure described by IS: 1479, Part 1, (1960). Fat content of milk was determined by Gerber Method as described by BIS (IS: 1224, part 1, 1977) [3].

2.4.2 Analysis of product: The following methods were adopted to carry out the chemical analysis of experimental Burfi samples as well as of control samples.

Moisture: The moisture content of Burfi was determined by standard gravimetric method described in IS: 1479 (Part II), 1961.

Total Solids: The total solids content of the product was obtained by subtracting the value of moisture out of 100 and it is expressed in per cent.

Sensory evaluation of the product:The sensory quality of the products prepared in the SSHE were judged by a panel of 8 judges with 25 point sensory score card.

2.5 Statistical Analysis: Factorial Completely Randomized Block Design with three factors described by Snedecor and Cochran (1994) was adopted to analyze the data.

2.6 Plan of work: The number of trials to be taken as per different process parameters are shown in table 1

Table 1: Trial codes for different processing parameters

Trial No.	Steam Pressure (kg/cm^2)	Scrapper speed (rpm)	Loading (kg)
1	2.0	40	20
2			30
3			40
4		30	20
5			30
6			40
7	2.5	40	20
8			30
9			40
10		30	20
11			30
12			40

3 Result and Discussion

The trials has been taken as per table 1 trial codes.

3.1 Energy consumption during the product manufacturing: The table 2 shows the steam and electrical power consumption durng the trials. It shows that 1.38 to 1.45 kg of steam is required per kg of water evaporated in different trials.The table shows that the electrical power consumption is 0.06 to 0.19 kWh per kg of product prepared.

Table 2: Energy consumption of SSHE during manufacture of burfi under various operating conditions

Trial No.	Steam consumption (kg/batch)	Batch time (h:mm)	Steam consumption (kg/kg of water evaporated)	Power Consumption (kWh/kgof product)
1	22.75	1:03	1.42	0.07
2	33.01	1:30	1.38	0.12
3	44.81	2:02	1.41	0.16
4	23.03	1:15	1.44	0.09
5	33.78	1:46	1.41	0.14
6	45.08	2:25	1.42	0.19
7	22.75	0:55	1.43	0.06
8	33.01	1:22	1.38	0.10
9	44.81	1:50	1.42	0.14
10	23.03	1:05	1.45	0.08
11	33.78	1:38	1.42	0.13
12	45.08	2:10	1.42	0.17

* Each value is an average of 3 replication

Table 3: Sensory quality of burfi manufactured in SSHE under various operating conditions

Trial No.	Sensory score			
	Flavour	Body & Texture	Colour & Appearance	Overall Acceptability (25)
1	6.75	6.05	3.40	16.20
2	7.30	6.50	3.50	17.30
3	6.63	6.90	3.68	17.01
4	7.05	5.95	3.50	16.50
5	7.25	6.55	3.92	17.72
6	7.00	6.40	3.80	17.20
7	7.00	6.15	3.50	16.55
8	7.30	6.55	3.55	17.40
9	6.80	7.00	3.73	17.60
10	7.15	6.05	3.55	16.75
11	7.30	6.65	4.00	17.95
12	7.20	6.45	3.85	17.55

* Each value is an average of 3 replication

Table 4: Statistical Analysis of Flavor score (CRD – 3 Factor)

Sr. No.	Particulars	S Em	C D 5%	C V %
1	Steam Pressure (SP)	0.02827	0.08253	1.70293
2	Scraper Speed (SS)	0.02827	0.08253	
3	SP * SS	3.99857	NS	
4	Loading (L)	3.46287	0.10108	
5	SP * L	4.89723	0.14295	
6	SS * L	4.89723	0.10108	
7	SP * SS * L	6.92573	NS	

3.2 Effect of operating parameter on flavor of burfi

The table 3 shows the flavor score of the product in different trials. The flavor score ranges from 6.63 to 7.30 out of 10. The trial no 2, 8 and 11 gives maximum flavor of the burfi prepared. The table 4 shows the statistical analysis of flavor score. The scrapper speed is inversely proportional to the flavor score. Lower speed increase the flavour of the product [4]. The higher steam pressure is also increases the flavor of the burfi. It shows that there is not significant effect of interaction of scrapper speed and steam pressure on flavour of the Burfi. The loading size having significant effect on flavor of the product. Optimum load is desirable for good flavour of the product. The interaction effect of loading with steam pressure and scrapper speed having significant effect on flavour of the product. It shows that there is not significant effect of interaction of scrapper speed, steam pressure and on flavour of the Burfi.

3.3 Effect of operating parameter on body and texture of burfi

The table 3 shows the body and texture score of the product in different trials. The body and texture score ranges from 5.95 to 7.00 out of 10. The trial no 9 gives maximum body and texture score of the burfi prepared.Table 5 shows the the statistical analysis of body and texture score of the burfi prepared. The scrapper speed is inversely proportional to the body and texture score. Lower speed improves the body and texture of the product [4]. The higher steam pressure is also improve the body and texture of the burfi. It shows that there is not significant effect of interaction of scrapper speed and steam pressure on body and texture of the Burfi. The loading size having significant effect on body and texture of the product. Optimum load is desirable for good body and texture of the product. The interection effect of scrapper speed and load having significant effect on body and texture of burfi. There is not significant effect of interaction of scrapper speed, steam pressure and on body and texture of the Burfi

Table 5: Statistical Analysis of Body & Texture score (CRD – 3 Factor)

Sr. No.	Particulars	S Em	C D 5%	C V %
1	Steam Pressure (SP)	1.55883	4.55009	1.02602
2	Scraper Speed (SS)	1.55883	4.55009	
3	SP * SS	2.20452	NS	
4	Loading (L)	1.90917	5.57269	
5	SP * L	2.69998	NS	
6	SS * L	2.69998	5.57269	
7	SP * SS * L	3.81834	NS	

3.4 Effect of operating parameter on color and appearance of burfi

The table 3 shows the color and appearance score of the product in different trials. The color and appearance score ranges from 3.4 to 4.00 out of 5. The trial no 11 gives maximum color and appearance score of the burfi prepared.Table 6 shows the the statistical analysis of color and appearance of the burfi prepared. The scrapper speed is directly proportional to the color and appearance score [4]. higher scrapper speed improves the color and appearance of the product. The steam pressure having not significant effect on color and appearance of the burfi. There is not significant effect of interaction of scrapper speed and steam pressure on color and appearance of the Burfi. The loading size having significant effect on color and appearance of the product. Higher load is desirable for good color and appearance of the product. The interection effect of scrapper speed and load having non-significant effect on color and appearance of burfi. The interaction effect of scrapper speed and load having significant effect on color and appearance of the burfi. There is not significant effect of interaction of scrapper speed, steam pressure and on color and appearance of the Burfi.

3.5 Effect of operating parameter on overall acceptability of burf

The table 3 shows the overall acceptability scores of the product in different trials. The overall acceptability score ranges from 16.20 to 17.95 out of 25. The trial no 11 gives maximum overall acceptability score of the burfi prepared.Table 7 shows the the statistical analysis of overall acceptability of the burfi prepared. The scrapper speed is directly proportional to the overall acceptability score. higher scrapper speed improves the overall acceptability of the product.

Higher steam gives good overall acceptability of the burfi. There is not significant effect of interaction of scrapper speed and steam pressure on overall acceptability of the Burfi. The loading size having significant effect on color and appearance of the product. Optimum load is desirable for good overall acceptability of the product. The interection effect of scrapper speed and load having non-significant effect on overall acceptability of burfi. The interaction effect of scrapper speed and load having significant effect on overall acceptability of the burfi. There is not significant effect of interaction of scrapper speed, steam pressure and on overall acceptability of the Burfi.

Table 6: Statistical Analysis of Colour & Appearance score (CRD – 3 Factor)

Sr. No.	Particulars	S Em	C D 5%	C V %
1	Steam Pressure (SP)	0.02032	NS	2.35944
2	Scraper Speed (SS)	0.02032	5.93172	
3	SP * SS	0.02874	NS	
4	Loading (L)	2.48888	7.26484	
5	SP * L	3.51982	NS	
6	SS * L	3.51982	7.26484	
7	SP * SS * L	4.97777	NS	

Table 7: Statistical Analysis of Overall acceptability score (CRD – 3 Factor)

Sr. No.	Particulars	S Em	C D 5%	C V %
1	Steam Pressure (SP)	4.25455	0.12419	1.05267
2	Scraper Speed (SS)	4.25455	0.12419	
3	SP * SS	6.01684	NS	
4	Loading (L)	5.21074	0.15209	
5	SP * L	0.07369	NS	
6	SS * L	0.07369	0.15209	
7	SP * SS * L	0.10421	NS	

3.6 Comparative study

The table 8 shows the comparative study between burfi prepared in SSHE and traditional method. The data shows comparative higher score in burfi prepared in SSHE as compared to control.

Table 8: Sensory score for comparative study

Sr. No.	Sensory Score	Mechanized Production	Traditional Production
1	Flavor	7.04	6.5
2	Body & Texture	6.45	6.08
3	Color & Appearance	3.65	3.13
4	Total	17.14	15.72

* Each value is an average of 3 replication

4. Conclusions

The multipurpose SSHE is suitable for the manufacture of Burfi from milk. The quality of Burfi manufactured in the SSHE is acceptable by panel of judges. Steam pressure 2.5 kg/cm^2, loading 30kg of milk and scrapper speed 30 rpm were optimized for manufacture of good quality of burfi in multipurpose scraped surface heat exchanger. The steam consumption during manufacturing of Burfi was 1.38 kg per kg of water evaporated and electricity consumption was 0.12 kWh per kg of product.

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