International Journal of Research Studies in Biosciences (IJRSB)
August 2015, PP 54-59
ISSN 2349-0357 (Print) & ISSN 2349-0365 (Online)
www.arcjournals.org

Development and Evaluation of Improved Small Scale Butter Churn

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Abstract: *The present study was proposed to develop a batch butter churn and characteristics of the churning process. The efforts were made to optimize the batch butter making process to obtain a high yield and good quality of butter. The effect of churning temperature and churn speed on the churning time and other butter output were investigated. The various factors viz. acidity, fat percentage, ageing temperature and time were kept constant. The churning temperature and churn speed and their interaction showed a significant effect on churning time and quality of butter. The further analysis indicated that churning of cream at churning temperature of 10˚C and churn speed of 60 rpm was found to be satisfactory for obtaining good quality of butter.*

Keywords: *butter churn, churning temperature, optimization, churn speed, butter.*

1. INTRODUCTION

Traditionally butter is produced from matured cream using a discontinuous process. Butter manufacturing is essentially a process of solidifying fats contained in milk by churning at a low temperature [1]. At the end of eighteenth century, butter churns began to receive consideration and the barrel butter churn made its appearance. The churning can be done either in continous process or with the simple batch churning process [2]. After pasteurization of the cream it undergoes cooling and ripening. The thermal treatment of the cream influences the extent and rate of partial coalescence of milk fat globules [3]. Churning is the next step after tempering the cream, and the cream is subjected to phase inversion (oil-in-water to water-in-oil emulsion). During churning, the cream is separated into butter grains and buttermilk in a churning cylinder, followed by draining of the butter milk and by processing of the butter grains and removal of the butter [2].

2. MATERIALS AND METHODS

2.1 Concept of Frustum Cone Shaped Butter Churn (FCSBC)

The butter is one of the most valuable product obtained from the milk and it acquires a good position in the Indian foods. The milk fat being one of the costliest components of the milk, the farmers can

fetch good money out of it by manufacturing the butter. The milk production in India is not concentrated at single place and mainly at farm level where the milk production is very stumpy; they require small equipments for manufacturing of milk products, hence to tackle this problem a frustum cone shaped butter churn was developed with a capacity of 10 liters.

The temperature control of the churning process is one most prominent step in manufacturing of butter, but there are no evidences showing effective work on temperature control of butter churn. In dairy industries they normally sprinkle chilled water over the churn to maintain the temperature, which has an effect of increased cost and unhygienic atmosphere in the dairy. To overcome this problem we had considered to develop a butter churner, insulated with a low thermal conductive material mainly foamed polyethylene which could maintain the desired churning temperature and avoid unhygienic and physical problems at the work place.

2.2 Some design consideration

The frustum cone shaped butter churn was designed with the following consideration

2.2.1 Functional requirements

The machine was light weight and easy to operate and transport. The machine was simple for construction and stable when in use. An A.C. motor and gear box was provided with pulley system for speed regulation of the churner.

2.2.2 Ergonomic consideration

Ergonomics is the scientific study of the relationship between man and its working environment. The goal of ergonomics is to design the task so that its demand stays within the capacities of workers. Its objective was to increase the efficiency of human activity by removing those features of design which were likely to cause inefficiency or physical disability in the long term and thus to minimize the cost of operation [4].

Some provision was made in the machine for ease of loading of cream and unloading of butter. The operator was able to operate the machine and should have sound knowledge about the parts of the machine. The machine was designed keeping in view of ergonomics considerations for both technical and non technical operators. The machine was light in weight so that two men can lift it up to one place to other. The machine was safe and comfort for the operator's and simple in operation and adjustment.

2.3 Selection of materials

Selection of proper materials for the manufacture of various components of FCSBC was very important. Standard and common sizes and sections as well as semi-finished and finished items which were easily available in local market are selected. Selection of machine components was made, keeping in view of their effectiveness and capacity. Table 1 gives the dimension of different components of a FCSBC.

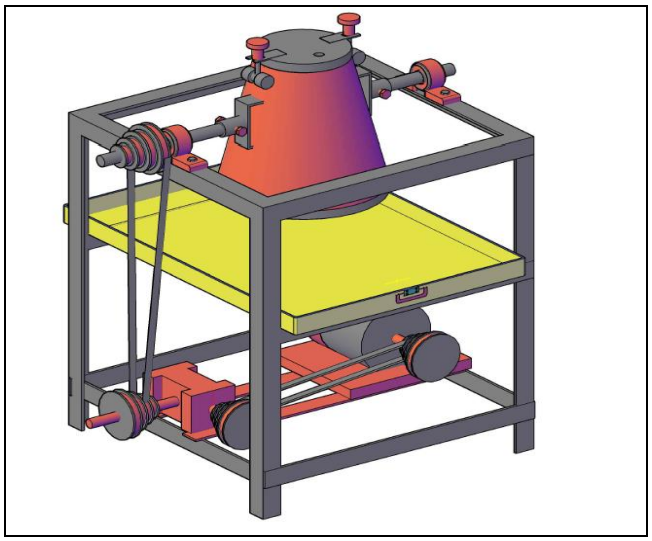

Fig. 1. *Frustum cone shaped butter churn*

Table 1. *Dimensions of different components of FCSBC*

S. No.	Name of component	Particulars	Dimensions
1	Inner AISI SS 304 frustum cone	Volume Height Upper radius Lower radius Slant height Total surface area Curved surface area Centroid	10 l 280 mm 70 mm 140 mm 289 mm 2675cm² 1905.7cm² 110 mm
2	Outer iron frustum cone	Volume Height Upper radius Lower radius Slant height Total surface area Curved surface area Centroid	15.1 l 300 mm 90 mm 160 mm 308 mm 3221.64cm² 2417.8cm² 127 m
3	Thickness	Inner SS frustum cone Outer iron frustum cone	4 mm 4 mm
4	Stirring wing	Hallow space	20mm
5	Motor	Size Volt Amp RPM frequency, phase	0.5 hp 220 3.5 1440 60Hz,1
6	Valves	S.S ball valves, 2	0.25 in.
7	Sight glass	perspex glass Thickness Width	 4mm 25mm
8	Gasket	Nitrile rubber Thickness	 3mm
9	Gear box	Speed ratio	1:20
10	Head and closure	SS 304 Thickness Diameter	 20mm 180mm
11	Step down pulley	4	2,2.5, 3, and 4 in.
12	Belts	2	A-38 in. A-52 in.

2.4 Design and fabrication of FCSBC

The machine was developed using functional drawing using AutoCAD and fabricated at the nearby fabricator workshop of Raipur city (C.G.) during year, 2013-2014. The locally available suitable materials were used for different components. The isometric view developed machine is shown in Fig. 1. The present invention relates to a method of producing butter, in a frustum cone shaped apparatus. The apparatus intended for this purpose consists of SS and iron frustum cone drum, head, stirring wing, shaft, motor and stand which are the main components of the apparatus as shown in the figure. The detail dimension of these components is given in Table 1.

2.5 Working of FCSBC

The one third of the total capacity of FCSBC was loaded with aged cream into the churn. The jacketed space was filled with the chilled water of required churning temperature, through the 0.25 inch value provided at the base. The FCSBC was closed and tightened through thumb screw. The churn was rotated at required speed (RPM) the gearing system of 1:20 ratio and step down pulley were provided to reduce or increase the RPM of the churn. The inclined wing inside the churn was provided to increase the rate of cooling. The foamed PE insulation was provided to maintain the temperature of chilled water in the jacketed space as well as cream inside the churn.

2.6 Procedure of the experiment

Several trials of churning were conducted in FCSBC. The standardized (40%) and pasteurized cream was procured from Chhattisgarh State Cooperative Dairy Federation Limited and it was immediately kept for ageing at 10˚C for 17h.

The cream was then distributed into three containers, containing 3.3 kg of cream. Then these containers were placed in the BOD incubator at desired temperature of 8, 10 and 12˚C. The cream once attained the churning temperature. It was loaded to one-third of the total capacity (3.3 kg) of FCSBC, and churned at three different speeds of 35, 60 and 85 rpm respectively. The procedure was conducted in different lots.

This experiment was carried out three times for each churn speed and churning temperature. Many parameters were recorded during the course of experiment which includes time required to churn cream for a given lot, chilled water temperature and cream feed temperature and yield of butter.

3. RESULT AND DISCUSSIONS

The experiment was carried out at three churning temperatures viz 8˚C, 10˚C, and 12˚C at three levels of churn speed of 35, 60 and 85 rpm each at 3 replications. For churn speed of 35, 60 and 85 rpm the mean time required to churn the cream were 53.8, 43.8 and 73.8 minutes, respectively. Similarly for churning temperature of 8˚C, 10˚C and 12˚C, the mean time required to churn the cream were 70.4, 52 and 49.2 minutes, respectively.

The moisture content of butter increased from 13.4 to 17% when churn speed was increased from 35 to 85 rpm. Similarly, when churning temperature was increased from 8˚C to 12˚C it increased from 13.37 to 17%. The fat content of butter decreased from 85.26 to 81.26% when churn speed was increased from 35 to 85 rpm. Similarly, when churning temperature was increased from 8˚C to 12˚C it decreased from 85.1 to 81.16%. The optimum for content of butter was obtained at churn temperature of 10^{o}C and churn speed of 60 RPM with good consistency and quality.

As per the techno economic study of the FCSBC, the cost of churning per kg of butter produced from churning of 5 and 3.3 kg of cream (1/2 and 1/3 loading) were 12.95 and 20.72 Rs./kg and break-even point were 191.4 and 876 batches/year.

4. CONCLUSIONS

It can be concluded that, developed Frustum cone shaped butter churn (FCSBC) provides better results at churning temperature of 10˚C and churn speed of 60 rpm without any remarkable changes in the quality of butter and also found techno economically feasible. Hence, this can be utilized at the farm level and small dairies where they handle small quantity of milk.

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Adarsh M. Kalla, was born on July 8th, 1990 at Gulbarga in Karnataka state. He passed his intermediate examination with 62.0% from Shree guru independent PU College, Gulbarga. He joined Dairy Science College, Karnataka Veterinary, Animal and Fisheries Science University, Gulbarga (Karnataka) for B.Tech degree in Dairy Technology, in 2008-09. After graduation with 82.5% in 2011-12, he joined the College of Dairy Technology, C.G.K.V., Raipur (C.G.) in the year 2012 for post graduation programme in the Department of Dairy Engineering. He has successfully developed Frustum Cone Shaped Butter Churn which is particularly suitable for butter production at rural areas.

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