An overview of mechanization in chhana production

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Abstract: Chhana, regarded as the Indian counter part of soft cottage cheese is a heat acid coagulated milk product that serves as the base for a variety of milk products such as Rasogolla, sandesh, paneer, cham cham, chhana podo, chhana kheer, kheermohan etc. Process mechanization of chhana and chhana based sweets is of huge scope due to the growing momentum in consumer demand for Traditional Indian milk products. Strengthening the knowledge base available for the technology of production of chhana is required to upgrade the existing systems with process automation and control. The main objective of all new technological interventions and improved mechanization systems for chhana developed so far is on yielding chhana of defined moisture content, soft texture and uniform quality along with reducing the cost and production time. Development of an improved mechanized systems for the rapid and hygienic production of chhana at small scale level is an urgent need of the hour. Mechanizations in various stages of chhana production can be integrated to the continuous system of chhana production. This article highlights the technological interventions and mechanization in the manufacture of chhana. In addition, the effect of coagulants in the manufacture of chhana, nutritive value and textural attributes of chhana are also discussed.

Keywords: Automation, Chhana, Process mechanization, Technological interventions

Introduction

In India about 50-55 % of the milk produced in the country is utilized for the production of traditional milk products. It implies the prominent role of traditional milk products in the economy of our country. Indigenous milk products have influenced the economic, social, cultural, nutritional and religious status of the people in the country. The potential of these traditional dairy products resulting in large production volume is attributed to simple technology, low investment, low cost of production, simple infrastructure, low operational overheads and the most interesting fact of high profit margins and established markets (Patel and Bhadania, 2012). Significantly R&D efforts has resulted into optimization of processing variable for mechanized production. There is urgent need to exploit the mass appeal over the product having a high profit margins as well as high export potential and to modernize this sector with innovations, mechanizations and automations to have large scale commercial production of high quality products with long shelf life.

Chhana is regarded as the Indian counter part of soft cottage cheese. Chhana is a heat acid coagulated product having marble white colour, spongy texture with mild acidic flavour. It is used as a base material for manufacturing a large variety of sweets such as rasogolla, Sandesh, rasomalai, chum chum and chhana murki. Cow milk is preferred for manufacturing chhana as the product obtained is soft with smooth texture and velvety body which are highly desirable attributes for making chhana-based sweetmeats particularly rasogolla (Minz and Singh, 2016). According to the Food Safety and Standards Regulation (FSSR 2011), chhana means “product obtained from cow or buffalo milk or combination thereof, by precipitation with sour milk, lactic acid, or citric acid. It shall contain not more than 70 % moisture and the fat content should not be less than 50 % expressed on dry matter”. Milk solids can also be used in chhana production. About 6% of the total milk production in India is converted to chhana through coagulation (Sahu and Das, 2007)
Dairy technologists foreseeing the potential of *chhana* and its products had undergone few works in recent years for the characterization of quality attributes of *chhana*, effect of coagulants on texture of *chhana*, sensory quality of *chhana* prepared from goat milk, development of continuous commercial manufacturing methods, development of kneader and ball former of *chhana* in *rasogolla* production etc. The mass appeal enjoyed by the diversified range of products prepared from base materials like *khoa* and *chhana* across the country enhances the commercial value of Traditional Indian Dairy Products. With progressive increase in volume of milk handled by the organized sector of the dairy industry, increasing commercial interest in *chhana* and other indigenous dairy products has been apparent in recent times. The huge demand for traditional dairy products across the country projects the need for improved process mechanization and new technological interventions in the respective area.

Design and development of mechanized systems for rapid and hygienic production of *chhana* and *chhana* based sweets at small scale level is an inevitable requirement of present day. Investigations carried out in the mechanization of *chhana* production always aimed at yielding product of defined moisture content, soft texture and uniform quality along with reducing the cost and production time. The technological aspects such as effect of type of coagulant, time-temperature combination and dilution on the texture, yield and quality of *chhana* produced were studied through various works on *chhana* production. The knowledge base attained through those studies can be used as inputs in the future attempts to develop improved mechanized systems of *chhana* production.

**Factors affecting quality of chhana**

Temperature, pH of coagulation, method of straining, fat level of milk and homogenization are some of the factors that affect physical quality of *chhana* (Kundu and De, 1972). Generally, cow milk is preferred for *chhana* preparation because it produces good quality *rasogolla*, with soft, smooth and spongy texture. *Chhana* produced from buffalo milk is hard and greasy and cannot be used for *Rasogolla* preparation (De and Ray, 1954). Several attempts were made to optimize the process parameters in order to utilize buffalo milk for production of *chhana* in the preparation of sweets as buffalo milk constitutes more than 55% of total milk production of India (IDF, 2008). Aneja et al. (1982) suggested that dilution of buffalo milk with 25% water prior to coagulation improved the softness of *chhana*. Even though yielded limited success the other suggested measures include coagulation at low temperature, addition of sodium citrates (Jagtiani et al. 1960), homogenization (Soni et al. 1980; Ahmed et al. 1981). Significant improvements in buffalo milk *chhana* was observed with altering certain processing parameters like dilution of milk with 25% water, adjustment of fat content in milk to about 4.0 to 4.5 %, adding of 0.05 % sodium citrate prior to boiling, homogenization at 140 kg/cm² and coagulation with 1.0 % citric or lactic acid solution. The body, texture, and flavor of sweets manufactured from *chhana* was improved with the use of calcium lactate as coagulant (Rajorhia, 1987). Maximum yield of good quality *chhana* could be obtained at 80°C temperature in a minimum of 15 sec (Aneja et al. 1982). Kundu and De (1972) reported that in order to obtain desirable body and texture of *chhana* the pH of coagulation should be 5.4, the temperature of coagulation should be 82°C and the coagulation time range from 0.5 to 1 min. The influence of process of homogenization is highly significant in retaining higher moisture content in the product as well as in reducing the hardness value to a minimum. The process results in a considerable increase in % moisture content, yield, and milk solids recovery.

**Effect of different coagulants on the quality attribute of chhana**

The technological knowhow regarding the coagulation step in the manufacture of *chhana* is therefore inevitable for the mechanization and continuous production of *chhana*. Studies have revealed the effect of different coagulants in the production of *chhana*. Banker et al. (2016) reported that *chhana* prepared by using 1% citric acid recorded significantly highest yield followed by 2 % lactic acid. The superior scores for overall appeal and color of the product was for *chhana* prepared from 1% citric acid and 2% lactic acid. Attempts were also made to prepare *chhana* from non-conventional organic coagulants like tartaric acid, fumaric acid, and acetic acid. It was found that the organic acid coagulants resulted in a chewy, gummy, hardy, elastic and cohesive *chhana* which is more suited for preparation of dry *chhana* sweets (Bandyopadhyay et al. 2006). Lactic acid used as milk coagulant recorded higher yield, total solids, fat, acidity, fat protein ratio, milk solid: sugar ratio but lower sucrose content compared to other coagulants in sandesh preparation (Singh and Ray, 1977). Technological interventions by the utilization of buffalo milk in preparation of *chhana* and *rasogolla* were also attempted by several workers as buffalo milk contributes more than 57% of total milk production of India (IDF, 2008). Kumar et al. (2015) reported that *chhana* prepared from admixture of sweet cream butter milk and buffalo milk using citric acid as coagulant was found most suitable for *rasogolla* making on the basis of textural and sensory characteristics. Sandesh of acceptable quality also was prepared from buffalo milk by standardized procedure (Sanyal et al. 2011).

**Nutritional value of chhana and its enhancement in chhana based sweets**

*Chhana* is an ample source of fat and protein. *Chhana* has a superior nutritive value attributed to the presence of whey proteins that are rich sources of essential amino acids. It is also a good source of fat soluble vitamins A and D and some minerals especially calcium and phosphorous. About 90% of fat & protein, 50% ash & 10 % lactose of the original milk is retained in *chhana*. It possesses a nutty flavor with slightly sour and sweet taste.
which makes it palatable to Indian palate. It is an ideal food for expectant and nourishing mothers, infants, growing children, adolescents and adults. The high protein and fat content along with low sugar content makes it a suitable food product for diabetic patients (De, 1980). Preparation and optimization of procedure for chhana podo was also done using buffalo, coconut and soy milk by response surface methodology. Soy milk contains a higher protein content than buffalo milk that adds to the nutritive value of product. The product can be successfully prepared and highly rated in organoleptic evaluation (Kumar and Singh, 2017). Herbal Sandesh was prepared with incorporation of different herbs possessing good antioxidant property. The study determined the total oxidative status by Randox method (Bandyopadhyay et al. 2007).

Textural attributes for chhana and chhana based sweets

Springiness of chhana is an important textural attribute in order to ascertain the syrup retention power and sponginess of chhana. Springiness of chhana can also be better defined as the extent to which chhana ball regained its shape when an applied force was removed from it. It also aids to establish distinct rheological differences between cow’s and buffalo’s milk chhana and to study the extent to which buffalo milk could, be adapted for chhana making. Gera (1978) developed an instrument for measuring the springiness of chhana. Springiness was observed the maximum at pH 5.7 for mixed and buffalo milk chhana, but pH 5.1 for cow milk. Springiness and softness of chhana were influenced by the temperature of coagulation. At higher temperature of coagulation, higher viscosity was evident whereas density remained unaffected. The hardness and viscosity of chhana were increased at lower pH of coagulation (4.6). Density of chhana was highest at pH 4.6. Worker also observed that higher viscosity of chhana was obtained with the use of citric acid as a coagulant. The type of coagulant causes slight variation in the compactness of chhana. The relationships between the composition, texture and microstructure of chhana and rasogolla were analyzed. Chhana contained a significantly higher proportion of fat, protein, lactose and minerals than Rasogolla. Cooking of chhana in 60% sucrose solution introduced sucrose and changed the texture and structure to that typical of rasogolla. As chhana was transformed to rasogolla, the Instron textural properties, hardness, gumminess and chewiness, fell significantly, whereas springiness increased dramatically (Adhikari et al. 1992). Textural attributes of chhana kheer prepared using three artificial sweeteners was studied by Gautam and his coworkers (2013). Aspartame and acesulfame-K at the level of 0.015% and sucralose at the level of 0.05% were used. Results demonstrated that increase in levels of acesulfame-K resulted in superior texture scores. The effects of time and temperature on the moisture content, oven spring, colour, texture and crumb grain characteristics of chhana podo during baking was studied (Kumari et al. 2015)

Shelf life and Packaging

Chhana has a shelf life of 3 days at 24°C and 6 days at 10°C. Refrigerated storage of chhana is needed to maintain the quality of chhana in most of the seasons across the country. Jagtap et al. (1973) reported that the keeping quality of chhana under ordinary packing is on average 2, 3, and 12 days at 37°C, 24°C, and 7°C respectively. Butter paper coated with sodium propionate solution prior to packaging can also extend the shelf life of chhana. Development of suitable packaging is essential for extending the shelf life of chhana and chhana based products. Heat sealable laminates, LDPE or transparent cellulose film and poster paper or aluminum foil may be used for packaging and storage of chhana. Oxygen scavengers, antimicrobial films, and gas impermeable packages emerged as a part of advancements in active packaging aids in keeping food fresh and safe. It retains food taste, color and preserves nutritious value of food products by effectively removing oxygen from the interior packaging environment.

Mechanizations in chhana production

The traditional method of chhana production is batch wise, manual, labor intensive, unhygienic and time consuming. Several studies were conducted for mechanization of various steps in chhana and chhana based sweets production. Mechanizations incorporated by various workers needs to be integrated for development of continuous system for chhana production.

Mechanized designs for coagulation step in chhana production

A continuous coagulator based on the principle of Transverse Jet Mixer-Reactor (T.J.M.R.) with di/D ratio of 0.125 was designed and developed by Patel (1998). Curdling occurs within 60 cm length of mixing point after instantaneous mixing of heated milk and acid. It has significantly helped in reducing the time required for coagulum formation. A laboratory scale continuous Chhana making machine with milk handling capacity of 60 l/h was designed by Singh (1994). Coiled tube heat exchangers were used for heating and cooling of milk. The acidulant flow rate through an electrically heated ‘U’-tube type heat exchanger was 0.2 l/min. Both milk and acidulant were fed perpendicular to the axis of the coagulation column from the bottom and coagulation was achieved at 70°C in the coagulation column (diameter 45 mm and height 800 mm).

A continuous heat acid coagulation unit with a vacuum assisted strainer was developed for chhana production. The moisture content of the chhana obtained in the unit was 0.583 kg per kg milk whereas the yield of chhana was 0.203 kg per kg milk, when the total milk solid in the milk used for coagulation was 0.141 kg per kg milk. The total milk solid recovery in chhana was 0.602 kg per kg milk solid when holding time of chhana was 135s and 680 mm Hg vacuum was maintained inside the vacuum chamber. The major advantages of the developed setup includes reduction in
time and energy, good solids recovery, improvement in quality and reduction in microbial contamination (Sahu and Das, 2009).

**Mechanized designs for draining of whey in chhana production process**

Batch wise whey drainage using muslin cloth manually is a time consuming and unhygienic operation. So, mechanization is required for the manufacture of uniform quality traditional dairy products rapidly and hygienically. Draining of whey from coagulated curd was performed in two stages in the continuous chhana making machine developed at NDRI, Karnal by Aneja et al. (1977). First and second stages comprised of a stationary double jacketed inclined sieve and a slow moving conveyor covered with a muslin cloth respectively. Chhana with 55% moisture content was obtained at the end of the process. In order to facilitate the continuous dewatering of Chhana coagulum, an endless conveyor filter was developed by Sinha (2000). For continuous dewatering the use of endless conveyor with nylon filter of 28, 40 and 50 mesh size with dewatering period of 10, 20 and 30 min, were studied. The milk flow rate was found to be 125-135 l/h for acid flow rate of 45 l/h (0.6% citric acid solution) in order to achieve a pH of 5.4 in whey. The average moisture content was found to be 56.14 percent and average penetrometer reading was found to be 134.37 at measuring temperature of 37 °C. The filter medium with 50 mesh with 10 min holding was found to be most suitable to produce chhana of optimum quality on this system.

**Mechanized system for compaction of chhana into paneer**

Impact type device for continuous production of paneer from chhana was developed by Das and Das (2009). Chhana was filled in rectangular cages made screen for pressing, and the cages were subjected to impact forces. The overall amount of energy imparted to chhana during impacts was associated with moisture loss, increased hardness of pressed chhana, and the solid extracted from pressed chhana by whey. The rate of change in moisture content, hardness, and solid degradation with the imparted energy was observed to obey the kinetics of first order reaction. An impact type prototype has provision to remove compacted chhana blocks at regular intervals. Number of other researchers have made efforts for mechanized production of paneer (Halder et al. 2011; Halder et al. 2012; Chitranayak et al. 2017a; Chitranayak et al. 2017b)

**Production of chhana from ultra-filtrated retentates**

Chhana was successfully manufactured from ultra-filtrated retentates. Ultrafiltration aids in concentration of milk and removal of most of soluble solids. Study focused on ultrafiltration behavior of pasteurized whole milk versus severely heated whole milk, the flux, energy requirement for concentration and retention coefficients. An increase of 31.4% in the yield of chhana on product basis and of 16.4% on dry matter basis was achieved (Sachdeva and Reuter, 1991). Only 4.35 kg of milk was used to produce 1 kg chhana by the ultrafiltration method against 5.7 kg of milk by the conventional method. Process automation and control are the benefits of the process.

**Mechanized designs for production of chhana based sweets**

Choudhary et al. (2002) developed an equipment for continuous production of chhana balls for production of Rasogolla and other similar products. The system comprises of two parts: chhana kneading and ball shaping unit. Chhana obtained after heat acid coagulation of milk is kneaded in a screw arrangement. From this unit, the homogenously kneaded chhana is cold extruded in cylindrical shape through a die. A knife cutter cuts the cylindrical chhana mass into small pieces. The cylindrical cut chhana pieces fall into the ball-forming unit’s inlet hopper. The cylindrical chhana pieces are rolled into spherical ball by a cylindrical gyration unit. Gyration unit has mechanism that to provides translatory motion in the horizontal and vertical axis while preventing the device from spinning. Capacity of this unit is 50 Chhana balls per minute or 3000 balls per hour (Choudhary et al. 2006).

Systematic efforts were made by Karunanithy et al. (2007 a, b & c) to mechanize unit operations in rasogolla making for its continuous production. Kneading of chhana is an important step in preparation of rasogolla. In conventional method it is carried out by hands. Chhana has to be manually kneaded and consistent quality of rasogolla sometimes becomes difficult to achieve. A kneader was developed for kneading of chhana. Experiments were conducted in four peripheral velocity (53.41, 66.76, 80.11 and 93.46 cm / s) using three different rotors. Kneading efficiency was determined in terms of degree of mixing, mixing index uniformity, increase in temperature and diameter expansion. Best results were obtained for kneading of chhana at 93.46 cm / s peripheral speed. The kneaded Chhana was formed manually into 2.5 g lumps. About 150 lumps (375 g) for producing spherical balls were fed into the ball former. The oscillator required 15 min to convert lumps into spherical balls. The variable parameters were: SS smooth, perforated and acrylic surface with 200 and 250 strokes / min, 5 and 10 cm stroke lengths, 0% and 5% slope as ball forming zones. Spherical form by sphericity was judged. Results established that good quality chhana ball could be prepared at 200 strokes / min, a stroke length of 5 cm on the flat SS surface of 0 percent slope. Sphericity values of chhana ball and rasogolla was 0.880 and 0.876, respectively using the mechanized system. On basis of parameters such as percentage of absorbed sugar syrup (121.28%), porosity (44.13%), expressible juice (49.43%), volume expansion (2.644) and overall acceptability (88.60), quality of rasogolla were found best at 200 strokes/min and 2.5 cm stroke length with 0% slope in SS plain surface. Rasogolla prepared using the mechanized system were comparable to the control and market samples.
Kumar and Das (2003) optimized the processing parameters viz. mixing, kneading and cooking of chhana and sugar mixture for the mechanized production of sandesh from cow milk. Kumar and Das (2007) subsequently developed a single-screw vented extruder for cooking of chhana and sugar mixture that can be integrated with the mechanized method for the continuous production of sandesh from cow milk. Studies undertaken on production of rasogolla by pressure cooker method revealed the influence of factors like moisture content, fat level and pH in milk or chhana on production of rasogolla. Initial moisture content in chhana is a critical factor in determining the quality of rasogolla. In order to produce a good quality rasogolla the moisture content in chhana should be between 50 to 60%. There is an increase in loss of fat in cooking syrup with respect to the increase of fat in milk or chhana, even though the rate of fat loss was less compared to traditional method (Bhattacharya and Raj, 1980). Studies were also conducted on optimization of process parameters for the preparation of rasogolla under atmospheric pressure conditions using genetic algorithm. The relation between the fourteen independent parameters that influence the quality of rasogolla and dependent parameters were found using neural network modeling (Mohanta and Srivastava, 2014).

Conclusions

Design of various improved mechanized systems for production of chhana and chhana based sweets in small scale level have huge scope and relevance as it facilitates the rapid, hygienic and effortless production of uniform quality soft textured chhana and chhana based sweets. Since majority of the production of chhana is in unorganized sector, mechanization is a need of the hour to preserve the hygiene, quality and texture of chhana and chhana based sweets. The available knowledge base can provide inputs to the future research in mechanization of chhana and chhana based products. However, elaborate studies are required to develop mechanized systems for rapid and hygienic production of chhana at small scale level. A concerted effort for mechanization in chhana production incorporating the recent upgraded technological knowhow is an inevitable area of future research.

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