Effect of coagulants on the quality of *chhana* and *rasogolla* obtained from admixture of buffalo milk and butter milk

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Revised: 27 July 2013 / Accepted: 8 August 2013 / Published online: 23 August 2013
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Abstract A study was carried out to investigate the effect of different coagulant (lactic acid, citric acid and calcium lactate) on yield, sensory and textural characteristics of *chhana* and *rasogolla* made from admixture of buffalo milk and sweet cream butter milk (SCBM). The highest yield of *chhana* was observed with calcium lactate whereas the minimum yield was found with citric acid. There was no significant difference found with respect to flavour and colour and appearances scores, however, significant ($p < 0.01$) difference found in body and texture of *chhana* samples prepared with different coagulant. In addition to that, significant ($p < 0.05$) difference observed with respect to body and texture, flavour and porosity of *rasogolla*, but no significant difference was observed in colour and appearance as well as sweetness of *rasogolla* prepared with *chhana* obtained from varying coagulants. Among different coagulants, citric acid was found best suitable for *chhana* as well as *rasogolla* making.

Keywords Buffalo milk · Sweet cream butter milk · Coagulant · *Chhana* · *Rasogolla*

Chhana refers to the milk solids obtained by the acid coagulation of boiled hot whole milk and subsequent drainage of whey. It is an indigenous milk product of Indian origin which is being produced throughout the year in the country on large scale and serves as base material for a large variety of Indian sweetmeats

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like *rasogolla*, *sandesh*, *chum-chum*, *chhana murki*, *chhana podo*, *rasomalai*, *chhana balushahi*, *khorma/belgrami*, *pantowa* etc. Pattern of milk consumption in India indicates that about 6 % milk is converted into *chhana* (Sahu and Das 2009).

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 may also be used for the preparation of *chhana*.

Generally, cow milk is preferred for *chhana* making as it produces soft body and smooth texture product which is highly suitable for *chhana* based sweets particularly *rasogolla* (Soni et al. 1980; Bhattacharya and Raj 1980). However, buffalo milk as such because of many inherent differences in physico-chemical make up as compared to cow milk, poses many technological problems in preparation of good quality *chhana* and *chhana* based sweets particularly *rasogolla*. High calcium content, different protein make up, higher total solids and curd tension of buffalo milk as compared with cow milk, resulted in harder, chewy and coarse texture in *chhana*, which are not suitable for good quality *rasogolla* (Soni et al. 1980; Ahmed et al. 1981; Bandyopadhyay et al. 2005). Since, buffalo milk constitutes more than 57 % of total milk production of India (IDF 2008) so, the utilization of buffalo milk is essential for preparation of good quality *chhana* and *rasogolla* by technological modification in the process. Therefore, several attempts has been made to optimize process parameters to utilize buffalo milk for preparation of *chhana* suitable for sweet making, sodium citrates (Jagtiani et al. 1960), dilution of buffalo milk with 20–30 % water (Rajorhia 1987), coagulation at low temperature and homogenization (Soni et al. 1980; Ahmed et al. 1981). However, these measures achieved only limited success in the preparation of good quality *chhana* and *rasogolla*.

Sweet cream butter milk (SCBM) is a by-product of butter industry. It is almost similar in composition and appearance to

skimmed milk, but contains most of the milk fat globule membrane (MFGM). The MFGM is rich in phospholipids, especially phosphatidylcholine (lecithin), phosphatidylethanolamine, and sphingomyelin (Kennan and Dylewski 1995), which improve the nutritive value of the product. Bhargava et al. (1988) reported that utilization of buffalo buttermilk solids in cow milk yielded slightly inferior quality *rasogolla*. However, springiness of buffalo buttermilk *rasogolla* was not significantly different from cow milk *rasogolla*. Buffalo buttermilk after 20 % enrichment with cow milk gave *rasogolla* of high acceptability. With 40 % incorporation of milk, the acceptability was even higher than that of cow milk *rasogolla*. The utilization of SCBM in the manufacture of paneer was studied by Pal and Garg (1989) and reported that addition of 30 % butter milk with buffalo milk improved the moisture retention, thereby increasing the yield by about 1 % over the control paneer without affecting the organoleptic and textural attributes. So, admixing of SCBM to buffalo milk could improve the quality of *chhana* and *rasogolla*.

The type of coagulant used for coagulation of milk has prominent role in maintaining quality of *chhana* as it regulates the moisture content in *chhana* and thereby affects the quality of *chhana*. Generally organic acids like citric or lactic acid, calcium lactate, lemon juice and sour whey are used as coagulant. De and Ray (1954) reported that lactic acid produced *chhana* with granular texture, suitable for *rasogolla* preparation, while citric acid resulted in pasty texture. Sharma and Reuter (1991) reported that use of 20 % lactic acid solution produced ultrafiltered *chhana* with granular texture. However, Kumar et al. (2005) found that satisfactory quality of *chhana* could be made from 10 % citric acid solution. The use of 4 % calcium lactate solution produced *chhana* with soft body, smooth texture and pleasant flavour (Sen and De 1984). Pandey et al. (2004) prepared *chhana* from cow milk coagulated by lactic acid and citric acid and found that yield of *chhana* was higher with lactic acid coagulant. The effects of different type of coagulant for the manufacture of good quality *chhana* prepared from admixture of SCBM and buffalo milk has not been studied earlier. Therefore, a study was undertaken in order to select the best coagulant for manufacture of good quality *chhana* from the admixture of SCBM and buffalo milk.

Material and methods

Milk Fresh raw buffalo milk (fat, 6.5–8.2 % and solid not fat, 9.0–10.10 %) was procured from the Experimental Dairy of the National Dairy Research Institute (NDRI), Karnal.

Cream Fresh buffalo milk cream having 60–65 % fat was obtained from Experimental Dairy of NDRI, Karnal.

Buffalo skim milk Fresh buffalo skim milk having fat, 0.05–0.1 % and total solid (TS), 9.6–10.25 % was procured from Experimental Dairy of NDRI, Karnal.

Sugar Refined cane sugar conforming to Indian standard specification IS: 1151 (1969) was procured from Experimental Dairy of NDRI, Karnal.

Coagulant Citric acid monohydrate (RFCL Ltd, New Delhi), Calcium lactate extra pure (Titan Biotech Ltd, New Delhi) and lactic acid AR grade (Titan Biotech Ltd, New Delhi) was procured from local market of Karnal, Haryana (India).

Preparation of SCBM The cream was standardized to 38–40 % fat by adding buffalo skim milk. The standardized cream was pasteurized (80 °C for 16 s) and was aged overnight at 4 °C thereafter, churned in hand operated butter churn (capacity 10 kg) until fat granules appeared; the granules were kneaded at approximately 20 rpm to release the buttermilk, which was filtered through muslin cloth to remove curd particles. The TS and fat content in SCBM were 9.50–10.0 % and 0.5–0.8 %, respectively.

Chhana making *Chhana* was prepared from admixture of SCBM to buffalo milk (60:100, on TS basis) and thereafter, standardized to the fat and SNF ratio (1:2.1) as per method described by Kumar et al. (2012) with slight modification. The modification included use of various types of coagulant in manufacture of *chhana* and its *rasogolla*.

For each trial of *chhana* preparation, 1 kg of standardized blends was taken in a beaker and heated at 95 °C on an electric heater for 5 min. The blends were cooled to coagulation temperature of 75 °C. The coagulant lactic acid and citric acid (@ 1 % solution) were used in order to get pH 5.2 for coagulation, while calcium lactate (@ 4 % solution) was used to obtain pH 6.1. Further, whey was drained from the respective coagulated mass by hanging for 15–20 min in a piece of muslin cloth.

Rasogolla making *Channa* obtained from different types of coagulant was used for preparation of *rasogolla* as per method given by Bhattacharya and Raj (1980) with some modifications. *Chhana* was kneaded to homogeneous and smooth dough, which was then, portioned into balls of size about 8–10 g weights. Balls were rolled in between palms for 1 min. Care was taken to avoid cracks on the surface. Sugar solutions of 40 % were prepared by dissolving sugar in calculated amount of water and heated upto boiling point. It was clarified with the addition of a little amount of raw milk during boiling and filtered through muslin cloth. Balls were put in syrup once it started boiling for cooking up to 20 min. A small amount of water was continuously added to maintain the concentration during cooking. After cooking, the balls were transferred to a

container with hot water (85–90 °C) for their texture stabilization and colour improvement. After 2–3 min of texture stabilization in hot water, the balls were soaked in sugar syrups of 40 % concentration. Finally, the product acquired the desired sugar concentration within 2–4 h at room temperature and stored at or below 10 °C.

Chemical analysis TS content of *chhana*, buffalo milk, buffalo skim milk, SCBM and whey was determined by standard gravimetric method (IS: SP: 18 1981). Fat content in *chhana*, SCBM and blend of SCBM to buffalo milk (60:100, on TS basis) were determined by Gerber method (IS: SP: 18 1981) for milk. The pH of *chhana* whey was measured using digital pH meter (LABINDIA, New Delhi, version I).

Sensory evaluation of *chhana* and *rasogolla* The samples of *chhana* were evaluated for flavour, body and texture, colour and appearance and overall acceptability on a 9-point hedonic scale. The samples of *rasogolla* were also measured using 9-point hedonic scale with respect to flavour, body and texture, colour and appearance, porosity, sweetness and overall acceptability by a sensory panel consisting of 8 judges from faculty of dairy processing group.

Textural analysis The textural profile analysis of *chhana* samples was done using texture analyser TA.XT2i, supplied by Stable Micro Systems, UK, attached with a sprit chart recorder and a printer to record uni-axial double cycled compression. Cylindrical sample of *chhana* of 19 mm diameter and 15 mm height were held at 20 °C and subjected to linear compression through a stroke length of 4 mm fitted with 100 N load cell and operated in two bite deformation cycle with a cross head speed of 50 mm/min and a chart speed of 100 mm/min. The force distance curve thus obtained was used to work out various textural profile parameters, namely hardness, cohesiveness, springiness, gumminess, adhesiveness and chewiness (Bourne 1978). Based on relevant literature and several experimental trials, 26.70 % compression was selected for the present study.

Data analysis The data were subjected to analysis of variance (ANOVA), using randomized block design and standard deviation (SD) was computed as described by Snedecor and Cochran (1989). The numbers of replicates were five.

Results and discussion

Effect of different coagulants on *chhana* production

Milk coagulated with varying coagulants affect the quality of *chhana* in terms of moisture retention, sensory quality,

textural attributes and suitability for sweet making. Several workers (Rao et al. 1989; Sen and Rajorhia 1991) have reported buffalo milk coagulated with different coagulants gave different quality of *chhana* as well as *rasogolla*. So, an investigation was carried out to prepare *chhana* from blends coagulated with different coagulants such as citric acid, lactic acid and calcium lactate and results are presented in Table 1.

A 4 % calcium lactate solution, as suggested by Sen (1986) was used for coagulation of cow milk at pH 6.1. *Chhana* made using calcium lactate was found significantly ($p < 0.05$) lower fat in *chhana* whey than other coagulants. The yield of calcium lactate coagulated *chhana* was significantly ($p < 0.05$) higher partly due to better moisture retention and partly due to increase in calcium content. The *chhana* obtained from calcium lactate coagulant was found with relatively better water retention than the *chhana* obtained from citric acid coagulant. In addition to that, higher yield of *chhana* was obtained from calcium lactate coagulant than the *chhana* obtained from citric acid coagulant. Our result is in similarity with the finding of Sen (1986) and Bandyopadhyay et al. (2005).

Effect of different coagulants on sensory quality of *chhana* and *rasogolla*

The sensory scores of *chhana* prepared from blend coagulated with different coagulants are presented in Fig. 1a. It is evident from Fig. 1a that there is no significant difference observed in flavor and color and appearance scores of *chhana* samples prepared from blend coagulated with different coagulants. The flavor of calcium lactate coagulated *chhana* was sweet and nutty because of higher pH of coagulation, while those prepared by using citric acid and lactic acid were slightly acidic.

However, there was highly significant ($p < 0.01$) difference in body and texture score of *chhana* samples prepared from blend coagulated with different coagulants. The body and texture score of *chhana* coagulated with calcium lactate was lower due to excessive moisture retention resulting in very weak, but smooth texture. Lactic acid produced grainy *chhana*, while citric acid produced pasty *chhana*. De and Ray (1954) also reported similar result for cow milk *chhana*. Sen and De (1984) reported that cow milk *chhana* prepared from calcium lactate produce soft body, smooth texture and pleasant flavor.

Sensory attributes of *rasogolla* prepared from *chhana* using different coagulants is presented in Fig. 1b. It is evident from Fig. 1b that there was no significant difference in color and appearance and sweetness scores of different *rasogolla* samples obtained from varying coagulants. However, there was significant difference ($p < 0.05$) observed in flavor and porosity scores and highly significant difference ($p < 0.01$) in body and texture score of *rasogolla* samples. *Rasogolla* prepared from *chhana* coagulated with calcium lactate was soft and fragile which broke into pieces when pressed between

Table 1 Effect of different coagulants on *chhana* production

Type of coagulant	Whey			<i>Chhana</i>	
	Amount (ml)	Total solids (%)	Fat (%)	Yield (%)	Moisture (%)
Lactic acid	941±0.71	6.13±0.31	0.43±0.15	16.10±0.41	57.60±0.49
Citric acid	944±0.55	6.15±0.21	0.48±0.13	15.80±0.39	57.00±0.41
Calcium lactate	956±0.61	6.15±0.20	0.24±0.11	17.75±0.45	62.14±0.52
F- ratio	7.312*	0.925	6.680*	6.534*	8.893*

Each value of mean ± SD of five replicates ($n=5$)

*Significant at 5 % level ($p<0.05$)

Quantity of standardized blend=1 kg; strength of coagulants: lactic acid and citric acid=1 % solution; Calcium lactate=4 %

palate and tongue. The experimental samples were also lacked in chewiness and not much increase in voluminosity during cooking of *rasogolla* balls in sugar syrup. So, calcium lactate failed to produce good quality *rasogolla*. The *rasogolla* samples prepared from *chhana* coagulated with citric acid and lactic acid had desired softness, sponginess and chewiness. The body and texture score of *rasogolla* samples prepared

from *chhana* coagulated with citric acid and lactic acid were 8.20 and 8.13, respectively, on 9-point hedonic score.

Effect of different coagulants on textural profile of *chhana*

Textural attributes of *chhana* prepared from blend coagulated with different coagulants is presented in Table 2. On the basis

Fig. 1 Effect of different coagulants on sensory quality of **a** *chhana* and **b** *rasogolla* (no of panellists =8; no of replicates=5)

Table 2 Effect of different coagulants on instrumental texture quality of *chhana*

Type of coagulant	Hardness (mN)	Cohesiveness	Springiness (mm)	Adhesiveness (mN)	Gumminess (mN)
Lactic acid	5.27±0.11	0.52±0.03	6.73±0.11	0.43±0.01	2.75±0.07
Citric acid	5.58±0.09	0.58±0.04	8.78±0.07	0.41±0.01	3.23±0.06
Calcium lactate	7.92±0.12	0.49±0.02	5.29±0.08	0.35±0.02	3.88±0.05
F- ratio	6.54**	1.78	9.78**	1.47	5.89**

Each value of mean ± SD of five replicates ($n=5$)

**Significant at 1 % level ($p<0.01$)

of sensory parameters among different coagulants, the best selected *rasogolla* using citric acid were analysed for different textural attributes which is presented in Table 3. It is observed (Table 2) that there were highly significant ($p<0.01$) differences in hardness, springiness and gumminess of *chhana* coagulated with different coagulants. The hardness, springiness and gumminess of *chhana* coagulated with citric acid were higher than that of lactic acid coagulated *chhana*. This is probably due to higher dissociation constant (K_a) of citric acid (8.7×10^{-4} at 25 °C) than lactic acid (1.39×10^{-4} at 25 °C), which makes the citric acid a stronger acid than lactic acid (Chang 1977).

Kumar et al. (1992) also reported that *rasogolla* prepared from citric acid coagulated *chhana* had greater hardness, gumminess and chewiness than that prepared by using lactic acid. *Chhana* prepared from blend using calcium lactate was harder due to increase in amount of calcium per unit mass of *chhana*. Gupta et al. (1993) reported that higher calcium content gave hardness in *chhana*, which support our findings. Citric acid coagulated *chhana* exhibited more cohesiveness due to less moisture retention in comparison to lactic acid coagulated *chhana*, which is responsible for making the *chhana* more elastic. Lower moisture content in *chhana* resisted deformation and did not rupture easily and thus found to be more cohesive. Bandyopadhyay et al. (2005) also observed that cohesiveness of *chhana* prepared using citric acid was higher than that of lactic acid coagulated *chhana* because citric acid is a stronger acid than lactic acid. Calcium lactate coagulated *chhana* had lower cohesiveness due to higher amounts of calcium per unit mass in *chhana*, which increased its moisture content. This may be due to water binding molecules of calcium ion (Sen and De 1984).

Table 3 Instrumental texture quality of the best selected *rasogolla* using citric acid

Hardness (mN)	Cohesiveness	Springiness (mm)	Gumminess (mN)
5.98±0.63	0.593±0.05	8.97±0.26	3.546±0.41

Each value of mean ± SD of five replicates ($n=5$)

Conclusion

The maximum yield of *chhana* was found with calcium lactate coagulant, while the minimum yield was found with citric acid. However, there was no significant difference observed with respect to flavour and colour and appearance scores of *chhana* manufactured with varying coagulants. The hardness, springiness, gumminess and chewiness of *chhana* coagulated with citric acid were found higher than the lactic acid coagulated *chhana*. On the basis of sensory and textural characteristics with its suitability for *rasogolla* making, citric acid (@ 1 % solution) was found most suitable for *chhana* making using admixture of SCBM and buffalo milk.

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