STUDIES ON QUALITY OF CHHANA FROM BUFFALO MILK AND ITS SUITABILITY FOR MAKING RASOGOLLA

By

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Chapter 1

INTRODUCTION

Milk and milk products are an integral part of human nutrition. About 60 per cent of milk produced in India is used in the manufacture of milk products (Anon, 1995).

Milk production in India has reached 81 Million tons (Chennegowda, 2002). Since milk is a perishable food, it is necessary to preserve the surplus by converting into milk products. Chhana, a well known traditional indigenous, milk product, is obtained by acid coagulation of hot milk and is used extensively as a base material for large variety of Indian delicacies namely rasogolla, sandesh, cham-cham, rasmalai and many other such products. Cow milk is usually preferred for chhana making because it yields a soft body and smooth textured product suitable for chhana based sweet meats.

The yield and quality of chhana depends on several factors viz. type of milk, heat treatment prior to acidification, coagulation temperature, acidity of milk, concentration of coagulant and the residence time of coagulation before separation (Jonkman and Das 1993; Choudhary et al., 1998; Singh, 1994).

In India, the main source of marketable surplus is the buffalo milk (Sindhu, 1995). Keeping in view the increased production of buffalo milk and surplus availability to the organised dairy sector, its utilization in the manufacture of various products is gaining momentum. However, the differences in the quantitative and qualitative aspects of various constituents and physico-chemical properties of cow and buffalo milk limit the application of process technology to buffalo milk on the lines of cow milk.
It is well known that buffalo milk possess certain problems during its conversion into certain milk products. The major inherent problems related with buffalo milk utilization for chhana making are rheological ones viz. hard body, coarse texture and lower cohesiveness which make it unsuitable for rasogolla making (De and Ray, 1953; Jagtiani et al., 1960; Gera, 1976). In addition, lower hydration capacity of buffalo casein and its higher calcium content further impair the quality of buffalo milk chhana.

Therefore, certain modifications are necessary in the processing techniques for conversion of buffalo milk so as to obtain good quality chhana. Some of the treatments which can be adopted are alteration in salt balance of buffalo milk prior to its heating and coagulation, lowering the coagulation temperature, reducing SNF content by dilution etc.

Earlier, few attempts were made to improve the quality of chhana from buffalo milk by modifying the process parameters (Suguna Rao et al., 1989; Choudhary et al., 1998). Since buffalo milk constitutes more than 62 per cent of total milk production in India, it is worthwhile to see the possibility of preparing chhana from buffalo milk. In view of this fact, the attempts were made in the present investigation to prepare good quality chhana from buffalo milk suitable for making rasogolla with following objectives.

1. To assess the suitability of buffalo milk to obtain desired quality chhana at different coagulation temperatures.
2. To study the efficacy of sodium citrate as stabilizer for getting the acceptable quality chhana from buffalo milk.
3. To evaluate chemical and sensory quality of chhana from buffalo milk.
4. To study the suitability of buffalo milk chhana for making rasogolla.
Chapter 2

REVIEW OF LITERATURE

Chhana is one of the indigenous milk products, usually prepared by acid coagulation of hot milk. It is a base material for the various Indian dairy confectionary products. Cow milk is invariably preferred as it yields chhana having soft body and smooth texture.

2.1 Type of milk:

De and Ray (1954) observed that chhana prepared from cow milk had a soft body and smooth texture. They further reported that buffalo milk was not suitable for chhana making.

Srinivasan and Anantkrishnan (1964) reported that chhana obtained from cow milk had soft body and smooth texture as compared to that of chhana made from buffalo milk.

Kundu and De (1972) reported that buffalo milk with 5 per cent fat was suitable for getting smooth texture of chhana.

Srivastava and Singh (1976) used sour milk (pH 5.3) and curdled milk (pH 4.7) either alone or their combinations in varying amounts in fresh milk to obtain quality chhana. They observed that only sour milk mixed with 75 per cent fresh milk (pH 6.25) was suitable for production of acceptable quality of chhana.

Soni et al. (1980) observed that desirable quality chhana could be obtained from buffalo milk subjected to boiling followed by coagulation with 0.5 per cent lactic acid at 70 °C.

Rao et al. (1989) observed that the chhana made from buffalo milk had fewer moisture and protein content but higher total solids. However, the product was harder than that made from cow milk and modified buffalo milk.

Karan and Bhargava (1990) observed that buffalo milk containing 2.3 per cent fat was admixed with 20 per cent of cow milk. They observed that chhana produced from buffalo milk had hard body and was not suitable for chhana making.

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Soni et al. (1980) observed that desirable quality chhana could be obtained from buffalo milk subjected to boiling followed by coagulation with 0.5 per cent lactic acid at 70 °C.
Suguna Rao et al. (1989) observed that the chhana made from buffalo milk had lower moisture and protein content but higher total solids. However, the product was harder and more spongy than made from cow milk and modified buffalo milk.

Katara and Bhargava (1990) observed that buffalo milk containing 2.3 per cent fat when admixed with 20 per cent soymilk produced acceptable quality chhana. However, they noticed that addition of soymilk in buffalo milk had adverse effect on flavour, sponginess and softness of chhana.

Joshi et al. (1991) compared the quality of chhana made from buffalo milk and goat milk. They observed that chhana produced from buffalo milk had hard body and coarse texture, but with acceptable flavour, whereas, the goat milk chhana had acidic flavour.

Devangare et al. (1995) reported that admixing of goat milk to cow milk to the extent of 50 per cent did not affect the organoleptic quality of chhana.

2.2 Fat levels of milk:

De (1952) reported that increase in fat levels of milk resulted in increase in fat content of chhana as well as proportionate fat losses in whey.

De and Ray (1954) observed that the yield of chhana increased gradually with increase in fat per cent of milk.

Jannawar (1973) documented adverse effect of higher fat levels of milk on the moisture content of chhana.

Chaudhari (1974) observed higher moisture content in chhana with 3.0 per cent fat milk, whereas lower moisture content was obtained with 6 per cent fat milk.

Ahmed et al. (1981) reported an increase in the yield of chhana with increase in levels of fat in milk. They further reported that the fat content had no effect on moisture content as well as on the acceptability of chhana.
Moorty and Rao (1982) reported higher yield of chhana with higher percentage of fat in goat milk. They further reported that as fat content was reduced to 3.0 per cent, there was proportionate increase in moisture content of chhana.

Bhargava et al. (1992) studied the effect of different fat levels on quality of chhana from goat milk. They reported that chhana obtained from milk with 3 to 6 per cent fat had a fine texture, soft body with a glossy white moist surface. The yield, total solids and fat content of chhana varied significantly with variations in fat levels of milk.

2.3 Type of coagulants:

It has been reported that as the strength of coagulant was reduced, there was proportionate increase in the yield and moisture content of chhana (De, 1952; De and Ray, 1954 and Chaudhari, 1974).

Jannawar (1973) observed higher moisture content in chhana (59.17%) with aged chhana whey whereas it was comparatively less (49.76 %) with citric acid.

Singh and Ray (1977a) obtained higher yield of chhana with sour whey as compared to citric acid and lactic acid. The composition of chhana also varied to some extent with use of different coagulants.

Singh and Ray (1977b) prepared chhana by using citric acid, lactic acid and sour chhana whey. They observed that good quality chhana was prepared by using lactic acid.

Ahmed et al. (1981) observed that the acceptability of chhana was decreased with increase in strength of coagulants. They also observed that the yield was highest with 1.0 per cent and lowest with 1.5 per cent coagulant.

Joshi et al. (1991) observed that yield of chhana did not vary much with different coagulants. However, the lactic acid produced good quality chhana which can be used for product preparation.
Sharma *et al.* (1995) prepared *chhana* from Jannapari and Barberi goat milk coagulated at different temperatures using citric acid, lactic acid, tartaric acid and sour whey. They reported that *chhana* obtained by using lactic acid was of good quality as compared to that of *chhana* prepared by using citric acid, tartaric acid and sour whey.

### 2.4 Coagulation temperature:

Jagtap and Shukla (1973) observed highest total solids and fat content in *chhana* when milk was coagulated at 82 °C. However, the protein content of *chhana* was highest at boiling temperature.

Ahmed *et al.* (1981) reported that the yield and moisture content of *chhana* were higher when milk was coagulated at 60 °C. However, the acceptability of *chhana* was better at 70 °C coagulation temperature.

Sen (1986) reported that the recovery of total solid was maximum at 80 and 85 °C coagulation temperatures.

Verma and Rajorhia (1995) standardized the method for production of *chhana* from standardized buffalo milk at different coagulation temperatures. They reported that coagulation temperature of 40 °C is most convenient for getting soft and smooth *chhana* for making *rasogolla*.

### 2.5 Modification of buffalo milk for *chhana*:

Higher calcium content and curd tension of buffalo milk as compared to cow milk influence the hardness of *chhana* making it unfit for *rasogolla* preparation. To reduce the calcium load, Jagtiani *et al.* (1960) applied ion exchange technique, but the product was not of good quality.

Kundu and De (1972) found that homogenization (176 kg/cm²) of standardized buffalo milk to 5 per cent fat improved the softness of *chhana*.

Suguna Rao *et al.* (1989) observed that the *rasogolla* prepared from *chhana* containing 20 per cent diluted buffalo milk added with 0.3 per cent sodium citrate using citric acid as a coagulant was comparable to cow milk *chhana*. 
Adhikari et al. (1992) reported that reduction in coagulation pH and subsequent washing of curd results in decreased mineral retention in buffalo milk chhana making it softer, smoother and less chewy. Such chhana may be used as a substitute for cow milk chhana in the manufacture of chhana based sweets.

Aneja (1997) suggested that dilution of buffalo milk with 25 per cent water prior to coagulation produced soft and desirable quality chhana.

2.6 Addition of stabilizers for improving quality of chhana:

Chandrasekhra et al. (1957) suggested treatment of buffalo milk with a mixture of sodium dihydrogen phosphate and disodium hydrogen phosphate for getting good quality chhana.

Date et al. (1958) reported that addition of mixture of disodium hydrogen phosphate and sodium hydrogen phosphate or 0.1-0.2 per cent sodium citrate produced soft chhana from buffalo milk.

Iyer (1978) documented the treatment of buffalo milk with 0.05 per cent sodium citrate prior to boiling, dilution with 25 per cent water and its coagulation with citric acid solution (1.0 %) improved the quality of chhana.

Panchabhai (1994) found that incorporation of 0.1 per cent of sodium alginate or gelatin or 0.2 per cent starch to cow milk yielded chhana highly suitable for rasogolla.

2.7 Composition of chhana:

De and Ray (1954) prescribed standards for acceptable quality chhana. The product should have moisture not more than 55 per cent and the fat, protein, lactose and ash content should not be less than 50, 34, 4 and 4 per cent respectively on dry matter basis.

According to PFA (1976), the chhana should have not more than 70 per cent moisture and the fat content should not be less than 50 per cent fat on dry matter basis.
The *chhana* from whole cow milk as specified by IS:5162-(1980) should have 65 per cent moisture (maximum), 50 per cent (minimum) milk fat (on dry matter basis) 25 per cent (minimum) milk protein (on dry matter basis) and total ash (maximum) 5.0 per cent (on dry matter basis).

Kumar and Srinivasan (1982) reported the chemical composition of *chhana* prepared from cow and buffalo milk. The moisture, total solids and fat content were 53.15, 46.85 and 24.85 per cent for cow milk and 51.69, 48.31 and 29.67 per cent respectively for buffalo milk *chhana*.

Sen (1986) observed increase in moisture content of *chhana* from 62.4 to 68.6 per cent with decrease in coagulation temperature from 95 to 80 °C using 4 per cent calcium lactate. He reported that *chhana* made using calcium lactate had higher calcium and moisture than that made by using citric acid as coagulant.

Bhargava *et al.* (1988) prepared *chhana* from buffalo sweet-cream buttermilk mixed with 40 per cent cow milk. The product had 68.26 per cent moisture, 11.61 per cent fat, 14.58 per cent protein, 3.62 per cent lactose and 1.93 per cent ash.

Adhikari *et al.* (1993) reported the composition of *chhana* from buffalo milk. It had 53.4 per cent moisture, 24.4 per cent fat, 18.25 per cent protein, 1.0 per cent lactose and 2.35 per cent ash.

2.8 **Textural properties of chhana and rasogolla**:

Jagtiani *et al.* (1960) and Bandyopadhyay *et al.* (1981) reported that the high calcium content and high curd tension of buffalo milk influenced the hardness of *chhana*.

Soni *et al.* (1980) studied the rheological properties of *rasogolla* prepared from buffalo milk (4 % fat) partially digested with trypsin. They reported that buffalo milk *rasogolla* was slightly harder in comparison to cow milk. The springiness and chewiness values were lower while cohesiveness and gumminess were almost similar to cow milk *rasogolla*. 
Desai et al. (1991) studied the textural characteristics of chhana prepared from cow, buffalo and mixed milk. They observed significant variations in the textural properties of chhana made from these milks.

Adhikari et al. (1992) studied the textural and microstructural properties of chhana and rasogolla. They reported that when chhana was transformed into rasogolla, the instron textural properties viz. hardness, chewiness and gumminess were decreased significantly whereas springiness increased. Further, they showed that chhana had a structure consisting of compact coalescence casein matrix with embedded fat globules while rasogolla had a cogglomerated ragged and porous casein matrix with uneven surface and numerous large void spaces.

Kumar et al. (1992) studied the textural properties of rasogolla from chhana made by using citric acid and lactic acid. They observed that rasogolla made from citric acid chhana had significantly greater hardness, cohesiveness, gumminess and chewiness than that made from lactic acid chhana. Good quality rasogolla was made from cow milk chhana using both lactic acid and citric acid at 70 °C coagulation temperature.

2.9 Quality of rasogolla:

De and Ray (1954) concluded that standardization of cow milk to 4 per cent fat and 8.5 per cent SNF was desirable for production of good quality rasogolla.

Kundu and De (1972) suggested homogenization, boiling and thereafter coagulation at 70 °C with 1 per cent citric acid to obtain chhana suitable for preparation of rasogolla.

Bhattacharya and Des Raj (1980) observed that the quality of rasogolla mainly depend on the quality of chhana and concentration of sugar syrup. They further reported that pressure cooker method for production of rasogolla was satisfactory using 1 kg/sq.cm pressures for 2-3 min.
Soni et al. (1980) reported that buffalo milk boiled and coagulated at 70 °C with lactic acid yielded chhana with soft body suitable for the manufacture of rasogolla.

Kumar et al. (1988) prepared rasogolla made from whole and standardized (3.5 and 5.0 per cent fat) buffalo milk at different coagulation temperatures. Though the chhana had a dull and creamy white appearance, poor body and texture but rasogolla made from chhana showed normal creamy white appearance and slightly soft body and spongy texture with pleasant flavour.

Desai et al. (1993) studied the chemical quality of market rasogolla and reported that the spongy rasogolla contained significantly higher moisture, fat and protein but less ash and carbohydrates than ordinary rasogolla.

Panchabhai (1994) found that incorporation of 0.1 per cent of sodium alginate or gelatin or 0.2 per cent starch to cow milk yielded chhana highly suitable for rasogolla.

Ravichandra et al. (1997) optimized the process for production of rasogolla of desired hardness. They concluded that desirable quality of chhana (58 % moisture) suitable for rasogolla could be obtained from milk (3.3 per cent fat and 8.0 per cent SNF) coagulated by 0.40 per cent lactic acid or milk acid mixture.

Sur et al. (2000) standardized method for the manufacture of rasogolla from buffalo milk. They reported that rasogolla made from buffalo milk (4% fat) partially digested with trypsin and coagulated at pH 5.7 using 1 per cent lactic acid was acceptable though it was slightly harder as compared to cow milk rasogolla.

Puranik (2001) reported that chhana prepared from recombined milk was not acceptable while the rasogolla was acceptable in respect of all sensory attributes.
Chapter 3

MATERIALS AND METHODS

3.1 Milk:
Fresh cow and buffalo milk obtained from the dairy units of the College of Veterinary and Animal Sciences and Agriculture College, Parbhani, respectively were used throughout the investigation.

3.2 Chemicals/Ingredients:
Citric acid (Emerck), sodium citrate (Sarabhai M Chemicals) and cane sugar (procured from the local market) were used in the present study.

3.3 Standardization of milk:
Cow milk was standardized to 4 per cent fat by using Pearson’s square method. Skim milk was used for standardization. Similarly, buffalo milk was standardized to 4, 5 and 6 per cent fat using buffalo skim milk.

3.4 Coagulant:
One per cent citric acid solution was used as coagulant throughout the investigation.

3.5 Stabilizer:
Sodium citrate in different concentrations (0.05, 0.10, 0.15 and 0.20%) was used as a stabilizer for obtaining smooth and soft chhana from buffalo milk.

3.6 Preparation of chhana:
Chhana was prepared by using the method of De (1980). Product standardization was done by using buffalo milk standardized at 6(T1), 5(T2) and 4(T3) per cent fat at different coagulation temperatures viz. 80 °C (C1), 70°C (C2), 60 °C (C3) and 50 °C (C4) using citric acid (1 %) as coagulant. Coagulated mass was transferred to muslin cloth and hung for whey drainage for 20 min. Chhana made from cow milk (4 % fat) and coagulated at 80 °C
temperature was used as control ($C_0$). The yield of *chhana* from each lot of standardized buffalo milk was recorded to calculate the per cent recovery.

Final trials were conducted from standardized buffalo milk with selected fat level and coagulated temperature using different levels of stabilizer. Sodium citrate was added to standardized buffalo milk prior to boiling for improving the quality of *chhana*.

<table>
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<tr>
<td>$S_0$</td>
<td>0 05%</td>
</tr>
<tr>
<td>$S_1$</td>
<td>0.05%</td>
</tr>
<tr>
<td>$S_2$</td>
<td>0.10%</td>
</tr>
<tr>
<td>$S_3$</td>
<td>0.15%</td>
</tr>
<tr>
<td>$S_4$</td>
<td>0.20%</td>
</tr>
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</table>

Soft body and good textured *chhana* obtained from standardized buffalo milk using selected level of sodium citrate was used to explore the suitability of the product for making *rasogolla* along with *chhana* made from cow milk (control).

### 3.7 Yield of *chhana*:

The per cent yield was calculated by weighing the *chhana* obtained from a lot of milk.

\[
\text{Per cent yield} = \frac{\text{Weight of } chhana}{\text{Weight of milk}} \times 100
\]

### 3.8 Fat and total solids recovery of *chhana*:

Per cent fat and total solids recovery of *chhana* were calculated by estimating the fat and total solids content of milk and *chhana* as per the procedure described in "IS:1479 Part-II (1961)."
3.9 Sensory evaluation of chhana:

Chhana samples were served to judging panel comprising of the six judges to evaluate the product for various sensory attributes viz. colour and appearance, body and texture, flavour and overall acceptability on 9 point hedonic scale (Amerine et al., 1965). All the judges were supplied with score card and were asked to judge the experimental product in respect of different sensory attributes.

3.10 Analyses of chhana:

Chhana samples obtained from different lots of standardized buffalo milk and cow milk were subjected to the following chemical analyses.

3.10.1 Determination of moisture:

Moisture content of chhana was determined according to the method described in ISI (1964).

Five gram chhana was weighed in an evaporating dish. It was heated in water bath till dryness. Dish was then transferred to hot air oven adjusted at 100 ± 1 °C. Heating was continued for 2 hours. Evaporating dish was taken out from the oven and cooled in a dessicator and weighed. The process of heating and cooling was repeated till the loss in weight between two successive weighings did not exceed 1 mg. The moisture percentage was calculated by the formula given below.

\[
\text{Loss in weight} = \frac{\text{Moisture \%}}{\text{Weight of sample}} \times 100
\]

3.10.2 Determination of total solids:

Total solids of chhana was determined by oven dry method as described above. The residue left after complete evaporation of moisture was used for the determination of total solids. The residue was weighed and total solids were calculated by using formula given.
Weight of residue
Total solids % = --------------------------------- x 100
Weight of sample

3.10.3 Determination of fat:

The fat content of chhana was determined according to the method described in ISI “Handbook of Food Analysis” Part XI (1981).

3.10.4 Determination of protein:

The protein content of chhana was determined by estimating the total nitrogen according to the method recommended by A.O.A.C “Official Methods of Analysis” (1975).

3.10.5 Determination of ash:

The ash content was determined according to the method of ISI “Handbook of Food Analysis” Part XI (1981).

Five grams of chhana was evaporated to dryness and ignited in muffle furnace adjusted at 550 °C until white ash was formed. The ash content was calculated as under:

Weight of ash
Ash % = --------------------------------- x 100
Weight of sample

3.10.6 Determination of lactose:

The lactose content was determined according to the method described in ISI “Handbook of Food Analysis” Part XI (1981).

3.10.7 Yield of chhana:

The per cent yield of chhana was calculated by weighing the chhana obtained from a lot of milk.

Weight of chhana
Per cent yield = --------------------------------- x 100
Weight of milk
3.10.8 Fat and total solids recovery of chhana:

Per cent fat and total solids recovery of chhana was calculated by estimating the fat and total solids content of milk and chhana as per the procedure described in "IS:1479 Part II" (1961).

3.11 Rheology of chhana:

Texture profile analysis of chhana was done as per the method described by Bourne (1966) using Instron Universal Testing Machine (Model-1000) in respect of hardness, cohesiveness, springiness, gumminess and chewiness.

a) Calibration: The instrument was calibrated by using 10 Newtons load transducer and tare weight of Anvil was balanced.

b) Gauge length: Gauge length was set at 15 mm by driving the moving cross head up or down using the push buttons on cross head control panel. The spacing between Anvil and specimen table was measured using a ruler.

c) Cross head limit: The upper and lower cross head limits were set accurately.

d) Test descriptions: The details of the test are as

1) Load - 10 Newtons

2) Cross head speed - 50 mm/min

3) Chart magnification - 1:5

4) Compression - 50 per cent

5) Sample size - 10 x 10 mm

Chhana samples having cross sectional area of 100 sq. mm were subjected to 50 per cent compression twice for obtaining the force deformation curve from which various textural attributes were measured.

Hardness (H): It is the force required to penetrate the sample with the probe. It is the peak value reached by the curve above the base line multiplied by the value of one division.
Cohesiveness (C): It is the ratio of two consecutive compression i.e. $A_2/A_1$

$A_1$ - Area under first bite downward
$A_2$ - Area under second bite downward

Gumminess (G): It is the product of hardness and cohesiveness.

$$G = H \times C$$

Springiness (S): The rate at which a deformed material goes back to its undeformed condition, after the deforming force is removed. It is the distance of the sample under compression during the second bite (mm).

Chewiness (Ch): The energy to masticate a solid food product to a state ready for swallowing and is related to the hardness, cohesiveness and springiness.

$$\text{Chewiness} = \text{Hardness} \times \text{Cohesiveness} \times \text{Springiness} \ (\text{Nmm})$$

3.12 Preparation of *Rasogolla*:

*Rasogolla* was prepared from *chhana* made from standardized buffalo milk added with selected level of sodium citrate and from cow milk (4 %)

**Flow diagram for the preparation of *rasogolla* from buffalo milk *chhana***:

1. Standardization of milk
2. Addition of sodium citrate
3. Heated to boiling
4. Cooling
5. Addition of coagulant (1 % citric acid)
6. Straining of coagulated mass
7. Preparation of *chhana* balls
8. Cooking for 25-30 min. (60 % sugar syrup)
9. Soaking (40 % sugar syrup)
10. Storage
3.13 Sensory evaluation:

Sensory evaluation of *rasogolla* was carried out in respect of colour and appearance, body and texture, juiciness and overall acceptability by a panel of judges using 9 point hedonic scale (Amerine *et al.*, 1965).

3.14 Chemical analyses of *Rasogolla*:

All the procedures used for the chemical analyses of *chhana* have been followed for the analyses of *rasogolla* except lactose.

3.15 Statistical Analysis:

The data obtained during the course of investigation were subjected to statistical analysis using Completely Randomised Design (CRD) (Panse and Sukhatme, 1967).
3.13 Sensory evaluation:
Sensory evaluation of *rasogolla* was carried out in respect of colour and appearance, body and texture, juiciness and overall acceptability by a panel of judges using 9 point hedonic scale (Amerine *et al.*, 1965).

3.14 Chemical analyses of *Rasogolla*:
All the procedures used for the chemical analyses of *chhana* have been followed for the analyses of *rasogolla* except lactose.

3.15 Statistical Analysis:
The data obtained during the course of investigation were subjected to statistical analysis using Completely Randomised Design (CRD) (Panse and Sukhatme, 1967).
Chapter 4

RESULTS

Results obtained during the present investigation are presented as under.

1) Effect of coagulation temperatures on:
   a) Sensory characteristics of chhana from buffalo milk (Table 1 to 3).
   b) Per cent yield, fat and total solids recovery of chhana from buffalo milk
      (Table 4 to 6).

2) Effect of fat levels on sensory quality of chhana (Table 7).

3) Effect of sodium citrate as stabilizer on sensory characteristics,
rheological properties and chemical quality of chhana (Table 8 to 11).

4) Sensory and chemical quality of rasogolla from buffalo milk chhana
   (Tables 12 to 13).

4.1 Effect of coagulation temperatures:

4.1.1 Sensory characteristics of chhana from buffalo milk:

Data pertaining to sensory quality of chhana made from buffalo milk
standardized to 4.0, 5.0 and 6.0 per cent fat are presented in Tables 1 to 3.

Table-1 reveals the effect of different coagulation temperatures on sensory attributes of chhana from buffalo milk standardized to 4.0 per cent fat. It is seen that different coagulation temperatures did not have any significant effect on colour & appearance and flavour score of chhana,
whereas body and texture and overall acceptability scores differed significantly. Chhana made from cow milk (control) recorded highest sensory score for body and texture (7.60) and overall acceptability (7.45) which were significantly superior to that of chhana made from buffalo milk coagulated at 80 °c temperature but at par with that of chhana from milk coagulated at 70
Table 1: Effect of coagulation temperatures on sensory characteristics of buffalo milk chhana (4% fat)

<table>
<thead>
<tr>
<th>Coagulation temperatures</th>
<th>Colour &amp; appearance</th>
<th>Body &amp; texture</th>
<th>Flavour</th>
<th>Overall acceptability</th>
</tr>
</thead>
<tbody>
<tr>
<td>Control (Cow milk)</td>
<td>8.25</td>
<td>7.60&lt;sup&gt;a&lt;/sup&gt;</td>
<td>7.30</td>
<td>7.45&lt;sup&gt;a&lt;/sup&gt;</td>
</tr>
<tr>
<td>80 °C</td>
<td>8.20</td>
<td>5.80&lt;sup&gt;b&lt;/sup&gt;</td>
<td>7.20</td>
<td>5.70&lt;sup&gt;b&lt;/sup&gt;</td>
</tr>
<tr>
<td>70 °C</td>
<td>8.10</td>
<td>7.10&lt;sup&gt;ab&lt;/sup&gt;</td>
<td>7.25</td>
<td>7.20&lt;sup&gt;a&lt;/sup&gt;</td>
</tr>
<tr>
<td>60 °C</td>
<td>8.20</td>
<td>7.30&lt;sup&gt;a&lt;/sup&gt;</td>
<td>7.25</td>
<td>7.30&lt;sup&gt;a&lt;/sup&gt;</td>
</tr>
<tr>
<td>50 °C</td>
<td>8.15</td>
<td>7.00&lt;sup&gt;ab&lt;/sup&gt;</td>
<td>7.15</td>
<td>7.05&lt;sup&gt;ab&lt;/sup&gt;</td>
</tr>
</tbody>
</table>

SE ± CD
57 ± NS
0.47 ± 1.46
0.52 ± NS
0.47 ± 1.46

*Common superscripts indicate treatments at par at 5% and 1% level of probability.
NS - Non significant.
and 60 °C. Lowering of coagulation temperature to 50 °C, there was further reduction in scores though not significantly.

Table 2 shows the sensory quality of chhana made from buffalo milk standardized to 5 per cent fat. It is revealed that different coagulation temperatures exhibited non significant differences in colour and appearance and flavour score of chhana. However, in respect of body and texture and overall acceptability, the differences were significant. Chhana made from cow milk (control) had highest sensory scores for body and texture (7.60) and overall acceptability (7.45) followed by chhana from buffalo milk coagulated at 60 and 70 °C temperatures. Significantly lowest scores (6.00 & 5.95) were observed at 80 °C coagulation temperature.

Sensory attributes of chhana from buffalo milk (6 % fat) coagulated at different temperatures are presented in Table 3. It is observed that the differences in respect of colour and appearance and flavour score were non significant. However, body and texture and overall acceptability scores differed significantly due to different coagulation temperatures. The sensory scores for body and texture (7.60) and overall acceptability (7.45) were highest in chhana made from cow milk (control) followed by C3, C2 and C4 treatments. Significantly lowest sensory scores for these parameters were recorded in the product made from buffalo milk coagulated at 80 °C.

4.1.2 Per cent yield, fat and total solids recovery of chhana:

Results in respect of yield, fat and total solids recovery of chhana made from buffalo milk at different coagulation temperatures are presented in Tables 4 to 6.

It is observed from Table 4 that the buffalo milk chhana exhibited significant improvement in yield over cow milk chhana. The yield of chhana was highest (23.80 %) from buffalo milk coagulated at 70 °C (C2) followed by C3, C4 and C1. However, all the treatments were at par. Cow milk chhana (control) recorded significantly lower yield (18.23 %). The total solids
Table 2: Effect of coagulation temperatures on sensory characteristics of buffalo milk chhana (5% fat)

<table>
<thead>
<tr>
<th>Coagulation temperatures</th>
<th>Colour &amp; appearance</th>
<th>Body &amp; texture</th>
<th>Flavour</th>
<th>Overall acceptability</th>
</tr>
</thead>
<tbody>
<tr>
<td>Control (Cow milk)</td>
<td>8.25</td>
<td>7.60&lt;sup&gt;a&lt;/sup&gt;</td>
<td>7.30</td>
<td>7.45&lt;sup&gt;a&lt;/sup&gt;</td>
</tr>
<tr>
<td>80 °C</td>
<td>8.20</td>
<td>6.00&lt;sup&gt;b&lt;/sup&gt;</td>
<td>7.20</td>
<td>5.95&lt;sup&gt;b&lt;/sup&gt;</td>
</tr>
<tr>
<td>70 °C</td>
<td>8.20</td>
<td>7.10&lt;sup&gt;ab&lt;/sup&gt;</td>
<td>7.25</td>
<td>7.20&lt;sup&gt;ab&lt;/sup&gt;</td>
</tr>
<tr>
<td>60 °C</td>
<td>8.25</td>
<td>7.50&lt;sup&gt;a&lt;/sup&gt;</td>
<td>7.20</td>
<td>7.35&lt;sup&gt;ab&lt;/sup&gt;</td>
</tr>
<tr>
<td>50 °C</td>
<td>8.20</td>
<td>7.05&lt;sup&gt;ab&lt;/sup&gt;</td>
<td>7.20</td>
<td>7.05&lt;sup&gt;ab&lt;/sup&gt;</td>
</tr>
<tr>
<td>SE ±</td>
<td>0.57</td>
<td>0.47</td>
<td>0.58</td>
<td>0.46</td>
</tr>
<tr>
<td>CD</td>
<td>NS</td>
<td>1.46</td>
<td>NS</td>
<td>1.42</td>
</tr>
</tbody>
</table>

*Common superscripts indicate treatments at par at 5% and 1% level of probability
NS - Non significant
Table 3: Effect of coagulation temperatures on sensory characteristics of buffalo milk chhana (6 % fat)

<table>
<thead>
<tr>
<th>Coagulation temperatures</th>
<th>Colour &amp; appearance</th>
<th>Body &amp; texture</th>
<th>Flavour</th>
<th>Overall acceptability</th>
</tr>
</thead>
<tbody>
<tr>
<td>Control (Cow milk)</td>
<td>8.25</td>
<td>7.60&lt;sup&gt;a&lt;/sup&gt;</td>
<td>- 7.30</td>
<td>7.45&lt;sup&gt;a&lt;/sup&gt;</td>
</tr>
<tr>
<td>80 °C</td>
<td>8.20</td>
<td>6.10&lt;sup&gt;b&lt;/sup&gt;</td>
<td>7.25</td>
<td>5.80&lt;sup&gt;b&lt;/sup&gt;</td>
</tr>
<tr>
<td>70 °C</td>
<td>8.25</td>
<td>7.15&lt;sup&gt;ab&lt;/sup&gt;</td>
<td>7.20</td>
<td>7.15&lt;sup&gt;ab&lt;/sup&gt;</td>
</tr>
<tr>
<td>60 °C</td>
<td>8.15</td>
<td>7.60&lt;sup&gt;a&lt;/sup&gt;</td>
<td>7.25</td>
<td>7.30&lt;sup&gt;a&lt;/sup&gt;</td>
</tr>
<tr>
<td>50 °C</td>
<td>8.15</td>
<td>7.05&lt;sup&gt;ab&lt;/sup&gt;</td>
<td>7.20</td>
<td>7.10&lt;sup&gt;ab&lt;/sup&gt;</td>
</tr>
<tr>
<td>SE ±</td>
<td>0.57</td>
<td>0.47</td>
<td>0.57</td>
<td>0.51</td>
</tr>
<tr>
<td>CD</td>
<td>NS</td>
<td>1.46</td>
<td>NS</td>
<td>1.54</td>
</tr>
</tbody>
</table>

*Common superscripts indicate treatments at par at 5 % and 1 % level of probability
NS - Non significant
Table 4: Effect of coagulation temperatures on yield, fat and total solids recovery of chhana from buffalo milk (4 % fat)

<table>
<thead>
<tr>
<th>Coagulation temperatures</th>
<th>Per cent yield</th>
<th>Per cent total solids recovery</th>
<th>Per cent fat recovery</th>
</tr>
</thead>
<tbody>
<tr>
<td>Control (Cow milk)</td>
<td>18.23&lt;sup&gt;b&lt;/sup&gt;</td>
<td>64.70&lt;sup&gt;b&lt;/sup&gt;</td>
<td>83.10</td>
</tr>
<tr>
<td>80 °C</td>
<td>22.24&lt;sup&gt;a&lt;/sup&gt;</td>
<td>65.28&lt;sup&gt;b&lt;/sup&gt;</td>
<td>81.73</td>
</tr>
<tr>
<td>70 °C</td>
<td>23.80&lt;sup&gt;a&lt;/sup&gt;</td>
<td>68.67&lt;sup&gt;a&lt;/sup&gt;</td>
<td>82.11</td>
</tr>
<tr>
<td>60 °C</td>
<td>23.65&lt;sup&gt;a&lt;/sup&gt;</td>
<td>67.45&lt;sup&gt;a&lt;/sup&gt;</td>
<td>82.42</td>
</tr>
<tr>
<td>50 °C</td>
<td>23.40&lt;sup&gt;a&lt;/sup&gt;</td>
<td>63.84&lt;sup&gt;b&lt;/sup&gt;</td>
<td>81.90</td>
</tr>
<tr>
<td>SE ± CD</td>
<td>0.57</td>
<td>0.55</td>
<td>0.99 NS</td>
</tr>
</tbody>
</table>

*Common superscripts indicate treatments at par at 5 % and 1 % level of probability
NS - Non significant
recovery enhanced significantly from buffalo milk coagulated at 70 °C followed by C3. With lowering of coagulation temperature from 60 to 50 °C, there was significant reduction in the recovery of total solids. The fat recovery in cow milk chhana (control) and chhana from buffalo milk coagulated at all the temperatures did not differ significantly. The highest recovery was however, observed in control followed by chhana from buffalo milk coagulated at 60 and 70 °C.

Table 5 reveals significant enhancement in the yield of chhana made from buffalo milk (5 % fat) at all coagulation temperatures over cow milk chhana (control), while there was significant decrease in the recovery of total solids from 62.16 per cent in control to 60.19 per cent in buffalo milk chhana coagulated at 80 °C. However, with decrease in coagulation temperature from 80 to 70 °C, the recovery improved significantly which was at par with that of control. Steady decline in recovery was noticed with further lowering of coagulation temperature to 50 °C but the differences were at par with C2 and C3. The per cent fat recovery did not differ significantly in control as well as in chhana from buffalo milk coagulated at different coagulation temperatures.

It is seen from Table 6 that the per cent total solids recovery of chhana from cow milk (control) as well as from buffalo milk (6 % fat) coagulated at different temperatures did not vary significantly but the per cent yield and fat recovery differed significantly. Significant enhancement in the yield of chhana made from buffalo milk coagulated at all temperatures was observed over control (18.30 %). Though the yield was highest with C2 but the differences in yield obtained at 80 °C (C1), 60 °C (C3) and 50 °C (C4) coagulation temperatures were at par. The fat recovery was highest in control chhana (83.26 %) which decreased significantly in the product made from buffalo milk at all coagulation temperatures. However, highest fat recovery was noticed at 70 °C (C2) followed by C3 treatment.
<table>
<thead>
<tr>
<th>Coagulation temperatures (°C)</th>
<th>Control (Cow milk)</th>
<th>80°C</th>
<th>70°C</th>
<th>60°C</th>
<th>50°C</th>
</tr>
</thead>
<tbody>
<tr>
<td>Per cent yield</td>
<td>17.97&lt;sup&gt;b&lt;/sup&gt;</td>
<td>24.00&lt;sup&gt;a&lt;/sup&gt;</td>
<td>24.63&lt;sup&gt;a&lt;/sup&gt;</td>
<td>24.20&lt;sup&gt;a&lt;/sup&gt;</td>
<td>24.10&lt;sup&gt;a&lt;/sup&gt;</td>
</tr>
<tr>
<td>Per cent total solids recovery</td>
<td>62.16&lt;sup&gt;a&lt;/sup&gt;</td>
<td>60.19&lt;sup&gt;b&lt;/sup&gt;</td>
<td>62.19&lt;sup&gt;a&lt;/sup&gt;</td>
<td>61.13&lt;sup&gt;ab&lt;/sup&gt;</td>
<td>60.85&lt;sup&gt;ab&lt;/sup&gt;</td>
</tr>
<tr>
<td>Per cent fat recovery</td>
<td>83.13</td>
<td>80.73</td>
<td>81.96</td>
<td>81.40</td>
<td>80.20</td>
</tr>
</tbody>
</table>

**Table 5**: Effect of coagulation temperatures on yield, fat and total solids recovery of chhana made from buffalo milk (5% fat)

*Common superscripts indicate treatments at par at 5% and 1% level of probability. NS - Non significant.*
Table 6: Effect of coagulation temperatures on yield, fat and total solids recovery of chhana made from buffalo milk (6 % fat)

<table>
<thead>
<tr>
<th>Coagulation temperatures</th>
<th>Per cent yield</th>
<th>Per cent total solids recovery</th>
<th>Per cent fat recovery</th>
</tr>
</thead>
<tbody>
<tr>
<td>Control (Cow milk)</td>
<td>18.30&lt;sup&gt;b&lt;/sup&gt;</td>
<td>64.37</td>
<td>83.26&lt;sup&gt;a&lt;/sup&gt;</td>
</tr>
<tr>
<td>80 °C</td>
<td>24.32&lt;sup&gt;a&lt;/sup&gt;</td>
<td>64.27</td>
<td>78.43&lt;sup&gt;b&lt;/sup&gt;</td>
</tr>
<tr>
<td>70 °C</td>
<td>24.83&lt;sup&gt;a&lt;/sup&gt;</td>
<td>64.23</td>
<td>79.45&lt;sup&gt;b&lt;/sup&gt;</td>
</tr>
<tr>
<td>60 °C</td>
<td>24.50&lt;sup&gt;a&lt;/sup&gt;</td>
<td>64.19</td>
<td>79.10&lt;sup&gt;b&lt;/sup&gt;</td>
</tr>
<tr>
<td>50 °C</td>
<td>24.40&lt;sup&gt;a&lt;/sup&gt;</td>
<td>63.74</td>
<td>78.48&lt;sup&gt;b&lt;/sup&gt;</td>
</tr>
<tr>
<td>SE ±</td>
<td>0.57</td>
<td>0.57</td>
<td>0.57</td>
</tr>
<tr>
<td>CD</td>
<td>1.66</td>
<td>NS</td>
<td>1.66</td>
</tr>
</tbody>
</table>

*Common superscripts indicate treatments at par at 5 % and 1 % level of probability
S - Non significant
4.2 Effect of fat levels:

Observations with respect to sensory characteristics of chhana made from buffalo milk standardized at different fat levels are presented in Table 7.

It is seen that the sensory scores for all the attributes exhibited non significant differences due to variations in fat levels of buffalo milk. Colour and appearance scores were almost similar in cow milk chhana (control) as well as in chhana made from buffalo milk with 4, 5 and 6 per cent fat. Highest scores for body and texture, flavour and overall acceptability were noticed in cow milk chhana, but the scores in respect of these sensory attributes decreased slightly in the product made from standardized buffalo milk. However, the differences in scores due to varying fat levels (4, 5 & 6%) were observed to be marginal. Based on these observations, buffalo milk standardized to 4 and 5 per cent fat were selected for further studies.

4.3 Effect of sodium citrate as stabilizer:

4.3.1 Sensory characteristics of chhana:

Results pertaining to sensory characteristics of buffalo milk chhana as influenced by levels of sodium citrate are depicted in Table 8.

It is revealed that the colour and appearance and flavour scores of chhana made from buffalo milk (4 & 5 % fat) added with different levels of sodium citrate did not differ significantly. However, levels of sodium citrate exhibited significant variations in body & texture and overall acceptability scores of chhana from buffalo milk at both fat levels. Chhana made from buffalo milk at 4 and 5 per cent fat had significantly lowest scores as compared to that of control. But with addition of sodium citrate the scores improved significantly. Addition of sodium citrate at 0.15 per cent level exhibited almost similar scores as that of control chhana. With further increase in sodium citrate to 0.20 per cent, body and texture scores were almost similar to that of S1, S2 and S3 treatments but the overall acceptability
Table 7: Effect of fat levels on sensory quality of buffalo milk chhana at 60 °C coagulation temperature

<table>
<thead>
<tr>
<th>Fat levels</th>
<th>Colour &amp; appearance</th>
<th>Body &amp; texture</th>
<th>Flavour</th>
<th>Overall acceptability</th>
</tr>
</thead>
<tbody>
<tr>
<td>Control (4 % cow milk)</td>
<td>8.00</td>
<td>7.50</td>
<td>7.40</td>
<td>7.45</td>
</tr>
<tr>
<td>4 %</td>
<td>8.00</td>
<td>7.20</td>
<td>7.25</td>
<td>7.20</td>
</tr>
<tr>
<td>5 %</td>
<td>7.90</td>
<td>7.25</td>
<td>7.30</td>
<td>7.15</td>
</tr>
<tr>
<td>6 %</td>
<td>8.00</td>
<td>7.30</td>
<td>7.30</td>
<td>7.20</td>
</tr>
<tr>
<td>SE ± CD</td>
<td>0.57</td>
<td>0.57</td>
<td>0.57</td>
<td>0.57</td>
</tr>
</tbody>
</table>

NS - Non significant

Superscripts indicate treatments at par at 5% and 1% level of probability.
Table 8: Effect of level of sodium citrate on sensory characteristics of buffalo milk chhana

<table>
<thead>
<tr>
<th>Level of sodium citrate</th>
<th>Fat level %</th>
<th>Colour &amp; appearance</th>
<th>Body &amp; texture</th>
<th>Flavour</th>
<th>Overall acceptability</th>
</tr>
</thead>
<tbody>
<tr>
<td>Control (cow milk without stabilizer)</td>
<td>4.0</td>
<td>8.10</td>
<td>8.00\textsuperscript{a}</td>
<td>8.15</td>
<td>8.00\textsuperscript{a}</td>
</tr>
<tr>
<td>No stabilizer (S\textsubscript{0})</td>
<td>4.0</td>
<td>8.00</td>
<td>6.35\textsuperscript{b}</td>
<td>8.05</td>
<td>6.25\textsuperscript{b}</td>
</tr>
<tr>
<td>0.05 % (S\textsubscript{1})</td>
<td>5.0</td>
<td>8.00</td>
<td>6.45\textsuperscript{b}</td>
<td>8.05</td>
<td>6.50\textsuperscript{b}</td>
</tr>
<tr>
<td>0.10 % (S\textsubscript{2})</td>
<td>4.0</td>
<td>7.90</td>
<td>7.20\textsuperscript{ab}</td>
<td>8.05</td>
<td>7.50\textsuperscript{ab}</td>
</tr>
<tr>
<td>0.15 % (S\textsubscript{3})</td>
<td>5.0</td>
<td>8.00</td>
<td>7.30\textsuperscript{ab}</td>
<td>8.05</td>
<td>7.60\textsuperscript{ab}</td>
</tr>
<tr>
<td>0.20 % (S\textsubscript{4})</td>
<td>4.0</td>
<td>7.90</td>
<td>7.70\textsuperscript{ab}</td>
<td>8.10</td>
<td>7.80\textsuperscript{ab}</td>
</tr>
<tr>
<td>5.0</td>
<td>8.00</td>
<td>7.70\textsuperscript{ab}</td>
<td>8.00</td>
<td>7.85\textsuperscript{a}</td>
<td></td>
</tr>
<tr>
<td>5.0</td>
<td>7.90</td>
<td>7.09\textsuperscript{a}</td>
<td>8.00</td>
<td>7.90\textsuperscript{a}</td>
<td></td>
</tr>
<tr>
<td>5.0</td>
<td>7.90</td>
<td>7.90\textsuperscript{a}</td>
<td>7.25</td>
<td>6.85\textsuperscript{ab}</td>
<td></td>
</tr>
<tr>
<td>SE ±</td>
<td>4.0</td>
<td>0.57</td>
<td>0.48</td>
<td>0.57</td>
<td>0.47</td>
</tr>
<tr>
<td>5.0</td>
<td>0.57</td>
<td>0.46</td>
<td>0.57</td>
<td>0.45</td>
<td></td>
</tr>
<tr>
<td>CD</td>
<td>4.0</td>
<td>NS</td>
<td>1.46</td>
<td>NS</td>
<td>1.44</td>
</tr>
<tr>
<td>5.0</td>
<td>NS</td>
<td>1.40</td>
<td>NS</td>
<td>1.38</td>
<td></td>
</tr>
</tbody>
</table>

Common superscripts indicate treatments at par at 5\% and 1\% level of probability.

NS - Non significant
scores reduced drastically to 6.85 and 6.60, respectively in chhana made from buffalo milk containing 4 and 5 per cent fat.

4.3.2 Yield, fat and total solids recovery of chhana:

It is seen from Table 9 that the yield of chhana made from buffalo milk with 4 and 5 per cent fat increased significantly as compared to that of control. However, the differences in the yield of chhana due to varying levels of sodium citrate were at par. Higher yields (24.00 and 24.94 %) were recorded in the product made from buffalo milk added with 0.15 % sodium citrate (S₃) while lower yields were in chhana made without addition of stabilizer.

The total solids recovery though significantly improved in buffalo milk chhana as compared to control but the variations due to levels of sodium citrate were marginal. Enhancement in total solids recovery was observed in chhana made from buffalo milk (4 % fat) added with 0.10 % sodium citrate followed by chhana made from buffalo milk (5 % fat) added with 0.15 %. With increase in level of sodium citrate, total solids content declined further.

Non significant differences were recorded in fat recovery of chhana made from 4 % buffalo milk while differences were significant in the product from buffalo milk with 5 % fat. Lowest recovery of fat was recorded in the product containing 0.10 and 0.20 % sodium citrate. However, the differences were at par with other treatments.

4.3.3 Rheological properties of chhana:

Table 10 depicts the textural characteristics of buffalo milk chhana made at 60 °C coagulation temperature with or without addition of sodium citrate. Chhana made from buffalo milk with 4 per cent fat without sodium citrate recorded higher values for hardness (31.00 mN), cohesiveness (0.72), springiness (8 mm), gumminess (22.32 mN) and chewiness (178.56 mNmm) as compared to that of product made from buffalo milk with 5 per cent fat and control. With incorporation of sodium citrate @ 0.15 per cent, the values for
Table 9: Effect of sodium citrate on yield, fat and total solids recovery of buffalo milk chhana

<table>
<thead>
<tr>
<th>Level of sodium citrate</th>
<th>Fat level %</th>
<th>Per cent yield</th>
<th>Per cent total solids recovery</th>
<th>Per cent fat recovery</th>
</tr>
</thead>
<tbody>
<tr>
<td>Control (cow milk without stabilizer)</td>
<td>4.0</td>
<td>17.67&lt;sup&gt;b&lt;/sup&gt;</td>
<td>60.21&lt;sup&gt;a&lt;/sup&gt;</td>
<td>84.37&lt;sup&gt;a&lt;/sup&gt;</td>
</tr>
<tr>
<td>No stabilizer (S&lt;sub&gt;0&lt;/sub&gt;)</td>
<td>4.0</td>
<td>23.65&lt;sup&gt;a&lt;/sup&gt;</td>
<td>67.45&lt;sup&gt;a&lt;/sup&gt;</td>
<td>81.94</td>
</tr>
<tr>
<td></td>
<td>5.0</td>
<td>24.23&lt;sup&gt;a&lt;/sup&gt;</td>
<td>63.64&lt;sup&gt;a&lt;/sup&gt;</td>
<td>81.50&lt;sup&gt;ab&lt;/sup&gt;</td>
</tr>
<tr>
<td>0.05 % (S&lt;sub&gt;1&lt;/sub&gt;)</td>
<td>4.0</td>
<td>23.78&lt;sup&gt;a&lt;/sup&gt;</td>
<td>67.76&lt;sup&gt;a&lt;/sup&gt;</td>
<td>82.04</td>
</tr>
<tr>
<td></td>
<td>5.0</td>
<td>24.40&lt;sup&gt;a&lt;/sup&gt;</td>
<td>64.06&lt;sup&gt;a&lt;/sup&gt;</td>
<td>81.00&lt;sup&gt;ab&lt;/sup&gt;</td>
</tr>
<tr>
<td>0.10 % (S&lt;sub&gt;2&lt;/sub&gt;)</td>
<td>4.0</td>
<td>23.82&lt;sup&gt;a&lt;/sup&gt;</td>
<td>67.60&lt;sup&gt;a&lt;/sup&gt;</td>
<td>82.29</td>
</tr>
<tr>
<td></td>
<td>5.0</td>
<td>24.55&lt;sup&gt;a&lt;/sup&gt;</td>
<td>64.75&lt;sup&gt;a&lt;/sup&gt;</td>
<td>79.54&lt;sup&gt;b&lt;/sup&gt;</td>
</tr>
<tr>
<td>0.15 % (S&lt;sub&gt;3&lt;/sub&gt;)</td>
<td>4.0</td>
<td>24.00&lt;sup&gt;a&lt;/sup&gt;</td>
<td>66.66&lt;sup&gt;a&lt;/sup&gt;</td>
<td>82.92</td>
</tr>
<tr>
<td></td>
<td>5.0</td>
<td>24.94&lt;sup&gt;a&lt;/sup&gt;</td>
<td>65.48&lt;sup&gt;a&lt;/sup&gt;</td>
<td>80.40&lt;sup&gt;ab&lt;/sup&gt;</td>
</tr>
<tr>
<td>0.20 % (S&lt;sub&gt;4&lt;/sub&gt;)</td>
<td>4.0</td>
<td>23.80&lt;sup&gt;a&lt;/sup&gt;</td>
<td>66.58&lt;sup&gt;a&lt;/sup&gt;</td>
<td>82.11</td>
</tr>
<tr>
<td></td>
<td>5.0</td>
<td>24.38&lt;sup&gt;a&lt;/sup&gt;</td>
<td>64.48&lt;sup&gt;a&lt;/sup&gt;</td>
<td>78.01&lt;sup&gt;b&lt;/sup&gt;</td>
</tr>
<tr>
<td>SE ±</td>
<td>4.0</td>
<td>0.57</td>
<td>0.55</td>
<td>0.98</td>
</tr>
<tr>
<td></td>
<td>5.0</td>
<td>0.57</td>
<td>0.42</td>
<td>1.59</td>
</tr>
<tr>
<td>CD</td>
<td>4.0</td>
<td>1.66</td>
<td>1.62</td>
<td>NS</td>
</tr>
<tr>
<td></td>
<td>5.0</td>
<td>1.67</td>
<td>1.23</td>
<td>4.64</td>
</tr>
</tbody>
</table>

Average of three trials.

Common superscripts indicate treatments at par at 5% and 1% level of probability.
NS - Non significant
Table 10: Effect of sodium citrate level on rheological properties from cow and buffalo milk chhana

<table>
<thead>
<tr>
<th>Type of milk</th>
<th>Fat levels (%)</th>
<th>Hardness (mN)</th>
<th>Cohesiveness</th>
<th>Springiness (MM)</th>
<th>Gumminess (mN)</th>
<th>Chewiness (mNmm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cow milk (control)</td>
<td>4</td>
<td>28.5</td>
<td>0.69</td>
<td>7.00</td>
<td>19.66</td>
<td>137.65</td>
</tr>
<tr>
<td>buffalo milk without sodium citrate</td>
<td>4</td>
<td>41.00</td>
<td>0.72</td>
<td>8.00</td>
<td>29.52</td>
<td>236.15</td>
</tr>
<tr>
<td></td>
<td>5</td>
<td>36.25</td>
<td>0.61</td>
<td>7.00</td>
<td>22.11</td>
<td>154.77</td>
</tr>
<tr>
<td>buffalo milk with 0.15% sodium citrate</td>
<td>4</td>
<td>29.75</td>
<td>0.65</td>
<td>7.00</td>
<td>19.34</td>
<td>135.36</td>
</tr>
<tr>
<td></td>
<td>5</td>
<td>28.08</td>
<td>0.66</td>
<td>6.33</td>
<td>18.53</td>
<td>117.31</td>
</tr>
</tbody>
</table>

Average of three trials.
all the textural properties of buffalo milk chhana were comparable to that of cow milk chhana.

4.3.4 Chemical composition of chhana:

Table 11 reveals the composition of chhana made from buffalo milk with or without addition of sodium citrate. It is seen that addition of sodium citrate had no any adverse effect on compositional constituents of chhana made from buffalo milk with 4 and 5 % fat. With addition of sodium citrate, the moisture content increased slightly from 60.50 to 60.80 and from 60.90 to 61.10 per cent in chhana from buffalo milk with 4 and 5 % fat, respectively while there was proportionate decrease in total solids content. On the contrary, the fat content decreased slightly from 14.50 to 14.00 and from 16.50 to 16.00 per cent respectively. However, the protein, lactose and ash contents were almost similar.

4.4 Quality of rasogolla from buffalo milk chhana:

4.4.1 Sensory characteristics:

Data regarding the sensory characteristics of rasogolla made from buffalo milk chhana with or without addition of sodium citrate are presented in Table 12.

It is seen that the differences in scores in all the sensory attributes of rasogolla made from chhana of cow milk and buffalo milk with or without addition of sodium citrate were non significant. However, the body and texture, juiciness and overall acceptability scores of rasogolla made from buffalo milk without addition of 0.15 % sodium citrate were much lower (6.80, 6.90 & 6.90) as compared to cow milk rasogolla. Slight improvement in sensory scores were noticed when sodium citrate was added. Though the rasogolla prepared from buffalo milk chhana with addition of sodium citrate was slightly hard and less juicy but was acceptable to judges.
Table 11: Effect of sodium citrate on chemical composition of buffalo milk chhana

<table>
<thead>
<tr>
<th>Type of milk</th>
<th>Fat per cent</th>
<th>Moisture</th>
<th>Total solids</th>
<th>Fat</th>
<th>Protein</th>
<th>Lactose</th>
<th>Ash</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cow milk (control)</td>
<td>4.0</td>
<td>55.70</td>
<td>44.30</td>
<td>19.10</td>
<td>21.10</td>
<td>2.10</td>
<td>2.0</td>
</tr>
<tr>
<td>Buffalo milk without sodium citrate</td>
<td>4.0</td>
<td>60.50</td>
<td>39.50</td>
<td>14.50</td>
<td>20.70</td>
<td>2.30</td>
<td>2.0</td>
</tr>
<tr>
<td></td>
<td>5.0</td>
<td>60.80</td>
<td>39.20</td>
<td>16.50</td>
<td>18.50</td>
<td>1.90</td>
<td>2.30</td>
</tr>
<tr>
<td>Buffalo milk with 0.15 % sodium citrate</td>
<td>4.0</td>
<td>60.90</td>
<td>39.10</td>
<td>14.00</td>
<td>20.60</td>
<td>2.0</td>
<td>2.30</td>
</tr>
<tr>
<td></td>
<td>5.0</td>
<td>61.10</td>
<td>38.90</td>
<td>16.00</td>
<td>18.70</td>
<td>1.90</td>
<td>2.30</td>
</tr>
</tbody>
</table>

Average of three trials.
Table 11: Effect of sodium citrate on chemical composition of buffalo milk chhana

<table>
<thead>
<tr>
<th>Type of milk</th>
<th>Fat per cent</th>
<th>Percentage constituents</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Moisture</td>
</tr>
<tr>
<td>Cow milk (control)</td>
<td>4.0</td>
<td>55.70</td>
</tr>
<tr>
<td>Buffalo milk without sodium citrate</td>
<td>4.0</td>
<td>60.50</td>
</tr>
<tr>
<td></td>
<td>5.0</td>
<td>60.80</td>
</tr>
<tr>
<td>Buffalo milk with 0.15 % sodium citrate</td>
<td>4.0</td>
<td>60.90</td>
</tr>
<tr>
<td></td>
<td>5.0</td>
<td>61.10</td>
</tr>
</tbody>
</table>

Average of three trials.
Table 12: Sensory characteristics of rasogolla from cow and buffalo milk chhana

<table>
<thead>
<tr>
<th>Type of chhana</th>
<th>Colour and acceptability</th>
<th>Body and texture</th>
<th>Juiciness</th>
<th>Overall acceptability</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cow milk</td>
<td>8.10</td>
<td>8.00</td>
<td>8.15</td>
<td>8.00</td>
</tr>
<tr>
<td>Buffalo milk without sodium citrate</td>
<td>7.90</td>
<td>6.82</td>
<td>6.90</td>
<td>6.90</td>
</tr>
<tr>
<td>Buffalo milk with sodium citrate</td>
<td>7.90</td>
<td>7.16</td>
<td>7.15</td>
<td>7.20</td>
</tr>
</tbody>
</table>

SE ±                             | 0.57                     | 0.57             | 0.58      | 0.54                  |
CD                                | NS                       | NS               | NS        | NS                    |

NS - Non significant
4.4.2 Chemical composition:

It is observed from Table 13 that the composition of *rasogolla* from buffalo and cow milk *chhana* differed slightly. *Rasogolla* made from buffalo milk *chhana* recorded lower total solids (48.95 & 46.41%) as compared to that of cow milk *rasogolla*. The fat content decreased but the protein and ash contents increased slightly in the product from buffalo milk *rasogolla*. Steady decrease was recorded in total carbohydrates content of rasgolla.
Table 13: Chemical composition of rasogolla from cow and buffalo milk chhana

<table>
<thead>
<tr>
<th>Type of chhana</th>
<th>Moisture</th>
<th>Total solids</th>
<th>Fat</th>
<th>Protein</th>
<th>Total carbohydrate</th>
<th>Ash</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cow milk (Control)</td>
<td>48.81</td>
<td>51.19</td>
<td>7.92</td>
<td>6.86</td>
<td>35.94</td>
<td>0.47</td>
</tr>
<tr>
<td>Buffalo milk without Sodium citrate</td>
<td>51.05</td>
<td>48.95</td>
<td>6.42</td>
<td>7.86</td>
<td>34.15</td>
<td>0.52</td>
</tr>
<tr>
<td>Buffalo milk with 0.15% sodium citrate</td>
<td>53.51</td>
<td>46.49</td>
<td>6.35</td>
<td>7.62</td>
<td>31.93</td>
<td>0.59</td>
</tr>
</tbody>
</table>

Average of three trials.
Chapter 5

DISCUSSION

Chhana a well known traditional milk product obtained by acid coagulation is used extensively as a base material for the production of large variety of Indian delicacies namely rasogolla, sandesh etc. Chhana based sweets though popular in different corners, but their production is mainly confined to the eastern parts of India. The quality of sweets entirely depends on the textural quality of chhana used for their preparation.

The quality of chhana varies from place to place and depends on the type and composition of milk used. Cow milk is preferred for production of chhana because it yields a soft body and smooth textured product which is suitable for chhana based sweets. On the other hand, buffalo milk which constitutes more than 62% of milk production, produces hard textured product due to its inherent differences in physico-chemical make up. Further, the conditions of coagulation viz. type of coagulant, its strength, pH and temperature of coagulation had a marked effect on the body and texture of chhana and its suitability for preparation of sweet meats.

Earlier reports indicated that good quality chhana can be prepared from buffalo milk with certain modifications in the processing techniques. Considering the availability of huge quantity of buffalo milk in India there is a great scope to utilize this milk for preparation of chhana. The present investigation was thus an attempt to improve the quality of chhana from buffalo milk by modifying the process parameters.

It is evident from the results that the sensory scores for body and texture and overall acceptability of chhana made from standardized buffalo milk at different coagulation temperatures differed significantly. Chhana made from cow milk (control) though recorded significantly highest scores
for body and texture and overall acceptability but the product made from
buffalo milk at all fat levels and coagulated at 70 and 60 °c temperature were
at par indicating that good quality chhana with desirable quality attributes can
be made from standardized buffalo milk.

Chhana obtained at 80 °c temperature exhibited significantly low
scores which may be attributed to hard body and more granular texture
indicating that this particular temperature is not desirable for getting quality
chhana. The results are in close agreement with those of Kundu and De
(1972) who reported that chhana obtained from buffalo milk at 80 °c had a
hard body and coarse texture and was not suitable for rasogolla making,
while at 70 °c chhana had a slightly soft body and smooth texture. Soni et al.
(1980) and Sen (1986) indicated that with lowering of coagulation
temperature, the moisture retention in chhana increases leading to softer body
and smooth texture. Lower coagulation temperature (50 °c) adversely affected
the body and sponginess of chhana indicating its unsuitability for making
rasogolla.

Results indicated significant improvement in the yield of chhana made
from buffalo milk over cow milk chhana. Increased yield may be attributed to
higher solids content of buffalo milk. With lowering of coagulation
temperature from 80 to 70 °c, the yield of buffalo milk chhana increased
steadily but thereafter declining trend was followed. Increase in yield at 70 °c
may be attributed to more retention of moisture which makes the product
slightly soft. Results are in close agreement with those of Kundu and De
(1980) who also reported increased yield of chhana at lower coagulation
temperature.

The total solids recovery was maximum in chhana made by
coagulating buffalo milk (4 % fat) at 70 and 60 °c temperature as compared to
that of buffalo milk chhana (5 & 6 % fat) and control chhana, but the solids
recovery of 5 and 6 per cent buffalo milk chhana was almost similar to that of
control chhana indicating that 60 and 70 °C temperature retained the solid constituents. The results are in agreement with those of Kundu and De (1972) who also reported maximum solids recovery in buffalo milk chhana. Higher solids recovery in chhana at 60 and 70 °C emphasizes better interaction of whey protein with casein due to which body and texture of product might have been improved (Ganguly, 1974).

It is evident that varying fat levels of buffalo milk did not show any significant difference in the scores of all the sensory attributes indicating that chhana made from buffalo milk with 4 and 5 per cent fat was equally good as compared to that made from buffalo milk with 6 % fat. Present findings with regards to quality of chhana made from buffalo milk (4 % fat) are contradictory but from buffalo milk with 5 % fat are in agreement to those reported by Kundu and De (1972). They reported that chhana made from buffalo milk with 5 % fat acquired slightly soft body and smooth texture which was similar to that of chhana from 6 % milk fat. In the present investigation, though the product made from buffalo milk (6 % fat) was comparable to 4 and 5 per cent fat in respect of sensory attributes but considering significant decline in fat recovery even at 60 °C, this particular treatment was not considered for subsequent trials.

Chhana with desirable quality attributes is generally made from cow milk. Chhana made from buffalo milk had a hard body and coarse texture which is not suitable for rasogolla making. To improve upon the body and texture, attempts were made to use sodium citrate as stabilizer. It is evident that addition of different levels of sodium citrate observed significant improvement in the quality of chhana. Body and texture and overall acceptability scores of chhana made from buffalo milk with 4 and 5 % fat added with 0.15 % sodium citrate were almost similar to that of control (cow milk chhana) indicating that desirable quality chhana could be produced from buffalo milk. Improvement in the quality of chhana made from buffalo milk
added with sodium citrate may be attributed to lowering of calcium content and alteration in salt balance which might have produced less firm coagulum. Present findings are in agreement with those of Iyer (1978) and Suguna Rao et al. (1989) who also reported that addition of sodium citrate in buffalo milk improved the quality of chhana.

Addition of sodium citrate in buffalo milk though improved the body and texture of chhana but per cent yield, total solids and fat recovery were marginally impaired. Buffalo milk standardized to 5 per cent fat added with 0.15 % sodium citrate recorded comparatively higher yield with lower fat and total solids recovery, while at 4 % fat, reverse trend was observed but the differences were marginal. Results are in close agreement with those of Suguna Rao et al. (1989) who reported higher total solids recovery in chhana made from buffalo milk added with 0.30 % sodium citrate than that of buffalo milk without stabilizer.

The textural quality of chhana is greatly influenced by the type and composition of milk. Earlier reports indicated that buffalo milk coagulated at higher temperature yielded chhana with hard and chewy body due to increased moisture expulsion. The present investigation aims to improve the rheological characteristics of buffalo milk chhana using sodium citrate without affecting its organoleptic quality. Results indicated that the hardness, springiness, gumminess and chewiness values were higher in chhana made from buffalo milk with 4 and 5 per cent fat as compared to that of cow milk chhana. But the cohesiveness values were almost similar. With incorporation of 0.15 per cent sodium citrate, the values of hardness, gumminess and chewiness declined to such an extent that these were almost equal to control chhana. This indicates that sodium citrate as a stabilizer played a key role in lowering down the textural properties comparable to that of cow milk chhana. Suguna Rao et al. (1989) reported that plain buffalo milk chhana was comparatively harder but the hardness and springiness values were
comparable to that of cow milk chhana, when prepared from diluted buffalo milk added with sodium citrate.

Type and composition of milk is one of the factors which greatly alters the chemical quality of chhana. It is evident that the composition of chhana made from buffalo milk (4 and 5 % fat) differed to some extent but the differences due to incorporation of 0.15 per cent sodium citrate were negligible except with slight decline in fat content. This indicates that sodium citrate has no any adverse effect on chemical quality of chhana made from buffalo milk. Suguna Rao et al. (1989) also reported non significant differences between the chemical composition of plain buffalo milk chhana and chhana made from buffalo milk added with 0.30 per cent sodium citrate.

The quality of rasogolla mostly depends on the type and composition of milk used for chhana making. It is indicated that the sensory scores in respect of colour and appearance, body and texture, juiciness and overall acceptability of rasogolla made from cow and buffalo milk chhana with and without sodium citrate did not differ significantly. Present findings are in agreement with Soni et al. (1980) who reported that the rasogolla prepared from buffalo milk chhana coagulated at 70 °C was rated as highly acceptable. Suguna Rao et al. (1989) also reported that rasogolla made from chhana obtained from diluted buffalo milk added with 0.30 per cent sodium citrate was equally acceptable as that of cow milk chhana.

Results indicated that the composition of rasogolla made from cow milk chhana and that made from buffalo milk with or without addition of sodium citrate differed significantly. The total solids, fat and total carbohydrates contents were higher in rasogolla made from cow milk chhana, whereas chhana made from buffalo milk with or without addition of sodium citrate had higher protein and moisture content, but the variations in these constituents were marginal. The decline in total solids content in rasogolla may be attributed to lower values of total carbohydrates content.
comparable to that of cow milk *chhana*, when prepared from diluted buffalo milk added with sodium citrate.

Type and composition of milk is one of the factors which greatly alters the chemical quality of *chhana*. It is evident that the composition of *chhana* made from buffalo milk (4 and 5 % fat) differed to some extent but the differences due to incorporation of 0.15 per cent sodium citrate were negligible except with slight decline in fat content. This indicates that sodium citrate has no any adverse effect on chemical quality of *chhana* made from buffalo milk. Suguna Rao *et al.* (1989) also reported non significant differences between the chemical composition of plain buffalo milk *chhana* and *chhana* made from buffalo milk added with 0.30 per cent sodium citrate.

The quality of *rasogolla* mostly depends on the type and composition of milk used for *chhana* making. It is indicated that the sensory scores in respect of colour and appearance, body and texture, juiciness and overall acceptability of *rasogolla* made from cow and buffalo milk *chhana* with and without sodium citrate did not differ significantly. Present findings are in agreement with Soni *et al.* (1980) who reported that the *rasogolla* prepared from buffalo milk *chhana* coagulated at 70 °C was rated as highly acceptable. Suguna Rao *et al.* (1989) also reported that *rasogolla* made from *chhana* obtained from diluted buffalo milk added with 0.30 per cent sodium citrate was equally acceptable as that of cow milk *chhana*.

Results indicated that the composition of *rasogolla* made from cow milk *chhana* and that made from buffalo milk with or without addition of sodium citrate differed significantly. The total solids, fat and total carbohydrates contents were higher in *rasogolla* made from cow milk *chhana*, whereas *chhana* made from buffalo milk with or without addition of sodium citrate had higher protein and moisture content, but the variations in these constituents were marginal. The decline in total solids content in *rasogolla* may be attributed to lower values of total carbohydrates content.
This might be due to slight hard and coarse texture of *chhana* from buffalo milk which has resulted in less absorption of sugar syrup.
Chapter 6

SUMMARY AND CONCLUSION

The present investigation was an attempt to explore the feasibility of using buffalo milk for obtaining desirable quality chhanna suitable for making rasogolla.

The body and texture and overall acceptability scores of chhanna made from buffalo milk with 4 and 5 per cent fat at 60 and 70 °C coagulation temperatures were almost similar to that of cow milk chhanna. Chhanna produced from buffalo milk at 80 °C temperature had hard and chewy body and coarse texture.

The per cent yield was highest in buffalo milk chhanna obtained at 70 °C coagulation temperature followed by 60 °C, whereas cow milk chhanna recorded significantly lower yield.

The fat and total solids recovery was higher in chhanna from buffalo milk with 4 per cent fat and coagulated at 60 and 70 °C temperature but the total solids recovery with 5 and 6 per cent fat milk was comparable to cow milk chhanna.

Cow milk chhanna though exhibited higher sensory scores but the sensory quality of chhanna made from buffalo milk with different fat levels and from cow milk did not differ significantly.

Addition of sodium citrate in buffalo milk improved the body and texture and acceptability of chhanna but the yield, fat and total solids recovery were affected marginally as compared to that made from buffalo milk without stabilizer.

The textural attributes viz. hardness, springiness, gumminess and chewiness of buffalo milk chhanna with addition of sodium citrate were comparable to that of cow milk chhanna. The chemical composition was also
comparable due to incorporation of sodium citrate except with slight decrease in fat content.

Though the chemical quality of rasogolla made from cow and buffalo milk chhana with or without addition of sodium citrate differed slightly but the rasogolla made from chhana were acceptable.

CONCLUSION:

Buffalo milk with 4 and 5 per cent fat and coagulated at 60 °c temperature yielded chhana with desirable sensory attributes but at 70 °c exhibited higher yields with better fat and total solids recovery.

The sensory quality of buffalo milk chhana was improved with incorporation of 0.15 % sodium citrate prior to heat treatment.

Acceptable quality rasogolla could be prepared from buffalo milk added with sodium citrate.
LITERATURE CITED


ABSTRACT

Abstract of dissertation of postgraduate student for the partial fulfilment of M.V.Sc. Degree.

Name of student : Chopde Ramesh Limbajirao

Regn.No. : 2000V6M

Major Subject : Dairy Science

Minor Subject : Cattle Management, Design of Experiment, Scientific Report Writing, Laboratory Technique and Physiology of Lactation.

Major Advisor : Dr. P.N. Zanjadi
Professor of Dairy Science
College of Veterinary & Animal Sciences, MAFSU, Parbhani.

Title of Research Topic : Studies on quality of Chhana from Buffalo milk and it's suitability for making Rasogolla.

A study was undertaken to assess the quality of chhana made from buffalo milk at different coagulation temperatures and its suitability for making rasogolla. Chhana was prepared from buffalo milk containing 4.5 and 6 percent fat and coagulated at 80, 70, 60 and 50°C coagulation temperatures. Sodium citrate was added before coagulation @ 0.05, 0.10, 0.15% to achieve further improvement in quality of buffalo milk chhana suitable for making rasogolla.

The body and texture and overall acceptability scores of buffalo milk chhana at 60 and 70°C were almost similar to that of cow milk chhana. Highest yield, fat and total solids recovery were recorded in buffalo milk chhana prepared at 60 and 70°C. However, chhana made from buffalo milk with different fat levels did not differ significantly in sensory quality.

Addition of 0.15 per cent sodium citrate in buffalo milk improved the scores for body and texture and acceptability of Chhana but the yield, fat and total solids recovery affected marginally as compared to its control. Further the values of rheological parameters (hardness, cohesiveness, gumminess, springiness and chewiness) of chhana from cow milk and buffalo milk with 0.15 per cent sodium citrate were nearly same. Thus, it was concluded that good quality rasogolla can be made from standardized (4% fat) buffalo milk chhana with addition of 0.15 per cent sodium citrate.