A STUDY TO STANDARDIZE THE MANUFACTURING TECHNIQUES OF BUFFALO MILK ROSOGOLLA AND TO EVALUATE THE PHYSICO-CHEMICAL CHANGES DURING ITS MANUFACTURING AND STORAGE

Thesis

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By

ASITAVA SUR

M.Sc. Dairying (D. Chem.),
B.Sc. (D.Tech.), Gold Medalist.

DEPARTMENT OF DAIRY CHEMISTRY
FACULTY OF VETERINARY AND ANIMAL SCIENCE
BIDHAN CHANDRA KRISHI VISWAVIDYALAYA
MOHANPUR, NADIA - 741 252
WEST BENGAL

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Regd. No. Ph.D. Vety. 1 of 1987-88

IN MEMORY

OF MY FATHER

Prof. A.K. Bandyopadhyay, M.Sc., Ph.D.
Head of the Department.

DEPARTMENT OF DAIRY CHEMISTRY
F/O. VETERINARY AND ANIMAL SCIENCE
BIDHAN CHANDRA KRISHI VISWAVIDYALAYA
MOHANPUR, NADIA, W.B. 741 252.

Dated : 10th April 1995.

This is to certify that the work recorded in the thesis entitled "A Study to standardize the manufacturing techniques of buffalo milk rasogolla and to evaluate the physico-chemical changes during its manufacturing and storage" submitted by Sri Asitava Sur was carried out by himself under my supervision and guidance. The research conducted by Sri Sur is a bonafide investigation and not submitted elsewhere for any other degree or diploma. The assistance during the course of investigation have been duly acknowledged.

(A.K. BANDYOPADHYAY)

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10.4.95

(ASITAVA SUR)

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CHAPTER - I

INTRODUCTION

1. INTRODUCTION

Rosogolla, one of the most popular chhana based sweetmeat of Bengal, is a delicate indigenous milk product with complex physico-chemical characteristics. It is manufactured by acid coagulation of boiled hot milk and subsequent drainage of whey. This coagulum is then cooked in sugar syrup after kneading them with some additives and making small balls. Finally these cooked balls are soaked in sugar syrup again.

Though rosogolla has been reported to exist since 1868 (Bhattacharya, 1987) as a brain child of Mr. Nabin Chandra Das of Calcutta and is being reproduced since then by thousand others, its actual manufacturing technique has neither been properly reported nor standardized. Thus it has remain an exclusive purview of sincere and articulate artisans commonly known as Halwais.

In recent past the popularity of this ancient delicacy has crossed the limit of Bengal, Eastern India, India as whole, and now being marketed throughout the world. But still the method employed for the manufacture have essentially remained unchanged and confined to the unorganised sector over the years. This fact could drag the attention of the scientists and the organised dairies as well, to make inroad into the intricacies of its method of manufacture. However, the standardization of the product in respect of compositional and physico-chemical characteristics has yet not been done completely. The paucity of adequate published information has kept the food law authorities silent in enforcing the detailed legal standards applicable to the product.

All the success that the organised sector still has in its hand is with cow milk only, since it has been found that only cow milk can produce the desired body and texture of rosogolla, whereas buffalo milk the predominant one in India (48.1% of the total milk produced vide FAO, 1992) has failed to produce good quality rosogolla because of its typical chemical composition and structure. To give this traditional product an organized shape, it was evident to go for a standardised technology for manufacturing rosogolla from buffalo milk more so in order to avoid the regional supremacy and utilization of the higher total solids in buffalo milk. Recently, some scattered trials have been made to suitably replace the cow milk but with limited success only.

Because of non-availability of proper legal standard and standardized methodology for manufacturing, the traders sell a myriad variety of rosogolla which varies from shop to shop and even batch to batch. However, in the Industry there are mainly two types of rosogolla :

(1) Spongy variety which is generally prepared from fresh chhana without any additives, and

(2) Soft variety which is commonly made up from aged chhana alongwith some additives like suji, maida, samudder jhaag, baking powder etc.

Since buffalo milk is known to produce a hard body and coarse textured chhana, whatever trials have been initiated with buffalo milk they were to produce softer variety only. The other variety has been kept aside for future workers.

As a consumable food item, with high moisture content storage of rosogolla has been detected as one of the most serious problems. Therefore, alongwith a standardized method of manufacture, one must look for a suitable packaging for higher storage life. Studies in this line are again not available.

The proposed series of studies were therefore, taken up to optimise the manufacturing of rosogolla from buffalo milk, to evaluate the physico-chemical changes during its manufacturing and storage with suitable packaging.

CHAPTER - II

REVIEW OF LITERATURE

2. REVIEW OF LITERATURE

The interest of the scientists has been shifted towards Indian dairy products in the recent past, because of their complex physico-chemical characteristics and huge international acceptance.

Popularitywise, rosogolla has always been placed onto the top of the Indian dairy products. The acceptability of rosogolla depends on its body, texture, flavour and colour. The physico-chemical make up of the product is very complex in nature and not well defined. However, it is clear that though manufacturing of rosogolla needs a short span of time, the milk has to go a long way in terms of chemical changes to take the final shape. The primary step for manufacturing rosogolla is the preparation of its base, namely chhana. Since chhana serves the medium of some other Indian dairy products like sandesh, chum-chum, pantoa, chhana kheer, chhana murki etc. as well, larger number of literature is available in this respect. Traditionally rosogolla is being prepared from cow milk, hence more of published informations has also been found with cow milk. In the present review the aim is to discuss about the manufacturing of it from buffalo milk but most naturally previous informations about cow milk has also been dealt with specific reference to the differences in the physico-chemical make up of cow and buffalo milk and modifications tried with buffalo milk. Influence of different packaging materials and additives on the preservation of rosogolla have also been described for a better understanding of the possible packaging system of rosogolla. While reviewing special emphasis has been laid towards the available data on the physico-chemical changes of the product during storage.

2.1 Transformation of Milk to Chhana.

Chhana is the most important phase which comes during the manufacture of rosogolla. It occupies a prominent place in the Indian dairy industry and is extensively used as a base for preparation of various Indian dairy products. According to PFA (1976) chhana is the product obtained from cow or buffalo milk or a combination thereof by precipitation with sour milk, lactic acid or citric acid. It should not contain more than 70% moisture, and the milk fat content should not be less than 50% of the dry matter.

2.1.1 **Production of chhana** :

Chhana has been reported to be manufactured since long as a traditional product. Davies (1948) has given a detailed account regarding its manufacturing in domestic and commercial scales. The process of coagulation of milk in Chhana was regarded due to combined chemical and physical changes in the casein by action of acid at a high temperature. This involves the formation of large structural aggregates of casein or curd from the normal colloidal dispersion of discrete casein micelles in which fat and coagulated serum proteins are entrained together with whey. In forming coagulum, the dispersed phase separartes entirely from the dispersion phase as a flocculant precipitate. During the process of boiling and subsequent coagulation by addition of acid, the casein micelles lose a part of its calcium and phosphate.

The conventional method of chhana preparation was described by Ray and De (1953) with variable parameters, Srinivasan and Anantakrishnan (1964) have also delineated preparation of chhana by batch method for small quantity of 0.5 to 1 kg. and bulk method for a voluminous production. In these methods basically milk was heated to boiling and transferred to a vessel. Aged acidic chhana whey, citric acid or lactic acid was added to milk till coagulation was completed. The milk was gently stirred during curdling. The content was then emptied over a piece of cloth held over another vessel and the whey was allowed to drain. The curd collected was named channa.

However, the traditional methods of chhana making was time consuming and labour intensive. The product was usually produced under unsanitary environment. A method for continuous production of chhana on large scale was developed by Aneja et al (1977) to produce 40 kg. of channa per hour. The device was further modified by the same group (1982) for better functioning without interference. Kishore and Aneja (1981) included a mechanical strainer for drainage of whey into the continuous chhana making equipment. The moisture content of the final chhana was adjusted to around 55% when it came out from the conveyor into the packaging bucket. Tarafdar et al (1988) developed another mechanical system for chhana making and used for suitable chhana production at a low pH.

2.1.2 Production of chhana from buffalo milk :

Channa made from pure cow milk was reported to have a soft body and smooth texture suitable for rosogolla preparation whereas pure buffalo milk was found to produce hard body and coarse textured chhana which is not suitable for rosogolla preparation (Ray & De 1953). This is because of variation in the physico-chemical status of cow and buffalo milk.

2.1.2.1 Physico-chemical status variation in cow and buffalo milk :

It is evident that buffalo milk contains higher proportion of fat, protein, lactose and minerals in comparison to cow milk. Buffalo milk is known for its higher pH, acidity, density, viscosity, buffer value, etc. Casein in buffalo milk mostly exist in micellar form while in cow milk soluble casein is present in higher concentration. Buffalo milk casein is less heat stable than that of cow milk. Fox (1978), and Ganguli and Majumdar (1967) reported a higher amount of casein in buffalo milk than that of cow milk. Buffalo milk has been reported to contain 44.4, 52.4 and 3.1 per cent of alpha, beta and gamma casein respectively by Ganguli and Bhalerao (1964), whereas the respective concentration in cow milk were 54.5, 39.0 and 6.4 per cent. So buffalo casein contains more of beta fraction than alpha fraction whereas the reverse is true with cow milk. Buffalo milk has been reported to have half the amount of sialic acid in comparison to cow milk. Ganguli (1973, 1976) has revealed that buffalo milk do not contain any genetic varient of alpha lactalbumin and beta lactoglobulin.

The fat globule size of buffalo milk is higher than that of cow milk, Rama Murthy and Narayanan (1971, 1972) found higher concentration of butyric acid, palmitic acid, stearic acid and oleic acid in buffalo milk fat compared to that of cow milk and lower concentration of caproic, caprylic, capric, lauric and myristic acid which made buffalo milk curd harder. Buffalo milk is also known for its higher concentration of calcium, magnesium and lower concentration of citrate and phosphate in comparison to cow milk. The soluble ionic form of calcium, magnesium and citrate are also lower in buffalo milk than in cow milk. Ismail (1971 and 1971b) and Menon and Ganguli (1971) found that buffalo milk contained larger amounts of colloidal calcium and phosphorus than cow milk.

2.1.2.2 **Changed methods of buffalo chhana production** :

Since buffalo milk was not found suitable for good quality chhana production, scientists looked into the status of the milk and its variation with cow milk and then started modifying the milk system for better quality chhana. De and Ray (1954) has suggested addition of 25% buffalo milk in cow milk could give satisfactory quality of chhana. Date et al (1958) reported a satisfactory quality chhana from buffalo milk standardized at 4.0 to 5.0% fat level. They suggested boiling of milk for 5 min and subsequent cooling to a temperature of 10-15°C before curdling with 0.5 to 0.75% lactic acid.

Jagtiani *et al* (1960) tried ion exchange resin to reduce calcium load of buffalo milk for satisfactory quality of chhana but reported to have no effect. Kundu and De (1972) demonstrated a modified method for buffalo milk chhana by standardizing the milk to 5% fat, homogenising at 176 kg./Cm^2 at 60°C and then put to boil followed by subsequent cooling to 70°C for rapid coagulation by 1% citric acid. They advised to cool the chhana beneath tapwater after draining the whey. Soni *et al* (1980) advocated delayed straining of chhana curdled at 70°C and pH 5.7 for suitable quality chhana. The workers tried trypsin treatment of buffalo milk for a better quality of chhana but with no favourable result. Ahmed *et al* (1981) prescribed a similar method. Gera (1978) observed the modification suggested by Iyer (1978) by addition of sodium dihydrogen phosphate and disodium hydrogen phosphate (9 gm+ 7 gm for every 12 lt. of buffalo milk) or mixing of 0.1 to 0.2 per cent sodium citrate to improve the rheological properties of chhana from buffalo milk, Rajorhia (1987) advised the following modifications for good quality chhana from buffalo milk. He suggested to standardize the milk at 4.0 to 4.5% fat, homogenization at 140 kg./Cm^2, addition of 0.05% sodium citrate prior to boiling, dilution with 25% potable water and coagulation with 1% citric or lactic acid solution. According to him calcium lactate was the most suited coagulant for improving body, texture and flavour of chhana.

2.1.3 Factors affecting quality of chhana :

2.1.3.1 Effect of dilution :

Since cow milk has been found to be suitable for chhana preparation, dilution was found as a most effective tool for lowering down the solid content in buffalo milk. De and Ray (1954) suggested dilution of buffalo milk with 75% cow milk for getting satisfactory chhana. Aneja et al (1977) supported these results. Iyer (1978) and Rajorhia (1987) reported a better quality of chhana by diluting buffalo milk with 25% water.

2.1.3.2 Effect of homogenization :

It was thought the size of fat globule might affect the final quality of chhana and therefore, homogenization was tried by various workers. Kundu and De (1972) reported homogenization at 176 kg./Cm^2 pressure of buffalo milk to produce a harder chhana which was not favourable for rosogolla production. Aneja et al (1977) found similar results which was confirmed by Ahmed et al (1981) and Soni et al (1980) at a lower pressure of 140 kg./Cm^2. kanwaji̇a and Rao (1975) however, did not notice any favourable effects of homogenization which again was supported by Gajendran and Rao (1976) and Iyer (1978). Rajorhia (1987) however, suggested homogenization at lower pressure to produce better quality chhana for sandesh preparation.

2.1.3.3 Calcium level of milk :

The calcium content of milk was reported to have a positive correlation with the hardness of chhana by Ismail et al (1971) and supported by Jagtiani et al (1960). Baisya and Bose (1974) observed that the addition of clacium and magnesium chloride to milk produced a softer chhana. Jagtiani et al (1960) however, failed to produce a softer chhana by reducing the calcium load of buffalo milk by ion exchange resins.

2.1.3.4 Enzyme action :

In order to break the proteins, proteolysis was tried by Soni et al (1980) by trypsin for a better quality of chhana. The coagulum however, was not found suitable for rosogolla preparations. Jagtiani et al (1960) tried the enzyme renin also for a softer variety of chhana but failed. The results were confirmed by Soni et al (1980).

2.1.3.5 **Fat content in milk** :

Fat level in milk was tried by various workers for its effects on the final quality of chhana. Ray and De (1953) observed 4.0 to 5.0% fat in cow milk as most suited. Bhattacharya & Desraj (1980) confirmed the earlier results and preferred 3.0 to 4.0% fat level. Buffalo milk has also been found to give the best results at a fat level of 4.0 to 4.5% . Bhattacharya & Desraj (1980)came to a conclusion that higher fat percentage in milk would give rise to a softer chhana but with higher fat loss in the whey.

2.1.3.6 Presence of colostrum :

A pasty chhana has been found by Srinivasan and Anantakrishnan (1964) when colostrum was present in the milk. This chhana was not fit for the production of rosogolla. De and Ray (1954) detected a deeper yellow colour in the chhana made from colostrum.

2.1.3.7 Effect of different additives :

In order to achieve better chhana, some additives have been tried by many workers. De and Ray (1954) observed a gelatenous or gummy chhana when starch was added into milk. Srinivasan and Anantakrishnan (1964) supported the results of the earlier workers. Chandrasekhara et al (1957) advised the addition of sodium dihydrogen phosphate and disodium hydrogen phosphate in buffalo milk for a better quality of chhana. Baisya and Bose (1974) observed a softer chhana when calcium and magnesium chloride was added into the milk whereas sodium chloride, sodium citrate and sodium acetate did not affect the body and texture of chhana significantly.

2.1.3.8 **Effect of coagulating medium and its strength** :

The coagulating medium has been found to affect the final quality of chhana to a great extent. Many coagulant has been tried with different concentration by different workers. De and Ray (1954) observed that use of 1 to 2% citric acid produced soft and smooth chhana. Date et al (1958) found 0.5 to 0.75% lactic acid to be a more suitable coagulant for obtaining superior quality of chhana. Kundu and De (1972) used 1% citric acid for a standardized method of chhana production. Singh and Ray (1977) reported citric acid as the best coagulant since it was not found to impart any flavour in the chhana whereas lactic acid and sour chhana whey resulted in slightly sour taste and acidic flavour. Bhattacharya and Desraj (1980) also advocated for citric acid but at a lower strength of 0.8%. De (1976) concluded that lactic acid tended to produce a granular texture in chhana which was suitable for rosogolla preparation whereas citric acid tended to produce a pasty one which was suitable for sandesh preparation. Soni et al (1980) obtained good quality chhana from buffalo milk by using lactic acid at a concentration of 0.5%. Sen and De (1984) detected the use of calcium lactate for chhana preparation and subsequently Sen and Rajorhia (1986) could prepare good quality chhana with calcium lactate which they prescribed to be suitable for sandesh preparation. Rajorhia (1987) advocated for the use of lactic acid or citric acid of 1% strength for production of good quality chhana from buffalo milk.

2.1.3.9 pH and temperature of coagulation :

Various informations revealed that the pH and temperature of coagulation after boiling the milk plays a vital role for the final yield. De and Ray (1954) observed that the pH of coagulation between 5.4 to 5.5 produced soft and smooth chhana while lower pH produced chhana with hard texture. Kundu and De (1972) reported pH 5.7 at 70°C temperature as the optimum condition for coagulation. These results were corroborated by Ahmed et al (1981). Chandrasakhara et al (1957)suggested a very high temperature of curdling of 92 to 95°C for buffalo milk chhana. Srinivasan and Anantakrishnan (1964) was however, opined for pH 5.3 as the optimum level. Soni et al (1980) while working with buffalo milk observed a temperature below 60°C and above 80°C was unsuitable for chhana to prepare rosogolla. Bhattacharya & Desraj (1980) found a pH of 5.4 at a temperature between 80°C to 90°C as the most suitable one for cow milk chhana to prepare rosogolla. They found the rosogolla was not acceptable if the chhana was curdled at lower pH of 5.2.

2.1.3.10 **Effect of the method of straining** :

The fctor is reported to affect the body and texture of chhana by influencing the moisture retention. Generally two methods have been tried extensively. One is immediate straining where the chhana is immediately strained and cooled the other one is delayed straining where the coagulated mass is left in whey loosely enclosed in a piece of cloth so as to cool at ambient temperature. Kundu and De (1972) advocated for the latter method for better quality of chhana. Bhattacharya and Desraj (1980) however, preferred immediate straining. Soni et al (1980) on the contrary preferred delayed straining for producing buffalo milk chhana. Singh and Ray (1977b) however, failed to find out any differences in the final quality of chhana by these two different process of straining.

2.1.4 Yield and composition of chhana :

The yield and composition of chhana largely depend upon the initial composition of milk, moisture retained in chhana, and loss of milk solids in chhana. Whey was reported to indirectly affect the composition of chhana. Kundu and De (1972) concluded an average yield of chhana from cow and buffalo milk to be as 16 to 18% and 22 to 24% respectively. De (1976) confirmed their earlier findings. Ray and De (1953) reported the average moisture, fat, protein, lactose and ash content of cow and buffalo chhana as follows : 53.4, 24.8, 17.4, 2.1 & 2.0 and 51.6, 29.6, 14.4, 2.3 & 2.0% respectively. Srinivasan and Anantakrishnan (1964) came out with the following results in a similar experiment. They found 53.4% moisture ,24.7%, fat 17.6% protein, 2.2% lactose and 2.1% ash in cow chhana whereas 51.6% moisture, 29.6% fat, 14.5% protein, 2.4% lactose and 1.9% ash in buffalo chhana, Kumar and Srinivasan (1982) studied the composition of cow and buffalo chhana in a similar fashion alongwith market chhana and reported market chhana to contain 62.3% moisture, 16.1% fat, 17.1% protein, 2.2% lactose and 2.2% ash. Cow chhana in their experiment showed 53.1% moisture, 24.8% fat, 17.8% protein 2.2% lactose and 2.1% ash. Whereas the composition of buffalo milk chhana was 51.7% moisture 29.7% fat 14.4% protein 2.3% lactose and 1.9% ash. The reports revealed wide variations. However, in general buffalo milk chhana thus reported to have more total solids. The moisture content of all the chhana sample was much lower than the maximised prescribed level by PFA.

2.1.5 Microbiological quality of chhana :

Chhana being a dairy product with high moisture content is highly prone to microbial contamination. The microbiological quality of chhana thus indicates the condition of manufacturing, storage, initial quality of milk, chances of post boiling contamination, age etc. of the product. Relatively fewer studies have been undertaken in this direction. In 1955 a study had been carried out at NDRI, Bangalore for total viable count and mould count per gm. of market chhana. The study revealed a huge total viable count per gm. of chhana as 16.0 X 10^3 which further increased to 11.0 X 10^7 after 48 Hours of storage and mould count per gm. of chhana as 260 which was increased to 3.85 X 10^5 after 48 hours of storage (Anon, 1955). The most common types of mould contaminent in chhana samples were of penicillium, aspergillus, mucor, rhizopus, fusarium and paecilomyces. In a more detailed study Singh and Mukhopadhyay (1975) reported total plate count ranging from 0 to 9X10^6 per gm., coliform count 0 to 139X10^5 per gm., staphylococcus count 0 to 22X10^4 per gm. and yeast and mould count 0 to 77X10^4 per gm. of market chhana which revealed poor conditions of manufacturing and storage of this product. Kumar and Srinivasan (1982b) also corroborated the above results in a comparison of microbiological quality of market chhana and laboratory prepared chhana.

2.1.6 Composition of chhana whey :

Chhana whey is the by product obtained during the production of chhana from milk. Generally, this whey is drained but it retains most of the water soluble solids of milk which is almost half the total solid content of milk. However, the composition of chhana whey indirectly reflects the composition of chhana. Srinivasan and Anantakrishnan (1964) stated that chhana whey contained lactose, minerals, water soluble vitamins and a small portion of milk protein and milk fat. The composition of chhana whey was found to be affected by the strength of coagulant, pH and temperature of coagulation, mode of straining etc. Whey from cow milk have been reported to contain lesser lactose and fat in comparison to the whey from buffalo milk. However, no significant difference in ash and protein content was detected. On ageing, chhana whey has been found to be soured by the production of lactic acid from lactose and this old whey has been reported to be used for curdling.

2.2 Transformation of Chhana to Rosogolla.

The final product is taken into a desirable shape from the intermediate phase of chhana through different steps namely kneading of chhana, cooking of chhana in sugar syrup and soaking of the cooked balls in another sugar syrup. Because of paucity of published informations PFA authority has yet not described any standard for rosogolla. However, Bureau of Indian standard has specified the following for canned rosogolla vide IS : 4075 (1967).

A. Requirements of Rosogolla :

	Characteristic	Requirement
1.	Moisture, percent by weight	Max. 55.0
2.	Fat percent, by weight	Min. 5.0
3.	Sucrose, percent by weight	Max. 45.0
4.	Protein, percent by weight	Min. 5.0

B. Requirements for Syrup :

	Characteristic	Requirement
1.	Acidity, ml of N/10 NaOH required to neutralize 100 ml of syrup	Max. 6.0
2.	Concentration	Max.55° Brix
3.	Bacterial count per gm.	Max. 500
4.	Coliform count per gm.	Nil

2.2.1 **Production of rosogolla :**

In the Industry there are mainly two types of rosogolla (i) 'Spongy variety' which is generally prepared from fresh chhana without any additives and (ii) 'Soft variety' which is commonly made up from aged chhana alongwith some additives like wheat flour, suji, maida, samudder jhag, baking powder etc. Date et al (1958) delineated the traders technique of preparation and packaging of rosogolla in general. Cow milk chhana was kneaded with or without any additives to a smooth consistency and cut into small chhana balls which were then cooked in a clarified sugar syrup known as cooking syrup. After complete cooking, the balls were taken into another clarified sugar syrup of thinner consistency commonly known as soaking syrup. Rosogolla alongwith this soaking syrup were filled in stailized cans and sealed during hot condition and then subsequently cooled under tap water. Most of the other workers (De and Ray, 1954, Goel, 1970, Bhattacharya and Desraj, 1980 and Soni et al, 1980) followed the same method and tried to standardize the above parameters. De (1976) suggested sprinkling of water during cooking, to maintain the sugar concentration of the cooking syrup by replacing the evaporated water. In later experiments Bhattacharya and Desraj (1980) and Soni et al (1980) followed the same and found better results. Bhattacharya and Desraj (1980b) suggested use of pressure cookers maintained at a pressure of 1 kg./Cm.^{2} to avoid the evaporation and employed a quicker cooking within 2 to 4 min. There is a patented dry rosogolla mix containing dried casein materials with Hindusthan Lever Ltd. (1972). Tarafdar et al (1988) frormulated a mechanical kneading system to replace manual kneading and reported satisfactory results. Tarafdar et al (1988) had also suggested cooking of the chhana balls in plain water and the soaking into a comparatively thicker soaking syrup which they had advocated to produce better results.

2.2.2 **Production of rosogolla from buffalo chhana** :

Rosogolla is traditionally been prepared from cow milk chhana only. Ray and De (1953) declared pure buffalo milk chhana to be non suited for rosogolla preparation. Soni et al (1980) has prescribed a method of preparation of rosogolla from buffalo milk Chhana. They had recommended a similar method only as has been outlined by De and Ray (1954) for cow milk chhana, along with few changes in the process parameters like addition of additives, cooking syrup and soaking syrup concentration, and modification in chhana production as has been discussed earlier.

2.2.3 **Factors affecting quality of rosogolla** :

2.2.3.1 **Composition of chhana** :

Since rosogolla is prepared from chhana, it is obvious that the composition of chhana affects the final quality of rosogola. Bhattacharya and Desraj (1980) reported a moisture level of 50 to 58% as the most desirable limit for good quality and acceptability of rosogolla in respect to its body and texture. Ray and De (1953) observed the composition of cow chhana was suitable for rosogolla preparation whereas that of buffalo chhana was not. De and Ray (1954) reported excessive greasiness in buffalo milk chhana due to high fat content making it unsuitable for rosogolla. Dubey and Bhargava (1980) suggested 3 to 4% of fat in chhana for an acceptable rosogolla, since they observed hard rind and lack of softness in rosogolla when prepared from chhana with 1 to 2% fat and flattened shaped rosogolla when prepared from chhana with 5 to 6% fat. Bhattacharya and Desraj (1980) observed best rosogolla with 3.5% fat in cow chhana. They reported higher fat loss in other fat concentrations.

2.2.3.2 Effect of additives:

Various additives have been tried with chhana for a good quality rosogolla. Srinivasan and Anantakrishnan (1964) used 50 to 100 gms of corn or maize flour, 50 mg. of boneol or edible camphor, 1 gm. of powdered cardamom and 50 mg. of baking soda with 100 gm. of chhana for good quality of rosogolla from cow milk. Goel (1970) used ritha in the cooking syrup and observed better cooking. Soni et al (1980) obtained good quality rosogolla from buffalo milk chhana by adding 2.125 gm. of suji, 8.50 gm. of maida, 1.50 gm. of samudder jhag to 250 gm. of chhana before kneading.

2.2.3.3 Cooking syrup concentration :

Since rosogolla is being cooked in this syrup, its concentration is likely to affect the physico-chemical quality of rosogolla. Date et al (1958) found 55-60% syrup concentration as the best for cooking whereas Srinivasan and Anantakrishnan (1964) suggested 60% sugar syrup for cooking. Singh and Ray (1977b) also found good results of cooking at 55% sugar syrup. All the above experiments were being carried out with cow milk. Soni et al (1980) used 80% sugar syrup for cooking which they advocated as the most suited one for buffalo milk chhana. Bhattacharya and Desraj (1980) tried many concentration of sugar for cooking cow milk rosogolla and suggested a range of 50 to 60%, 55% being the optimum. Tarafder et al (1988) deviced cooking in plain water followed by dipping in soaking syrup and opined for that.

2.2.3.4 Time and temperature of cooking :

Date et al (1958) suggested a cooking time between 20 to 30 min. at boiling temperature which has been corroborated by all later workers namely De (1976), Singh and Ray (1977). Bhattacharya and Desraj (1980) observed brown discolouration, hard body, decomposed texture and decomposition of rosogolla when cooking for higher span of time, and soft body, less spongy and raw flavoured rosogolla when cooked for a smaller span of time. Bhattacharya and Desraj (1980b) deviced a quicker cooking at a higher pressure of 1 kg./Cm.^{2} in a pressure cooker and found satisfactory results.

2.2.3.5 Evaporation of water during cooking :

While rosogolla is being cooked at a boiling temperature, water from cooking syrup gets evaporated. Srinivasan and Anantakrishnan (1964) detected this phenomenon to disturb the body of rosogolla. De (1976) suggested sprinkling of water during cooking, in order to replace the water and thus avoided the defect. In later experiments Bhattacharya and Desraj (1980) and Soni et al (1980) confirmed it. Bhattacharya and Desraj (1980b) while cooking in pressure cooker, avoided the sprinkling of water by minimising the chances of evaporation.

2.2.3.6 Soaking syrup concentration :

Soaking syrup, where the rosogolla finally remains in, had been reported to affect the quality of rosogolla. Date et al (1958) found 50 to 55% sugar concentration as the best for soaking medium which was little lower than that of the cooking one. But Srinivasan and Anantakrishnan (1964) opined for the same concentration level of 60% in the soaking syrup as well. Soni el al (1980) however suggested a far lower concentration of sugar for soaking (40%) for buffalo rosogolla. Tarafder et al (1988) suggested 57.50 Brix soaking syrup sugar concentration after cooking in plain water.

2.2.4 Composition of rosogolla :

The composition of rosogolla largely depends upon the initial quality of chhana, its chemical composition and process parameters like sugar syrup concentration, cooking time temperature combination, kneading, additives. Finally the storage conditions and drainage of sugar syrup also affects the composition. Mitra et al (1967) analysed different types of rosogolla from Calcutta market. On the basis of the body and texture, the products were placed in two categories namely 'Ordinary' and 'Sponge'. Starch was absent in ordinary rosogolla. Chemical analysis revealed 38.3% moisture, 7.3% fat, 43.6% sucrose and 6.2% protein in the ordinary category. The sponge rosogolla had 50.0% moisture, 5.3% fat 37.0% sucrose and 5.5% protein. Singh and Ray (1977) compared the composition of market rosogolla with rosogolla prepared by three different coagulant namely citric acid, lactic acid and soured whey. Moisture percentage was noted 37.99, 45.57, 51.35 and 52.24% in the respective categories. Fat percent in those samples were 5.66, 7.15, 6.70 and 6.03% whereas the sucrose content were 48.16 39.57, 36.31 and 35.73% respectively. Sharma and Zariwala (1978) in a similar study to assess the composition of market rosogolla of Bombay, reported 29.70 to 53.40% moisture 2.00 to 9.00% fat, 10.60 to 59.40% sucrose. Soni et al (1980) while preparing rosogolla from buffalo milk compared their rosogolla composition with those of Karnal market rosogolla and Yamuna nagar market rosogolla. They reported 37.00, 30.90 and 35.20% of moisture in these three categories. Fat was found to be 4.20, 5.70 and 4.60% respectively, whereas sucrose concentrations were 51.30, 55.10 and 53.60 respectively. These results shows a huge variation in the composition of rosogolla which is evident because of lack of any standardized method.

Since the sugar syrup had also been noted to differ in their qualities, Singh and Ray (1977) studied the sugar syrups of market rosogolla and compared them with syrup prepared by Singh et al (1975). Sugar concentration found in market samples, samples prepared using lactic acid, samples prepared with citric acid and samples prepared with sour whey were 52.9, 38.4, 36.9 and 38.6% respectively. The specific gravity in the respective order were 1.25, 1.17, 1.16 and 1.17. The acidity in terms of 0.1 (N) NaOH solution required to neutralize 100 ml. of syrup in the respective samples were 8.4, 3.9, 5.1 and 3.9% respecttively. The poor manufacturing conditions of market rosogolla was clearly revealed by the last parameter.

2.2.5 Microbiological quality of rosogolla :

Comparatively lower number of works had been carried out to assess the mocrobiological qualities of rosogolla. Date et al (1958) reported an early spoilage of market canned rosogollas which was evident by souring, bleaching and off flavour development. They made the following factors like improper sealing, absence of vaccum packing, poor sterilization of the cans before packaging and lower concentration of sugar syrup responsible for tne early spoilage. Singh and Mukhopadhyay (1975) studied market rosogolla for different kind of microbes and reported the presence of all types of organisms including coliforms, staphylococci and yeast & moulds. However they observed absence of some organisms in few samples. The total count, coliform count, staphylococcal count and yeast & mould counts were reported to remain within 0 to $127X10^3$, 0 to $154X10^1$, 0 to $57X10^2$ and 0 to $3X10^3$ per gm. respectively. There studies again revealed the wide variations in the processing condition and storage atmosphere of rosogolla in the market.

2.2.6 Rheological quality of rosogolla :

The final acceptibility of rosogolla is largely dependent on its body and texture. De and Gupta (1971) stated that the assessment of the body and texture of dairy products by the grader carried out by subjective tests were dependent on the accuracy and consistancy of human observation and were subject to certain physico chemical errors including adaptation and contrast effects. The terms used by the graders to describe various qualities of body and texture did not always correspond to the qualities expected by the consumers. Mechanical or instrumental methods of measuring such properties were obvious. Friedman et al (1963) and Szczesniak et al (1963) came up with an innovative general food texture profiling technique for both sensory and instrumental analysis of textural properties of foods. The instrumental analysis was performed with a Texturometer that simulated the chewing action of mouth by compressing a 'bite-size' piece of food and subjected twice to 70-80% compression simulating two sensory bites. The force time relationship was plotted on a high speed recorder and analyzed to give textural parameters for solid foods viz. hardness, cohesiveness, elasticity which has later been named as springiness by Szczesniak (1975), adhesiveness- brittleness which later been named as fracturibility, chewiness and gumminess and each of these parameters were correlated with the results of sensory pannel, Bourne (1968, 1974) adapted the instrumental part of texture profile test to the Instron testing machine by compressing 1 Cm. cubes of food, two times in a reciprocating linear cyclic motion to 80% of their original height. Henry and Katz (1969) used the Instron to assess the textural profiles of semi solid foods and added the adhesion portion of the textural profile. Breene(1975) reviewed the principles and application of texture profile analysis (TPA).

Since no published information was available regarding textural profile analysis of rosogolla, earlier informations could not be studied. De and Gupta (1971) felt the necessary of such studies with all Indian dairy products but the future workers did not pay much attention in this respect. From the analysis done with different varieties of cheese, it was evident the textual properties of rosogolla may not be related to those of cheese.

2.2.7 Sub-micro structure of rosogolla :

The study of submicroscopic structures of various milk gels has revealed the orientation of different components in the product resulted by the complex interaction between them. Since a wide variation in the final body and texture of rosogolla has been noted it may be interesting to find out how does the different components exist in the final product. As is evident from the manufacturing techniques, it is obvious that milk has to undergo lot of changes during processing with particular reference to boiling, acid curdling, kneading, cooking in hot sugar syrup etc. The submicro structure of rosogolla will be unique in its kind and there is no published literature available. However the submicro structures of other products may throw some light to the actual structure of rosogolla. Calapji (1968) studied the corpuscular micro structure of milk and noted casein micelles which were basically protein globules of approximately 100 nm. in diameter. The low content of structural solids in gelled milk were reported to produce high porosity in the protein matrix. Henstra and Schmidt (1970) observed the fat globules whose size was dependent whether the milk had been homogenized or not. Kalab & Harwalkar (1973) studied variety of food gels including heat induced and acid heat milk gels. They observed gels prepared by coagulating hot milk with citric acid had a coarser structure than heat induced milk gels. Although they had detected some particles of the size of unaltered casein micelles, but generally the building units were several times larger. Carroll (1971) showed swelling of casein micelles of 100 mμ to 300 mμ size as a result of heat treatment to milk. Kalab et al (1988) however, reported particle size of approximately 1μ in acid heat gels. They also noted a fact of fusion whereby particles were linked together. They found particles to form thick chains with spherical particles of various sizes attached to such chains which formed a thick network. However it was not clear whether the fusion was strictly between casein micelles or products of interaction between casein and whey proteins.

Adhikri et al (1993) carried out scanning electron microscopy on chhana and observed cow milk chhana to show a threaded, smooth protein agglomerates interlinked through thick protein bridges forming numerous small voids inbetween. Whereas buffalo milk chhana had large, ragged, coalesced protein particles, forming a dense, carded-cotton like structure with fewer voids. According to them the dissimilarities in cow and buffalo milk protein was due to the variations in casein micelle size, soluble and miceller proportion of casein and salt balance in the respective milks.

While discussing about scanning electron microscopic structure Kalab (1984) had warned about the possibilities of artefacts which in scanning electron microscopy may be defined as products of sample preparation and imaging procedures which alter the subject under study contrary to the interest of the microscopist. Since no work has been done with this complex products chances of artefacts and their detection is also important while studying the submicroscopic structure of rosogolla.

2.2.8 Status of protein in terms of electrophoretic mobility :

From the method of manufacture it is evident milk proteins, casein in particular, play a major role in rosogolla and chhana. Electrophoretic study may reveal the exact scenario. Since chhana is basically a heat acid curd from which rosogolla is being prepared the type of study will reveal the status of casein in it. Not much work has been done in this direction so far, Ramachandran et al (1973) found differences between the electrophoretic behaviour of casein from cow and buffalo milk. Hence study with buffalo milk may reveal different picture. Soni et al (1980) revealed the appearance of some heat degraded low molecular weight components in all the samples isolated from previously boiled milk which was noted earlier by Bandopadhyay and Ganguli (1975). Soni et al (1980) detected the absence of some slow moving protein components in chhana when delayed straining method was employed. They observed drastic change in the proteins of rosogolla and detected some low molecular components which was degraded during production of rosogolla. Extensive degradation of milk protein was observed by these workers by the action of trypsin on milk which gave softer chhana. Several new anodic and cathodic components were detected which were suggested to be responsible for the change in the body and texture of chhana.

2.3 Packaging of Rosogolla.

Packaging is the technique of using the most appropriate containers and components to protect, carry, identify and merchandise any product. Packaging, in general and for Indian dairy products in particular, has not been looked with serious concern in India. Rosogolla is generally sold fresh in the market and served in earthen pot with some amount of sugar syrup to carry. Date et al (1958) and Jagtiani et al (1960) studied the packaging of rosogolla and noted the use of tin cans where rosogolla was packed with sugar syrups with the increase of export of this particular product. Sachet made up of metallised polyester laminates have also came into use in the market. Kumar et al (1975) investigated the effect of different packages on the shelf life of Khoa, Kumar & Srinivasan (1982) & Paine & Paine (1983) have indicated the use of metallic laminates namely Aluminium foils in the packaging of various dairy products. The best chosen packaging materials for rosogolla are tinned can and metallised polyester laminates.

2.3.1 **Tinned metal can** :

This type of metal cans were reported as the most widely used and best type of container for rosogolla. They consist, a thin sheet (0.25 mm thick) of mild steel coated both side with a thin protective layer of pure tin (2.5 mμ thick) either by hot dipping or electrolytic process. An internally lacquered can with food grade lacquerring of epoxy phenolic type provides resistance to corrosion and contamination with tin. This type of package has the merits of good strength, excellent barrier properties etc. and the demerits of high cost, heavy weight, difficult reclosure and disposal.

2,3.2 **Metallized polyester laminates** :

At times one single film is not sufficient to preserve the required characteristics of the product. Therefore, a process of lamination for producing films of wrapping materials which combines the properties of two or more individual components was evolved. Selby (1968) found that the laminate polyester (Polyethylene terephthalate) and aluminium foil was practically the most impermeable to all gases and vapours. Burton (1968) and Bowler (1970) defined the process of lamination for producing such kind of films. This kind of packaging material has been found better suited for burfi packaging by Bhatele (1983). The poor permeability of vapour, gases, odour and high barrier property to light and radiant heat of aluminium foil and excellent tensile strength, tear resistance, and good ageing properties of polyester films are combined together in this packages. They are easily heat sealable and cheaper variety of package.

2.4 Spoilage of Rosogolla during Storage :

Once rosogolla is prepared, like all other products, it is stored, either as such dipped in the soaking syrup or after packaging generally in cans till it is being consumed. And like all other dairy products, deterioration takes place during storage. Only a limited literatures are available on the spoilage of rosogolla during storage, transportation and distribution. The major defects encountered in rosogolla are browning discolouration loss of crispness and flavour defects.

2.4.1 Browning discolouration :

When milk was exposed to heat during manufacture and storage darkening of colour was evident by Dutra et al (1958) who called it browing discolouration and reported to be the result of Maillard type browning due to reaction between amino acid and lactose. Patton & Josephson (1949) had observed some role of the whey proteins also. Kon & Henry (1949) listed the undesirability of browning reaction in milk for its poor palatability, appearance and physical properties, off flavour production and loss of nutritive values. Patton (1955) suggested to keeping of moisture, heating treatment storage temperature and storage period to minimal level for reducing browning.

Since, while producing rosogolla, a high heat treatment is given and generally it is being stored at high temperature browning is highly expected which was observed by Date et al (1958), who established a significant negative correlation of the colour with sodium chloride soluble protein content. Jagtiani et al (1960) corroborated the earlier work and observed rosogolla to turn brown within 3 months when stored at a high temperature of 55°C whereas they remain white uptil six months of storage when stored at room temperature, only 20% of the rosogolla samples stored at 34°C were found white after six months of storage.

2.4.2 Loss of crispness :

The desirable crispness of rosogolla was losing during storage as was observed by Date et al (1958). They found a good correlation between the crispness and percent sodium chloride soluble protein which arrived from the possible denaturation of proteins. Jagtiani et al (1960) agreed with the the earlier work and observed the presence of higher percent of sodium chloride soluble protein (40.67 to 64.01%) in the rosogolla samples stored at ambient temperature in comparison to those stored at an elevated temperature of 37°C. (18.47 to 36.87%).

2.4.3 Flavour defects :

Along with browning and loss of textural qualities of rosogolla during storage, change in the desirable flavour because of various chemicals and microbiological reasons is also obvious. Date et al (1958) had reported the presence of off flavours in stored rosogolla. But no detailed published information is available regarding the flavour defects of rosogolla during storage.

2.5 Extension of Shelf life of Rosogolla :

From the reports of Singh and Mukhopadhyay (1975) the presence of several types of micro-organism including Staphylococci, Colliforms, Yeasts and Moulds were evident. These micro-organisms brought various kind of spoilage during storage of rosogolla and kept them suitable for consumption for a shorter span of life. In order to extend the shelf life the contamination and growth of the micro organisms ought to be checked. Secondly, some chemical changes even without the presence of microbes are also possible as has been noted in all dairy products. They may also be controlled by the control of various processing and storage parameters. Only one study has been noted in this connection by Date et al (1958).

2.5.1 Better packaging and lower storage temperature :

Date et al (1958) reported the absence of vacuum packaging, improper sealing, and low concentration of sugar (25-30° Brix) in canned rosogolla to contribute early spoilage as manifested by souring, bleaching and off flavour development. Cans where rosogolla has been filled hot, exhausted in boiling water for half an hour and then sealed, showed complete absence of yeast and mould spores and vegetative cells of bacteria. However spores of flat souring organisms of the type, Bacillus stereothermophillus and of a mesophilic aerobic organism were still found to exist.

2.5.2 Addition of some chemical preservatives :

A few chemical preservatives had also been tried by Date et al (1958) in order to extend the shelf life. 0.02% of Geraniol a constitutent of rose essence with high phenol coefficient was reported to percolate a pleasant aroma only but no betterment in the storage life was observed below 0.1% concentration. Higher concentration however, reported to impart a bitter taste in the product. Addition of sulpher dioxide in boiling syrup was also found unacceptable since the rosogolla took up the flavour. Potassium metabisulphite and sodium metebisulphite in 50 ppm concentration to the syrup was also observed undesirable since it was reported to disintegrate the rosogolla samples.

2.5.2 Concentration of sugar syrup :

Date et al (1958) advocated storage of rosogolla in previously sterilized cans and pouring boiling hot syrup in 55 to 60° Brix concentration, sealing while hot and finally exhausting in boiling water for half an hour to achieve best results. Srinivasan and Anantakrishnan had also found best results with 60% sugar concentration. The higher concentration of sucrose helped in increasing the shelf lives by restricting the growth of micro organism present by lowering the water activity and the presence of soluble oxygen in sugar syrup. (Lueck, 1980).

CHAPTER - III

MATERIAL AND METHODS

3. MATERIAL AND METHODS

3.1 Raw and Packing Material.

3.1.1 Milk :

Fresh cow and buffalo milk were obtained from Haringhata Dairy Farm. The samples of milk were standardized at the different desired fat level by skimming the milk and adding the skim milk into whole milk.

3.1.2 Rosogolla :

Samples of rosogolla were collected from different shops located at Calcutta, Kanchrapara, Naihati, Chinsurah and Kalyani.

3.1.3 Cans :

Tinned cans lacquerred from inside were obtained from Containers Pvt. Ltd. Calcutta with the following specifications. Capacity : 500 ml. Thickness : 4 mm., Inside epoxy phenollic type food lacquer.

3.1.4 Metallized polyester :

Metallized polyester laminate was collected from M/s. Garware Plastic & Polyester Pvt. Ltd., Bombay with the following specification : Metallized Polyester 12 Micron LDPE 300 Gauge. Moisture Vapour Transmission Rate (38°C, 90% RH, 24 Hour) 14-20 gm./m^2. Oxygen Permeability 85-95 ml./m^2/24 Hour Grease Resistance very good.

3.2 Method of Production.

3.2.1.1 Production of chhana from milk :

The method outlined by De and Ray (1954) was followed with suitable modifications. Standardized milk was taken in a stainless steel Karahi and heated on an electric heater. During heating, the milk was occasionally stirred to avoid skin formation. Heating was stopped after 10 min. of boiling. The temperature of the milk was brought down to the curdling temperature. The milk was coagulated by adding the coagulant solution which was brought to curdling temperature before curdling. The coagulated mass was then poured over a muslin cloth spread over an empty vessel. When the loosely bound whey was completely removed the muslin cloth alongwith the chhana was dipped in the whey for removing any remaining acid. A part of the moisture was then removed by applying mild pressure to the coagulum. The fresh chhana was used. For some samples the delayed straining method was also used where the coagulum was allowed to be dipped inside the whey for 30 min. and then the same procedure was applied. Various other process parameters were also been used as has been mentioned like dilution with potable water, homogenization, addition of additives etc.

3.2.1.2 Homogenization :

Milk was preheated to a temperature of 60°C and then homogenized in a two stage homogenizer at a pressure of 175 kg./sq. cm. and 35 kg./sq. cm.

3.2.1.3 Trypsin digestion of buffalo milk :

Milk was heated to and maintained at a temperature of 37°C. 0.5 ml./100 ml. of milk, of trypsin solution (50 mg./ml.)

was added to it. The enzyme was allowed to function for different time intervals ranging from 10 min. to 20 min. The enzyme was inactivated by boiling the milk after the allowed time. Then the milk was treated as usual for chhana production.

3.2.2 Production of rosogolla from chhana :

3.2.2.1 Preparation of chhana balls :

Chhana mass was ground to smooth paste with the help of a Bajaj Mixie for 2 min. at slowest speed. Additives if any, was added here. The mixture was thoroughly kneaded on a wooden slab to render it soft and smooth for 2 min. Dough was subsequently rolled and cut into small pieces of 10 gm. each. They were rounded to small balls by hand.

3.2.2.2 Preparation of sugar syrup :

Sugar syrup of different concentration were prepared on weight to weight basis for cooking and soaking. Each of the sugar syrup was boiled and few ml. of skim milk was added during boiling and strained through a muslin cloth for clarification.

3.2.2.3 Cooking chhana balls :

Two litres of freshly prepared cooking syrup was brought to boil in a stainless steel Karahi. Freshly prepared chhana balls were gently dropped into the boiling syrup. To compensate the loss of moisture due to evaporation, after every 5 min. of cooking 25 to 30 ml. of water was sprinkled into the Karahi. Balls were gently stirred with effervesence on to the top. The balls then started sinking into the syrup. Too much rigorous heating was stopped by controlling the heating. After 20 min. cooking was over. The balls were almost drawned into the syrup.

The balls were than transferred to clarified hot soaking syrup. The product was allowed to remain in the soaking syrup for 12 hours and then taken for sensory evaluation and chemical analysis. For preparation of cow rosogolla the method suggested by Bhattachaya and Desraj (1980), was followed without any additives.

3.2.2.4 Packaging :

The cans and lids were put to boiling water for 30 min. Then they were filled up with soaking syrup and 12 pcs. of sample and seamed. The metallized polyester sachets were exposed to ultraviolet rays for 20 min. Then they were filled up with soaking syrup and 12 pieces of sample, and then heat sealed.

3.2.2.5 Storage :

The packed rosogolla samples were stored at refrigerated storage maintained at 5°C and at ambient temperature maintained at 25°C.

3.2.2.6 Yield of rosogolla :

Rosogolla samples were allowed to drain the syrup for 10 min. through a standard sieve with 1 Cm^2 opening and then the yield was taken.

3.3 **Analytical Methods.**

3.3.1 **Analysis of milk and whey :**

3.3.1.1 Fat :

Fat content in milk and whey was determined by Gerber method as given in IS 1224 (1958).

3.3.1.2 **Total solid and solids not fat** :

The total solid and solids not fat content in milk and whey was estimated by the method described by Ling (1956).

3.3.1.3 **Acidity** :

Acidity in milk was determined by the method described in IS 1479 (1961).

3.3.1.4 **pH** :

pH of whey was determined by digital pH meter (Elico Make) at 20°C.

3.3.1.5 **Calcium** :

Calcium content in milk was determined as per the procedure given by Davies and White (1962).

3.3.1.6 **Lactose** :

Lactose was estimated by Lane and Eynon method as described by Ling (1956).

3.3.1.7 **Protein** :

Protein was estimated by micro kjeldhal method as described by Rowland (1938).

3.3.1.8 **Ash** :

The total ash content in milk was determined by the method described by Ling (1956).

3.3.2 Analysis of chhana :

3.3.2.1 Fat :

About 2 gm. of chhana was taken in the extraction tube and 10 ml. of concentrated hydrochloric acid was added. The content was mixed well and 10 ml. of ethyl alcohol was added. The contents were mixed thoroughly 25 ml. of solvent ether was then added. The tube was closed with stopper and the content was shaken vigorously. Similarly the content was shaken with 25 ml. of petroleum ether. The tube was allowed to stand until the ethereal layer was clear and completely separated from the aqueous layer. The ethereal layer was then transferred into a dry and previously weighed conical flask.

The extraction was repeated twice more by using 15 ml. of each solvent. The fat content in the sample was calculated by the difference of weight.

3.3.2.2 Total solid :

Total solid content in chhana was determined according to IS 2785 (1979).

3.3.2.3 Protein :

Total protein content in chhana was determined by micro-kjeldahl method according to Mckenzie and Murphy (1970).

3.3.2.4 Lactose :

Lactose was estimated by using Lane and Eynon method as described by Ling (1956).

3.3.2.5 **Ash** :

The total ash content in chhana was estimated by the procedure described in IS 4079 (1967).

3.3.3 **Analysis of rosogolla** :

3.3.3.1 **Fat** :

Fat content in rosogolla was determined according to IS 4079 (1967).

3.3.3.2 **Total solid** :

Total solid percentage of rosogolla was determined by the method described in IS 4079 (1967).

3.3.3.3 **Protein** :

Protein content in rosogolla was measured by the method described in IS 4079 (1967) by Micro Kjeldhal method.

3.3.3.4 **Soluble protein** :

About 2 gm. of rosogolla sample was accurately weighed in a 100 ml. volumetric flask. The volume was made 100 ml. with 5% NaCl solution. The content were allowed to stand at 40°C for 1 hour and filtered through Whatman filter paper No. 40. Two ml. portion was taken and protein estimation was done as in the earlier case.

3.3.3.5 Sucrose :

Sucrose content in rosogolla was examined by Lane and Eynon method as described in IS 4079 (1967).

3.3.3.6 Ash :

The amount of total ash in rosogolla was estimated by the procedure described in IS : 4079 (1967).

3.3.3.7 Sugar concentration :

The specific gravity of sugar syrup were measured by Baume Hydrometer.

3.3.3.8 Syrup acidity :

The acidity of the sugar syrups were determined by the method described in IS 4079 (1967). The results were expressed in terms of ml. of 0.1N.NaOH solution required to neutralize 100 ml. of syrup.

3.3.3.9 Volatile fatty acid :

Volatile fatty acid was determined by the method of Hempenius and Liska (1968) with slight modification (Kuila, 1972). 50 gms. of sample was taken in a woulf flask fitted with standard joint. 3 ml. of 1N.H_2SO_4 was added to it. Steam supply was connected to one of the necks of the flask into the sample. The other neck was connected to the condensor. 100 ml. of steam distillate was collected and titrated against 0.01 N. NaOH using phenolphthalein indicator. The volatile fatty acidity was expressed as ml. of 0.01 N. NaOH required for neutralizing 100 ml. of the distillate from 50 gm. of the sample.

3.3.3.10 **Peroxide value** :

30 gm. of rosogolla sample was weighed in a glass stoppered conical flask. 75 ml. of chloroform was added into it. The flask was shaken vigorously to dissolve the fat and allowed to stand for 4 hours with occasional shaking. Then it was filtered through whatman No. 1 filter paper. Chloroform of the flask was evaporated and the fat was used for estimating peroxide value according to the method described in IS : 3508 (1966). A blank was run simultaneously. The Peroxide values were expressed in terms of milli equivalent of peroxide oxygen per kg. of sample.

3.3.3.11 **Sensory evaluation** :

Rosogolla prepared under different experimental conditions and those collected from the market were judged independantly by a panel of judges selected from the personnels at B.C.K.V., Mohanpur. The products were evaluated in respect of flavour, body and texture and overall acceptance according to 9 point hedonic scale evaluation card specially prepared for this purpose.

Acceptability rating of rosogolla in respect of Flavour (F), Body & Texture (B) and Overall acceptance (O).

	Score	Sample-I F. B. O.	Sample-II F. B. O.	Sample-III F. B. O.
Like extremely	9			
Like very much	8			
Like moderately	7			
Like slightly	6			
Niether like or Dislike	5			

Dislike slightly	4
Dislike moderately	3
Dislike very much	2
Dislike extremely	1

3.3.3.12 **Microbiological estimation** :

3.3.3.12.1 **Sampling** :

The samples of rosogolla was aseptically withdrawn in a sterilized chamber of U.V. radiation. 11 gm. of rosogolla sample was weighed and transferred to a sterilized mortar. The sample was dissolved in sterile 99 ml. of2% sodium citrate solution. Subsequent dilutions were prepared with 9 ml. of sterile 0.9%. Sodium chloride solution to 1 ml. of the mother solution. Suitable dilutions of various rosogolla samples were plated in duplicate according to the requirements for counting the different types of micro organisms. a control plate was also run simultaneously without sample for comparison.

3.3.3.12.2 **Total viable count (TVC)** :

The TVC of rosogolla was counted according to IS 1479 (Part-III) (1977). The composition of Agar media used was as follows.

Ingredients	gm./litre
Tryptone	5.0
Yeast Extract	2.5
Dextrose	1.0
Agar	15.0
pH	7.0±0.2

23.5 gm. of the above media was suspended in 1 litre of water. It was then boiled for dissolving. Finally it was autoclaved at 1.05 kg./Cm^2 for 15 min. (121°C) for sterilization.

3.3.3.12.3 **Yeast & Mould count (Y & M)** :

The Y & M count of rosogolla was enumerated by APHA (1978) using Potato dextrose agar of the following composition.

Ingredients	gm./litre
Potato infusion	100.0
Dextrose	20.0
Agar	15.0
pH	5.6 ± 0.2

39 gm. of the above media was suspended in 1 litre of water and similar process followed as TVC. pH of the media was adjusted to 3.5 by using sterile 10% tartaric acid at the time of pouring. The plates were incubated at 22°C for 3 to 5 days.

3.3.3.13 **Rheological characteristics of rosogolla** :

In order to evaluate the textural properties of rosogolla in terms of hardness, cohesiveness, springiness, gumminess, and chewiness. Instron Universal testing machine, Model No. 4301 attached with a strip chart recorder and a printer supplied by M/s. Instron Ltd. England was used. The record was taken as Uniaxial double cycled compression under the following testing conditions.

Sample size : Cylindrical sample of 2.0 Cm. diameter.
Cross sectional area. 3.14 Cm^2

Height : 1.5 Cm.

Compression : Based on relevant literature and experimental trials 26.70% compression was selected for the present study to determine the non destructive texture profile.

Load cell : 10 N load cell with 50% load range was used with full scale deflection of the strip chart and 1 : 5 proportion was used.

Crosshead speed : 5 Cm/min. as suggested by Breene (1975) for cheese.

Chart speed : 5 Cm/min.

Test Temperature : 20°C after tempering for 4 hrs.

From the typical force deformation curve obtained for double cycled compression the parameters were measured in the method as has been described by Breene (1975).

Hardness : Maximum force recorded during the first compression cycle (mN)

Cohesiveness : (Area under curve A_2)/(Area under curve A_1).

Springiness : Width of the downstroke in curve A_2 mm.

Gumminess : Hardness X Cohessiveness m/N

Chewiness : Gumminess X Springiness mN. mm

Since the response of the instrument in respect of adhesiveness was negligible for rosogolla, this parameter was not taken into consideration.

3.3.3.14 **Scanning electron microscopy study** :

Scanning electron microscopy study was carried out by the method laid out by Kalab et al (1988)

a) Sampling : Rosogolla samples were taken from beneath the surface on a mesh of size 200 for about 1 hour to drain the excess sugar solution.

The samples were then cut into small pieces of 1X1X5 mm^3 size with sharp blades.

They were then kept in distilled water at 37°C for 15 min. and washed out for 3 to 4 times to remove the sugar syrup completely.

Excess water was drained.

b) Fixing : To stabilize the protein matrix and to facilitate the removal of soluble constituents the samples were then fixed in 2.8% glutaraldehyde solution in phosphate buffer (pH 7.3) for 2 hours and washed 3 times by the same buffer at an interval of ½ hour.

The samples were then post fixed by 2% OsO_4 in 1.35 (M) phosphate buffer and washed 3 times by the same buffer. This step is required only for fatty samples to stabilize and fix fat If milk fat globule membrane (MFGM) is ruptured only unsaturated fats have been reported to be fixed.

c) Dehydration : For removal of the water, the acqueous phase was replaced with a cryoprotective medium of absolute alcohol by dehydrating with a sereis of ethyl alcohol namely. 50%, 60%, 70%, 80%, 90% and 100% for 30 min. each.

d) Defatting : Generally this is followed by defating with chloroform for 15 min. and then returned to absolute alcohol. But for some samples this step was omitted since samples were examined for fat also.

e) Freeze Fracturing : The samples were then put into a freeze fracturing tube and fractured with a sharp knife under liquid nitrogen to expose the undamaged interior.

It was then taken back to absolute ethanol for critical point drying at 30°C slightly below atmospheric pressure. It may be noted if fixing is not done properly the structure may change during critical point drying. Starch, if present may get shrunken here.

f) Mounting : They were then observed under compound microscope for subsequent gold coating and scanning electron microscopy.

The samples were then fixed on a metal slab with adhesive and dried.

g) Gold coating : The samples were then taken in an Ion coater (model GIKO IB-3, Japan) to coat the sample with a uniform coating (for avoiding artefacts) of gold for rendering the specimen electrically conductive under 0.1 torr vacuum for 5 min. at an ion current of 6 mV.

h) Scanning electron microscopy : The gold coated samples were then taken under an electron microscope (model Hitachi-S-405A, Japan) and scanned at 25 KV. at different magnification for the desired microstructure.

i) Photography : When the desired field has achieved a photographic reversal was done like common photographs and the micrographs were taken on 35 mm film for storage of information and detailed study.

3.3.3.15 Poly acrylamide gel electrophoretic study :

Poly acrylamide gel electrophoresis (PAGE) of milk casein and chhana and rosogolla proteins were carried out according to the method of Kolar and Brunner (1970) excepting that 2 drops of 2-mercaptoethanol was added while preparing the sample.

a) Gel buffer : Boric acid buffer of pH 8.6 was used. It was prepared by dissolving 2.1 gm. sodium hydroxide and 13.0 gm. boric acid in distilled water and the volume was made to 1 litre. This buffer was used for both gel preparation and electrophoresis run.

b) Acrylamide solution : 47.5 gm. acrylamide and 2.5 gm. N, N' - Methylenebis acrylamide (Bis) were mixed together. 8 gm. of the above mixture and 27 gm. urea were then dissolved in the boric acid buffer (pH 8.6) and 0.1 ml. N, N, N', N' tetramethylenediamine (Temed) was then added and the volume was made to 100 ml. by the same buffer.

c) Staining and destaining solution : Staining solution was prepared by mixing 2 gm. of amido black, 50 ml. of glacial acetic acid, 250 ml. of methanol and 250 ml. of distilled water. For proper mixing magnetic stirrer was used for half an hour and the mixture was filtered through whatman number 42 filter paper.

The destaining solution used was 7% glacial acetic acid in distilled water.

d) Gel : 30 ml. of Bis-acrylamide solution was taken in a beaker and 1 ml. of freshly prepared ammonium persulphate (100 mg. in 15 ml. of distilled water) was added to it. After proper mixing the gel tubes were filled with gel. A few drops of water was layered on the top of the gel before complete polymerization.

e) Sample : 40 ml. of milk sample was taken in a 100 ml. volumetric flask and 40 ml. distilled water was added into it. The content was wormed to 35°C. To this 4 ml. of 10% acetic acid was added and after 10 min. 4 ml. of 1 N. Sodium acetate was added. After cooling to room temparature, the volume was made upto 100 ml. and filtered through whatman number 40 filter paper. The coagulum was then thoroughly washed with water and a solvent mixture of petroleum ether & Chloroform (1:1) and dried. Similar washing and drying was done with chhana and rosogoll samples.

20 mg. of this dried sample of protein was dissolved in 10 ml. of sucrose solution (15% in borate buffer) followed by the addition of 2 drops of 2-mercapto ethanol and one drop of bromophenol blue solution.

f) Sample application : After the prerun 20 ml. of protein solution was applied to the gels using microsyringe.

g) Electrophoretic procedure : All the gel tubes filled with gel were subjected to pre electrophoresis run to remove all charged particles other than proteins and acetate anions at 2 mA/tube. Electrophoresis was performed at a constant current of 4 mA/tube for about 3 hours. Electrophoresis was stopped when the dye was about to leave the gel tube.

h) Staining and destaining of the gel rod : The gels were stained for 10 min. by the staining solution in test tubes and then they were destained with the destaining solution by several washing till the separated components became prominent.

3.4 Statistical Analysis.

The data were analysed for analysis of variance (ANOVA), standard error and multiple regression analysis as has been directed by Snedecor and Cochran (1967).

CHAPTER - IV

RESULTS AND DISCUSSION

4. RESULTS AND DISCUSSION

The aim of the present investigation was to standardize the manufacturing techniques of rosogolla from buffalo milk and to evaluate the physico-chemical changes during its manufacturing and storage with suitable packaging. The study was carried out in three phases. In the first phase, experiments were undertaken to optimize the desired manufacturing techniques. In the second phase, the physico-chemical changes during manufacturing were evaluated and in the third phase physico chemical changes leading towards the spoilage of rosogolla during storage were studied to achieve a longer shelf life. The results have been tabulated and interpreted with the help of suitable illustrations under the different headings.

4.1 Standardizing the Manufacturing of Rosogolla from Buffalo Milk.

Since milk has to undergo a long process flow for production of rosogolla, in order to standardize the manufacturing technique an innumerable permutation and combination of process parameters are possible. Hence different process parameters as has been suggested by the earlier workers (De and Ray, 1954; Kundu and De, 1972; De, 1976; Bhattacharya and Desraj, 1980 and Soni et al, 1980) both for cow milk and buffalo milk were tried with various desired permutation and combination at random as a set of preliminary trials. The results of the preliminary trials were not displayed but on the basis of the preliminary judgment the following process was standardized to go for further study for the final optimization. Since the preliminary trials were still to produce the desired acceptability.

Two litres of buffalo milk containing 6.61% fat was heated to boiling for 10 min. and then allowed to cool to the coagulation temperature of 70°C. Freshly prepared 0.5% lactic acid solution was added slowly to the milk with gentle stirring till the milk coagulated at a pH of 5.7. The coagulated mass of chhana was strained immediately through muslin cloth. The fresh hot chhana was then squeeze and ground in a mixie for 2 min. at the slowest speed and kneaded on a wooden slab for 2 min. They were then rounded in small pieces of 10 gms. each, balls. Eight to ten such freshly prepared balls were then cooked in 2 litres of boiling cooking syrup containing 70% sugar for 25 min. To compensate the loss of moisture due to evaporation, after every 5 minutes 25 to 30 ml. of water was sprinkled in the Karahi. The cooked balls were then transferred to freshly prepared soaking syrup containing 40% sugar for 1½ hours and then stored.

4.1.1 Modification of buffalo milk make up :

The following modifications in the milk make up was tried in order to optimize the manufacturing of rosogolla from buffalo milk. Each of chhana, whey and rosogolla samples were examined for final interpretation.

4.1.1.1 **Effect of addition of water** :

Cow milk has been found to be suitable for rosogolla manufacturing whereas buffalo milk as an unsuitable one with its higher total solid content (De and Ray, 1954). Dilution of the milk with potable water, therefore, was considered as a suitable method for tuning the milk. Buffalo milk was diluted with 20%, 25% and 30% of water by weight of milk and the quality of chhana, whey and rosogolla was examined as expressed in table 4.1.1.1.

Table : 4.1.1.1 Effect of Addition of Water in Buffalo Milk on Chhana, Whey and Rosogolla.

Quality attributes	Control (with no added water)	Percent addition of water by weight of milk		
		20%	25%	30%
Chhana				
Total Solid (%)	37.88-39.87	36.88-40.01	37.01-39.11	36.22-38.99
	38.57±0.35	38.49±0.65	37.92±0.47	37.51±0.48
Yield (%)	21.90-23.12	21.99-24.12	22.01-23.01	21.00-24.12
	22.99±0.35	22.68±0.39	22.45±0.23	22.04±0.59
Recovery of	62.01-65.01	62.12-65.71	61.78-64.48	60.12-63.12
Milk Solids	63.19±0.49	62.93±0.53	62.71±0.49	62.00±0.54
Sensory Comments	Soft,Coarse	Soft. Smooth	Soft, Smoother	Soft, Smoother
Whey				
Total Solid (%)	5.42-7.01	4.99-6.09	5.12-6.88	4.00-6.00
	6.36±0.29	5.80±0.21	5.71±0.33	5.2±0.34
Fat (%)	0.3-0.8	0.2-0.9	0.3-0.8	0.1-0.6
	0.6±0.08	0.52±0.12	0.5±0.08	0.32±0.09
Rosogolla				
Body and Texture	3-7	2-7	2-7	2-7
Score (Max.9)	5.24±0.25	5.32±0.24	5.52±0.25	5.51±0.26
Overall acceptability	2-7	3-8	4-7	4-7
Score (Max. 9)	5.52±0.25	5.5±0.36	5.8±0.17	5.76±0.18
Sensory Comments	Hard, Granular, Cracks	Hard, Granular	Less harder, Granular	Less harder, Granular

Figures represent the range, mean and standard error.

It was observed that the softness and smootheness of chhana increased alongwith dilution because of higher retention of moisture. The recovery of milk solids and yield was maximum in the control which decreased alongwith dilution. The results were in agreement with the observations made by earlier workers (Aneja et al, 1977; Iyer, 1978 and Rajorhia, 1987). The improvement in the softness and smoothness of chhana with dilution may be explained by the fact of reduction in the soluble calcium content of milk per unit volume. The analysis of whey showed reduction in the total solid and fat content which was evident because of increase in the volume of whey along with dilution of milk.

4.1.1.1.A. ANOVA on Sensory Characteristics of Rosogolla for the Effect of Addition of Water in Buffalo Milk.

S.O.V.	d.f.	Body & Texture		Overall Acceptability	
		MSS	F	MSS	F
Treatment	3	0.6533	1.06	0.57	1.30
Judgement	4	14.49	23.51**	15.115	34.46**
Tr. X Jud.	12	2.77	4.49**	0.8383	1.89**
Replicate	4	2.89	4.69**	3.665	8.35**
Error	76	0.6163		0.4387	

* Significant at 5% level. ** Significant at 1% level.

Finally rosogolla was evaluated for its sensory attributes by the panel of judges. statistical analysis of the sensory scores are shown in table 4.1.1.1.A. It was found that the changes were not significant because of dilution on the contrary the scores were significantly variable with replicates and judgement. This variation might be because of personal choice factor and wide variation amongst the products. However from this set of experiment and variance analysis dilution of milk with 25% potable water was considered to produce the best result. This result was in corroboration with the findings of Rajorhia (1987).

4.1.1.2 **Effect of fat ıevel in buffalo milk** :

A fat content of 4.0% to 5.0% was found most suitable for chhana preparation for rosogolla manufacturing both from cow milk and buffalo milk (Ray and De, 1953; Bhattacharya and Desraj, 1980). In the present study buffalo milk was standardized to 4.0, 4.5 and 5.0% fat level by the addition of diluted buffalo skim milk in order to investigate the desirabilities of chhana and rosogolla. The results are shown in Table 4.1.1.2.

Table : 4.1.1.2. Effect of Fat Level in Buffalo Milk on Chhana, Whey and Rosogolla.

Qualityy Attributes	Control (5.28% Fat)	% Fat in Milk 5.0	4.5	4.0
Chhana				
Total Solid (%)	37.01-39.11	36.28-39.11	36.11-38.69	36.01-39.67
	37.92±0.47	37.92±0.47	37.65±0.48	37.54±0.67
yield (%)	22.01-23.01	21.12-23.12	21.34-23.56	21.34-22.99
	22.45±0.23	22.27±0.36	22.11±0.38	22.09±0.37
Recovery of Milk	61.78-64.48	60.11-63.88	60.45-63.89	61.89-63.56
Solid (%)	62.71±0.49	62.70±0.67	62.43±0.56	62.58±0.30
Sensory Comments	Soft, Smooth	Soft, Smooth	Less Softness Smooth	Lesser Softness, Coarse.
Whey				
Total Solid (%)	5.12-6,88	4.89-6.22	4.72-6.25	4.56-6.01
	5.71±0.33	5.71±0.24	5.54±0.34	5.46±0.31
Fat (%)	0.3-0.8	0.3-0.6	0.1-0.6	0.4-0.6
	0.5±0.08	0.49±0.06	0.44±0.08	0.47±0.04
Rosogolla				
Body & Texture	2-7	4-7	4-7	4-9
(Max. 9)	5.52±0.25	5.68±0.16	5.92±0.18	7.16±0.32
Overall Acceptance	4-7	4-7	4-7	4-9
(Max. 9)	5.8±0.17	5.8±0.17	5.96±0.17	7.28±0.31
Sensory Comments	Surface Crack Non-uniform	Non-uniform Sweetness	Less Soft few Cracks	No cracking Uniform

Figuress represent the range, mean and standard error.

Fat has been found to contribute softness and smoothness in chhana. On the other hand, the fat content in milk has been found to contribute little influence towards the variation in the yield of chhana and the recovery of milk solids, both of which has been found to increase with the increase in fat level to small extent in general. Similarly a slight increase in the total solid content and fat content of whey was also noticed with the increase of fat content in milk. Rosogolla made from milk with 4% fat has been reported to be the best amongst all by the judges because of their body and texture. The smaples with higher fat milk had soft and granular body with cracks on the surface. The sweetness in the middle of rosogolla samples was less and uniform sweetness was only available with the samples made up from 4% fat milk (Table 4.1.1.2). This fact might be attributed by the barrier properties of fat which hindered sugar solution to enter inside the balls.

Table : 4.1.1.2.A. ANOVA on Sensory Characteristics of Rosogolla for the Effect of Fat Level in Buffalo Milk.

S.O.V.	d.f.	Body & Texture		Overall Acceptability	
		MSS	F	MSS	F
Treatment	3	4.0667	6.08**	3.48	4.94**
Judgement	4	24.375	36.47**	29.415	41.75**
Tr. X Jud.	12	1.2417	1.86*	1.355	1.92*
Replicate	4	3.9	5.83**	4.515	6.41**
Error	76	0.6684		0.7045	

* Significant at 5% level. ** Significant at 1% level.

Kundu and De (1972) advocated for a fat content of 5% for buffalo milk chhana for a softer product. The present experiment had also shown supportive results but finally while judging the rosogolla, the lesser soft chhana has been found to produce a better rosogolla in terms of its softness in the body and uniformity in sweetness. Hence 4% fat buffalo milk has been preferred for manufacturing rosogolla. Bhattacharya and Desraj (1980) has also reported rosogolla with better body and texture with increase of fat % in buffalo milk within 3.0% to 4.0% but with higher fat loss in the cooking syrup.

The sensory scores for body and texture and overall acceptability of rosogolla were analysed for variance and depicted in Table 4.1.1.2.A. Which revealed a highly significant variation amongst the different fat levels thus confirming a strong contribution of variation in fat levels towards the final desirability of rosogolla. The variations were found significant with changes in judges and treatments also.

Hence it was concluded from the above study that high fat buffalo milk was not suitable for the desired body and texture of rosogolla and a fat level of 4% was most suitable for rosogolla manufacture.

4.1.1.3 Effect of Calcium level in buffalo milk :

Chhana is curdled by the action of acid at high temperature. Hence the mass of chhana is basically a mass of discrete casein micelle into which the fat and coagulated serum protein are entrained together. Calcium content of milk thus supposed to impart hardness in chhana. Jagtiani et al (1960) and Ismail et al (1971) reported a positive correlation between the hardness of chhana and calcium content in milk. Hence higher level of calcium in buffalo milk (Menon and Ganguli, 1971) may be one of the factors to produce harder chhana and undesirable rosogolla with buffalo milk. The calcium content of cow milk and buffalo milk therefore, analysed and the results are stated in Table 4.1.1.3.

Table : 4.1.1.3. Calcium content in Cow and Buffalo Milk

Type of Milk	Calcium Content mg./100 ml.
Cow Milk	110.78-114.01
	112.19±0.52
Buffalo Milk	140.08-141.56
	140.66±0.28

Figures represent the range, mean and standard error.

The average calcium content of cow milk and buffalo milk was found to be 112.19 mg./100 ml. and 140.66 mg./100 ml. respectively. Since for manufacturing rosogolla from buffalo milk ,the milk was suggested to be diluted by adding 25% potable water in the present investigation, the final calcium content in the resultant buffalo milk was similar to that of cow milk. Trials had not been taken in this direction to modify the manufacturing techniques. It may be mentioned here, that Jagtiani et al (1960) had tried to reduce the calcium load of buffalo milk by ion exchange resin but failed to produce softer chhana.

4.1.1.4 Effect of homogenization :

On homogenization milk fat globules are subdivided into smaller size which is supposed to effect the quality of chhana and therefore the rosogolla made therefrom. Hence a comparative study was made between unhomogenized and homogenized milks for chhana production. The homogenization was done in a two stage homogenizer at a pressure of 175 kg./sq.cm. and 35 kg./sq. cm. at 60°C. The results are presented in Table 4.1.1.4.

Table : 4.1.1.4. Effect of Homogenization of Buffalo Milk on Chhana, Whey and Rosogolla.

Quality Attributes	Unhomogenized Milk	Homogenized Milk 175 kg./sq.cm.& 35 kg./sq.cm.
Chhana		
Total Solid (%)	36.01-39.67	34.45-36.78
	37.54±0.67	35.48±0.42
Yield (%)	21.34-22.99	22.04-24.19
	22.09±0.37	23.4±0.41
Recovery of Milk Solid(%)	61.89-63.56	63.89-65.01
	62.58±0.30	64.45±0.22
Sensory Comments	Slightly hard, Coarse	Harder
Whey		
Total Solid (%)	4.56-6.01	4.01-6.12
	5.46±0.31	5.31±0.39
Fat (%)	0.4-0.6	0.2-0.4
	0.47±0.04	0.25±0.04
Rosogolla		
Body and Texture	4-9	2-7
(Max. 9)	7.16±0.32	5.2±0.27
Overall Acceptance	4-9	2-7
(Max. 9)	7.28±0.31	5.52±0.25
Sensory Comments	Slightly hard, uniform sweetness	Hard, lacks in sweetness at the centre.

Figures represent the range, mean and standard error.

Homogenization has been found to increase the yield and recovery of milk solids whereas the softness of chhana was reduced. This might be due to the formation of new smaller fat globules and increased surface area of milk fat globule membrane wherein higher amount of calcium caesinate complex get involved. This fact was further supported by the lowering of total solid and fat loss in whey. The sensory evaluation of rosogolla, however showed an adverse effect of homogenization. The rosogolla prepared from homogenized milk was harder with nonuniform sweetness, specially at the centre. This might be because of the hardeness of chhana and more milk fat globule membrane surface area.

Table : 4.1.1.4.A. ANOVA on Sensory Characteristics of Rosogolla for the Effect of Homogenization of Buffalo Milk

S.O.V.	d.f.	Body & Texture		Overall Acceptability	
		MSS	F	MSS	F
Treatment	1	10.58	14.50**	11.52	14.06**
Judgement	4	7.75	10.62**	10,27	12,53**
Tr. X Jud.	4	0.83	1.14	0.97	1.18
Replicate	4	1.15	1.58	1.62	1.98
Error	37	0.7297		0.8195	

* Significant at 5% level. ** Significant at 1% level.

Statistical data (Table 4.1.1.4.A.) showing variations in the sensory characteristics of rosogolla for the effects of homogenization were observed highly significant at 1% level for both body and texture and overall acceptability.

The results are in tune with the findings of earlier workers (Kundu and De, 1972; Kanawjia and Rao, 1975; Gajendran and Rao, 1976; Aneja _et al_, 1977; Iyer, 1978; Soni _et al_ 1980 and Ahmed _et al_, 1981).

4.1.1.5 **Effect of tryptic digestion :**

The effect of partial digestion of buffalo milk protein with the enzyme trypisn was tried to see its effect on the quality of chhana and its suitability for rosogolla production. The results are given in Table 4.1.1.5. trials were taken with different gradation of digestion namely 10 min., 15 min., and 20 min.

Table : 4.1.1.5. Effect of Tryptic Digestion in Standardised Buffalo Milk on Chhana, Whey and Rosogolla.

Quality Attributes	Control	Tryptic digestion period		
		10 min.	15 min.	20 min.
Chhana				
Total Solid (%)	36,01-39.67	36.99-38.44	36.99-37.88	36.99-37.34
	37.54±0.67	37.58±0.26	37.40±0.15	37.18±0.08
Yield (%)	21.34-22.99	21.01-23.12	20.89-23.01	20.21-23.01
	22.09±0.37	22.07±0.45	22.02±0.45	21.25±0.47
Recovery of Milk	61.89-63.56	61.02-64.01	61.02-64.41	61.02-63.51
Solids (%)	62.58±0.30	62.41±0.51	62.49±0.57	63.13±0.50
Sensory Comments	Slightly hard, Coarse	Soft	softer	Softer
Whey				
Total Solid (%)	4.56-6.01	4.09-7.01	4.56-7.01	5.12-7.01
	5.46±0.31	5.55±0.49	5.65±0.42	6.23±0.38
Fat (%)	0.4-0.6	0.2-0.5	0.4-0.5	0.3-0.8
	0.47±0.04	0.43±0.06	0.48±0.02	0.53±0.09
Rosogolla				
Body & Texture	4-9	4-9	4-9	1-6
(Max. 9)	7.16±0.32	7.2±0.33	7.4±0.35	4.0±0.33
Overall Acceptance	4-9	4-9	4-9	1-6
(Max. 9)	7.28±0.31	7.24±0.31	7.6±0.33	4.24±0.39
Sensory Comments	Hard	Less Hard Lack of pores	Soft, Smooth Porous Surface	Very Soft dissociate while Cooking

Figures represent the range, mean and standard error.

It may be observed from Table 4.1.1.5 that softness was increasing alongwith the severity of digestion. This may be explained by the fact of reduction in protein chain length with digestion by trypsin. Alongwith the increase in incubation time, recovery of milk solids in chhana and solid losses in whey were affected only to a small extent but with a positive growing trend. The tendency might be because of new reactions caused by the smaller proteins. An electrophoretic study was also undertaken to understand this effect. (Fig. No. 4.3.2). However, the rosogolla produced from the treated samples of chhana was found markedly different and the softness of rosogolla was observed to increase alongwith the severity of treatment.

Table : 4.1.1.5.A. **ANOVA on Sensory Characteristics of Rosogolla for the Effect of Tryptic Digestion in Buffalo Milk.**

S.O.V.	d.f.	Body & Texture		Overall Acceptance	
		MSS	F	MSS	F
Treatment	3	16.7067	13.40**	20.9967	18.20**
Judgement	4	18.265	14.65**	16.685	14.47**
Tr. X Jud.	12	2.8317	2.27*	2.6383	2.29*
Replicate	4	10.115	8.11**	6.885	5.97**
Error	76	1.2466		1.1534	

* Significant at 5% level. ** Significant at 1% level.

Statistical analysis as shown in Table 4.1.1.5.A revealed a high degree of significance in the variation at 1% level with the tryptic digestion. The variations due to judgement and replicate were also found significant because of personal likelyhoods towards softness of the product.

From the above results it was interpretted that a digestion for 15 min. was the most suitable one for rosogolla preparation from buffalo milk. A higher incubation period resulted into very soft rosogolla which tended to dissociate during cooking and lower incubation period had given rise to harder products which lacked in the desired porosity as well.

4.1.2 Chhana preparation from buffalo milk :

Alike many other Indian dairy products, chhana is the base for rosogolla manufacturing. Hence, preparation of chhana largely imparts to the final product. The following experiments were undertaken to optimize the manufacturing method of chhana from buffalo milk.

4.1.2.1 Effect of coagulation temperature :

Temperature of coagulation has been reported as one of the most important factors on the yield and quality of chhana by all earlier workers. From the available data on coagulation temperature ranging from 40°C to boiling condition, 60°C to 75°C was considered to produce better results. Hence in the present study a range of coagulation temperature from 60°C to 75°C was taken into account. The results are tabulated in Table 4.1.2.1. Total solid content in chhana was found to increase alongwith increased temperature excepting a slight decrease at the lowest one of 60°C. On the contrary, the yield was found to decrease alongwith the increase in temperature with a slight increase at 60°C. The lowest yield was found at a temperature of 65°C wherein the chhana contained highest total solid. From the analysis of whey comparatively lower losses were noted at lower temperatures of coagulation both with total solid and fat content level.

Table : 4.1.2.1. Effect of Buffalo Chhana Coagulation Temperature on Quality of Chhana, Whey and Rosogolla.

Quality Attribute	Control (70°C)	Temperature of Coagulation 75°C	65°C	60°C
Chhana				
Total Solid (%)	36.99-37.88	35.89-37.90	37.56-39.12	37.56-38.78
	37.40±0.15	36.83±0.37	38.36±0.28	38.14±0.20
Yield (%)	20.89-23.01	20.56-23.12	20.99-22.01	20.99-22.89
	22.02±0.45	22.48±0.48	21.24±0.20	21.58±0.36
Recovery of Milk	61.02-64.41	61.31-64.01	61.01-63.01	61.01-63.01
Solid (%)	62.49±0.57	62.62±0.45	62.16±0.45	62.09±0.42
Sensory Comments	Soft	Softer	Still Soft	Very Soft
Whey				
Total Solid (%)	4.56-7.01	4.89-6.23	4.34-6.23	4.34-6.23
	5.65±0.12	5.65±0.25	5.54±0.34	5.34±0.31
Fat (%)	0.4-0.5	0.2-0.6	0.2-0.6	0.1-0.6
	0.48±0.02	0.43±0.07	0.42±0.08	0.38±0.09
Rosogolla				
Flavour (Max.9)	6-9	6-9	6-9	6-9
	7.72±0.23	7.92±0.23	8.20±0.16	8.48±0.14
Body and Trxture	4-9	5-9	4-9	6-9
(Max.9)	7.4±0.35	7.41±0.25	7.52±0.27	7.56±0.22
Overall Acceptance	4-9	5-9	6-9	6-9
(Max.9)	7.6±0.33	7.72±0.25	7.80±0.22	7.92±0.22
Sensory Comments	Soft, Chewy	Hard, Chewy	Spongy	More Spongy

Figures represent the range, mean and standard error.

From the sensory scores for the respective rosogolla samples, it was evident that the higher temperature of coagulation resulted into harder and chewy type bodied rosogolla alongwith cooked flavour. Comparatively better products were prepared at lower temperature. A temperature of coagulation of 60°C was found as the most suitable one for rosogolla production, though with comparatively lesser yield of chhana, and was selected for the further modification (Table 4.1.2.1).

Table : 4.1.2.1.A. ANOVA on Sensory Characteristics of Rosogolla for the Effect of Buffalo Chhana coagulation Temperature.

S.O.V.	d.f.	Flavour		Body & Texture		Overall acceptance	
		MSS	F	MSS	F	MSS	F
Treatment	3	2.7467	6.06**	0.17	0.17	3.9067	6.97**
Judgement	4	9.515	21.00**	11.165	11.03**	10.375	16.12**
Tr. X Jud.	12	1.3883	3.06**	1.0117	1.00	0.8817	1.37
Replicate	4	0.99	2.18	2.165	2.14	1.075	1.67
Error	76	0.4532		1.0124		0.6434	

* Significant at 5% level. ** Significant at 1% level.

The analysis of variance (Table 4.1.2.1.A.) showed a high degree of significance at 1% level which was evident from the chemical analysis as well. The variance amongst the judges were also found highly significant might be because of degree of likings towards the softness varied from judge to judge. However the sensory scores revealed that the buffalo milk coagulated at 60°C produced best quality rosogolla.

These results apparently seemed to be different to those reported by Soni et al (1980). The reasons might be because of the additives used by the earlier workers. It may be mentioned here that the higher temperature of coagulation of 92 to 95°C by Chandra Sekhara et al (1957) and Bhattacharya and Desraj (1980) for cow chhana was not found suitable for buffalow chhana

The lower pH level used by those workers may be one of the active factors in this regard.

4.1.2.2 Effect of type and strength of coagulant :

Citric acid and lactic acid are generally used as coagulant for the manufacture of chhana. In the present study both the above acids were tried for their suitability at a strength between 0.5% to 1.0%. The results are depicted in Table 4.1.2.2.

Table : 4.1.2.2. Effect of Type and Strength of Coagulant for Buffalo Chhana on Quality of Chhana, Whey and Rosogolla.

Quality Attribute	Control (0.5% Latic Acid)	Latic Acid		Citric Acid	
		0.75%	1.0%	0.5%	1.0%
Chhana					
Total Solid (%)	37.56-38.78 38.14±0.20	37.61-39.02 38.35±0.25	37.52-40.01 38.53±0.42	37-23-40.12 38.96±0.47	38.55-40.12 39.22±0.25
Yield (%)	20.99-22.89 21.58±0.36	20.99-22.49 21.50±0.32	20.99-22.01 21.44±0.23	20.12-21.71 21.04±0.26	19.34-22.01 20.36±0.45
Recovery of Milk Solid (%)	61.01-63.01 62.09±0.42	61.01-63.01 62.07±0.42	61.01-62.78 62.07±0.43	60.09-62.78 61.57±0.48	60.29-62.12 61.09±0.30
Sensory Comments	Very Soft, Smooth	Very Soft, Smooth	Soft, Smooth	Hard, Coarse	Hard Coarse
Whey					
Total Solid(%)	4.34-6.23 5.34±0.31	4.34-6.34 5.38±0.39	4.34-6.01 5.30±0.32	4.89-6.99 6.21±0.39	4.34-6.09 5.49±0.35
Fat (%)	0.1-0.6 0.38±0.09	0.1-0.5 0.36±0.08	0.1-0.5 0.39±0.07	0.2-0.4 0.31±0.04	0.1-0.4 0.29±0.06
Rosogolla					
Flavour (Max. 9)	6-9 8.48±0.14	6-9 8.52±0.15	6-9 8.52±0.15	6-9 8.52±0.17	7-9 8.60±0.12
Body & Texture (Max. 9)	6-9 7.56±0.11	4-9 7.56±0.28	5-9 7.80±0.30	6-9 7.64±0.24	3-9 7.20±0.39
Overall Acceptance (Max.9)	6-9 7.92±0.22	5-9 7.92±0.26	4-9 8.12±0.25	6-9 7.92±0.23	3-9 7.28±0.36
Sensory Comments	Spongy, Close texture	Spongy, Close texture	Spongy, Higher porousity	Granular, Coarse	Granular, Coarse

Figures represent the range, mean and standard error.

It was observed that the yield of chhana was higher with lactic acid in comparison to those with citric acid in general and was decreasing alongwith the increase of acidity. Total solid content in chhana was more with citric acid in comparison to those with lactic acid and was increasing alongwith the increase of acidity. The recovery of milk solid was highest with 0.5% citric acid and lowest with 0.75% and 1.0% lactic acid. Similarly, citric acid whey was found to contain more total solid and less fat in comparison to lactic acid whey. However, the chhana produced with citric acid was hard and coarse whereas the chhana produced with lactic acid were soft and smooth in comparison. The softness of lactic acid chhana was more with lower concentration of acid.

Table : 4.1.2.2.A. ANOVA on Sensory Characteristics of Rosogolla for the Effect of Type and Strength of Coagulant for Buffalo Chhana.

S.O.V.	d.f.	Flavour		Body & Texture		Overall Acceptance	
		MSS	F	MSS	F	MSS	F
Treatment	4	0.08	0.18	3.452	3.69**	6.468	4.93**
Judgement	4	1.66	3.78**	46.132	49.27**	29.428	22.44**
Tr. X Jud.	16	0.465	1.06	1.727	1.84	2.193	1.67
Replicate	4	1.58	3.60*	4.632	4.95*	1.628	1.24
Error	96	0.4383		0.9362		1.3133	

* Significant at 5% level. ** Significant at 1% level.

Rosogolla prepared from the respective chhana had also shown similar results to that of chhana. The citric acid chhana gave rise to granular and coarse rosogolla and lactic acid chhana found to produce spongy rosogolla. One per cent lactic acid has been found to produce the most desirable kind of spongy rosogolla with higher porosity and hence it was chosen for further studies. These findings are in agreement with the earlier observations of De (1976) and Rajorhia (1987).

The statistical analysis (Table 4.1.2.2.A.) showed a highly significant variation with different coagulants and their strength. Variations were also noted amongst the different replicates and the judgements which might be because of initial qualities of milk and likelihood levels.

Our results were in agreement with the results found by De(1976), Soni et al(1980) & Rajorhia(1987) for lactic acid as a better coagulant for chhana preparation for rosogolla manufacturing. The suggestion of Bhattacharya and Desraj (1980) for citric acid however, failed to give the desired results.

4.1.2.3 Effect of pH of coagulation :

Chhana, whey and rosogolla prepared from previously boiled buffalo milk were analysed after coagulating them at various pH ranging from 5.4 to 5.7 at a fixed temperature of 60°C since all the earlier workers observed satisfactory results within this range only. The results are expressed in Table 4.1.2.3. It was noticed that the control chhana obtained at pH 5.7 was soft and smooth and the softness was decreasing alongwith the decrease in pH of coagulation. The chhana pertaining to the pH of 5.4 was the most hard and coarse one. The total solid content in chhana was found to increase with the lowering of pH of curdling and on the contrary the recovery of milk solids in chhana was found to decrease. The yield however, did not show any particular trend. At pH 5.5 the maximum yield was observed which was slightly more than that at the pH of 5.7. The analysis of whey revealed more or less similar total solid and fat losses in the whey. The lowest losses were observed at pH 5.4.

Table : 4.1.2.3. Effect of pH of Coagulation for Buffalo Chhana on Quality of Chhana, Whey and Rosogolla.

Quality Attribute	Control (pH 5.7)	pH of Coagulation 5.6	5.5	5.4
Chhana				
Total Solid (%)	37.52–40.01	38.67–39.99	38.89–41.89	40.23–42.01
	38.53±0.42	39.47±0.30	40.33±0.48	41.19±0.34
Yield (%)	20.99–22.01	20.08–22.01	19.99–21.34	19.01–21.08
	21.44±0.23	21.09±0.32	20.53±0.29	20.13±0.41
Recovery of Milk	61.01–62.78	61.01–63.13	60.98–62.81	60.12–62.34
Solid (%)	62.07±0.43	61.83±0.46	61.72±0.42	61.32±0.39
Sensory Comments	Soft, Smooth	Less Soft,	Slightly hard & Coarse	Hard, Coarse
Whey				
Total Solid (%)	4.34–6.01	4.34–6.11	4.31–6.03	4.13–6.01
	5.30±0.32	5.32±0.36	5.28±0.35	5.22±0.37
Fat (%)	0.1–0.5	0.2–0.5	0.2–0.5	0.2–0.5
	0.39±0.07	0.38±0.06	0.37±0.06	0.32±0.06
Rosogolla				
Flavour (Max.9)	6–9	6–9	3–9	4–9
	8.52±0.15	8.52±0.17	8.52±0.25	8.32±0.25
Body & Texture	5–9	3–9	3–9	2–9
(Max.9)	7.80±0.30	7.32±0.36	6.92±0.41	6.12±0.48
Overall Acceptance	4–9	4–9	2–9	3–9
(Max.9)	8.12±0.25	7,52±0,33	7.16±0.43	6.52±0.40
Sensory Comments	Spongy, Pourous	Less Spongy, Close Texture	Lack Porousity	Chewy

Figures represent the range, mean and standard error.

Rosogolla prepared from such chhana exhibited similar ts as was evident in the respective chhana samples (Table 2.3). The control rosogolla with a curdling pH of 5.7 was spongy with the desired porosity, whereas the rosogollas with lower pH of curdling were less spongy and closer textured with lack of porosity . The rosogolla made from buffalo chhana curdled at a pH of 5.4 was hard and chewy without the desired porosoty.

The sensory characteristics of rosogolla samples were statistically analysed. The results are displayed in Table 4.1.2.3.A. From the statistical analysis it was exposed that the flavour scores were not varied significantly alongwith the change of pH. Whereas the body and texture and overall acceptance were significantly variable at 1% level. The replicate were almost homogenious but the variation from judge to judge were also highly implicit.

Table : 4.1.2.3.A. **ANOVA on Sensory Characteristics of Rosogolla for the Effect of pH of Coagulation for Buffalo Chhana.**

S.O.V.	d.f.	Flavour		Body & Texture		Overall Acceptance	
		MSS	F	MSS	F	MSS	F
Treatment	3	1.0933	0.86	12.64	7.63**	11.21	6.68**
Judgement	4	2.685	2.11	22.585	13.64**	14.115	8.41**
Tr. X Jud.	12	0.8183	0.64	12.7983	7.73**	9.8016	5.84**
Replicate	4	4.085	3.21*	1.035	0.62	2.215	1.32
Error	76	1.2745		1.6560		1.6782	

* Significant at 5% level. ** Significant at 1% level.

From the above study it was concluded that a pH of 5.7 was the most suitable for curdling buffalo milk at a temperature of 60°C for the preparation of spongy type rosogolla. The results were in line with the findings of Kundu and De (1972), Soni et al (1980) and Ahmed et al (1981) who also had suggested the same pH level for soft quality chhana suitable for rosogolla preparation. Srinivasan and Anantakrishnan (1964) and Bhattacharya and Desraj (1980), however, had advocated for a lower pH in contradiction to the results of the present study.

4.1.2.4 Effect of straining method :

Immediate straining and delayed straining methods were tried for preparation of buffalo chhana. The comparative analysis is shown in Table 4.1.2.4.

Table : 4.1.2.4. Effect of Straining Method for Buffalo Chhana on Quality of Chhana, Whey and Rosogolla.

Quality Attribute	Immediate Straining	Delayed Straining
Chhana		
Total Solid (%)	37.52-40.01 38.53±0.42	35,23-36,23 35.69±0.17
Yield (%)	20.99-22.01 21.44±0.23	22.81-25.39 24.33±0.52
Recovery of Milk Solid (%)	61.01-62.78 62.07±0.43	61.78-63.24 62.54±0.30
Sensory Comments	Soft, Smooth	Very Soft & Smooth
Whey		
Total Solid (%)	4.34-6.01 5.30±0.32	4.11-5.89 5.20±0.35
Fat (%)	0.1-0.5 0.39±0.07	0.2-0.4 0.33±0.04
Rosogolla		
Flavour (Max.9)	6-9 8.52±0.15	7-9 8.56±0.12
Body & Texture (Max.9)	5-9 7.80±0.30	2-9 7.16±0.43
Overall Acceptance (Max.9)	4-9 8.12±0.25	3-9 7.52±0.38
Sensory Comments	Spongy Porous	Large Pores, Loose texture, Flattened body

Figures represent the range, mean and standard error.

It may be observed from Table 4.1.2.4 that delayed straining method caused a softer and smoother chhana in comparison to those obtained by immediate straining. This fact may be because of higher water retention by the first method which was evident from the higher yield and lower total solid content of the respective chhana. The recovery of milk solid in chhana samples were also found to be little higher in those obtained by delayed straining method. The whey obtained by immediate straining method was also found to contain higher total solid and fat content in comparison to those obtained by delayed straining method.

Rosogolla prepared from the respective samples exhibited that those obtained by delayed straining contained large pores with loose texture and flattened body whereas immediate straining method produced a better quality of spongy and porous rosogolla.

Table : 4.1.2.4.A. ANOVA on Sensory Characteristics of Rosogolla for the Effect of Straining Method for Buffalo Chhana.

S.O.V.	d.f.	Flavour		Body & Texture		Overall Acceptance	
		MSS	F	MSS	F	MSS	F
Treatment	1	0.50	0.52	0.08	0.12	0.32	0.27
Judgement	4	0.87	0.91	6.08	9.19**	3.68	3.06*
Tr. X Jud.	4	0.95	0.99	15.68	23.70**	1.52	1.26
Replicate	4	2.77	2.90*	0.88	1.33	1.58	1.31
Error	37	0.9546		0.6616		1.2022	

* Significant at 5% level. ** Significant at 1% level.

The sensory scores on statistical analysis as tabulated in Table 4.1.2.4.A. revealed that the method of straining imparted no significant variation whereas the judgement for body and texture and overall acceptance were found to vary a little. Therefore from the average scores and sensory comments immediate straining method was chosen for better suitability for rosogolla preparation from buffalo milk. The results obtained by Singh and Ray (1977b) who failed to find any change in the body and texture of chhana by the method of straining however are not in agreement with the present set of results. The present results are apparently not in agreement with the earlier findings of Kundu and De (1972) and Soni et al (1980) who suggested delayed straining method for better rosogolla from buffalo milk. The reasons might be because of the earlier workers'choice to soft variety of rosogolla instead of the present inclination towards spongy variety. Otherwise, the present study, had also exposed a softer chhana with delayed straining. Bhattacharya and Desraj (1980) had also opined for immediate straining method for good quality rosogolla from cow milk.

4.1.3 Preparation of rosogolla from buffalo chhana :

As has been discussed earlier, chhana plays an important role for manufacturing rosogolla from milk. The earlier set of trials therefore was taken to standardize a suitable quality of chhana from buffalo milk. The next important part is to produce rosogolla from the buffalo chhana. The following trials had been undertaken to standardize the method of rosogolla manufacturing from the buffalo chhana.

4.1.3.1 Effect of addition of wheat flour :

Though in the preliminary trials it was observed that the commonly used additives adversely affected the desired spongyness in the body and texture of the rosogolla. Studies were carried out to find out the optimum amounts of wheat flour and baking powder required to produce acceptable rosogolla from buffalo milk.

Table : 4.1.3.1. Effect of Addition of Wheat Flour in Buffalo Chhana on the Quality of Rosogolla.

Quality Attribute	Control	Addition of Wheat Flour by % weight of Chhana		
		2	3	5
Total Solid (%)	44.01-46.02 45.13±0.39	43.01-45.01 44.33±0.37	42.98-44.86 44.29±0.36	43.99-45.90 44.89±0.30
Yield (% Weight of Chhana)	347.01-349.01 348.15±0.35	337.09-339.78 338.47±0.46	331.02-333.89 332.39±0.56	327.45-329.34 328.19±0.31
Flavour (Max.9)	6-9 8.52±0.15	4-9 8.32±0.26	4-9 8.04±0.27	5-9 7.92±0.24
Body & Texture (Max.9)	5-9 7.80±0.30	4-9 7.72±0.32	3-9 7.52±0.38	2-9 6.88±0.41
Overall Acceptance (Max.9)	4-9 8.12±0.25	5-9 7.96±0.23	3-9 7.60±0.33	3-9 6.60±0.34
Sensory Comments	Spongy, Porous	Less Spongy	Soft, Smooth Surface	Very Soft Do not regain the shape on Squeeze.

Figures represent the range, mean and standard error.

Effect of addition of wheat flour in buffalo chhana at the level of 2, 3 and 5% by the weight of chhana were studied against the control where no wheat flour was added before kneading. The total solid content and yield of rosogolla by % weight of chhana were found to decrease alongwith the addition of wheat flour with an exception in the total solid content of rosogolla with 5% addition of wheat flour which was slightly higher. It was observed from the sensory scores that each of flavour, body and texture and overall acceptance was decreasing with addition of wheat flour. The spongy and porousness of the control rosogolla was found to decrease with the increase in the level of addition. Finally at the highest level of addition, the rosogolla samples failed to regain their shapes on squeezing and were very soft.

Table : 4.1.3.1.A. ANOVA on Sensory Characteristics of Rosogolla for the Effect of Addition of Wheat Flour in Buffalo Chhana.

S.O.V.	d.f.	Flavour		Body & Texture		Overall Acceptance	
		MSS	F	MSS	F	MSS	F
Treatment	3	1.84	1.57	4.3467	2.29	11.6367	6.43**
Judgement	4	0.8	0.68	14.49	7.63**	7.365	4.07**
Tr. X Jud.	12	1.7733	1.51	7.4967	3.95**	2.845	1.57
Replicate	4	4.175	3.55*	3.44	1.81	1.615	0.89
Error	76	1.175		1.8979		1.8097	

* Significant at 5% level. ** Significant at 1% level.

The sensory scores enumerated by different judges were statistically analysed and presented in Table 4.1.3.1.A. The overall acceptance was found to vary in a highly significant way at 1% level. The other attributes however showed not much of significance. Hence the control rosogolla with highest average score in regards to each of flavour, body and texture and overall acceptnce was considered as the best one for further optimization. From the earlier literatures it was observed that most of the workers had preferred to add similar additives for achieving desirable quality of rosogolla. Srinivasan and Anantakrishnan

(1964) advocated the addition of corn or maize flour alongwith some other additives. Soni et al (1980) had also preferred addition of wheat flour alongwith some other additives. The comparative studies were however, not reported by them. The present study revealed that for preparation of good spongy rosogolla from buffalo milk made out of fresh chhana would be best when no wheat flour is added into it.

4.1.3.2 Effect of addition of baking powder :

In order improve the body and textural quality of rosogolla from buffalo milk, samples were prepared using three different levels of baking powder namely 0.6, 0.5 and 0.25% by weight of chhana before kneading. All the samples were subjected to chemical and sensory evaluation, the results are depicted in Table 4.1.3.2.

Table : 4.1.3.2. Effect of Addition of Baking Powder in Buffalo Chhana on the Quality of Rosogolla.

Quality Attribute	Control	Addition of baking powder by % weight of Chhana		
		06	0.5	0.25
Total Solid (%)	44.01-46.02 45.13±0.39	38.99-41.43 40.37±0.42	41.99-43.72 42.87±0.38	43.51-44.56 43.92±0.20
Yield (% weight of Chhana)	347.01-349.01 348.15±0.35	312.45-314.56 313.16±0.38	320.78-322.51 321.54±0.29	321.12-324-45 323.18±0.59
Flavour (Max.9)	6-9 8.52±0.15	3-9 7.64±0.38	6-9 8.52±0.15	5-9 8.52±0.18
Body & Texture (Max.9)	5-9 7.80±0.30	5-9 7.32±0.39	2-9 7.52±0.39	2-9 7.84±0.35
Overall Acceptance (Max.9)	4-9 8.12±0.25	2-9 7.40±0.42	5-9 8.04±0.23	4-9 8.20±0.29
Sensory Comments	Spongy, Porous	Disintegrating Loose body	Spongy, big pores, Cracks.	Songy nonuniform pores

Figures represent the range, mean and standard error.

It was observed that the total solid content and yield of rosogolla decreased down progressivelyy alongwith the addition of baking powder. The sensory scores revealed that the flavour was not much affected till the addition of 0.5% baking powder and decreased on addition of 0.6% only. The average body and texture and overall acceptance scores were noted at the highest level when 0.25% baking powder was added though the variation of its score with the control was negligible. The scores however exhibited a definite decreasing trend on further addition.

Table : 4.1.3.2.A. ANOVA on Sensory Characteristics of Rosogolla for the Effect of Addition of Baking Poweder in Buffalo Chhana.

S.O.V.	d.f.	Flavour		Body & Texture		Overall Acceptance	
		MSS	F	MSS	F	MSS	F
Treatment	2	4.84	4.28**	1.5067	0.73	3.3467	1.82
Judgement	4	5.975	5.29**	19.615	9.51**	6.935	3.78*
Tr. X Jud.	12	1.9483	1.72	4,3817	2.12*	4.255	2.32*
Replicate	4	0.325	0.29	4.315	2.09	1.81	0.99,
Error	76	1.1303		2.0624		1.8363	

* Significant at 5% level. ** Significant at 1% level.

The statistical analysis of the sensory scores as represented in Table 4.1.3.2.A. exposed that the variation in flavour was highly significant whereas they were not much of importance for body and texture and overall acceptance. Hence from the average scores the control method of production without addition of baking powder was chosen as the best method for further optimization of the manufacturing process.

4.1.3.3 Effect of moisture content of chhana :

From the available published literature it is evident that the moisture content in chhana largely affect the final quality of rosogolla. Most of the workers tried to report about the moisture content of chhana while standardizing the other process parameters. In order to optimize the initial moisture content of chhana, it was compressed and calculated amount of water was added into it before kneading, to achieve the desired level of moisture in chhana. The average moisture content in the control chhana was 62% in average. The moisture level was standardized to 50, 60 and 70% for comparative analysis and optimization, and the observations were depicted in Table 4.1.3.3.

Table : 4.1.3.3. Effect of Moisture Content of Buffalo Chhana on the Quality of Rosogolla.

Quality Attribute	Control (Average moisture: 62%)	Moisture Content in Chhana		
		50	60	70
Total Solid (%)	44.01-46.02 45.13±0.39	50.89-52.67 51.87±0.32	44.29-46.54 45.37±0.38	56.34-58.78 57.51±0.41
Yield (% Weight of Chhana)	347.01-349.01 348.15±0.35	320.03-322.89 321.46±0.46	347.02-348.01 347.22±0.20	307.01-309.78 308.16±0.66
Flavour (Max.9)	6-9 8.52±0.15	4-9 8.20±0.33	7-9 8.52±0.15	4-9 8.48±0.22
Body and Texture (Max.9)	5-9 7.80±0.30	2-9 6.88±0.55	5-9 7.8±0.30	2-9 5.2±0.64
Overall Acceptance	4-9 8.12±0.25	4-9 7.96±0.34	6-9 8.32±0.21	2-9 5.12±0.55
Sensory Comments	Spongy, Porous	Hard, Close	Soft, Spongy, Porous	Loose, flattened disintegrating

Figures represent the range, mean and standard error.

The total solid contents of rosogolla samples were noted to decrease with the increase in moisture level of chhana with a notable increase at the highest moisture content, which might have resulted from the disintegration of rosogolla at this moisture level of chhana. The corresponding yield was also found to increase with increase in the moisture content of chhana because of higher water retention by the rosogolla samples with an exceptional low yield with 70% moisture chhana because of the disintegrated nature of rosogolla body. The sensory scores revealed that the rosogolla prepared from chhana with 60% moisture level was rated as the highest one and was almost similar to the control rosogolla. The scores were found lesser both with 50% level and 70% level of moisture content in chhana in regards to flavour, body and texture and overall acceptance. The flavour score was least at the lowest moisture level of chhana. The 50% moisture containing chhana yielded a harder body but 70% moisture containing chhana was rated still lesser because of the loose, flattend and disintegrated nature of the rosogolla samples.

Table : 4.1.3.3.A. ANOVA on Sensory Characteristics of Buffalo Rosogolla for the Effect of Moisture Content in Buffalo Chhana.

S.O.V.	d.f.	Flavour		Body & Texture		Overall Acceptance	
		MSS	F	MSS	F	MSS	F
Treatment	3	0.5967	0.51	37.5733	16.30**	57.2933	35.94**
Judgement	4	2.965	2.53*	27.065	11.74**	13.615	8.54**
Tr.X Jud.	12	1.0717	0.91	21.1317	9.16**	11.535	7.24**
Replicate	4	1.715	1.46	0.89	0.39	3.915	2.46
Error	76	1.1729		2.3058		1.5939	

* Significant at 5% level. ** Significant at 1% level.

The sensory scores were analysed for variance, and the results are displayed in Table 4.1.3.3.A. It may be seen from the table that the variance in flavour scores were not statistically significant whereas the scores for body and texture and overall acceptance were found highly significant at 1% level with change in initial moisture content of chhana. The judgement variations were also noted to be significant because of the changes in likelihood towards the softness of body.

From the above study it was concluded that a moisture level of 60% in the buffalo chhana was the most suitable one for rosogolla preparation. Lower moisture level of chhana caused a harder body and higher moisture level an undesirable softness leading towards disintegration of the final product. Bhattacharya and Desraj (1980) in a similar study with cow milk had advocated for 50 to 58% moisture level in chhana. The present observations are in close agreement with that of Soni et al (1980).

4.1.3.4 Effect of sugar concentration in cooking syrup :

Next to the composition of chhana, sugar concentration in the cooking syrup is considered to impart a lot in the quality of rosogolla, since the chhana balls are boiled in this syrup. Various concentrations of sugar syrup namely 60%, 65% and 80% on weight to weight basis was compared with the control of 70% sugar syrup as cooking medium. The process of cooking was same in all the cases.

The results presented in Table 4.1.3.4 revealed that, the total solid content in the rosogolla samples was increasing alongwith the increase in sugar content in the cooking syrup. The yield of rosogolla were more or less same within a range of 60% to 70% concentration and was notably decreased at 80% concentration might be because of lower retention of moisture at this level which was evident from the hardness of the body of rosogolla. The highest yield was observed with 60% sugar syrup. The flavour scores were widely varying from judge to judge with more or less similar rating for all the variations excepting a comparatively poor average rating at 80% concentration level. The body and texture was found to improve in regard to softness and spongyness with the reduction in sugar concentration. A brown tinge of colour was evident with the highest concentration of sugar in the cooking medium. It was absent at 60% level, wherein the rosogolla samples were noted white in colour. The 60% cooking syrup also resulted into highest average body and texture scores which tended to reduce alongwith the increase in concentration. The overall acceptance rating was same in average for 60% and 65% concentration and was graded least at 80% concentration.

Table : 4.1.3.4. Effect of Sugar Concentration in Cooking Syrup on the Quality of Buffalo Rosogolla.

Quality Attribute	Control (70% Sugar)	% Sugar Concentration in Cooking Syrup		
		80	65	60
Total Solid (%)	44.29-46.54 45.37±0.38	47.17-49.90 48.33±0.48	45.12-46.54 45.64±0.26	43.56-45.67 44.80±0.39
Yield (% weight of Chhana)	347.02-348.01 347.22±0.20	308.01-310.01 309.18±0.39	347.01-349.56 347.97±0.48	347.45-349.90 348.54±0.42
Flavour (Max.9)	7-9 8.52±0.15	2-9 6.52±0.50	5-9 8.52±0.20	6-9 8.52±0.15
Body & Texture (Max.9)	5-9 7.80±0.30	2-9 6.20±0.51	4-9 7.84±0.28	5-9 8.08±0.27
Overall Acceptance (Max.9)	6-9 8.32±0.21	2-9 6.24±0.48	5-9 8.48±0.20	6-9 8.48±0.19
Sensory Comments	Spongy, Porous	Brown, Hard Less sweet in the centre	Slightly brown, spongy	White,Soft spongy.

Figures represent the range, mean and standard error.

The statistical analysis of the above results are presented in Table 4.1.3.4.A. The variations in flavour, body and texture and overall acceptance scores were found highly significant at 1% level. The judges however, opined differently for different set of products which is evident from the fact that the judgement variations for all the attributes were significant whereas replicate factor was not significantly variable.

Table : 4.1.3.4/A. ANOVA on Sensory Characteristics of Buffalo Rosogolla for the Effect of Sugar Concentration in Cooking Syrup.

S.O.V.	d.f.	Flavour		Body & Texture		Overall Acceptance	
		MSS	F	MSS	F	MSS	F
Treatment	3	25.3433	28.18**	18.3833	12.43**	30.0267	29.51**
Judgement	4	7.14	7.94**	6.965	4.71**	5.99	5.89**
Tr. X Jud.	12	8.1933	9.11**	12.125	8.20**	9.1767	9.02**
Replicate	4	0.415	0.46	1.49	1.01	0.765	0.75
Error	76	0.8992		1.4795		1.0176	

* Significant at 5% level. ** Significant at 1% level.

The above findings leads to the conclusion that a 60% sugar content in the cooking syrup was the most favourable one for the production of rosogolla from buffalo milk. Which does not agree with the results of Soni et al (1980) who had suggested 80% concentration as the best one for buffalo rosogolla. This might be because of the additives which was not used in the present set of experiment. The above results however agreed with the other workers findings with cow milk (Date et al, 1958; Srinivasan and Anantakrishnan, 1964; Singh and Roy, 1977b and

Bhattacharya and Desraj, (1980) who all had advocated 55% to 60% sugar concentration for rosogolla preparation.

4.1.3.5 **Effect of cooking time** :

As has been discussed at the begining that the chhana balls were cooked in boiling cooking syrup at 110 to 115°C. The effect of the intensity of cooking on the final desirability of rosogolla was examined by varying the cooking time. From earlier reports it is clear that all the researchers agreed to a range of 20 to 30 minutes cooking time as the optimum requirement of the desired cooking. In the present study, cooking was done for 20 min. and 30 min. The results were compared with the control method of cooking for 25 min. and presented in Table 4.1.3.5.

Table : 4.1.3.5. Effect of Cooking time on the Quality of Buffalo Rosogolla.

Quality Attribute	Control (25 min.)	Cooking time in minutes 20	30
Total Solid (%)	43.56-45.67 44.80±0.39	42.45-49.12 43.16±0.32	45.34-47.12 46.31±0.35
Yield (% weight of chhana)	347.45-349.90 348.54±0.42	322.01-324.07 323.18±0.39	324.45-326.89 325.63±0.51
Flavour (Max.9)	6-9 8.52±0.15	3-9 7.32±0.39	4-9 7.52±0.28
Body & Texture (Max.9)	5-9 8.08±0.27	4-9 8.04±0.31	4-9 8.12±0.26
Overall Acceptance (Max.9)	6-9 8.48±0.19	4-9 7.52±0.33	3-9 7.64±0.36
Sensory Comments	White, Spongy, Soft.	Raw in the Centre, Soft	Brown, Hard Cooked flavour

Figures represent the range, mean and standard error.

It was observed from Table 4.1.3.5 that the control method was giving the most suited result. The lower cooking period left the inside of the rosogolla balls raw and on the contrary the higher cooking period produced overcooked rosogolla with brownish appearence, hard body and cooked flavour. The total solid content of rosogolla was observed to be increasing with the increase in cooking time. The yield was however, highest at 25 min. cooking and lowest when they were cooked for 20 min. This might be the result of incorporation of sugar syrup into the balls. The flavour scores were most desired at the control method of 25 min. cooking. The other samples were rated low because of raw and overcooked flavours. The body and texture scores remained in the same region in all the three treatments. Looking from the angle of overall acceptance the jugdges had preferred 25 min. cooking as the best one. The average overall acceptance score was rated lowest for 30 min. cooking time.

Table : 4.1.3.5.A. ANOVA on Sensory Characteristics of Buffalo Rosogolla for the Effect of Cooking time.

S.O.V.	d.f.	Flavour		Body & Texture		Overall Acceptance	
		MSS	F	MSS	F	MSS	F
Treatment	2	10.3333	7.97**	0.04	0.03	6.84	4.84*
Judgement	4	9.68	7.47**	3.1467	2.42	6.98	4.94**
Tr. X Jud.	8	4.6	3.55**	5.4067	4.16**	5.64	3.99**
Replicate	4	1.4467	1.12	3.2133	2.47	2.5133	1.78
Error	56	1.2967		1.2990		1.4133	

* Significant at 5% level. ** Significant at 1% level.

The ANOVA on the sensory characteristics of buffalo rosogolla for the effect of cooking time (Table 4.1.3.5.A) revealed that the flavour and overall acceptances only changes significantly *alongwith* the change in cooking time. The changes in body and texture were insignificant. The statistical significance in judgement and treatment X judgement and inisgnificance in the replicate variation proved that the likelihood varied significantly amongst the panel of judges.

On the basis of the above results a cooking time of 25 min. was considered to be best suited for preparation of rosogolla from buffalo milk. The present result were in confirmation with the earlier reports by Date et al (1958), De (1976), Singh and Ray (1977), Bhattacharya and Desraj (1980) who all had advocated for a similar time limit as the best suited cooking time. Bhattacharya and Desraj (1980) also observed similar kind of defects at lower and higher cooking time span.

4.1.3.6 Effect of sprinkling of water during cooking :

In the control method of rosogolla production, while cooking, after every 5 minutes interval 25 to 30 ml of water was sprinkled into the cooking medium to compensate the loss of moisture due to evaporation as had been suggested by De (1976). Trials were made to see the effectivity of this method towards the final desirability of rosogolla by comparing them with products made by cooking without sprinkling of water. The results are displayed in Table 4.1.3.6. It was observed the cooking without the compensation of the loss of moisture, resulted into a harder product with a brownish colour and cooked flavour. The total solid content of such products were higher and the yield was lesser in comparison to the control method.

The statistical analysis of the sensory scores (Table 4.1.3.6.A) showed that the method caused a statistically significant variation in flavour and overall acceptance. The changes in the body and texture was insignificant. But the

ANOVA revealed the variation amongst the judges towards the likelihood of this product.

Table : 4.1.3.6. Effect of Sprinkling of Water during Cooking on the Quality of Buffalo Rosogolla.

Quality Attribute	Cooking with Sprinkling of water	Cooking without Sprinkling of water
Total Solid (1%)	43.56-45.67	46.45-48.12
	44.80±0.39	47.14±0.28
Yield (% weight of	347.45-349.90	323.78-325.23
Chhana)	348.54±0.42	324.59±0.29
Flavour (Max.9)	6-9	3-9
	8.52±0.15	7.32±0.38
Body and Texture	5-9	4-9
(Max.9)	8.08±0.27	7.88±0.27
Overall Acceptance	6-9	3-9
(Max.9)	8.48±0.19	7.44±0.39
Sensory Comments	White, Spongy	Brown, Hard,
	Soft	Cooked flavour.

Figures represent the range, mean and standard error.

Viewing the above results it was inferred that sprinkling of water while cooking, increased the suitability of rosogolla and suggested for the final method. The present findings are in agreement with the results of earlier works by De (1976), Bhattacharya and Desraj (1980) and Soni et al (1980). Wherein they had suggested this method to improve the final desirability of the product.

Table : 4.1.3.6.A. ANOVA on Sensory Characteristics of Buffalo Rosogolla for the Effect of Sprinkling of Water during Cooking

S.O.V.	d.f.	Flavour		Body & Texture		Overall Acceptnce	
		MSS	F	MSS	F	MSS	F
Treatment	1	19.22	20.04**	0.72	0.56	5.12	4.76*
Judgement	4	7,03	7.33**	4.6	3.55*	2.85	2,65*
Tr. X Jud.	4	6.97	7.27**	2.32	1.79	3.97	3.69*
Replicate	4	1.53	1.60	1.4	1.08	0.95	0.88
Error	37	0.9589		1.2973		1.0757	

* Significant at 5% level. ** Significant at 1% level.

4.1.3.7 <u>Effect of repeated use of cooking syrup</u> :

In general practice people uses the cooking syrup repeatedly in the industry which has been found to impart bad effects on the final quality of rosogolla. In order to enumerate the above effects trials were undertaken to produce rosogolla by using the same cooking syrup uptil third repeat the results are exhibited in Table 4.1.3.7. It was noted that the products tended to conceive a brownish colour possibly from the cooked sugar syrup and greasiness in the body, possibly from the fat losses in the cooking medium alongwith the repeated use. The effects were increasing with the number of repeats. The spongyness were also found to decrease with increase in the hardness of rosogolla. This might be due to the increased concentration of sugar syrup. The yield was found to increase to a small extent while for the first repeat and was then decreasing gradually. The total solid content was observed to decrease slightly along-with the repeated use.

Table : 4.1.3.7. Effect of Repeated Use of Cooking Syrup on the Quality of Buffalo Rosogolla.

Quality Attributes	Control (Fresh)	Repeated use of Cooking Syrup 1st repeat	2nd repeat	3rd repeat
Total Solid (%)	43.56–45.67	43.34–45.89	43.34–45.25	43.01–44-99
	44.80±0.39	44.63±0.46	44.32±0.35	44.18±0.35
Yield (% weight of chhana)	347.45–349.90	347.89–349.88	347.34–349.01	345,99–349.00
	348.54±0.42	348.61±0.37	348.24±0.34	347.11±0.51
Flavour (Max.9)	6–9	7–9	6–9	3–9
	8.52±0.15	8.56±0.13	8.48±0.15	7.68±0.32
Body & Texture	5–9	3–9	4–9	4–9
(Max.9)	8.08±0.27	8.10±0.34	8.08±0.26	7.92±0.26
Overall Acceptance	6–9	6–9	4–9	4–9
(Max.9)	8.48±0.19	8.44±015	8.44±0.22	7.84±0.24
Sensory Comments	White, Spongy, Soft.	Spongy, slightly greasy	Slightly brown, less spongy greasy	Cooked flavour, Hard, Brown, Greasy.

Figures represent the range, mean and standard error.

The flavour and body and texture scores were similar to those of fresh looking uptill second repeat and found to decrease on third repeat. The average flavour and body and texture score for the first repeat was noted slightly higher than that of fresh cooking, might be because of liking of cooked flavour and slightly greasy body by some of the judges. The overall acceptability also remained in the same vicinity till the third repeat. The highest overall acceptability score however, was evident with the fresh cooking only.

Table : 4.1.3.7.A. ANOVA on Sensory Characteristics of Buffalo Rosogolla for the Effect of Repeated Use of Cooking Syrup.

S.O.V.	d.f.	Flavour		Body & Texture		Overall Acceptance	
		MSS	F	MSS	F	MSS	F
Treatment	3	4.5867	4.67**	0.3467	0.20	2.7033	2.73*
Judgement	4	0.815	0.83	3.365	1.98	1.015	1.02
Tr. X Jud.	12	0.6283	0.64	2.1383	1.26	0.7283	0.73
Replicate	4	3.14	3.20*	4.465	2.62	3.465	3.50*
Error	76	0.9821		1.7018		0.9913	

* Significant at 5% level. ** Significant at 1% level.

From the statistical analysis of the above sensory scores (Table 4.1.3.7.A.) it was noticed that the changes in the flavour and overall acceptability scores were statistically significant whereas those in body and textural scores were statistically insignificant.

Hence, from the above study it may be suggested that repeated use of cooking syrup might be used till second repeat. From the third repeat it affected the final acceptability of the product. The findings by Bhattacharya and Desraj (1980) are in line with the present investigation. They had suggested only upto the first repeat for desirable results might be because of more severe cooking in their method of production.

4.1.3.8 Effect of sugar concentration in soaking syrup :

After cooking, the cooked balls are placed in soaking syrup wherein the rosogolla takes the final shape. Hence the concentration of sugar in the soaking syrup is supposed to play a vital role in the final desirability of rosogolla. in the present investigation 30% and 50% sugar syrup calculated on weight to weight basis were tried and compared with that of the control maintained at 40% concentration. the results are furnished in Table 4.1.3.8.

Table : 4.1.3.8. Effect of Sugar Concentration in Soaking Syrup on the Quality of Buffalo Rosogolla.

Quality Attribute	Control (40%)	% Sugar Concentration in Soaking Syrup	
		30	50
Total Solid (%)	43.56-45.67	42.01-44.12	43.87-45.89
	44.80±0.39	43,17±0.34	44.83±0.35
Yield (% weight of chhana)	347.45-349.90	349.76-351.89	329.89-331.91
	348,54±0.42	350.52±0.39	330.92±0.44
Flavour (Max.9)	6-9	4-9	4-9
	8.52±0.15	7.40±0.37	7.40±0.33
Body & Texture	5-9	4-9	4-9
(Max.9)	8.08±0.27	8.04±0.27	7.40±0.34
Ooverall Acceptance	6-9	3-9	4-9
(Max.9)	8.48±0.19	7.20±0.41	7.24±0.34
Sensory Comments	White, Spongy soft.	Very soft, Less sweet	Hard, Heavy more sweet.

Figures represent the range, mean and standard error.

It was observed that on decreasing the sugar concentration the rosogolla turned to a very soft body, which had lower sweetness as well. On the contrary on increasing the sugar concentration, the rosogolla became hard with high sweetness. The total solid content in rosogolla was found to decrease on lowering the concentration might be because of lesser incorporation of sugar into it, whereas it remained almost similar on increasing the concentration. The yield was found to increase with lowering of the concentration of soaking syrup might be as a result of higher water retention. The flavour score was highest at the control rate of 40% concentration and found to decrease both on lowering and increasing the concentration. The overall acceptance scores also had a similar trend to those furnished by flavour scores. The body and texture scores however, maintained a similar level at 30 and 40% concentration and decreased down at 50% level because of unwanted hardness.

Table : 4.1.3.8.A. ANOVA on Sensory Characteristics of Buffalo Rosogolla for the Effect of Sugar Concentration in Soaking Syrup.

S.O.V.	d.f.	Flavour		Body & Texture		Overall Acceptance	
		MSS	F	MSS	F	MSS	F
Treatment	2	3.8933	2.08	14.0933	9.04**	11.2133	7.85**
Judgement	4	2.7467	1.47	10.38	6.66**	13.2467	9.28**
Tr. X Jud.	8	2.9767	1.59	7.31	4.69**	2.4967	1.75
Replicate	4	2.5133	1.34	2.38	1.53	1.8133	1.27
Error	56	1.8705		1.5586		1.4276	

* Significant at 5% level. ** Significant at 1% level.

On statistical analysis of the sensory scores it was found (Table 4.1.3.8.A.) that the variations caused by flavour were not statistically significant whereas those caused by body and texture and overall acceptance were highly significant at 1% level. A significant variation had also been noted amongst the judges proving a variable preference level amongst them.

It was observed from the above results that a concentration of 40% sugar in the soaking syrup was optimum for preparing rosogolla from buffalo milk. The results are in agreement with the findings of Bhattacharya and Desraj (1980) and Soni et al (1980) who had also advocated 40% concentration of sugar in the soaking syrup for cow rosogolla and buffalo rosogolla respectively. The suggested concentration is however lower in comparison to those suggested by Date et al (1958) and Srinivasan and Anantakrishnan (1964) who had advised higher concentrations for cow rosogolla. A gradual diffusion of sugar during soaking from the rosogolla to the relatively dilute soaking syrup might be responsible for improving the body and textural qualities.

4.2 Studies on the Chemical Changes Occuring during Transformation of Milk to Rosogolla.

The basic raw material used for the manufacturing of rosogolla is milk which is a dynamically balanced mixture of fats, proteins, carbohydrates, ash and water co-existing as emulsions, colloidal suspensions and true solution. Rosogolla is prepared by alteration of these relationships by heat and acid coagulation whereby some of the components are partially removed and some other changes their forms and then the physical and chemical characteristics further change by addition of sugar. The composition of milk thus changes a lot from its native array. Since chhana is the most important intermediate phase, investigations were undertaken to evaluate the composition of milk, chhana and rosogolla. In order to understand the anomaly in buffalo milk, while studying the composition both cow milk and buffalo milk were tried. For the cow rosogolla preparation the method suggested by Bhattacharya and Desraj (1980) was followed without the addition of any additives and buffalo rosogolla was prepared as per the standardized method developed during this study.

4.2.1 Chemical composition of milk :

The gross composition of cow milk and buffalo milk samples were analysed. The findings are displayed in Table 4.2.1.

Table : 4.2.1. Chemical Composition of Milk.

Component (%)	Cow Milk	Buffalo Milk
Total Solid	11.23-13.31	14.67-16.98
	12.29±0.40	15.95±0.43
Fat	3.4-5.1	5.34-7.67
	4.16±0.28	6.61±0.47
Protein	2.67-4.67	3.10-5.21
	3.62±0.36	4.01±0.36
Lactose	3.34-4.67	4.10-5.40
	3.95±0.22	4.92±0.21
Ash	0.59-0.78	0.59-0.78
	0.68±0.04	0.72±0.04

Figures represent the range, mean and standard error.

The average total solid, fat, protein, lactose and ash content of buffalo milk were noted as 15.95%, 6.61%, 4.01%, 4.92% and 0.72% respectively and those of cow milk were found to be 12.29%, 4.16%, 3.62%, 3.95% and 0.68% respectively.

Ganguly (1974) and Rama Murthy (1981) had reviewed the compositional pattern of this two kinds of milks. The present findings are in agreement with the earlier results.

4.2.2 Chemical composition of chhana :

Alike the milk samples, the gross composition of cow and buffalo chhana were also analysed. The observations are furnished in Table 4.2.2. It might be mentioned here that the buffalo chhana in this case does not represent whole buffalo chhana since the milk make up was changed before producing the chhana as per the standardized method as has been mentioned earlier.

Table : 4.2.2. Chemical Composition of Chhana.

Component (%)	Cow Chhana	Buffalo Chhana
Total Solid	40.56-42.02	37.67-38.89
	41.39.±0.31	38.52±0.22
Fat	22.01-24.67	23.56-25.34
	23.13±0.49	24.36±0.31
Protein	15.85-16.98	14.56-15.69
	16.67±0.21	14.98±0.21
Lactose	1.10-2.91	1.21-3.01
	1.90±0.34	2.11±0.39
Ash	1.21-3.12	1.21-3.01
	2.13±0.41	2.06±0.37

Figures represent the range, mean and standard error.

The average total solid, fat, protein, lactose and ash content in buffalo chhana was found as 38.52%, 24.36%, 14.98%, 2.11% and 2.06% respectively. The corresponding contents in cow chhana was 41.39%, 23.13%, 16.67%, 1.90% and 2.13% respectively The composition of the two chhana samples were closer in comparison to the earlier findings obtained by Ray and De (1953), Srinivasan and Anantakrishnan (1964) and Kumar and Srinivasan (1982) in similar experiments. This is because of the modifications those have been made with the buffalo milk before curdling.

4.2.3 Chemical composition of rosogolla :

The gross compositions of cow and buffalo rosogolla were similarly analysed and presented in Table 4.2.3. It may be mentioned here that method of manufacturing was different for the two types of rosogolla.

Table : 4.2.3. Chemical composition of Rosogolla.

Component (%)	Cow Rosogolla	Buffalo Rosogolla
Total Solid	48.45-50.89	43.12-45.67
	49.72±0.42	44.79±0.50
Fat	6.71-8.69	4.98-5.67
	7.93±0.34	5.39±0.13
Protein	6.55-7.29	5.12-7.78
	7.93±0.32	6.82±0.45
Sucrose	30.12-32.88	31.12-33.78
	31.43±0.55	32.43±0.46
Ash	0.22-0.39	0.24-0.39
	0.32±0.03	0.32±0.02
Yield (% weight of	270.89-273.67	347.67-349.09
Chhana)	272.31±0.47	348.53±0.28

Figures represent the range, mean and standard error.

The average total solid, fat, protein, sucrose and ash content in buffalo rosogolla were noted as 44.79%, 5.39%, 6.82%, 32.43% and 0.32% respectively. The corresponding contents in cow rosogolla were 49.72%, 7.93%, 7.93%, 31.43% and 0.32% respectively. Most interestingly, in buffalo rosogolla all the milk components were found in comparatively less concentration than in cow rosogolla. The sucrose content was higher in buffalo rosogolla than in cow rosogolla. Soni et al (1980) reported 63% total solid, 4.2% fat, 6.8% Protein and 51.9% sucrose in buffalo rosogolla prepared during their study. Compositional difference was found less in the present study. Since the method of manufacturing was different for different kind of milk it will not be wise to comment on the physico chemical make up of the native milk on the basis of these results.

Reports are available on the composition of rosogolla which varied widely amongst themselves (Mitra et al, 1967; Singh and Ray, 1977b; Sharma and Zariwala, 1978 and Soni et al, 1980) since no standardized methodology is available this kind of variations are normal. In the present investigation, trials were made to standardize the methodology with some modifications in the milk make up and process parameters hence the present results are not comparable with the earlier results.

The present investigation had revealed a higher yield of rosogolla (348.53% by weight of chhana) from modified buffalo milk in comparison to only 272.31% yield of rosogolla by weight of chhana from cow milk.

4.3 Studies on the Poly Acrylamide Gel Electrophoretic (PAGE) Pattern Changes during the Transformation of Milk to Rosogolla.

Rosogolla is prepared from chhana which is basically a heat and acid induced gel. The chhana is then kneaded and cooked at a high temperature in concentrated sugar syrup. It is obvious from this manufacturing techniques that milk proteins, casein in particular, plays a major role in the changes that occurs during preparation of rosogolla from milk. Hence the poly acrylamide gel electrophoretic pattern changes of the proteins from milk to chhana, and from chhana to rosogolla might be suggestive to understand the complex changes. Ramachandran et al (1973) reported differences between the electrophoretic behaviour of casein from cow and buffalo milk. Hence the PAGE pattern during the said transformation for cow rosogolla production and buffalo rosogolla production were studied. Since partial digestion of milk proteins by the action of the enzyme trypsin was incorporated in the standardized methodology for production of suitable buffalo rosogolla in the present work and extensive degradation of milk protein was observed by Soni et al (1980) by trypsin digestion. The effect of trypsin treatment on the PAGE pattern of milk proteins were also studied in the present investigation.

4.3.1 Changes in the PAGE pattern during the transformation of cow milk to rosogolla :

PAGE pattern of the proteins isolated from cow milk were studied alongwith the PAGE pattern of the proteins isolated from the corresponding chhana and rosogolla. The electrophoregram is presented in Figure 4.3.1. The electrophoretic pattern revealed the appearence of two low molecular weight components in the chhana samples. The boiling of milk before the curdling might be the root cause as had been suggested by Bandyopadhyay and Ganguli (1975). The rosogolla samples showed prominent band having lower and higher electrophoretic mobility as a result of evolution of break down product. Similar findings were observed by Soni et al (1980) who reported a drastic change in the protein during rosogolla manufacturing.

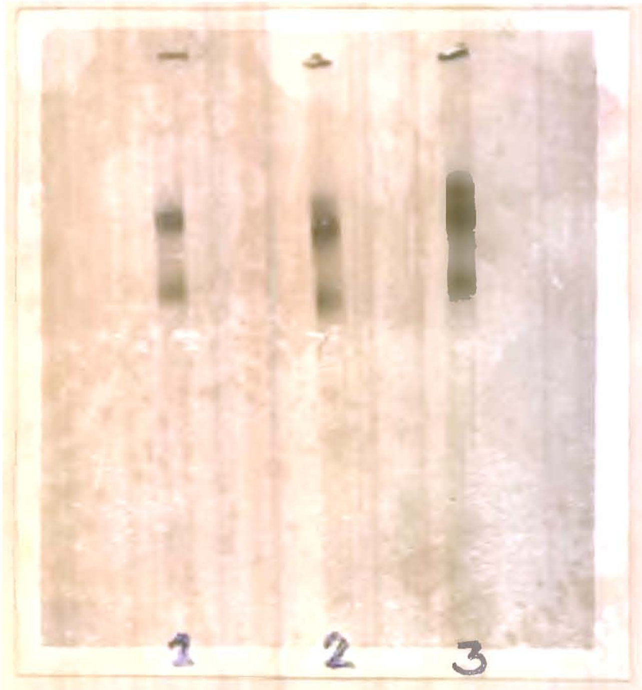

Figure 4.3.1. Electrophoregram of Cow Milk Proteins Isolated from (1) Cow Milk (2) Cow Chhana and (3) Cow Rosogolla.

4.3.2 <u>Changes in the PAGE pattern during the transformation of buffalo milk to rosogolla</u> :

Since standardized buffalo milk with lower total solid content was partially digested with trypsin for 15 min. at 37°C before the production of chhana, PAGE pattern of proteins isolated from milk before the treatment and after the treatment were studied alongwith the PAGE pattern of proteins isolated from the corresponding chhana and rosogolla. The electrophoregram is furnished in Figure 4.3.2. The trypsin treatment was found to produce some break down components. The results were in agreement with the findings of Soni <u>et al</u> (1980) who had reported more of decomposition of α- and β - casein during this treatment and found k - casein to be more stable against tryptic digestion

In the present study this partial digestion of the proteins were found to be beneficial for the production of rosogolla from buffalo milk. Hence these fraction of proteins might be responsible for the desired softness in the body of rosogolla.

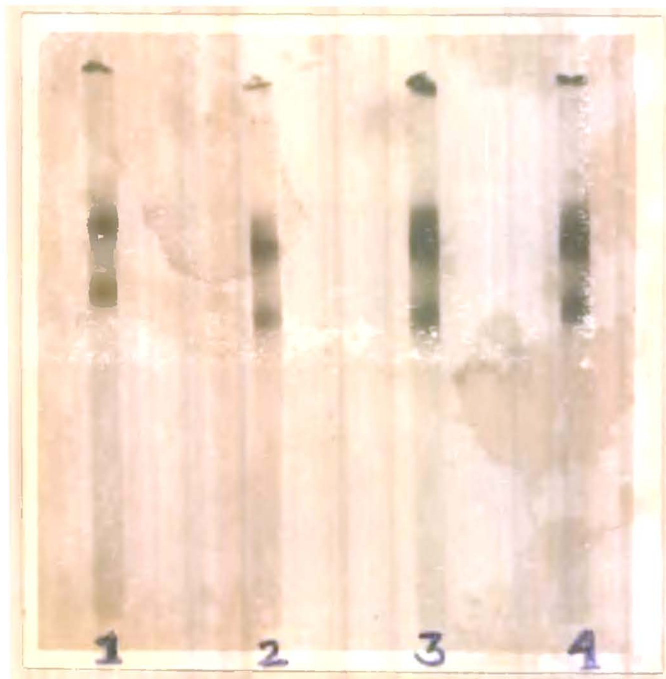

Figure 4.3.2. **Electrophoregram of Buffalo Milk Proteins Isolated from (1) Buffalo Milk (2) Buffalo Milk after Trypsin Treatment (3) Buffalo Chhana and (4) Buffalo Rosogolla.**

The changes observed in the buffalo chhana protein electrophoretic pattern were similar to those of cow chhana. This bands however, were more prominent, might be because of the breakdown products which had undergone more severe degradation during further heating and acid curdling. The changes in the electrophoretic mobility of buffalo rosogolla proteins were similar to those of cow rosogolla proteins.

4.4 Microbiological Quality of Rosogolla.

In order to comment on the quality of rosogolla, in addition to the chemical composition, investigation of its microbilogical quality is also essential. Since it indicates the condition of manufacturing, initial quality of milk and chhana, chances of post cooking contamination, age etc. In order to assess the microbilogical quality of rosogolla the total viable count and yeast and mould count were taken. The results are shown in Table 4.4. The samples exhibited wide variation amongst themselves. Hence instead of reporting the mean value, which may be misleading, the range only is being furnished. The total viable count per gram was observed to be 372-756 for cow rosogolla and 324-982 for buffalo rosogolla. The total viable count for cow rosogolla and buffalo rosogolla remained in the same zone excepting one buffalo rosogolla which had very high count.

Table : 4.4 Microbiological Quality of Rosogolla.

Attribute	Cow Rosogolla	Buffalo Rosogolla
Total viable count/gm	372-756	324-982
Yeast & Mould count/gm	7-52	12-22

Range of 8 Samples

The yeast and mould count per gm. for cow rosogolla was ranging between 7-52 and the same for buffalo rosogolla ranged between 12-22. Two cow rosogolla samples contained very high count.

Singh and Mukhopadhyay (1975) on a study on market rosogolla observed verv high total viable count ranging from 0 to 127 X 10^3 and yeast and mould count ranging from 0 to 3 X 10^3 per gram. This could be due to the poor initial quality of milk and chhana, unhygienic condition of manufacture and storage. The lower counts in some market samples however, proved sterility of the products.

4.5 Rheological Quality of Rosogolla :

While discussing about the desirability of rosogolla, it was observed that they were highly dependent on the body and textural properties which were dependant on human observations. Many a time we have come across to the variation amongst different judges. Hence the rheological properties enumerated by instrumental techniques were used. In the present study, the rheological characteristics of rosogolla prepared from cow milk and buffalo milk were measured with the help of Instron Universal Testing Equipment and compared in Table 4.5. The average hardness of cow rosogolla and buffalo rosogolla was 16.26 mN and 14.05 mN. respectively. Since buffalo milk is known to produce hard body, from the results it may be commented that the modification in milk make up and process parameters as has been standardized in the present study were effective enough.

From the Table 4.5 it may also be noted that the cohesiveness and gumminess of both the rosogolla samples were lying in the same range with very close average value which revealed the textural similarities of these two products. The springiness and chewiness however, was observed to be lower in the buffalo rosogolla in comparison to the cow rosogolla. Which showed the presence of differences in the two rosogollas though they were graded similarly for body and textural scores.

Table : 4.5. Rheological Quality of Rosogolla.

Attribute	Cow Rosogolla	Buffalo Rosogolla
Hardness (mN)	15.81-17.12	13.12-15.08
	16.26±0.23	14.05±0.31
Cohesiveness	0.59-0.73	0.61-0.73
	0.65±0.28	0.67±0.02
Springiness (mm)	4.8-6.9	3.1-4.5
	6.0±0.36	4.0±0.25
Gumminess (mN)	9.78-11.12	9.78-11.56
	10.45±0.25	10,54±0.32
Chewiness (mNmm)	65.98-67.02	41.01-43.34
	66.47±0.21	42.19±0.37

Figures represent the range, mean and standard error.

Since no published literature is available in this regard the data could not be compared with any other experimental findings.

4.6 Quality of Market Rosogolla :

The quality of market rosogolla has been reported to vary widely since the method of manufacture practised by different shops are trade secrets. In the present investigation samples were taken from three reputed shops and the gross composition of the rosogolla samples were analysed. The results are reported in Table 4.6 alongwith the composition of the buffalo rosogolla made by the suggested standardized method. It may be seen, the total solid protein and ash content was lowest in the samples of the present study. The fat and sucrose content was higher in the rosogolla obtained from two shops whereas one shop contained even lesser fat and another contained lesser sucrose in their rosogolla samples as compared to the samples prepared in the laboratory.

Table : 4.6. Quality of Market Rosogolla.

Component(%)	Present Study	Shop I	Shop II	Shop III
Total Solid	43.12-45.67	51.80-53.35	47.98-49.12	50.89-51.98
	44.79±0.50	53.16±0.19	48.27±0.21	51.53±0.24
Fat	4.98-5.67	6.84-8.39	3.65-5.12	6.45-8.67
	5.39±0.13	7.63±0.32	4.40±0.28	7.58±0.39
Protein	5.12-7.78	7.61-9.46	8.76-10.34	6.23-8.12
	6.82±0.45	8.53±0.37	9.22±0.29	7.17±0.3
sucrose	31.12-33.78	31.81-34.37	33.98-35.45	30.44-31.67
	32.43±0.46	33.07±0.41	34.69±0.30	31.11±0.20
Ash	0.24-0.39	1.06-1.37	0.23-0.71	0.34-1.50
	0.32±0.02	1.4±0.09	0.55±0.08	0.93±0.18

Figures represent the range, mean and standard error.

Mitra et al (1967) analysed the market rosogolla from Calcutta in a similar experiment and found 38.3% moisture, 7.3% fat, 43.6% sucrose and 6.2% protein in ordinary category and 50.0% moisture, 5.3% fat, 37.0% sucrose and 5.5% protein in spongy category Sharma and Zariwala (1978) on a similar investigation of market rosogolla from Bombay reported 29.70 to 53.40% moisture, 2.00 to 9.00% fat, 10.60 to 59.40% sucrose. Soni et al (1980) on evaluation of market rosogolla from Karnal observed 30.9 to 37.00% moisture, 4.2 to 5.7% fat, 51.30 to 55.10% sucrose. The present study also revealed a wide range of variation amongst the market rosogolla sample. All of them, excepting samples from one shop which lacked in the prescribed fat content, were however, conforming to the ISI specification for canned rosogolla.

4.7 Submicro Structure of Rosogolla.

The various components of milk undergo complex interaction amongst themselves and with the added acid and sugar molecules during the process of manufacturing, with particular reference to boiling of milk, acid curdling, kneading of chhana, cooking in hot sugar syrup etc. The investigation was therefore, undertaken to study the submicrostructure of rosogolla to determine their topography and internal structure for better understanding of the typical body and structure of this Indian dairy product. In order to achieve a comparative study of the ultrastructural attributes, rosogolla made both from cow milk and buffalo milk were compared with samples from Calcutta market.

Alike the other acid and heat induced milk gels, the casein micelles were found to be the building blocks of rosogolla. These building blocks are the macromolecular assemblies of γ_s', β and k-caseins held together by amorphous calcium phosphate-citrate. On acidification the casein micelles aggregate by charge neutralization under the formation of network of chains and clusters (Heertji et al, 1985). The heating caused casein micelles to link together by short thin fibres composed of expounded protein particles, closely attached to each other forming thick chains and network (Kalab and Harwalkar, 1973). Besides this mechanical stress during kneading, cooking etc. were also supposed to change the ultrastructure. Since no published literature is available in this respect, the ultrastructural changes that had been detected in rosogolla could be because of such process parameters.

The following micrographs (Figure 4.7.1.1 to 4.7.3.3.) showed the presence of units which are several time larger than that of the size of casein micelles, the average diameter being 1 micron. The most important feature noted in the ultrastructures were the linking amongst different protein particles. Thick chain of particles were observed with various sizes of particles attached to such chains which formed thick network. However, it was not clear whether fusion was strictly between casein micelles or products of interaction between casein micelles and whey proteins.

Fat was also found to be present in the form of fat globules. Because of kneading, severe cooking in hot syrup and soaking in concentrated sugar syrup the globules were being broken down into small sizes, though they were not been homogenized. A possibility of artefact also remained, because of the rupturing of the fat globule membranes which caused the unsaturated fats to be fixed only causing the size still lower. High temperature heating during rosogolla manufacturing caused extensive dephosphorylation and insolubilisation of serum calcium leading their precipitation on the casein micelles either as Ca^{++} or as $Ca_3(PO_4)_2$, which rendered the micelle unstable and enhanced its precipitation (Morrissey, 1969).

4.7.1 Submicro structure of cow rosogolla :

Figure 4.7.1.1 represents the scanning electron micrograph of cow rosogolla at a low magnification. The bar length as shown in the micrograph represents 10 X 10^4 nm. or 100 μ.

It is evident from the figure no. 4.7.1.1. that the surface was compact and uneven, obscured with fat. The casein micelles coalesced together to form a large compact agglomerate leaving no single subunits because of the severeness of heating during the manufacture of rosogolla. Thick bridges were visible forming loose matrix with numerous large voids, might be the air spaces filled with sugar syrup.

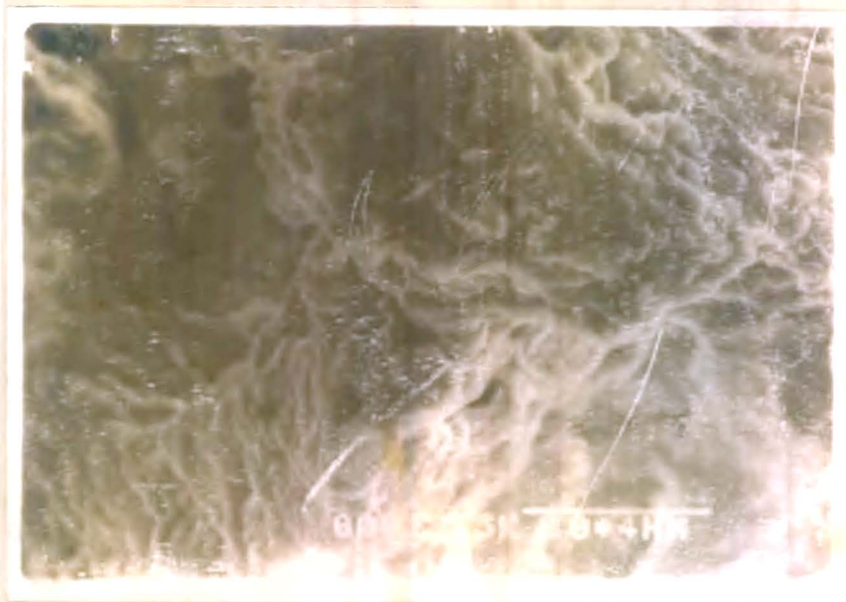

Figure : 4.7.1.1. Scanning Electron Micrograph of Cow Rosogolla at Low Magnification.

The surface was uneven. Smooth surfaced small fat globules of 1 to 2 μ size were also visible. Some sort of thermal degradation took place in the casein whey protein complexes which ultimately fused with lactose and sugar forming thread like ragged mass with fuzzy appearance. (Figure 4.7.1.1).

Figure 4.7.1.2 depicts the same cow rosogolla sample as is furnished in Figure 4.7.1.1. taken at a higher magnification. The scale represented a length of 30 X 10^3nm or 30 μ in this case is written on the Figure itself. The coalesced protein agglomerates with thick bridges are clearly seen alongwith some small fat globules and void spaces. The array of the conglomerated mass of protein showed no particular orientation.

Figure : 4.7.1.2. Scanning Electron Micrograph of Cow Rosogolla at Higher Magnification.

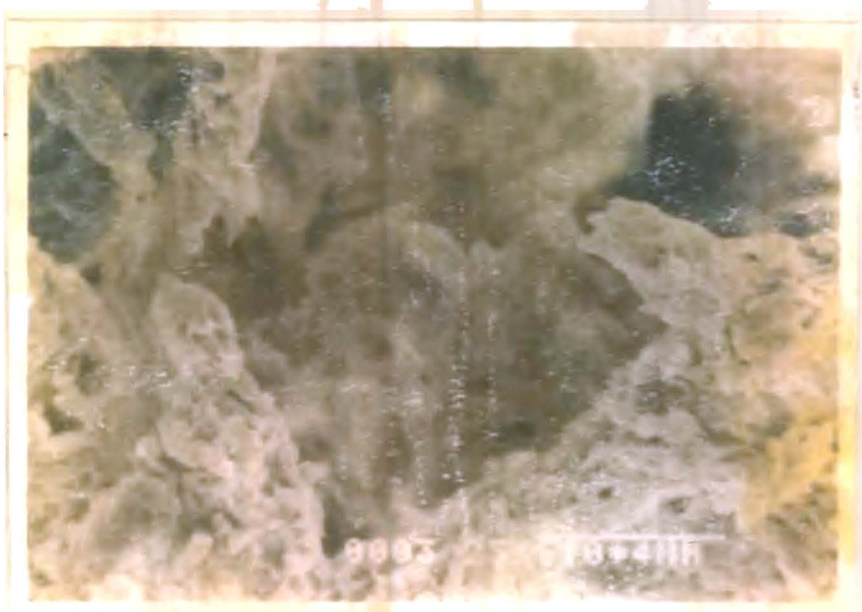

Figure : 4.7.1.3. Scanning Electron Micrograph of Defatted Cow Rosogolla at Low Magnification.

Figure 4.7.1.3. displays the same cow rosogolla samples under electron microscopy at low magnification after defatting and washing. The surface of this micrograph is more clear. in comparison to the earlier micrographs. The small globuler voids might have been produced due to the removal of fat during sample preparation for submicroscopic study while the irregular voids of comparatively large space might be the air spaces filled with sugar syrup.

4.7.2 <u>Submicrostructure of buffalo rosogolla</u> :

Figure : 4.7.2.1. Scanning Electron Micrograph of Buffalo Rosogolla at Low Magnification.

Figure 4.7.2.1. describes the micrograph of buffalo rosogolla at low magnification. The ultrastructure was similar to that of cow rosogolla with uneven surface and compact protein

agglomerates. The heat fusion of protein with lactose and sugar were so strong that not a single casein micelle had restored its subunit size. Alike the cow rosogolla very small fat globules were visible. The surface of buffalo rosogolla samples were found more rough and uneven in comparison to that of cow rosogolla samples. The porosity of buffalo rosogolla was observed to be lesser in comparison to those of cow rosogolla.

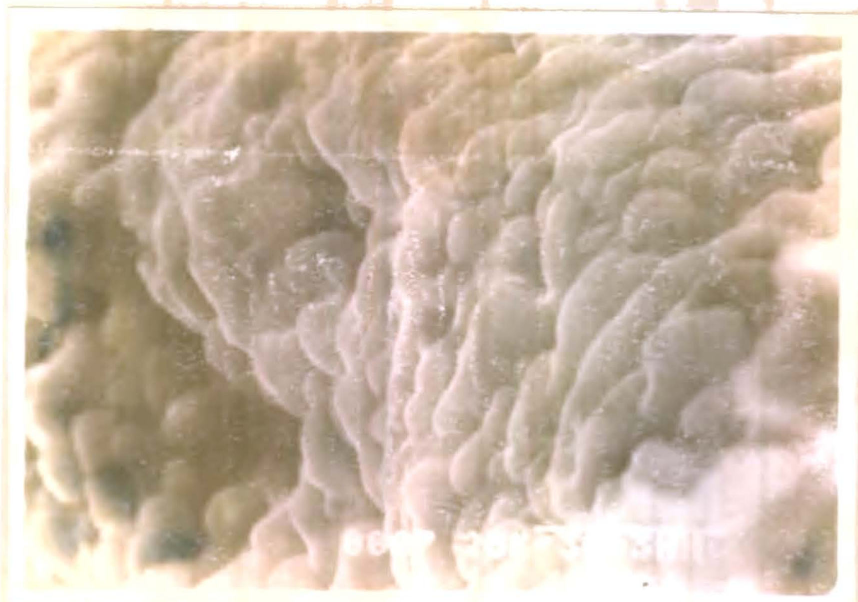

Figure : 4.7.2.2. Scanning Electron Micrograph of Buffalo Rosogolla at Higher Magnification.

Similar to that of cow rosogolla, buffalo rosogolla were scanned at a higher magnification and is displayed in Figure 4.7.2.2. The micrograph revealed a higher compactness in the body matrix of buffalo rosogolla in comparison to cow rosogolla A scale type entity of casein micelle conglomerate was noted wherein the fat globules were entrained. The porosity was lesser in buffalo rosogolla as has been noted in lower magnification with a regular array of bridges.

Figure : 4.7.2.3. Scanning Electron Micrograph of Defatted Buffalo Rosogolla at Low Magnification.

The buffalo rosogolla samples were defatted and washed to study the defatted submicrostructure of rosogolla at a low magnification and depicted in Figure 4.7.2.3 . The micrograph revealed a comparatively rough and wretched surface in comparison to the corresponding cow rosogolla micrograph (Figure 4.7.1.3). The size of the small globular void spaces representing the presence of fat globules suggested a lower fat globule size in case of buffalo rosogolla.

4.7.3 Submicrostructure of rosogolla from market :

Figure : 4.7.3.1. Scanning Electron Micrograph of Market Rosogolla at Low Magnification.

As has been done with cow rosogolla and buffalo rosogolla, rosogolla samples collected from market were studied for their submicroscopic structure. Figure 4.7.3.1. shows the ultrastructure at low magnification. It may be observed that the structures were similar to that of cow rosogolla (Figure 4.7.1.1) with the presence of more number of small fat globules. The protein aglomerates and array of void spaces were similar. A big lump of more than 100μ size was detected. The even surfaced lump might represent the presence of starch which is generally added in rosogolla. It might be some other additives also.

Figure : 4.7.3.2. Scanning Electron Micrograph of Market Rosogolla at Higher Magnification.

Figure 4.7.3.2 is the scanning electron micrograph of market rosogolla at a higher magnification. It reveled a similar ultrastructure to that of cow rosogolla as may be evident in Figure 4.7.1.2. The presence of more fat globules as was found in the lower magnification micrograph (Figure 4.7.3.1) were confirmed which is different from the scale type entity found in buffalo rosogolla (Figure 4.7.2.2).

In a similar study as had been done with cow rosogolla and buffalo rosogolla, the market rosogolla samples were also defatted and studied under electron microscope. The micrograph (Figure 4.7.3.3.) revealed a similar structure to that of cow rosogolla (Figure 4.7.1.3). Hence it may be concluded that the market rosogolla were also been prepared from cow milk possibly with little higher fat content. From Figure 4.7.3.1 the presence of additives, most possibly starch were also detected in market rosogolla.

Figure : 4.7.3.3. Scanning Electron Microograph of Defatted Market Rosogolla at Low Magnification.

Though the submicrostructures of cow and buffalo rosogolla were similar but a positive difference had been detected in these two types of rosogolla. But it may be mentioned here, that since the buffalo milk rosogolla under consideration were prepared by the modified and standardized technology, they did not reveal the true picture of buffalo rosogolla as such. More of dissimilarities might be expected with buffalo rosogolla as such which might lead the body and texture of the product towards unacceptability.

4.8 Studies on Spoilage of Rosogolla during Storage.

For any processed dairy product, the physicochemical behaviour during storage is one of the prime interests of the producers and the consumers since it leads towards termination of the shelf life of the product. Rosogolla dipped in soaking syrup is normally stored under ambient conditions. In the present study trials were undertaken to examine the physicochemical changes of buffalo rosogolla under ambient conditions and refrigerated storage. Two types of most suitable package viz. metallized polyester package and tinned cans were studied for observing their effectivities.

4.8.1 Effect of metallized polyester packaging on storage of rosogolla :

Buffalo rosogolla samples stored in metallized polyester packaging with 12μ LDPE 300 gauge were analysed for syrup acidities, volatile fatty acidities, peroxide values and sodium chloride soluble protein percentages while being stored at a temperature of 25±1°C (ambient conditions) and 5±1°C (refrigerated conditions) and compared with their sensory scores. The investigation were continued at a regular interval of two weeks only and was terminated when the product was found unacceptable by the judges.

4.8.1.1 Effect of storage at ambient temperature (25±1°C) :

Buffalo rosogolla stored in metallized polyester package were studied for the above mentioned attributes while stored at ambient temperature and the results are presented in Table 4.8.1.1. The flavour and overall acceptance scores were decreased very sharply during the first few days storage whereas the body and texture scores were little more stable as had been reflected by the sensory evaluation (Table 4.8.1.1.). At the end of four weeks, the flavour and overall acceptance score lowered down below the acceptability limits. Hence termination of shelf life in metallized polyester package at ambient temperature was found to be very low, below 4 weeks.

Table : 4.8.1.1. Effect of Storage of Buffalo Rosogolla at Ambient Temperature (25±1°C) in Metallized Polyester Package.

Days of Storage	Flavour Score (Max.9)	Body & Texture Score (Max.9)	Overall Acceptance Score (Max.9)	Syrup Acidity (ml.0.1 N.NaOH/ 100 ml. Syrup)	Volatile Fatty Acidity (ml.0.01 N NaOH/ 50 gm.)	Peroxide value (m.eq.of Peroxide Oxygen/kg Sample)	Sodium Chloride Soluble Protein (% on Dry Matter
Initial	8.57	8.12	8.53	1.25	1.8	0.24	11.39
14	5.0	7.9	5.3	6.59	7.3	0.72	9.02
28	4.2	7.1	4.1	8.81	10.12	0.79	8.51

From the chemical analysis, it was observed the initial syrup acidity of 1.25 ml. was increasing very sharply during the storage of rosogolla. Which might be due to the microbial degradation of the product. On termination of the shelf life the syrup acidity was observed to be 8.81 ml. only.

Volatile fatty acid contents of stored buffalo rosogolla determined at the similar intervals revealed that the initial level of 1.8 ml. was increasing steadily throughout the storage period. At the termination point the volatile fatty acidity was noted as 10.12 ml. This observation reflected the extent of fat hydrolysis in rosogolla during storage. Since the objectionable rancid flavour is caused by the lower chain fatty acids (less than 12) as reported by Scanlan et al (1965) the volatile fatty content might be highly correlated to the fat hydrolysis. The steady increase in the volatile fatty acids can be explained in the light of high rate of lipolysis by the lipases which is favoured at the experimental temperature and other condition.

Table : 4.8.1.1.A. Linear Regression Equations for the Changes of Sensory Characteristics of Buffalo Rosogolla when Stored at Ambient Temperature in Metallized Polyester Package.

Deduced Variable	Defined Variable	Linear regression equation	Correlation Coefficient
Y_1	X_1	$Y_1 = 9.22-0.59\ X_1$	0.9864
	X_2	$Y_1 = 9.39-0.54\ x_2$	0.9723
	X_3	$Y_1 = 10.45-7.76\ X_3$	0.9969
	X_4	$Y_1 = -8.67+1.51\ X_4$	0.9999
	$X_1X_2X_3X_4$	$Y_1 = 45.26+4.5X_1-3.58X_2-29.22X_3-2.53X_4$	0.9877
Y_2	X_1	$Y_2 = 8.36-0.12\ X_1$	0.7258
	X_2	$Y_2 = 8.42-0.11\ X_2$	0.7692
	X_3	$Y_2 = 8.49-1.34\ X_3$	0.5616
	X_4	$Y_2 = 5.08+0.27\ X_4$	0.6104
	$X_1X_2X_3X_4$	$Y_2 = 30.69-1.7X_1+0.69X_2+1.14X_3-1.93X_4$	0.9791
Y_3	X_1	$Y_3 = 9.25-0.59\ X_1$	0.9994
	X_2	$Y_3 = 9.44-0.54\ X_2$	0.9944
	X_3	$Y_3 = 10.39-7.57\ X_3$	0.9783
	X_4	$Y_3 = -8.32+1.48\ X_4$	0.9904
	$X_1X_2X_3X_4$	$Y_3 = -37.91+2.93X_1-2.14X_2+4.91X_3+3.99X_4$	0.9995

Y_1 = Flavour Score, Y_2 = Body & Texture Score, Y_3 = Overall acceptance Score, X_1 = Syrup acidity, X_2 = Volatile fatty acidity X_3 = Peroxide value, and X_4 = Sodium chloride soluble protein.

Peroxide value was estimated and expressed in terms of mili equivalent of peroxide oxygen content per kg. of sample (Table 4.8.1.1.). It was observed that the initial value of 0.24 increased very sharply during the first fourteen days to 0.72. Comparatively slower increase was observed then and found to be 0.79 at the termination of shelf life. This represented the oxidative deterioration of milk fat in particular, present in rosogolla during storage at this temperature which however, was noted to be very high.

Five percent sodium chloride solution as suggested by Date et al (1958) was used to estimate the sodium chloride soluble protein. The initial sodium chloride soluble protein percent on dry matter was 11.39% and decreased to a 8.51% level on termination of the shelf life alongwith the lowering of the body and textural profile of the rosogolla. The findings of Date et al (1958) and Jagtiani et al (1960) with cow rosogolla were similar to the present observations.

The relative contribution of syrup acidity (X_1), volatile fatty acidity (X_2), peroxide value (X_3) and sodium chloride soluble protein (X_4) with regards to flavourscores (Y_1), body and texture scores (Y_2) and overall acceptance scores (Y_3) were tried to be evaluated by multiple regression analysis in which the relationship between the combination of defined variables (X) and the deduced variables (Y) were estimated. The results of the analysis are described in Table 4.8.1.1.A.

The overall determination coefficients of the defined variables (X) with the deduced variables namely flavour scores (Y_1), body and texture scores (Y_2) and overall acceptance scores (Y_3) were found 0.9877, 0.9791 and 0.9995 respectively. Therefore the parameters studied were responsible for 98.77%, 97.91% and 99.95% respectively of the flavour changes, body and texture changes and overall acceptance changes of buffalo rosogolla during storage in metallized polyester packages at ambient temperature. The determination coefficient of simple regression analysis exhibited that all the parameters studied were highly significant towards the change of different sensory scores. From the table 4.8.1.1.A. it was found that overall acceptance had been best defined by the attributes under study. Body and texture changes had the least correlation with the attributes under study.

The overall regression equations (Table 4.8.1.1.A.) were as follows :

$$Y_1 = 45.26+4.5X_1-3.58X_2-29.22X_3-2.53X_4$$

$$Y_2 = 30.69-1.7X_1+0.69X_2+1.14X_3-1.93X_4$$

$$Y_3 = -37.91+2.93X_1-2.14X_2+4.91X_3+3.99X_4$$

4.8.1.2 **Effect of storage at refrigerated temperature (5±1°C):**

Same series of buffalo rosogolla samples, displayed variations in the observations of the sensory and chemical attributes under study while on storage at refrigerated temperature (Table 4.8.1.2). A delayed trend towards spoilage of the rosogolla samples were observed on storage at lower temperature as compared to the ambient temperature. (Table 4.8.1.1). Uptill 28 days of storage, the flavour and overall acceptance was found to deteriorate sharpely and then the degree of deterioration was less. However at the end of 42 days both the flavour score and the overall acceptance score were below the acceptibility limits making the shelf life of buffalo rosogolla packed in metallized polyester package below 42 days when stored under refrigerated condition. The body and texture was found to be comparatively stable and was satisfactory even after 42 days of storage.

Table : 4.8.1.2. Effect of Storage of Buffalo Rosogolla at Refrigerated Storage (5±1°C) in Metallized polyester Package.

Days of Storage	Flavour Score (Max.9)	Body & Texture Score (Max.9)	Overall Accept-ance Score (Max.9)	Syrup Acidity (ml.0.1 N.NaOH/ 100 ml. Syrup)	Volatile Fatty Acidity (ml.0.01 N NaOH/ 50 gm.)	Peroxide value (m.eq.of Peroxide Oxygen/kg Sample)	Sodium Chloride Soluble Protein (% on Dry Matter
Initial	8.57	8.12	8.53	1.25	1.8	0.24	11.39
14	6.7	7.9	7.2	3.21	3.3	0.72	9.83
28	5.4	7.7	5.4	6.81	7.4	0.76	8.97
42	4.8	7.6	4.7	8.93	8.6	0.78	8.03

The initial syrup acidity of 1.25 ml. was increasing steadily throughout the storage period and noted to be 8.93 ml. on the termination of shelf life. It might be because of the unfavourable condition for the growth of the microbes. The volatile fatty acidity was also increasing steadily but at a comparatively lesser extent as was found at ambient temperature. The reason might be because of lower lipolysis at refrigeration temperature. The final volatile fatty acidity was 8.6 ml. at refrigerated temperature as compared to 10.12 ml. when stored at ambient temperature.

On the other hand changes in peroxide value was found to be more or less similar at both the temperatures indicating similar oxidative deterioration. The sodium chloride soluble protein content was also found to decrease in a similar trend as it was evident in the ambient temperature of storage and noted to be 8.03 % on dry matter basis at the end of 42 days of storage.

Table : 4.8.1.2.A. Linear Regression Equations for the Changes of Sensory Characteristics of Buffalo Rosogolla when Stored at Refrigerated Storage in Metallized Polyester Package.

Deduced Variable	Defined Variable	Linear regression equation	Correlation Coefficient
Y_1	X_1	$Y_1 = 8.72-0.47\ X_1$	0.9352
	X_2	$Y_1 = 8.97-0.49\ X_2$	0.9208
	X_3	$Y_1 = 10.1-5.96\ X_3$	0.8495
	X_4	$Y_1 = -4.47+1.15\ X_4$	0.9525
	$X_1X_2X_3X_4$	$Y_1 = 7.36-0.02X_1-0.27X_2-2.05X_3+0.2X_4$	0.9966
Y_2	X_1	$Y_2 = 8.16-0.07\ X_1$	0.9683
	X_2	$Y_2 = 8.2-0.07\ X_2$	0.9547
	X_3	$Y_2 = 8.33-0.79\ X_3$	0.7899
	X_4	$Y_2 = 6.35+0.16\ X_4$	0.9301
	$X_1X_2X_3X_4$	$Y_2 = 14.93-0.41X_1+0.29X_2-2.13X_3-0.55X_4$	0.9429
Y_3	X_1	$Y_3 = 8.97-0.5\ X_1$	0.9861
	X_2	$Y_3 = 9.26-0.53\ X_2$	0.9834
	X_3	$Y_3 = 10.04-5.73\ X_3$	0.7227
	X_4	$Y_3 = -4.4+1.15\ X_4$	0.8819
	$X_1X_2X_3X_4$	$Y_3 = 2.04+0.36X_1-0.73X_2+0.87X_3+0.63X_4$	0.9964

Y_1 = Flavour Score, Y_2 = Body & Texture Score, Y_3 = Overall acceptance Score, X_1 = Syrup acidity, X_2 = Volatile fatty acidity X_3 = Peroxide value, and X_4 = Sodium chloride soluble protein.

The relative contribution of the chemical attributes (X) with regards to the sensory scores (Y) on multiple regression analysis revealed the relationship between the combination of defined variables (X) and the deduced variables (Y) as shown in Table 4.8.1.2.A. The overall determination coefficients of the defined variables (X) with flavour scores (Y_1), body and texture scores (Y_2) and overall acceptance score (Y_3) were 0.9966, 0,9429 and 0.9964 respectively. Hence the chemical attributes under observation were found to contribute significantly in the changes of the sensory scores. Combinedly the defined variables contributed 99.66%, 94.29% and 99.64% of the variations in flavour, body and texture and overall acceptibility scores. The overall regression equations (Table 4.8.1.2.A.) were :

$$Y_1 = 7.36-0.02X_1-0.27X_2-2.05X_3+0.2X_4$$

$$Y_2 = 14.93-0.41X_1+0.29X_2-2.13X_3-0.55X_4$$

$$Y_3 = 2.04+0.36X_1+0.73X_2+0.87X_3+0.63X_4$$

The simple regression analysis in Table 4.8.1.2.A. displayed all the chemical attributes under study had highly significant correlations with the changes of each of the sensory scores.

4.8.2 Effect of tinned can packaging on storage of rosogolla :

Samples of buffalo rosogolla were packed in 500 ml. tinned cans of tickness 4 mm. with inside tinning and epoxy phenolic type food lacquerring. The cans were sterilized in boiling water for 30 min. along with the lids before filling with soaking syrup and then seamed. In order to investigate the spoilage of rosogolla while stored in tinned cans, the samples were stored at ambient temperature and refrigerated temperature. The cans were opened after 14 days interval to evaluate their sensory quality and chemical status.

4.8.2.1 <u>Effect of storage at ambient temperature (25±1°C)</u> :

The results relating to sensory quality and chemical attributes of tinned packed rosogolla at ambient temperature are presented in Table 4.8.2.1. The average flavour score and overall acceptability score came below the acceptability limit after 56 and 70 days of storage making the rosogolla unsuitable whereas the body and texture was found satisfactory till then (Table 4.8.2.1.). Hence, the shelf life of rosogolla was found to be almost 2 months when packed in tinned cans in comparison to less than 1 month when packed in mentallised polyester packaging

Table : 4.8.2.1. Effect of Storage of Buffalo Rosogolla at Ambient Temperature (25+1°C) in Tinned Can.

Days of Storage	Flavour Score (Max.9)	Body & Texture Score (Max.9)	Overall Acceptance Score (Max.9)	Syrup Acidity (ml.0.1 N.NaOH/ 100 ml. Syrup)	Volatile Fatty Acidity (ml.0.01 N NaOH/ 50 gm.)	Peroxide value (m.eq.of Peroxide Oxygen/kg Sample)	Sodium Chloride Soluble Protein (% on Dry Matter
Initial	8.57	8.12	8.53	1.25	1.8	0.24	11.39
14	8.32	7.9	8.33	4.12	2.7	0.31	10.04
28	7.02	7.9	7.57	5.17	2.9	0.37	9.83
42	6.3	7.8	7.0	6.35	3.4	0.42	9.77
56	4.8	7.6	5.3	7.63	6.1	0.80	8.97
70	4.3	7.5	4.7	8.79	9.2	0.83	8.32

It was evident from the Table 4.8.2.1 that the syrup acidity increased at a slower rate and achieved a level of 8.79 ml. on termination of shelf life possible because of the presence of lower microbial population in the cans. The lipolysis was also found to be lesser in comparison to the metallised polyester packages as was evident from the trend of increase in volatile fatty acidity which was found to be 9.2 ml. on termination of shelf life. The reason might be the lower presence of lipase producing organisms.

Table : 4.8.2.1.A. Linear Regression Equation for the Changes of Sensory Characteristics of Buffalo Rosogolla when Stored at Ambient Temperature in Tinned Can.

Deduced Variable	Defined Variable	Linear regression equation	Correlation Coefficient
Y_1	X_1	$Y_1 = 10.01-0.62\ X_1$	0.8986
	X_2	$Y_1 = 9.07-0.58\ X_2$	0.8342
	X_3	$Y_1 = 9.85-6.66\ X_3$	0.9254
	X_4	$Y_1 = -8.56+1.56\ X^4$	0.8431
	$X_1X_2X_3X_4$	$Y_1 = 29.82-0.83X_1-0.15X_2-3.46X_3-1.68X_4$	0.9897
Y_2	X_1	$Y_2 = 8.26-0.08\ X_1$	0.9509
	X_2	$Y_2 = 8.13-0.08\ X_2$	0.8771
	X_3	$Y_2 = 8.22-0.84\ x_3$	0.9140
	X_4	$Y_2 = 5.75+0.21\ X_4$	0.9611
	$X_1X_2X_3X_4$	$Y_2 = 7.52-0.03X_1-0.01X_2-0.26X_3+0.06X_4$	0,9921
Y_3	X_1	$Y_3 = 9.93-0.54\ X_1$	0.8535
	X_2	$Y_3 = 9.26-0.54\ X_2$	0.9091
	X_3	$Y_3 = 9.94-6.13\ X_3$	0.9741
	X_4	$Y_3 = -6.59+1,39\ x_4$	0.8334
	$X_1X_2X_3X_4$	$Y_3 = 22.36-0.45X_1-0.2X_2-3.67X_3-1.05X_4$	0.9974

Y_1 = Flavour Score, Y_2 = Body & Texture Score, Y_3 = Overall acceptance Score, X_1 = Syrup acidity, X_2 = Volatile fatty acidity X_3 = Peroxide value, and X_4 = Sodium chloride soluble protein.

The initial peroxide value of 0.24 was increasing slowly uptil 42 days and a sudden growth was observed on 56 days following which again the increase was not very significant. The sudden increase might be because of partial exposure of the metal surface, otherwise the oxidation was also lesser in comparison to the earlier package as a result of lower oxygen tension in the samples as they were filled to the brim with sugar syrup. Sodium chloride soluble protein content should a similar trend as was evident in Table 4.8.1.1. The value at the end of shelf life being 8.32% on dry matter basis.

On multiple regression analysis of the examined chemical parameters (X) and sensory scores (Y), the relationships were found as has been expressed in Table 4.8.1.2.A. The overall determination coefficients of the defined variables (X) with flavour scores (Y_1), body and texture scores (Y_2) and overall acceptance scores (Y_3) were found as 0.9897, 0.9921, and 0.9974 respectively. Hence 98.97%, 99.21% and 99.74% of the changes in flavour scores, body and texture scores and overal acceptance scores were justified by the chemical attributes under consideration. The overall regression equations (Table : 4.8.1.2.A) were as follows :

$$Y_1 = 29.82-0.83X_1-0.15X_2-3.46X_3-1.68X_4$$

$$Y_2 = 7.52-0.03X_1-0.01X_2-0.26X_3+0.06X_4$$

$$Y_3 = 22.36-0.45X_1-0.2X_2-3.67X_3-1.05X_4$$

The determination coefficients of simple regression analysis displayed highly significant relationship of the changes in sernsory scores with the chemical parameters undertaken for study.

4.8.2.2 <u>Effect of storage at refrigerated temperature (5±1°C)</u> :

Similar studies were undertaken with buffalo rosogolla samples in tinned cans under refrigerated storage. The observations are explained in Table 4.8.2.2 and revealed the highest shelf life of almost 5 months. After 140 days both the flavour and overall acceptance of the product were judged unsuitable. Alike the other studies, the body and texture was still found satisfactory.

Table : 4.8.2.2. Effect of Storage of Buffalo Rosogolla at Refrigerated Storage (5±1°C) in Tinned Can.

Days of Storage	Flavour Score (Max.9)	Body & Texture Score (Max.9)	Overall Acceptance Score (Max.9)	Syrup Acidity (ml.0.1 N.NaOH/ 100 ml. Syrup)	Volatile Fatty Acidity (ml.0.01 N NaOH/ 50 gm.)	Peroxide value (m.eq.of Peroxide Oxygen/kg Sample)	Sodium Chloride Soluble Protein (% on Dry Matter
Initial	8.57	8.12	8.53	1.25	1.8	0.24	11.39
14	8.49	7.6	8.04	2.13	1.9	0.26	11.32
28	8.27	7.6	7.9	2.34	1.9	0.27	10.31
42	8.12	7.6	7.9	2.47	2.0	0.27	10.05
56	7.8	7.6	7.88	2.65	2.0	0.28	9.84
70	7.75	7.6	7.83	2.77	2.1	0.31	9.32
84	7.6	7.6	7.82	2.93	2.2	0.32	9.63
98	7.2	7.4	7.13	2.97	4.5	0.39	9.42
112	6.8	7.4	6.8	3.10	5.7	0.45	9.05
126	5.1	7.3	5.7	3.57	5.9	0.53	8.91
140	4.7	7.2	4.9	3.80	6.1	0.63	8.88
154	4.4	7.0	4.6	4.12	7.3	0.65	8.63

The syrup acidity level was observed to increase at a very small extent in comparison to all other samples and found only 3.80 ml. when the rosogolla was declared unacceptable. Since this level of syrup acidity was evident in rosogolla with acceptable sensory scores in the earlier experiments, it may be interpretted that the spoilage in this case might not be because of microbial growth as was evident in all the earlier cases and the growth of microbes were restricted to a large extent under this kind of storage conditions. The fact was supported by a similar low lipase activity as was observed with these samples from the lower increase in volatile fatty acidity which was found to be 6.1 ml. only at the termination of shelf life. However a sudden increase in the volatile fatty acidity was observed after 98 days of storage might be because of some spores which germinated at this stage of storage. The oxidative deterioration was also found to be the lowest in this set of observation. The maximum peroxide value of 0.63 was noted at the end of the shelf life which was further increased to 0.65 only after 154 days of storage. The level was still lower than all the other samples at their termination points. The sodium chloride soluble protein percent however came down, though with a slower rate to a level of 8.88% on dry matter basis which was more or less similar to the same in the earlier sets of trial.

Multiple regression analysis for the changes of sensory characteristics of buffalo rosogolla with the chemical attributes under study when stored at refrigerated storage in tinned cans (Table 4.8.2.2.A) revealed the overall determination coefficient of the defined variables (X) with flavour scores (y_1), body and texture scores (Y_2) and overall acceptance scores (Y_3) were 0.9061, 0.7953 and 0.9222 respectively. Hence the observed chemical attributes could justify 90.61%, 79.53% and 92.22% of the changes in flavour scores, body and texture scores and overall acceptibility scores respectively.

Table : 4.8.2.2.A. Linear Regression Equation for the Changes of Sensory Characteristics of Buffalo Rosogolla when Stored at Refrigerated Storage in Tinned Can.

Deduced Variable	Defined Variable	Linear regression equation	Correlation Coefficient
Y_1	X_1	Y_1 = 12.07-1.76 X_1	0.8312
	X_2	Y_1 = 9.48-0.67X_2	0.8754
	X_3	Y_1 = 10.92-10.05 X_3	0.9752
	X_4	Y_1 = -5.23+1.25 X_4	0.5296
	$X_1X_2X_3X_4$	Y_1 = 10.55-0.49X_1-0.58X_2+0.99X_3-0.03X_4	0.9061
Y_2	X_1	Y_2 = 8.47-0.34 X_1	0.9214
	X_2	Y_2 = 7.90-0.11 X_2	0.7146
	X_3	Y_2 = 8.13-1.64 X_3	0.7595
	X_4	Y_2 = 5.01+0.25 X_4	0.6407
	$X_1X_2X_3X_4$	Y_2 = 7.64-0.14X_1-0.05X_2-0.15X_3+0.05X_4	0.7953
Y_3	X_1	Y_3 = 11.44-1.53 X_1	0.8204
	X_2	Y_3 = 9.22-0.59 X_2	0.8902
	X_3	Y_3 = 10.47-8.84 X_3	0.9841
	X_4	Y_3 = -3.51+1.08 X_4	0.5128
	$X_1X_2X_3X_4$	Y_3 = 10.9-0.46X_1-0.56X_2+1.6X_3-0.1X_4	0.9222

Y_1 = Flavour Score, Y_2 = Body & Texture Score, Y_3 = Overall acceptance Score, X_1 = Syrup acidity, X_2 = Volatile fatty acidity X_3 = Peroxide value, and X_4 = Sodium chloride soluble protein.

The simple regression analysis exhibited that each of the examined chemical parameters had significant correlation with changes of all the sensory attributes. The overall regression equations (Table 4.8.2.2.A.) were found as follows :

$$Y_1 = 10.55-0.49X_1-0.58X_2+0.99X_3-0.03X_4$$

$$Y_2 = 7.64-0.14X_1-0.05X_2-0.15X_3+0.05X_4$$

$$Y_3 = 10.9-0.46X_1-0.56X_2+1.6X_3-0.1X_4.$$

CHAPTER - V

SUMMARY, CONCLUSION AND RECOMMENDATIONS

5. SUMMARY, CONCLUSION AND RECOMMENDATIONS

5.1 Summary.

The study was conducted to standardize the manufacturing techniques of rosogolla from buffalo milk and to evaluate the physicochemical changes during its manufacturing and storage with suitable packaging. In order to standardize the manufacturing techniques a series of preliminary trials were undertaken with different permutation and combination of process parameters for an initial standardization. The optimum technology was then achieved by studying the effectivity of the important process parameters towards the acceptability of the product on their variation. The physico-chemical changes occuring during the production were studied by investigating the composition of buffalo milk, buffalo chhana and buffalo rosogolla, and the status of milk protein in them. They were compared with cow milk, cow chhana and cow rosogolla. The microbiological quality, rheological attributes, chemical composition of commercially available samples and submicro structure of buffalo rosogolla were also analysed and compared with cow rosogolla for better understanding. The physicochemical changes of buffalo rosogolla during its storage leading towards spoilage were also examined for different chemical attributes alongwith their sensory qualities at ambient temparature (25±1°C) and refrigerated temperature (5±1°C) in two types of packaging namely metallized polyester package and tinned cans.

i) Dilution of buffalo milk with potable water was found to increase the softness of both chhana and rosogolla. Dilution with 25% potable water was considered to be the most suited one for rosogolla manufacture.

ii) High fat buffalo milk was not found suitable for rosogolla production. Rosogolla made from 4% fat buffalo milk had the most desired body and texture.

iii) Since milk was diluted with 25% potable water, the calcium content of diluted buffalo milk was observed to be similar to that of cow milk. Hence the effect of higher calcium load in buffalo milk was nullified.

iv) The rosogolla prepared from homogenized buffalo milk was harder with non uniform sweetness, specially at the centre. Hence homogenization was not suggested for rosogolla preparation from buffalo milk.

v) Partial digestion of buffalo milk with the enzyme trypsin at 37°C resulted a softer chhana and rosogolla. Digestion for 15 min. was recommended for the desired soft rosogolla production since higher incubation period resulted into very soft rosogolla, which tended to dissociate during cooking.

vi) Temperature of coagulation of chhana played an important role towards the acceptability of rosogolla. A temperature of coagulation at 60°C was selected for quality rosogolla production, though with comparatively lesser yield of chhana.

vii) One percent lactic acid was chosen as the coagulant for production of buffalo rosogolla considering its ability towards production of spongy type body and higher porosity. Citric acid coagulated chhana gave rise to granular and coarse type rosogolla.

viii) The rosogolla prepared from the chhana curdled at a pH of 5.7 was most spongy with desired porosity. Which was missing in the rosogolla samples made with chhana curdled at lower pH.

ix) Though delayed straining method yielded a softer chhana it resulted into larger size pores, loose texture and flattened body in the rosogolla. Immediate straining, on the contrary, resulted into the desired porosity softness and smoothness in the body of rosogolla and hence was accepted for the standardized technology.

x) Wheat flour and baking powder failed to produce any betterment in the final acceptability of rosogolla when added in chhana before kneading at different level.

xi) A moisture level of 60% in the buffalo chhana was concluded to be the most suitable level for rosogolla preparation from buffalo milk. Lower moisture in chhana caused harder body and higher moisture content leading towards undesirable degree of softness and disintegration of the final product.

xii) Sugar concentration of 60% was found most suitable for cooking the rosogolla balls. Increased concentration attributed adverse effects towards the flavour, colour, body and texture and overall acceptance of the products.

xiii) A cooking period of 25 min. was observed suitable for rosogolla preparation since lower cooking time left the rosogolla undercooked specially at the centre and higher cooking time resulted into overcooking of rosogolla with hard body, cooked flavour and brownish colour.

xiv) Sprinkling of water after every 5 min. was found essential during cooking of rosogolla to compensate the loss of moisture due to evaporation which otherwise caused a harder product with brownish colour and cooked flavour.

xv) Repeated use of cooking syrup revealed that cooking syrup might be used till the second repeat. From the third repeat, it affected the final acceptability of the products.

xvi) It was observed that on concentration of 40% sugar in the soaking syrup was optimum for preparing rosogolla from buffalo milk, in order to achieve the desirable flavour, body and texture and overall acceptance.

xvii) The average total solid, fat, protein, lactose and ash content was higher in the initial buffalo milk as compared to those of cow milk. Whereas the gross composition of buffalo chhana and cow chhana were in proximity, because of the modification in buffalo milk make up. The buffalo chhana was having less of total solid and protein and more of fat in comparison to that of cow chhana. Contrary to the variations found in milk samples, buffalo rosogolla samples were observed to contain less of total solid, fat and protein, and higher sugar content as compared to cow rosogolla, as a result of the change in process parameter combination. The average total solid, fat, protein, sucrose and ash content in buffalo rosogolla were noted as 44.79%, 5.39%, 6.82%, 32.43% and 0.32% respectively. The yield of buffalo rosogolla was 348.53% by weight of chhana which was considerably high in regards to cow rosogolla.

xviii) From the PAGE pattern of the proteins isolated from milk, chhana and rosogolla of both cow and buffalo it was noted that two low molecular weight components were evoluted during chhana preparation and the protein had undergone severe changes during the transformation of chhana to rosogolla. The trypsin treatment, as had been done with the buffalo milk before the production of chhana, was observed to produce some breakdown components which further degraded during chhana production.

xix) The total viable count and yeast and mould count of both the cow and buffalo rosogolla were lying in more or less similar range, having exceptions in one or two samples.

xx) The rheological studies of buffalo and cow rosogolla samples with the help of Instron Universal Testing Equipment revealed that buffalo rosogolla was slightly harder in comparison. The springiness and chewiness however, were observed to be lower in buffalo rosogolla and the cohesiveness and gumminess of both the rosogolla samples were lying in the same range.

xxi) On the compositional analysis of market rosogolla a wide range of variation was revealed, all of them, excepting samples from one shop which lacked in the prescribed fat content, were however, conforming to the ISI specification for canned rosgolla.

xxii) From the submicrostructures of rosogolla, the presence of units, several times larger than that of the size of casein micelles were observed in thick chains leaving no single subunits. Numerous large voids, noted, might be the air spaces filled with sugar syrup. Small size fat globules were also visible though the milk was not homogenized. The surface of buffalo rosogolla were found more rough and uneven, with a scale type entity of casein micelle conglomerate in comparison to cow rosogolla. The porosity was also less in buffalo rosogolla. Market rosogolla revealed similar ultrastructure to that of cow rosogolla showing the presence of additives in it.

xxiii) The shelf life of buffalo rosogolla in metallized polyester packaging found to be very low, below 4 weeks when stored at ambient temparature and below 6 weeks when stored at refrigerated condition mainly because of its flavour deterioration and lowering of overall acceptability. The body and textural attributes were however found to be little more stable. The change in each of syrup acidity, volatile fatty acidity, peroxide value and sodium chloride soluble protein content were found significantly contributing towards the spoilage of rosogolla. The unfavourable changes in the sensory qualities were mostly defined by the above parameters as was evident by the multiple regression analysis.

xxiv) Buffalo rosogolla remained acceptable for almost 2 months in ambient temperature and almost 5 months at refrigerated conditions, when stored in tinned cans. In this type of packaging also body and texture was least vulnerable and the chemical attributes under consideration were highly contributive towards these changes. The unfavourable changes in the sensory qualities were mostly defined by the above parameters as was evident by the multiple regression analysis.

5.2 Conclusion and Recommendation.

In order to produce satisfactory quality of spongy rosogolla from buffalo milk the following procedure was recommended. Buffalo milk diluted with 25% potable water was standardized to a fat level of 4% and partially digested with the enzyme trypsin for 15 min. at 37°C. It was then heated to boiling for 10 min. and then allowed to cool to the coagulation temperature of 60°C. Freshly prepared 1% lactic acid solution previously heated to the coagulating temperature was added slowly to the milk with gentle stirring till the milk coagulated at pH 5.7. The coagulum was strained immediately through muslin cloth and the moisture content of chhana was adjusted at 60% level by squeezing the coagulum and adding water if needed. The freshly prepared chhana was ground in a mixie for two min. at slow speed and kneaded on a wooden slab for 2 min. They were then rounded in small balls and cooked for 25 min. in boiling clarified cooking syrup containing 60% sugar. The loss of moisture during cooking was compensated by sprinkling water after each 5 min. of cooking. The cooked balls were then transferred to freshly prepared clarified soaking syrup containing 40% sugar for 1½ hours and stored in the same syrup.

Tinned can having inside epoxy type food lacquer was found most suitable for storage of rosogolla. While filling, care was taken to sterilize the cans properly and seaming them, after filling the cans leaving least air space in hot condition.

The initial quality of milk, manufacturing, packaging and storage conditions were noted to be highly sensative towards final acceptability of the product specially during extended storage. Hence these factors need to be taken care of during the production.

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