UTILIZATION OF GOAT MILK FOR PREPARATION OF MOZZARELLA CHEESE

By

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THESIS

Submitted in partial fulfilment of the requirement for the degree

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DECLARATION

I hereby declare that the thesis entitled **UTILIZATION OF GOAT MILK FOR PREPARATION OF MOZZARELLA CHEESE** is a bonafide record of research work done by me during the course of research and that the thesis has not previously formed the basis for the award to me of any degree, diploma, associateship, fellowship or other similar title of any other University or Society.

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PHOLA KONYAK, W.

To my beloved Mother
and in loving memory of
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Introduction

INTRODUCTION

Mozzarella cheese is used as a topping on pizza pie owing to its inherent stretching quality. It was traditionally manufactured from high fat buffalo milk in Italy where it was originated. The technology has hence been modified for cow milk and is widely used all over European countries and USA.

Under Indian conditions, the milk that finds its way to the processing sector is of mixed type, the majority being buffalo milk, the next cow and goat milk.

From the time immemorial, rearing of goat has been a traditional practice of Indian rural population mainly for the purpose of meat and milk. Goat is aptly referred to as "Poor Mans' Cow". Area in the world where the goats contribute to the development of dairying include the Mediterranian, South West Asia, India and Eastern Europe (Kosikowski, 1982)

The role of goat farming in upliftment of rural economy in our country is well recongnised, this is mainly because of the fact that goats can thrive extreme rough weather conditions, and can be conveniently reared on uncultivable land where dairy farming based on buffalo and cow is un economical.

India ranks the highest in goat population in the world accounting 152 million goats and the milk produced by them is estimated to be 1.90 million tonnes (Dairy India, 1992). Merely increase in the population of goat and milk produced by them is not to be considered a real achievement and will not serve the purpose unless to find a place for the proper utilisation of goat milk.

In India goat milk is often criticized as it possesses a characteristics "Goaty odour". It is not liked by many for direct consumption, and is used entirely for beverage purposes. Goat milk is also found to be unsuitable for manufacture of various fat rich dairy products such as Cream, butter and ghee, due to poor creaming property of goat milk as a result of small fat globule size (Fahmi et al., 1956).

Among the dairy products, cheese is probably the oldest and most popular product manufactured from milk. Cheese is a product obtained from milk by coagulating the casein with the help of rennet or similar enzymes in the presence of lactic acid produced by added or adventitious micro-organisms, from which part of the moisture has been removed by cutting, cooking and / or pressing, which has been shaped in a mould and then ripened by holding it for sometime at suitable temperature and humidity (Davis, 1965).

There are different varieties of cheeses produced in cheese making countries showing a considerable regional differences. In course of time, certain variety of cheese become known for the particular regions, such as England for Cheddar cheese, France for Roquefort, Switzerland for Swiss, Holland for Gouda, Italy for Mozzarella cheese. Although all cheese names are geographical, they have no regional significance, Cheddar cheese is probably the best known cheese in the world originated in cheddar town in England but there is no evidence that the best cheese ever come from cheddar.

Mozzarella cheese was originated in the Battipaglia region of Italy, and was traditionally prepared from high fat buffalo milk. However, Mozzarella cheese is now prepared from cow milk all over the Europian countries and United States of America with certain modifications.

Pizza as a fast food is gaining wide popularity among the urban populations in India, particularly in cosmopolitan cities Viz, Delhi, Bombay, Calcutta and Madras. For preparation of this speciality, Mozzarella cheese become a key ingredient which is irreplaceable by any other types of cheese owing to its unique properties of stretchability. Both pizza as well as Mozzarella cheese are relatively new introduction to Indian dietary system, with the cultivation of taste for Mozzarella cheese the demand has been gathering momentum. The future trends of production of Mozzarella cheese in India is quite promising (Dairy India, 1992).

Mozzarella cheese belong to 'pastafilata' a stretch curd. It is white, soft and unripened variety of cheese. It involves the principle of stretching the curd when hot to get a smooth texture and very lively surface sheen. Mozzarella cheese owes it characteristics mainly due to the action of lactic acid on dicalcium para caseinate. At pH between 5.2 to 5.4 dicalcium para caseinate get converted to monocalcium para caseinate which provides the strings and sheen to the cheese (Kosikowski, 1958).

Whey, the by-product of cheese, paneer, chhana and casein contains almost all the nutrients that are present in milk. Paradoxically, India having a largest population facing an inadequate food and milk production resulting malnutrition, under nutrition or even some times starvation, at the same time valuable food of milk solids in the form whey is not only being wasted but also creating an environmental pollution. A few attempts have been made to utilize the whey, but unfortunately these are not being commerically adopted due to various limitations, and large quantity of whey are draining out in our country.

Since the whey is derived from milk, it contains, whey proteins, containing almost all essential amino acids especially lysine and cysteine, almost all the lactose, minerals and vitamins. The nutritional value and composition of whey qualifies the whey drinks to be chosen for the special purposes like drink associated with sports as thirst quencher, recharged energy or as part of diet and refreshing drinks.

Attempt had been made to develope the technology for economic exploitation of goat milk for developing various dairy products in the country. Recently, the National Dairy Research Institute, Karnal, made an attempt to manufacture Mozzarella cheese using admixture of buffalo and goat milk. The results were quite encouraging for utilization of goat milk for manufacture of Mozzarella cheese in combination with buffalo milk.

So far, the technology relating to the manufacture of soft and unripined varieties of cheese from a mixture of cow and goat milk has not yet been reported in India. Hence the present study was undertaken to utilize the goat milk for the manufacture of Mozzarella cheese in combination with cow milk and also goat milk alone with the following objectives:-

1. To assess the suitability of goat milk for the manufacture of Mozzarella cheese.

2. To compare the quality of Mozzarella cheese prepared from cow milk, goat milk and combination of cow milk and goat milk at the ratio of 1:1.

3. Preparation of whey drinks from the whey obtained from the above experiments and to asses the keeping quality at room and refrigerated temperatures.

Review of Literature

REVIEW OF LITERATURE

The milk of several mammals have been used for the manufacture of different milk products including cheese. Among them, cow milk has been used most extensively. This is followed by buffalo milk, goat milk and sheep milk etc. (Foster et al. 1957).

The technical procedure employed in making of different varieties of cheese from cow milk have been described by several workers. Use of goat milk for preparation of different milk products are relatively scanty.

2.1 Gross composition of goat milk

The composition and characteristics of goat milk have been reviewed by Parkash and Jenness (1968) and Jenness (1980).

2.1.1 Milk fat

Considerable variation has been reported in the composition of goat milk in respect of fat. The causes of these variations were observed to be breed, stage of lactation, age, geographical location, season and feed (Sachdeva, 1971, Agarwal and Bhattacharya, 1978, Mittal, 1979, Devendra, 1980, Jenness, 1980, Breendehauge and Abrahamsen, 1986).

Nirmalan and Nair (1962) analysed pooled samples of milk from Malabari Goat and reported a fat percentage of 4.95 whereas Devendra (1980) got a value of 4.96 for the same breed.

French (1970) reported a lowest fat content of 2.81 per cent in the milk of saanen goats.

Devendra (1972) studied the fat content of milk from British Alpine and Anglo- Nubian goat and values were 3.42 and 4.46 per cent, respectively.

Ueckermann _et al_. (1974) reported a very high fat content of goat milk with 5.65 per cent. Mba _et al_. (1975) also reported a high fat content of 5.32 per cent in the milk of saanen goats at mid lactation.

Mena and Escamilla (1977) obtained an average fat percentages of 4.26, 4.13 and 4.38 for Saanen, French Alpine and Nubian breed of goats, respectively.

Agarwal and Bhattacharya (1978) obtained the fat content of 3.83, 4.66 and 4.92 per cent, respectively in the milk of Black Bengal, Barbari and Black Bengal X Barbari Nannies. Quereshi _et al_. (1981) reported the fat content of 4.70 per cent in individual sample and 4.71 per cent in herd samples of Jamnapari goat milk.

Baiju (1981) reported an average milk fat content of 6.29 ± 0.18 and 5.64 ± 0.09 per cent in Alpine X Malabari and Saanen X Malabari crossbred goats respectively.

2.1.2 Milk Proteins

Nirmalan and Nair (1962) obtained a total protein content of 4.04 per cent in Malabari goats. While Devandra (1980) found the protein content of 3.89 per cent in the milk of Malabari goats.

The protein content in the milk of Saanen goats were found to be 2.17 per cent (French 1970).

Mittal and Pandey (1971) reported a total protein of 3.74 per cent in the milk of Barbari goats and 3.5 per cent in Jamnapari goats.

Devandra (1972) analysed the milk of British Alpine and Anglo-Nubian which revealed 2.89 and 3.38 per cent of protein respectively.

Sachdeva (1971) reported the value of 3.76 per cent for Barbari goats 3.74 per cent for Jamnapari goats respectively.

Ranawana and Kellaway (1977 a, 1977 b) worked on the milk protein of Australian Saanen goats and reported a value ranging from 4.01 to 4.61 per cent. Mena and

Escamilla (1977) also reported the protein content of 3.14 per cent for Saanen, 3.34 per cent for French Alpine and 3.70 per cent for Nubian milk. Chang and Kim (1978) reported a value of 3.65 per cent protein content in Saanen goat milk.

Agarwal and Bhattacharya (1978) studied the protein content of milk of Black Bengal, Barbari and their Crosses. They reported that an average protein content of 4.13, 5.83 and 5.07 per cent respectively.

Qureshi et al. (1981) reported a protein content of 3.31 per cent for individual milk sample and 3.32 per cent for herd sample of milk in a flock of Jamnapari goats. A value of 3.31 per cent protein was reported in the milk of Parbatsar goat by Mittal and Ghosh (1985).

The average protein content in the milk of Alpine X Malabari and Saanen and Malabari crossbred goats was reported by Baiju (1981) during the lactational studies. The average values are 4.40 ± 0.03 and 4.40 ± 0.02 per cent respectively.

2.2 Chemical properties of goat milk

2.2.1 Lipids

A great deal of work has been devoted to study of the adsorbed stabilizing materials on membrane of the fat globules of cows' milk. No information is available on the membrane of the goats milk fat globules.

An important characteristics of the fat globules of goat milk is that they are smaller in size than those in cows and buffalo milk . (Fahmi et al. 1956). Unlike buffalo and cow milk, the goat milk showed invariably two peaks in the fat globules size distribution curves (Puri et al., 1961), having about 1 to 4 microns in diameter.

Jenness and Parkash (1971) stated that, the poor creaming quality of goats milk at low temperature appears to be due to the lack of agglutinating euglobulins and not due to the small size of the fat globule as has often been naively stated.

Patton et al. (1980) observed an increase in the number of phospholipids suggesting that fat globule membrane may be susceptible to damage causing the release of short chain fatty acids from the fat globules core resulting goaty flavour during the storage of raw milk.

2.2.2 Proteins

The proteins in goat milk have been less extensively studied than those in cow milk (Jenness, 1980). However, various workers have isolated and characterised the major components of goat milk caseins.

Richardson et al (1974) examined the casein micelles of sheep, goat and cow under electron microscope as well as gel electrophoresis and reported that the casein micelles in goat milk were smaller than those in cow milk. The micelles contain relatively minor proportion of casein and the major components appears to be Beta-casein.

Pellisier and Manchon (1976) compared the whole casein of goat, ewe and cow milk in respect of their relative content of the component of caseins. They observed that alpha S_1 casein is more in cow milk casein.

Singh and Ganguli (1977) reported that the relative proportion of alpha - casein and beta-casein fraction in whole acid casein sample were 39.27 per cent and 60.96 per cent respectively. Beta-casein concentration was found to be dependent on the micelles casein particle size which increases with increase of micelles particle size unlike alpha-casein.

Jenness (1980) reported that goat milk have five principle proteins alpha-lactalbumin, Beta-lactoglobulin, K-casein, Beta-casein and alpha S_1-casein closely resemble their homologue in cow milk, however, goat milk lacks a homologue of bovine alpha S_1 - casein the most abundant protein in cow milk.

Khatoon and Joshi (1987) reported that goat milk casein was observed to be of less susceptibility to rennet action as compared to corresponding cow milk casein fractions in relation to the release of proteose peptone and non-protein nitrogen. Goat milk has a large amount of non-protein nitrogen than cow milk (Parkash and Jenness, 1968).

2.3 Utilization of goat milk

A great deal of study has been done on the various dairy products made from cow milk, but the literature on the utilisation of goat milk for different dairy products is relatively scanty. Cheese is one of the product prepared from goat milk among the dairy products. The varieties of cheese made from goat milk include soft and semi-hard cheese, like Feta, Roqueforte, Chevre, Saint-maure, Chebichou etc. (Davis, 1976). Morrison et al. (1980) reported that there are over 400 varieties of cheese out of which a great number of cheese are made from goat milk and combination of goat milk with milk of other species.

In France, goat milk is made into cheese directly on the farm itself or in Dairy Plant. The type of cheese produced are, Sain-maure, Chabichou, Pyramide and Silk-sur-chev (Gargouet, 1971). In U. K. small amount of goat milk cheese is made by enthusiasts, that is not generally avai-lable. The most popular is a small (3 kg) pressed cheese. Stilton, Cambridge, Bondon, Gervais and Pout l' Ereque have also been made (Davis, 1976).

Rakshy and Hassan (1971) demonstrated the suitability of goat milk for manufacture of cheese variety similar to Domiati cheese. The suitability of goat milk for cheddar cheese has been demonstrated by Rathore (1983), Davide et al. (1986). Park and Attaie (1988) reported that goat milk cheddar cheese found to be firmer but paler than cow milk cheddar cheese although texture was similar.

Anil Kumar (1985) compared the hard variety of cheese prepared from goats' milk and cows' milk during the ripening periods upto 13 weeks at 5°C to 10°C. The author reported that there is not much significant difference between the cheeses.

Gross composition of ripined cow and goat milk Chedder cheese was comparable (Davide et al. 1986), Goat milk cheese was found to have a mild, pleasant and well accepted flavour and waxy, smooth and mellow body and texture.

Park and Attaie (1988), concluded that Chedder cheese can be successfully produced from goat milk. Further more, the products had no detectable goaty odour, nor abnormal texture and flavour.

Admixing of goat milk with buffalo milk had synergistic effect for obtaining good quality Cheddar cheese (Rao, 1990). As buffalo milk is considerd not suitable for the manufacture of Cheddar cheese, but addition of 10 to 20 per cent of goat milk to buffalo milk yield good quality Cheddar cheese (Singh et al., 1992).

David et al (1990) compared Blue vien and Camembert cheese made from goat and cow milk. Flavour intensity of the goat milk cheese was found to be stronger than that of cow milk cheese, however, both goat and cow milk were highly accepted .

Rish (1992) studied the Rheological properties of goat milk cheese and observed that compressive moduli of elasticity and stress relaxation characteristics of soft goat milk cheese were lower than those of cow milk cheese. Betaway et al (1992) studied the effect of salting methods on the ripening of Ras cheese made from a mixture of goat and cow milk at the ratio of 1:1. Ammarel et al. (1994) also studied accelerating of Ras cheese ripening made from mixture of cow and goat milk (1:1) using autolysed starter and cheese slurry.

Lathasabikhi and Kanawjia (1992) manufactured Mozzarella cheese from admixture of goat and buffalo milk at different levels. The cheese made from 1:1 ratio gave a good quality product in respect of Physico chemical, rheolcgical and Organoleptic properties of the product.

2.4 Type of milk for Mozzarella cheese

Traditionally Mozarella cheese is manufactured from buffalo milk which is white in colour. When cow milk is used some neutralizing agents such as benzoyl peroxide and titanium dioxide at the rate of 0.03 per cent is used to mask natural B-carotene (Shaw, 1986).

Upadhyay et al. (1986) reported that buffalo milk is more suitable than cow milk for manufacture of Mozzarella cheese as it gives more piquant and aromatic quality and physical characteristics of the cheese. The suitability of buffalo milk for manufacture of Mozzarella cheese was reported by Patel et al. (1986) and Scott (1986).

Bonassi et al. (1982) did not find any difference in Mozzarella cheese made from buffalo milk, cow milk and their combination (1:1) in respect of taste, aroma, body and texture.

Singh et al. (1985) outlined the technical procedure for the manufacture of Mozzarella cheese from buffalo milk as well as cow milk. Upadhyay *et al*. (1986). Standardized two methods for manufacture of Mozzarella cheese from pasturized milk of buffalo using starter culture and direct acidi-fication with lactic acid .

NDRI (1987) standardised the manufacturing technique of Mozzarella cheese from buffalo milk using microbial rennet. It was found that an initial fat level of four per cent in milk gave the best result.

Lathasabikhi (1991) reported a 1:1 blend of buffalo and goat milk found to be highly suitable. The organoleptic qualities, melting and baking characteristics and eating quality of the cheese on pizza was adjudged to be very good. Johnson (1995) reported that suitability of skim milk filled with coconut fat for Mozzarella cheese.

2.5 Standardization of milk

Milk meant for cheese making is standardized to meet the legal compositional requirement in the finished product and also to improve the quality and yield. Shukla and Ladkani (1989) made Mozzarella cheese of satisfactory quality from buffalo milk with 2, 3 and 4 per cent fat by direct acidification method.

Ravisundar and Upadhyay (1990) made Mozzarella cheese from buffalo milk with casein - fat ratios of 0.5, 0.6, 0.7, 0.8 and 0.9. Fat on Dry Matter (FDM) and protein contents of the cheese were significantly affected by casein - fat ratio of the milk.

Ravisunder and Upadhyay (1991 b) reported that melting and fat leakage properties of Mozzarella cheese were significantly influenced by C:F ratio. Cheese made from low C:F ratio showed the highest melting and fat leakage. Rheological characteristics of the cheese were also significantly influenced by C:F ratio of cheese milk. Cheese made from 0.7 C:F ratio milk had the highest total sensory score.

Ghosh and Singh (1990 b) standardised the manufacturing technique using different levels of fat in the milk (3, 4 and 5 per cent). They observed that Mozzarella cheese from 4 per cent fat in milk was highly suitable for pizza making. The cheese milk having 3 per cent fat was found to be coarse and hard where as from 5 per cent fat cheese yielded was too soft with excessive leakage of fat.

Lathasabikhi (1991) studied the effect of different fat levels viz. 2, 3 and 4 per cent in goat and buffalo milk mixed in the ratio of 1:1. The same author reported that 3 per cent fat in milk gave the best quality Mozzarella cheese.

Lou *et al.* (1992) standardised the bulk tank milk to 5 levels of fat (3.0, 3.2, 3.6, 3.8 and 4.0 %) and similarly to 5 levels of protein and used for cheese preparations. Cheese samples and whey was analysed for total solids, fat, protein and salt.

Richard *et al.* (1994) manufactured Mozzarella cheese of reduced fat to contain upto 50 per cent less fat than conv-entional part skim milk Mozzarella cheese, milk which had been standardised to a casein-fat ratio of 1:2, 1:6, 2:0 or 2:4. The stretch and melt characteristics of Mozzarella cheese containing upto 50 per cent less fat were similar to the part skim milk Mozzarella cheese.

Johnson (1995) standardised Mozzarella cheese milk to four per cent fat using skim milk filled with coconut fat at the levels of 100 and 50 per cent. The resultant cheese was found to be similar to control cheese made from cow milk.

2.6 Pasteurization of cheese milk

Mozzarella cheese from whole milk pasteurised at 71.95°C (161.5°F) for 15 seconds was first made by Kosikowski (1951). He observed that the flavour, yield and other physical properties of cheese were inferior in case of raw milk than pasturised milk cheese. Kosikowski (1982) further recommended pasteurization of milk at 72°C for 15 seconds for all types of Mozzarella cheese.

Schafer and Olson (1975) made satisfactory quality of Mozzarella cheese from pasteurized and/or ultra-high temperature treated milk and obtained increased yield, compared to that made from raw milk.

Caserio et al. (1977) investigated the effect of the curd plasticising process on microbiological quality of Mozzarella cheese and reported that it does not destroyed pathogen. Hence stress is laid on the need for pasteuerisation of the cheese milk and for strict hygienic standards during and after manufacture of the cheese.

Partidge et al. (1982) found no significant difference in the quality of Mozzarella cheese either made from fresh or stored pasteurised milk (upto 10 days).

Fernandez and Kosikowski (1984) prepared low moisture Mozzarella cheese from retenates or vaccum evaporated milk heated at 75°C and processed for 10 minutes with trisodium citrate, salt and water.

Cavaliere et al. (1990) compared Mozzarella cheese made from buffalo milk pasteurised at 67°C, 78°C with that made from raw milk. The fat percentage increased in milk pasteurised at 78°C. However, they did not observe significant differance in the yield of cheeses.

Ghosh and Singh (1990 a) made Mozzarella cheese from raw, pasteurised (63°C/ 30 minutes) and high temperature heated (71°C for 30 minutes) buffalo milk standardized to 4 per cent fat. Cheese made from raw and pasteurised milk was superior to those prepared from milk heated to high temperature. The flavour characteristics of pasteurised milk cheese was superior to that of raw milk cheese.

2.7 Use of starter culture

Kosikowski (1951) reported that Mozzzarella cheese from pasteurised milk inoculated with 0.20 to 0.5 per cent DK (Streptococcus faecalis) starter was of excellent quality in terms of flavour , yield and melting on pizza pies as compared to cheese made from raw milk under similar processing condition.

Reinbold (1963) advocated the use of 1.5 per cent or more starter culture depending upon initial acidity of milk. Christensen (1966) suggested the addition of starter culture in mixture containig Streptococcus thermophilus and Lactobacillus bulgaricus or L. helviticus for low moisture Mozzarella cheese, whereas for high moisture Mozzarella cheese, Streptococcus lactis, Streptococcus durans or Streptococcus faecalis starters have been recommended.

Reinbold and Reddy (1979) pointed out that use of starter culture composed of one or more species of Pediococcus cerevisiae, Lactobacillus plantarum, Lactobacillus casei, Streptococcus faecalies and Streptococcus durans in addition to the standard starter culture had given Mozzarella cheese containing less than 0.3 per cent lactose, reduced burning or blistering of the cheese during baking on pizza.

Kosikowski (1982) suggested the addition of 1.5 per cent L. bulgariccus or 0.75 per cent S. thermophilus and 0.75 L. bulgaricus for the manufacture of low moisture Mozzarella cheese from pasteurised milk.

Johnson and Olson (1985) reported that Mozzarella cheese when made with a combinations of S. thermophilus non-galactose (NG) and galactose fermenting (GF) strains and L. helviticus (GF) and L. bulgaricus (NG) reduced the incidence of non-enzymatic browning of Mozzarella cheese. Hutkins et al. (1986) also reported that combined culture of S. thermophilus and L. bulgaricus is useful in the manufacture of Mozzarella cheese.

An active starter culture consisting of S. thermophilus and L. bulgaricus at 1:1 ratio is added at the rate of 1 to 2 per cent for manufature of Mozzarella cheese from buffalo milk (Upadhyay et al., 1986; Ghosh and Singh, 1990b, 1991a).

Athar and Anwar (1992) compared Mozzarella cheese prepared from buffalo milk by starter culture and direct acidification. The cheese preapred by starter culture technique (SCT) contained higer contents of total solids, protein and ash and lower contents of lactose and fat. Starter culture technique produced significantly higher (P <0.05) cheese yields. Kiely et al. (1993) observed changes that occured in the microstructure of low-moisture part skim milk Mozzarella cheese made with a mixture of starters consisting of Streptococcus salivarious var. thermophillus and Lactobacillus delbrueckii var. bulgaricus. It was suggested that the occurance of microcavities progressively throughout the storage may be due to proteolysis or carbondioxide production by starter culture.

2.8 Coagulating agents in cheese making

2.8.1 Renneting the cheese milk

Though calf rennet has been considered the ideal coagulant for cheese making, it has been replaced by microbial rennet due to growing scarcity of the former.

A fungal rennet produced from Mucor pusillus is satisfactory for manufacture of cheese (Richardson et al., 1967). Sandoval et al. (1969) compared Mozzrella cheese made with calf rennet and microbial rennet and recomended the suitability of microbial rennet in the manufacture of Mozzarella cheese.

Kosikowski (1982) stated that addition of 60 to 85 ml of single strength rennet extract per 100 lbs milk just after the starter inoculation is optimum. He further reported that the calculated amount of rennet extract should be diluted to 1:40 with cold water just before the addition to cheese milk. Matteo et al. (1982) suggested that degradation of casein in Mozzarella cheese can be minimisied by using little quantity of rennet as possible in the cheese milk.

Oberg et al. (1990) made four types of cheeses using different enzymes viz. Chymosine, Bovine pepssin, Porcine pepsin and Rhizo muco miehei protenase. They did not observe any changes in the physical properties of Mozzarella cheese prepared with each of the enzyme, after storing at 4°C for 28 days.

Ghosh and Singh (1992) stated that the good quality Mozzarella cheese could be prepared by using microbial rennet. Body and texture of the cheese made by using modilase rennet were similar to cheese made by using calf rennet.

Kindstedt et al. (1993 a) reported that coagulant types did not have any affects on pH, moisture, protein and fat contents of cheese, however, the milk coagulants used for the manufacture of Mozzarella cheese plays an important role in proteolysis during extended period of storage.

2.8.2 Rennet coagulating time

Rennet coagulation was faster in buffalo milk due to the much faster rate of secondary action with high calcium (Puri and Parkash, 1965; Ganguly and Menon, 1971) eventhough, the primary action is much slower (Ganguly, 1973). Buffalo milk curd was always firmer and stronger than cow milk curd of the same solid content.

Storry et al. (1983) reported that goat milk had a shorter rennet coagulation time than cow milk, which could be due to high beta-casein and lower alpha S-casein. He reported that rennet coagualtion time is negatively correlated with beta-casein and total calcium content and positively with alpha S_1- casein and beta-casein ratios. Coagulum, strength is strongly related to total casein concentration , but unaffected by total fat content or by casein-fat ratio. However, goat milk has a consistently lower curd strength than cow milk, despite having a similar quantity of casein.

Grandison (1986) stated that smaller micellar size gave rise to a firmer curd than large micellar at the same total casein concentration. This could be the reason for weak curd in goat milk which has larger micelles caseins as compared to cow and buffalo milk.

Ambrosoli et al. (1988) reported that curd firmness was dependent on proportion of alpha S_1 - casein, which was less in goat milk as compared to beta - casein.

Cow milk has the most significant effect on rennet coagulation time followed by buffalo, goat and ewes milk. (Saleem et al., 1990). However, both acidity and pH were closely related to rennet clotting time for all types of milk and highly significant while milk constituents showed low correlation coefficient. Verdalet et al. (1991) reported that rennet coagulation time was significantly correlated with nitrogen:non-protein nitrogen ratio, mineralisation of calcium and phosphorus and portion of alpha S - casein, curd fimness correlated with total calcium concentration and colloidal calcium.

2.9 Cutting of coagulum

Larson et al. (1967) made Mozzarella cheese by cutting the curd into 0.64 cm cubes or by continuously agitating the milk during rennet coagulation, which formed small curd particles which subsequently aggregated into agglomerates of varying sizes mainly in the range of 1 to 3 cm in diameter.

Scott (1981) recommended curd size of 1 to 1.5 cm (Walnut size) where as Kosikowski (1982) suggested the use of 1.6 or 1.9 cm (5/8 or 3/4 inch) knives. He also recommended cutting the curd by 1.27 cm (1/2 inch) knives to control moisture in low moisture Mozzarella cheese and suggested size variation in cheese knives for low and high moisture Mozzarella cheese.

2.10 Cooking the curd

The cooking of the cheese curd should be started about 10 to 15 minutes after cutting (Reinbold, 1963). Christensen (1966) recommended the cooking temperature between 110 to 114°F for 35 to 45 minutes for low moisture Mozzarella cheese. Whereas Kosikowski (1982) recommended the cooking temperature of 105°F in 35 minutes or 118°F for 45 minutes depending upon the desired moisture level in low moisture Mozzarella cheese. Kosikowski (1982) suggested that high moisture Mozzarella cheese curd should be cooked by soaking in warm whey for about 15 minutes, with gentle agitation, but did not mention the cooking temperature.

Demott (1983) manufactured a Mozzarella cheese-like product from non-fat dry milk by employing cooking temperature of 36 to 38°C. Fernandez and Kosikowski (1986 b) reported 44°C as the cooking temperature of Mozzarella cheese. Hutkins et al (1986) cooked the curd at 43°C.

Ghosh and Singh (1991 a) found that a cooking temperature of 41°C was optimum to yield a good quality Mozzarella cheese. Latha Sabikhi and Kanawjia (1992) heated the curd gradually with continuous stirring at 37°C and cooked at this temperature till firm.

Kindstedt et al. (1993 b) studied the impact of cooking temperature on chemical composition, proteolysis and functional properties of Mozzarella cheese using different cooking temperatures (38, 41 and 44°C). No significant affect of cooking temperature on fat, protein and salt content of the cheese was detected. However, high cooking temperature produced cheese with low moisture content.

2.11 Stretching and moulding

Christensen (1966) stretched curd in 82.2°C (180°F), water to a temperature of between 49 to 57.2°C (120 to 135°F). Nilson (1968) stretched the curd in 82.2 - 87.8°C (180 to 190°F) water, after the desired acidity was reached.

Kosikowski (1982) suggested that milled, raw, acidified curd should be placed in hot water, approximately 82.2°C (180°F) for a few minutes, but not long enough for the curd temperature to exceed 57.2°C (135°F). Hutkins. et al. (1986) stretched the curd in hot water of 77°C temperature.

Upadhyay et al. (1986) stretched the salted curd using sufficient quantity of boiling water to cover the curd and allowed contact time of about 4 to 5 minutes. Curd acidity of 0.4 per cent had a profound effect on stretching. Shukla and Ladkani (1989) stretched the curd and moulded in hot water at 85°C.

Ghosh and Singh (1990 a) carried out the 'stretch test' when the titratable acidity of the fresh whey reached 0.75 per cent, sufficient hot water at 80 to 83°C was added to cover the curd. Jana and Upadhyay (1992) stretched the curd at 85°C to 90°C for 1 to 3 minutes, which yielded satisfactory stretching of the curd.

2.12 Yield of Mozzarella cheese

The yield of Mozzarella cheese is affected by casein and fat contents of milk, the losses of solids during processing and the moisture left in the curd.

Kosikowski (1982) reported that average yield of commercial Mozzarella cheese is 11.5 per cent containing

53.6 per cent moisture made from 3.0 per cent fat cow milk. Cheese yield and fat content were significantly higher when buffalo milk alone was used (Bonassi et al., 1982).

Demott (1983) compared the yield of Mozzarella cheese made by adding starter culture and direct acidification and observed that use of starter culture gave higher recovery of fat, protein and total solids.

Patel et al. (1986) reported that the fat recovery in cheese was lower when high fat milk was used and vice-versa which was due to significantly higher fat losses in whey and moulding water.

Ravisunder and Upadhyay (1990) obtained yield of cheese 16.47 per cent which was the highest yield made from 0.5 casein - fat ratio, where as the lowest yield of 13.75 per cent was observed for cheese made from milk having 0.9 casein - fat ratio .

2.13 Salting/brining of Mozzarella cheese

Christensen (1966) reported that optimum salt content range is from 1.5 to 1.7 per cent, and that too high a salt content gave a chesse with poor melting characteristics. Nilson (1968) developed a system in which the salt is directly sprinkled over the hot stretched curd followed by shaping it into five pound loaves. Leake and Nilson (1969) concluded that brining temperature affected moisture content of Mozzarella cheese, but had little effect on the salt penetration.

Kosikowski (1982) stated that after cooling and washing in chilled water, the firm curd blocks should be dipped in saturated brine (about 23 per cent) at 7.2°C (45°F) and satisfactory salting depends on the size and shape of the cheese.

Cervantes et al. (1983) reported that an interaction between salt concentration and age, on texture of the cheese. At a salt concentrations of 0.27 per cent, cheese become softened with age whereas at salt concentrations between 1.0 and 2.4 per cent there was no significant effect of aging on texture upto 24 days at 5.6°C.

Fernandez and Kosikowski (1986 b) reported that hot brine stretching of curd in 10 per cent brine resulted in cheese of uniform salt distribution, but slightly lower salt concentrations than control cheese made by hot water stretching and cold brining. Ghosh and Singh (1991 c) reported that melting quality of Mozzarella cheese is influenced by both salt content and brining period.

2.14 Packaging

The high moisture content in Mozzarella cheese makes it susceptible to spoilage due to microbial attack and loss of moisture. The packing materials for Mozzarella cheese should posses oxygen barrier and moisture barrier properties.

Scott (1981) suggested that Mozzarella cheese and pizza cheese could be packaged in saran, a multicoated or mulilayers films and stored at low temperature (4°C) until used. Kosikowski (1982) advocated that cheese should be dried for sometime and wrapped in parchment, saran or vacuum packaged in cryovac, polyethylene or cellophane pouches, followed by refrigerated storage.

Patel et al. (1986) packaged the cheese ball in clean sanitized polyethylene bags and stored at 8°C±1°C until used. Dried cheese blocks were packaged in food grade polyethylene pouches of 300 gauge thickness, sealed with aluminium clips (Ghosh and singh, 1991 a, 1991 b).

2.15 Preservation and storage

Matteo et al. (1982) studied the changes in Mozzarella cheese made from cow, buffalo and mixed milk during storage and reported that there was an increase in soluble nitrogen, lowering of lactose content and decrease in pH. Patel et al. (1986) stored Mozzarella cheese sample at 8°±1°C for two weeks and pH, titratable acidity, acid degree value and tyrosine contents were measured at zero, one and two weeks.

Ghosh and Singh (1991 a) reported that Mozzarella cheese package on polyethylene pouches was acceptable upto a period of 14 and 90 days when stored under refri-gerator (8 to 9°C) and deep-freeze (-10 to -15°C) respec-tively. The unsalted product keeps well upto 10 to 12 days under refrigerated conditions. The shelf life of salted cheese in 17 to 19 days, microbial growth is observed on the surface of the cheese on further storage (Ghosh and Singh, 1991 b).

2.16 Rheological properties

Rheology is the science of deformation and flow of matter. It includes the study of physical properties like, stretchability, meltability, body and texture. Rheological properties of Mozzarella cheese have been reviewed by Ghosh et al. (1990).

2.16.1 Meltability

The most commonly reported methods for meltability assessment were described by schreiber (Kosikowski,1982) and Arnott et al. (1957). Both methods are based on heating a standard cylindrical specimen of cheese, under specified conditions of oven temperature and time, followed by measuring the specimen's diameter increase (Schreiber) or height decrease (Arnott). However, several researchers have used various specimen diamensions and heating conditions that they found most suitable (eg. Breene et al. 1964, Keller et al., 1974; Schafer and Olson, 1975; Rayan et al. 1980, Kosikowski, 1982). Park et al. (1984) after comparing the Schreiber test, the Arnott test and two other microwave modification tests concluded that there is a marked lack of correlation between the first two tests.

Kindstedt et al. (1989) described a method for measurement of Mozzarella cheese melting by helical viscometry and stated that cheese composition affected the melting properties. A quantitative test for free oil formation in melted Mozzarella cheese was suggested by Kindstedt and Rippe (1990). They concluded that free oil formation increase with increasing cheese fat on a dry matter basis.

Kindstedt et al. (1992) determined the locational differences in compositions of a cheese block affected melting characteristics. They opined that, it may be because in part by exchange of sodium with casein bound calcium at the cheese surface, which enchanced the emulsifying ability of soluble casein, resulting in a more emulsified fat phase at the cheese surface and less formation of free oil.

2.16.2 Stretchability

Mozzarella cheese acquires the optimum texture and grain during the stretching procedure, which consists of kneading and pulling the acidified curd in hot water at 60 to 80°C (Kosikowski, 1958). Kosikowski (1982) suggested a 'stretch test' to determine whether Mozzarella curd is ready for stretching or not.

Scott (1981) reported that the curd at pH 5.1 to 5.4 placed in hot water at 82°C and stretched out to one metre long thread.

The curd of Mozzarella cheese is usually heated at 55 to 60°C after it has matted and is worked while hot until it became very elastic, shiny, stringy and free from mechanical openings (Webb et al., 1987).

2.16.3 Textural characteristics

Textural property of Mozzarella cheese are extremely important especially when they are incorporated into a more complicated food system such as pizza. The Instron Universal Testing Machine (IUTM) is used to test the textural parameter of cheese (Lewis, 1986).

Chen *et al*. (1979) examined 11 varieties of cheese for textural qualities and found that Mozzarella had a relatively low value for hardness, but had the highest value for elasticity and among the highest for cohesiveness, adhesiveness, chewiness and gumminess.

Cervantes *et al*. (1983) reported that increasing salt concentrations of cheese increased the firmness and force at 50 per cent compression, but decreased cohesiveness. Freezing and thawing of Mozzarella cheese did not significantly affect compression force at 50 per cent compression, firmness or cohesiveness.

Fernandez and Kosikowski (1986 a) observed that Mozzarella cheese from ultra-filtered whole milk with low concentrated retentates, showed improved physical properties over those of non retentates control whole milk.

Ghosh and Singh (1991 b) reported that hardness, springiness, gumminess and chewiness of Mozzarella cheese from buffalo milk decreased with cheese from buffalo milk decreased with increase in storage period regardless of packaging material and storage temperature.

Lathasabikhi and Kanawjia (1992) reported that the textural characteristics of Mozzarella cheese from admixture of buffalo and goat milk were obtained in decreasing trend with the increasing amount of goat milk.

Buffalo milk has the highest values for hardness, springiness cohesiveness, gumminess and chewiness, whereas goat milk had the lowest value.

Tunick et al. (1993) reported that low fat Mozzarella cheese containing less than 25 per cent fat on dry matter (FDM) with textural properties similar to those of a fullfat Mozzarella cheese if the product contains enough moisture and is stored under refrigeration for several weeks.

2.17 Utilization of whey

The disposal of whey is a serious problem to the dairy industry as it contains higher amount of organic constituent, require a Biological Oxygen Demand (BOD) much higher 38,000 to 46,000 ppm as compared to 200 ppm for domestic sewege (Bambha et al., 1972; Gupta and Mathur, 1989). Whey has now been recognised as a valuable raw materials which can be used in infant foods, weaning foods, bakery products, confectionery dairy products, pharmaceuticals and animal feeds (Patel et al., 1991). Full utilization of whey even with new technology has not been achieved (Zall, 1984). It may, therefore be concluded that the utilization of dairy by-products for refreshing and nutritive beverages ensure the techno-economic feasibility for their production as well as disposal (Paul, 1990).

The preparation of different whey beverages have been reported by Dordevic and Kolev (1966). The most important among them is 'Revilla' produced and marketed in Switzerland, 'Whevit' in India (Bambha et al., 1972) and 'Acidowhey' a fermented type beverages (Gandhi, 1984).

The technology for processing and marketing of whey drinks have been described in detail by Prendergast (1985). The manufacturing procedures adopted by Dyachenko and Saures-solis (1985) include the filtration of fresh whey, cooling to 4°C to 6°C, addition of recipe ingredients, pasteurization of the mixture at 74 ± 2°C for 15 seconds and the products reported to have shelflife upto 5 days at 4 to 6°C.

Jayaprakasha et al. (1986) reported soft drinks from the clarified and deproteinized whey from cheese and chhana with and without carbonation. Carbonated whey drinks were found to be superior in average sensory score. Gargrani et al. (1987) reported that whey beverage prepared from mango juices having 15 per cent whey in it was found to be superior in respect of sensory evaluation scores.

Reddy et al. (1987) reported that acceptable quality of sterilised beverage could be manufactured with the addition of 8 per cent lemon juice and 14 per cent sugar to whey.

Hamad *et al.* (1987) developed a chocolate flavoured drink from equal parts of whole milk and sweet whey from manufacture of white soft cheese using cocoa powder and vanilla flavoured. The whey drink was reported to be stable at 4°C for 10 days.

Krishnaiah *et al.* (1991) formulated three categories of whey beverages. The first whey beverage was by the addition of 10 per cent sugar and 0.2 per cent citric acid. Second by mixing 3 parts of acid whey one part of toned milk with pineapple essence, third by 3 parts of acid whey one part of toned milk with banana essence. On sensory evaluation the second and third categories of beverages were found to be more acceptable than the first due to added toned milk.

Excellent whey drinks were prepared from paneer whey (Minijose, 1992) and Mozzarella cheese whey (Johnson, 1995) using lemon and pineapple essence.

Materials and Methods

MATERIALS AND METHODS

3.1 Milk

Pooled fresh cow milk and goat milk were procured from the University livestock Farm, Mannuthy and All India Co-ordinated Research Project on goats for milk, Mannuthy, respectivity.

3.1.1 Analysis of milk

3.1.2 Collection of milk samples

The samples of milk required for analyses were collected as per ISI standards (IS: 1479, Part I 1961).

3.1.3 Chemical analysis of milk samples

The following analyses were carried out on the milk samples.

3.1.3.1 Fat in milk

The fat percentage of both cow and goat milk was deter-mined according to ISI standard (IS:1224, Part I 1977).

3.1.3.2 Protein in milk

Protein contents in milk was determined by micro kjeldahl method as per ISI Standards (IS: 1479, Part II 1961).

3.1.3.3. Fat globules size

Fat globule sizes were measured based on the techniques described by Fahmi et al. (1956).

A medium was prepared for the microscopic examamination consisting of an aqueous solution of 2 per cent sodium citrate, 0.5 per cent sodium hydroxide and 5 per cent agar-agar. This mixture was heated in a steamer and filtered. Portions of 9 ml of the filtrate were placed in test-tubes which were plugged and sterilised.

Before use, the agar tubes were melted in a water-bath and kept at 45°C till required. To each tube of the melted agar 1 ml. of the milk to be tested and a drop of a saturated alcoholic solution of gentian violet was added. This mixture was well shaken and then immersed in boiling water for 1 minute to expell any air bubbles. The prepared sample was kept at 45°C till the microscopic examination was over. This was carried out by placing one drop of the milk-agar mixture on a slide on to which a coverslip was placed after cooling. The diamter of the fat globules were then measured under the microscope by means of a calibrated occular micrometer, the scale of which being previously determined by a stage micrometer.

To ensure that all the fat globules viewed in the field were recorded, the microscopic field was divided into sections by full rotation of the graduated eye piece micrometer. The diameter of every fat globule present in the circular space were counted by rotating the graduation of the eye piece, a full rotation were noted. In this way a repeated measurement of the same fat globules was avoided.

3.1.3.4 Total solids in milk

The total solids percentage of milks were estimated by gravimetric method as per ISI Standards (IS: 1479, Part II, 1961).

3.1.3.5 Titratable acidity

The titratable acidity of milks were determined according to the ISI specifications (IS: 1479, Part II, 1961).

3.1.3.6 pH value

The pH value of the milk samples were measured by using a digital pH meter (M.c. Dalal).

3.2 Starter culture

Pure starter cultures of Streptococcus thermophilus and Lactobacillus bulgaricus were procured from National Dairy Research Institute, Karnal -130032, Haryana.

3.2.1 Maintenance and propagation of starter cultures

The pure cultures were maintained separately by propagating them in sterilised skim milk every five days. The inoculated cultures were incubated at 40°C for 16 to 18 hours and transferred to refrigerator maintained at 4°C. The activated cultures were transferred to sterilised skim milk at the rate of 2 per cent to obtain feeder culture to be used in the cheese preparation.

3.3 Rennet

Microbial rennet (Rennilase) was procured from M/s Hansen's Laboratory Ltd. Denmark, was used in the preparation of Mozzarella cheese.

3.4 Methods

Mozzarella cheese were prepared from cow milk (control), goat milk (experimental - I) and combination of cow and goat milk at the ratio of 1:1 (experimental - II) as per the procedure described by Kosikowski (1982). Flow charts are given in (Appendix - I).

The milk was standardized to the level of 1:0.7 casein-fat ratio and pasteurized at 72°C for 16 seconds, immediately cooled to 30°C. Active starter cultures consisting of Streptococcus thermophilus and Lactobacillus bulgaricus at the rate of 1:1 was added to the cheese milk at the rate of two per cent (v/v). The culture was mixed thoroughly in the cheese milk and allowed to ripen at 30°C for 10 to 15 minutes. Twelve ml of one per cent Rennilase solution per kg of milk was added and allowed 30 to 45 minutes for setting the curd. The curd was cut into 1 cm cubes and allowed to stand undisturbed for 10 minutes. Then the curd cubes were stirred with a laddle and temperature is enhanced at the rate of 1°C for every 5 minutes till the cooking temperature of 40°C was obtained with occassional stirring till the acidity reached 0.35 per cent lactic acid. The stretchability of the curd was determined in accordance with Kosikowski (1982) 'stretch test' to make sure the stretching of the curd. When the acidity of the whey reached 0.35 per cent the whey was drained and dipped the curd in the hot water at 82 to 85 °C for a contact time of 1 to 2 minutes. The curd was then kneaded, stretched and moulded by hand. The hot plastic curd was then moulded into balls and cooled immediately by dipping them into pasteurized chilled water at 5°C for two hours. The cheese was removed from the chilled water and stored in refrigerator for analysis.

3.5 Analysis of Mozzarella cheese

3.5.1 Sampling of cheese

An approximately 100 g of cheese was cut from the centre of the ball, including the core of the sample. It was then grated through a stainless steel grater. The grated cheese was mixed and used for analysis.

3.5.2 Chemical analysis of cheese

3.5.2.1 Total solids

Total solids percentage of cheese was estimated as per the procedure described in IS: 2785, (1964).

3.5.2.2 Fat in cheese

Fat content of Mozzarella cheese was determined by the method described in IS:1224, Part II (1977).

Ten ml of sulphuric acid (90-91 per cent) was transerred into the butyrometer followed by warm water (30 - 40°C) to form a layer on the top of acid. Then 3 g of grated cheese sample was added to the butyrometer. One ml of amyl alcohol was added followed by warm water (30 to 40°C) upto 5 mm below the shoulder. The mouth of the butyrometer was closed with the stopper, contents were mixed thoroughly and transferred into a water-bath at 65±2°C for 3 to 10 minutes. Then it was centrifuged for 5 minutes. After that it was transferred into a water-bath as described above and then fat percentage was noted.

3.5.2.3 Protein in cheese

Total protein in cheese was estimated as described by Kosikowski (1982).

3.5.2.3.1 Reagents

i. Acetic acid solution (25 per cent glacial acetic acid)

ii. Concentrated sulphuric acid approximately 98 per cent by weight and nitrogen free

iii. Sodium hydroxide solution- 50 per cent by weight.

iv. Standard sulphuric acid solution 0.35 N.

v. Catalyst mixture : consisting 80 g of potassium sulphate and 20 g of copper sulphate

vi. Indicator solution : mixed equal volume of a saturated solution of methyl red in ethanol (95 per cent by volume) and a 0.1 per cent solution of methylene blue in ethanol (95 per cent by volume).

3.5.2.3.2 Procedure

Five grams of grated cheese was ground well with a small quantity of 25 per cent glacial acetic acid solution and the volume was made upto 50 ml with the same solution. After keeping it in a water-bath at 50°C for 15 minutes transfered 10 ml of aliquote (equivalent to 500 mg of cheese) to a kjeldahl flask to which 1 g of catalyst mixture and 10 ml of concentrated sulphuric acid was added. The mixture was then digested under moderate heat 80 to 90°C for three to four hours. The digested sample was rinsed with distilled water and made upto the volume to 50 ml using a standard volumetric flask. Transfered 10 ml of the sample to a kjeldahl distillation unit. Neutralised the sample by adding 20 ml of 50 per cent sodium hydroxide solution. Dry steam was then turned on and boiled the mixture vigorously. About 40 ml distillate was collected in a 100 ml conical flask containing 10 ml of saturated boric acid solution and 1 to 2 drops of the mixed indicator. It was then titrated against N/35 sulphuric acid solution to a faint pink colour as the end point. Similar procedure was followed for blank using distilled water as sample. The total percentage of protein was calculated using the formula

$$\text{Percentage of protein} = \frac{\text{A-B X normality } H_2SO_4 \text{ X } 0.014 \text{ X } 100}{\text{Weight of the sample}} \text{ X } 6.38$$

where A = Volume of sulphuric acid used for the titration of the sample

B = Volume of sulphuric acid used for the titration of the blank

(6.38 is the correction factor)

3.5.2.4 Titratable acidity

Titratable acidity was determined according to A.O.A.C. (1990). Ten gram of cheese was mixed with 105 ml of distilled water at 40 to 50°C to obtain a homogenous suspension, which was then filtered through whatman filter paper No.40. Twenty five ml of filtrate was titrated against 0.1 N sodium hydroxide solution using phenolpthalein as indactor and acidity was expressed in per cent lactic acid.

$$\text{Per cent lactic acid} = \frac{\text{Volume of NaoH used} \times 0.009}{2.5} \times 100$$

3.5.2.5 pH

pH of the cheese was determined by a digital pH meter using homogenous cheese paste prepared by mixing 10 g of cheese in 10 ml of distilled water.

3.5.3 Stretchability test

Stretchability test was carried out as per the principle of 'stretch test' described by Kosikowski (1982). About 10 g of cheese taken in 250 ml beaker containing 3/4th of its volume of hot water maintained at 82 to 85°C in a water-bath, and it was kept in a beaker for about one to two minutes. A glass rod was inserted into the molten cheese sample and then pulled out slowly after providing few turns by hand. This ensured proper adherence of the product to the glass rod. Cheese thread formations was observed when the rod was being gradually lifted. The length of the thread is assumed as the stretchability parameter. Longer threads indicated better stretching characteristics. The stretchability was graded on a 5 point arbitrary scale, where 5 represented the maximum stretchability character of the cheese.

3.5.4 Sensory evaluation

Mozzarella cheese was evaluated organoleptically for different quality attributes such as appearance, body, texture and flavour by a pannel of 5 judges. An 18 point score card (Appendix -II) developed by Duthie et al. (1980) was used for this purpose. Average of the score awarded by the judges for each treatment was used for statistical analysis. Score less than 10 points were considered unacceptable.

3.6 Preparation of whey drinks

Whey drinks were prepared using whey obtained during the prepartion of Mozzarella cheese according to the method suggested by Gandhi (1984) with slight modifications. The whey was collected and added sugar into it at the rate of 12 per cent. It was then heated at 70°C for 10 minutes to destroy the residual rennet enzymes and filtered through a muslin cloth. Cooled the whey to room temperature and required flavour (pineapple, orange, lemon and mango at the rate of 4 ml/litre) and colours (Orange, yellow and Apple green, at the rate of 3 ml of one per cent solution/litre) was added. Consumers' acceptance studies were carried out to deter-mine the acceptability of the whey drinks. The flavour and colour which became the first and second in the consumers' acceptance studies were used in the preparation of whey drinks for further studies. One set of whey drinks after preparation was stored under refrigeration temperature (5±1°C). A second set of whey drinks were carbonated by passing carbondioxide in to the bottles containig the whey drink. Then the bottles were sealed with crown cork and stored at room temperature (29°C).

3.6.1 Analysis of whey

3.6.1.1 Total solids in whey

Total solids in whey was estimated following the ISI specification (IS: 1479, Part II, 1961).

3.6.1.2 Fat in whey

Fat content in whey was determied by Gerber's method as described in IS:1224, Part I, (1977).

3.6.1.3 Protein in whey

Protein content in whey was estimated by micro kjeldahl method as per ISI standards (IS: 1479, Part II, 1961).

3.6.2 Sensory evaluation of whey drinks

The carbonated whey drinks stored at room temperature (29°C) and non-carbonated whey drinks stored at refrigeration temperature (5±1°C) were subjected to sensory evaluation by a pannel of 5 judges. The quality of the whey drinks for human consumption was assessed at the end of 24, 48 and 72 hours of storage at the respective temperature using score card (Appendix III) as per IS: 7768, 1975).

3.6.3 Bacteriological assessment in whey drinks

The total bacterial counts in whey drinks at the end of 24, 48 and 72 hours of storages were carried out according to the standards procedure (IS:18, Part XI, 1980).

3.6.4 Statistical analysis

The data obtained was subjected to statistical analysis using analysis of variance technique (CRD) described by Snedecor et al. (1968).

Appendices

APPENDIX - I

STEPS IN MOZZARELLA CHEESE MANUFACTURE

Time/Temperature		Operation
	RAW MILK	
		Filtration/straining Standardisation
72°C/15 seconds		Pasteurization
	CHEESE VAT	
30-32°C/15 minutes (ripen)		Starter culture @2%v/v
30-32°C/30-45 minutes (set)		Rennet 12 ml/litre
	COAGULUM	
		Cut:1.0 - 1.5 cm
30-32°C ---------> ----> 39-41°C in 135-150 minutes		Scald (Cook) Stir (Occassionaly)
		Acidity 0.35-0.38 % (Lactic acid)
	CURD/WHEY	
		Settle Whey off
	CURD	
82-85°C water/ 1-2 minutes 57°C curd		Kneading/stretching in hot water
5-6°C chilled water /2hours		Moulding/cooling
	CHEESE	
5°C		Stored/Analysis

APPENDIX - II

SCORE CARD FOR MOZZARELLA CHEESE

Date	Code number for each sample		
Panelist	1	2	3
APPEARANCE DEFECTS (Packages and Colour) Excellent = 3			
Acid-cut			
Misshapen			
Mold			
Mottled			
No defect			
Rough surface			
Salt spots			
Soiled surface			
Unnatural			
Wavy			
Wrinkled package			
Panelist score/for APPEARANCE			
BODY/TEXTURE DEFECTS Excellent score = 5			
Coarse			
Gassy			
Lacks flexibility			
Mealy			
No defect			

Open
Pasty
Slitty
Sweet holes
Weak
Panelist score for BODY/TEXTURE
FLAVOUR DEFECTS Excellent score = 10
Acid
Bitter
Flat
Foreign
Fruity
Liployzed
Musty
No defect
Salty
Sour
Unclean
Whey-taint
Yeasty
Panelist score for FLAVOUR
Total score for each sample (Excellent score = 18)
Placement of each sample in the group

Description of defects and numerical ratings

APPEARANCE (Excellent Score = 31)	Slight	Definite	Pronounced
Acid-cut (dull, faded or bleached-colored blotches)	-1	-2	-3
Misshapen (deformed from normal shapes)	-1	-2	-3
Mold (growth of mold)	-3	-3	-3
Mottled (colored blotches around, openings, "mixed curd")	-2	-3	-3
No defect (agrees completely with ideal)	x	x	x
Rough surface (Lacks smoothness)	-1	-2	-3
Salt spots (large light-colored sopts or areas	-2	-3	-3
Soiled surface (Discoloo̲ration on the surface)	-3	-3	-3
Unnatural (unnatural color)	-1	-2	-3
Wavy (color appears as layers or waves)	-1	-2	-3
Wrinkled package (definite, unattractive wrinkles)	-1	-2	-3
BODY/TEXTURE (Excellent score = 5)			
Coarse (feels rough, dry and sandy)	-1	-2	-3
Gassy (gas holes of various sizes)	-2	-3	-5
Lacks flexibility (Plug breaks when bent)	-0.5	-1.5	-3
Mealy (short body, salvy, feels like corn meal)	-2	-3	-5
No defect (agrees completely with ideal)	x	x	x
Open (mechanical openings)	-0.5	-1.5	-3

Pasty (soft and sticky)	-2	-3	-5
Slitty (slits from gassy or yeasty, "fish eyes")	-2	-3	-4
Sweet holes (spherical gas holds)	-1	-2	-3
Weak (soft but not sticky)	-1	-3	-4
FLAVOUR (Excellent score = 10)			
Acid (distinct sour taste)	-1	-3	-5
Bitter (distasteful, strong, lingering aftertaste	-5	-7	-10
Flat (lack ideal flavor development)	-0.5	-1.5	-3
Foreign (unlike milk-associated flavors)	-3	-6	-10
Fruity (fermented, overripe fruit)	-2	-4	-5
Lipolyzed (baby vomitodor and strong aftertaste, rancid)	-4	-6	-10
Musty (moldy odor and lingering aftertaste)	-3	-5	-7
No defect (agrees completely with ideal)	x	x	x
Salty (a taste sensation)	-0.5	-1.5	-3
Sour (high acid with objectionable flavour)	-1	-3	-5
Unclean (not bitter: but strong, lingering aftertaste)	-2	-4	-5
Whey-taint (fermented whey, sour whey)	-2	-3	-5
Yeasty (yeast fermentation)	-4	-6	-10

APPENDIX - III

Proforma for Evaluation card for Whey drink.

Date: Taster: Code No:

A. Assign scores for each sample for different characteristics

	Characteristic	Maximum score	Sample score
1.	Appearance	10	
2.	Odour	20	
3.	Flavour	40	
4.	Body	30	

B. Indicate the degree of defects if any such as the following. Encircle the one applicable and deduct from appropriate attributes. Defects may be underlined.

Characteristic	Defect	Degree of defect suspicion	Slight	pronounced
1. Appearance	Suspended particles, filth, foreign matter	2	4	10
2. Odour	Stale, abnormal	5	10	15
3. Flavour	Cooked, oxidized, rancid metallic, neutralizer, feed, barny, cowy, flavour defects due to adulterants and other additives	5	10	20
4. Body	Ropy, curdy	5	10	15

C. Grading:

Quality	Scores	Grade
Excellent	90 and above	A
Good	80 - 89	B
Fair	60 - 79	C
Poor	59 and below	D

Results

RESULTS

Mozzarella cheese and whey drinks were prepared from cow milk (control), goat milk (experimental - I) and combination of cow milk and goat milk at the ratio of 1:1 (experimental - II). The cheese milk were subjected to chemical analysis. The resultant cheeses were also subjected to chemical analysis, stretching test and organoleptic evaluation. The whey obtained as a by-product was used for preparation of whey drinks which was also subjected to chemical analysis, organoleptic evaluation and bacteriological quality tests.

The data presented in the case of control and experimental cheese milk represent the average with ranges of six trials for each of the parameters studied. In the case of Mozzarella cheese the data obtained for all the six replications were presented in the Tables. The data obtained were subjected to analyses statistically to compare different parameters of control and experimental samples of Mozzarella cheese using CRD technique. The data on Chemical composition of whey were also subjected to a statistical analysis and presented in the Tables and data on whey drinks were tabulated and averaged.

4.1 Chemical composition of cheese milk.

4.1.1 Moisture

The moisture content of cheese milk had an average value of 87.16±0.04 (87.12 - 87.37), 86.54 ± 0.06 (86.32 - 86.73) and 86.68 ± 0.08 (86.44 - 86.99) per cent respectively for control, experimental - I and II. These are presented in Table I.

4.1.2 Fat

The fat percentage of milk used for Mozzarella cheese are presented in Table I. The average values were 4.00 (4.00 - 4.05), 4.10 ± 0.02 (4.00 - 4.15) and 4.10 ± 0.01 (4.00 - 4.10) per cent for control, experimental - I and II, respectively.

4.1.3 Protein

The protein content of cheese milk had an average percentage of 3.6±0.04 (3.38 - 3.67), 3.76 ± 0.07 (3.58 - 4.05) and 3.62±0.06 (3.51 - 3.87) for control, experimental I and II respectively (Table I).

4.1.4 Total Solids

The average total solids content of cheese milk were, 12.84 ± 0.04 (12.63 - 12.88), 13.46 ± 0.06 (13.27 - 13.68) and 13.32 ± 0.08 (13.05 - 13.56) per cent, respectively for control, experimental I and II (Table I). Total solids were higher in experimental I and II cheese milk.

4.1.5 pH

The average pH value of cheese milk were 6.58±0.05 (6.40 - 6.70), 6.64 ± 0.06 (6.40 - 6.80) and 6.60 ± 0.06 (6.40 - 6.80) for control, experimental I and II, respectively (Table I). No significant differences were observed among the values.

4.1.6 Acidity

The average acidity of control, experimental I and II cheese milk were found to be 0.166 (0.148 - 0.175) per cent lactic acid, 0.157 (0.140 -0.166) and 0.166 (0.140 - 0.175) per cent lactic acid respectively (Table 1). The acidity were slightly higher than normal value of 0.14 per cent lactic acid in control and experimental II cheese milk.

4.2 Fat globule size and frequency distribution

The average size of fat globule in cow and goat milk were measured and presented the data in Table 2. The average size of fat globule in cow milk was 4.55 microns where as that of the goat milk was 3.46 microns. The frequency distribution of the fat globules of cow and goat milk are also illustrated in Fig. 1. It was found that the percentage distribution of smaller size fat globules (0 -1.5 and 1.6 - 3 microns in diameter) was 44.04 per cent in cow milk. In the case of goat milk the corresponding value was 64.03 per cent. The larger size fat globules (3.1 - 12 microns diameter) in cow milk was 55.96 per cent where as in goat milk it was 35.97 per cent. The result showed that the frequency distribution of smaller size fat globule in goat milk was more than that of cow milk.

4.3. Acid development during cooking process

The average value of acidity (per cent lactic acid) development during the cooking of Mozzarella cheese are presented in Table 3 and Fig. 2. It was observed that control cheese took less cooking time (135 minutes) where as experimental I and II cheese samples took 150 minutes to reach the required acidity for stretching.

4.4 Chemical composition of Mozzarella cheese

The result presented in Table 4, 5 and 6 reveals the chemical composition of control, experimental I and II Mozzarella cheese respectively.

4.4.1 Yield

The average yield of Mozzarella cheese was 13.57± 0.09 (13.28 - 13.86), 11.39±0.32 (10.96 - 11.72) and

12.42±0.14 (11.94 - 12.82) per cent, respectively for control, experimental I and II (Table 4, 5 and 6). The maximum yield of Mozzarella cheese was 13.86 per cent (Table 4) and minimum of 10.96 per cent (Table 5). The data were subjected to statistical analysis (Table 7a). The yield of control, experimental I and II Mozzarella cheese were significantly different ($P < 0.01$) between each other. The difference between control and experimental I was 2.18 and that of control and experimental II was 1.15. where as between experimental I and II, it was found to be 1.03 which also indicate the significant difference.

4.4.2 Moisture

The average moisture content of control, experimental I and II Mozzarella cheese were 48.82±0.14 (48.32 - 49.16), 52.26±0.15 (51.83 - 52.64) and 50.22±0.14 (49.78 - 50.63) per cent, respectively. Individually maximum moisture content of 52.64 per cent (Table 5) and minimum of 48.32 percent (Table 4) were observed. Statistical analysis showed, significant difference ($P < 0.01$) between control and experimental cheese (Table 7 b). The difference in moisture content between the control and experimental II was found to be 1.40 per cent where as that of control and experimental I was 3.44. The difference between experimental I and II was 2.04 Percent

4.4.3 Fat

The fat content of control and experimental Mozzarella cheese samples were 22.33±0.16 (22 - 23) per cent, 20.33±0.33 (20 - 22) and 21.33±0.17 (21 - 22) per cent, respectively. The fat content in individual Mozzarella cheese samples varied between 20 to 23.00 per cent (Table 4 and 5). Analysis of variance (Table 7c) showed that there were significant differences ($P < 0.01$) between the control and experimental Mozzarella cheeses. The difference between control and experimental II Mozzarella cheese was 1.0 and that of control and experimental I was 2.0 where as the difference between experimental I and II was 1.0 which also indicate difference.

4.4.4 Protein

The mean protein contents of Mozzarella cheese were 22.43±0.12 (21.76 - 22.71), 18.50±0.12 (18.11 - 18.88) and 20.54±0.09 (20.16 - 20.72) per cent, respectively for control, experimental I and II (Table 4, 5 and 6). The maximum protein content was 22.71 per cent in control and the minimum was 18.11 per cent in experimental I (Table 4 and 5). Analysis of variance (Table 7 d) indicated that there was significant differences ($P < 0.01$) between the control and experimental I cheese samples and between control and also between experimental I and II Mozzarella cheese samples.

4.4.5 Total solids

The total solids content of control and experimental Mozzarella cheese were 51.17±0.14 (50.84 - 51.68), 47.74 ±0.15 (47.36 - 48.17) and 49.77±0.14 (49.37 - 50.22) per cent, respectively (Table 4, 5 and 6). The maximum total solids content was 51.17 per cent (Table 4) and a minimum of 47.79 per cent (Table 5). Analysis of variance (Table 7 e) indicated significant differences ($P < 0.01$) in the total solids contents in control and experimental Mozzarella cheeses.

4.4.6 pH

The pH value of Mozzarella cheese control, experimental I and II were 5.62±0.006 (5.60 - 5.64), 5.61 ±0.005 (5.60 - 5.63) and 5.61±0.006 (5.60-5.64) (Table 4, 5 and 6) respectively. Statistically, pH value of Mozzarella cheese control and experimental were not significantly (Table 7f) different.

4.4.8 Acidity

The titratable acidity (per cent lactic acid) of control, experimental I and II Mozzarella cheeses were

0.33 $\pm$0.06 per cent, 0.342$\pm$0.006 and 0.336$\pm$0.006 per cent (Table 4, 5 ad 6), respectively. Analysis of variance (Table 7g) indicated no significant difference between control and treatments with regard to acidity.

4.5 Stretchability of Mozzarella cheese

Table 8 illustrates the stretchability of Mozzarella cheese. The mean score of control Mozzarella cheese was 4.78$\pm$0.04 (4.63 - 4.89) and for experimental I and II, respectively were 3.83$\pm$0.03 (3.78 - 3.95) and 4.36$\pm$0.01 (4.28 - 4.42). The highest score of 4.95 was obtained for control cheese and lowest score of 3.78 in the experimental I cheese (Table 8). Analysis of variance (Table 8a) showed a significant difference ($P < 0.01$) between control and experimental Mozzarella cheese.

4.6. Sensory evaluation of Mozzarella cheese

The total score of sensory evaluation for control, experimental I and II Mozzarella cheeses are presented in Table 9. The mean score of control was 16.28$\pm$0.04 (16.18 - 16.42) and that of experimental I and II were 11.31$\pm$0.04 (11.17 - 11.45) and 15.20$\pm$0.02 (15.13 - 15.30), respectively. The highest score of 16.43 was obtained in control sample against the lowest score of 11.17 for individual sample of experimental I. Analysis of variance (Table 9a) shows highly significant differences (P < 0.01) between control and experimental Mozzarella cheeses. The difference between the mean score of control and experimental II sample was 1.08 where as that of control and experimental I was 4.97 which was highly significant. The difference between experimental Iand II was found to be 3.89 which also was significantly different.

4.7 Chemical compositions of whey

4.7.2 Fat

The fat content of control and experimental Mozzarella cheese whey are illustrated in Table 10. The mean value of 0.46±0.03 (0.40 - 0.60), 0.86 ±0.01 (0.80 - 0.90) and 0.71±0.03 (0.60 - 0.80) per cent, respectively for control, experimental I and II. Analysis of variance (Table 10a) showed significant difference (P < 0.01) between the fat content of control and both experimental whey. Where as the fat content of experimental I and II did not show any significant difference between them.

4.7.3 Protein

The mean protein content in whey for control, experimental I and II were 0.85±0.01 (0.76 - 0.93), 1.53±0.05 (1.27 - 1.78) and 1.04±0.02 (0.97 - 1.13) per cent, respectively are presented in Table 10. The individual sample of experimental I whey had a maximum protein content of 1.78 per cent and the corresponding lowest value of 0.76 per cent was observed in the control whey. Analysis of variance (Table 10 b) showed significant difference ($P < 0.01$) between the protein content of control and experimental I whey. There was no difference between control and experimental II. Experimental I and II also differed significantly.

4.7.3 Total solids

The mean total solids content in whey are presented in Table 10. The mean values were 7.65±0.12 (7.18 - 7.92), 8.77±0.06 (8.58 - 8.96) and 8.27±0.05 98.16 - 8.34) per cent, respectively for control, experimental I and II. Statistically there was a significant difference ($P < 0.01$) between control and experimentals as well as between experimental I and II whey with regard to total solids content (Table 10c).

4.8 Organoleptic evaluation of whey drinks

Table 11 shows the overall total scores obtained in sensory evaluation of pineapple flavoured whey drinks control, experimental I and II stored at refrigeration temperature (5±1°C). The mean total score obtained for pineapple flavoured whey drinks at the end of 24, 48 and 72 hours of storage of control samples were, 94.23±0.23, 91.59±0.13 and 88.20±0.29, respectively. For experimental

I and II were 94.13±0.40, 91.37±0.20, 87.50±0.26 and 94.12±0.39, 91.27±0.31 and 87.59±0.20, respectively.

The mean total scores obtained for lemon flavoured whey drinks at the end of 24, 48 and 72 hours stored at 5±1°C were 94.43±0.21, 91.85±0.11, 88.21±0.25 for control sample and 94.15±0.25, 91.52±0.22 and 88.00±0.18, 94.25±0.26, 91.80±0.14 and 88..7±0.25 for experimental I and II whey drinks (Table 12).

Both pineapple and lemon flavoured whey drinks stored at refrigeration temperature (5±1°C) was found to be similar and also the mean total scores for both control and experimental I and II were same. However, total scores were in decreasing trend toward increasing storage period (Fig. 4 and 5).

Table 13 illustrate the mean total scores of carbonated Pineapple flavoured whey drinks stored at room temperature (29°C) for 24, 48 and 72 hours. The overall scores were 88.32±0.15, 84.47±0.13 and 78.11±0.15 for control, 87.65 ± 0.17, 83.79 ± 0.16 and 77.57 ± 0.16 experimental I and 877.86±0.21, 83.75±0.12 and 77.78±0.15, experimental II.

Table 14 furnished the total scores of carbonated lemon flavoured whey drinks stored at room temperature (29°C) for 24, 48 and 72 hours. The mean total scores obtained were 88.19±0.24, 84.34±0.27 and 78.14±0.10 for control, 87.84±0.15, 84.05±0.14 and 77.76±0.13 for experimental I and 87.85±0.16, 84.11±0.16 and 77.87±0.16 for experimental II respectively.

In this case also there was no difference between the scores for pineapple and lemon flavour, neither between control and experimental carbonated whey drinks. The overall total scores were less than that of non carbonated whey drinks and the scores were lower with increase in period of storage (Fig. 6 and 7). Non carbonated whey drinks were graded as **Excellent** at the end of 24 and 48 hours of storage and **Good** at the end of 72 hours of storage. Carbonated whey drinks were graded under the category of **Good** at the end of 24 and 48 hour and **Fair** at the end of 72 hour of storage.

4.9 Total bacterial count in whey drinks

Table 15 shows the total bacterial count of control and experimental whey drinks stored at (5±1°C) for 24 hourly intervals upto 72 hours. The average total bacterial count in whey drinks were 32.5×10^3, 34.5×10^3 and 37.5×10^3 in control sample of whey drinks and 31.5×10^3, 33.5×10^3 and 35.5×10^3; 32.3×10^3, 34.3×10^3 and 36.5×10^3 colony forming units (CFU)/ml of whey drinks respectively at the end of 24, 48 and 72 hours of storage for control, experimental I and II whey drinks.

The total bacterial counts in carbonated whey drinks stored at room temperature (29°C) were, 30.8×10^3, 32.6×10^3, 35.2×10^3 CFU/ml for control whey drinks, 30.3×10^3, 31.7×10^3, 34.5×10^3 CFU/ml for experimental I and 30.8×10^3, 32.5×10^3, and 34.8×10^3 CFU/ml for experimental II respectively at 24, 48 and 72 hours of storage (Table 16).

Tables and Figures

Table. 1. Chemical composition of milk used in Mozzarella cheese making

	Percentage Composition		
Attributes	Cow milk	Goat milk	Cow milk + Goat milk (1:1)
Moisture	87.16±0.04 (87.12-87.37)	86.54±0.06 (86.32-86.73)	86.68±0.08 (86.44-86.95)
Fat	4.00±0.00 (4.00-4.05)	4.10±0.02 (4.00-4.15)	4.10±0.01 (4.00-4.10)
Protien	3.46±0.04 (3.38-3.67)	3.76±0.07 (3.58-4.05)	3.62±0.06 (3.51-3.87)
Total Solids	12.84±0.04 (12.63-12.88)	13.46±0.06 (13.27-13.68)	13.32±0.08 (13.05-13.56)
PH	6.58±0.05 (6.40-6.70)	6.64±0.06 (6.40-6.80)	6.65±0.06 (6.40-6.80)
Acidity	0.166±0.00 (0.148-0.175)	0.157±0.00 (140-0.166)	0.166±0.00 (0.140-0.175)

* Figures in paranthesis indicate range

Table 2. **Fat globules size and frequency distribution in cow and goat milk**

Species	Cow		Goat	
Size in Microns	No. in groups	Percentage distribution	No. in groups	Percentage distribution
0 - 1.5	20	11.90	70	30.70
1.6 - 3.0	54	32.14	76	33.33
3.1 - 4.5	41	24.40	42	18.42
4.6 - 6.0	27	16.07	26	11.40
6.1 - 7.5	13	7.73	10	4.38
7.6 - 9.0	7	4.16	3	1.32
9.1 -10.5	4	2.38	1	0.43
10.6-12.0	2	1.19	-	-
Total	168		228	
Average fat globules size	4.55 Microns		3.46 Microns	

* Average of six trials

Fig.1 FAT GLOBULES SIZE AND FREQUENCY DISTRIBUTION IN COW AND GOAT MILK

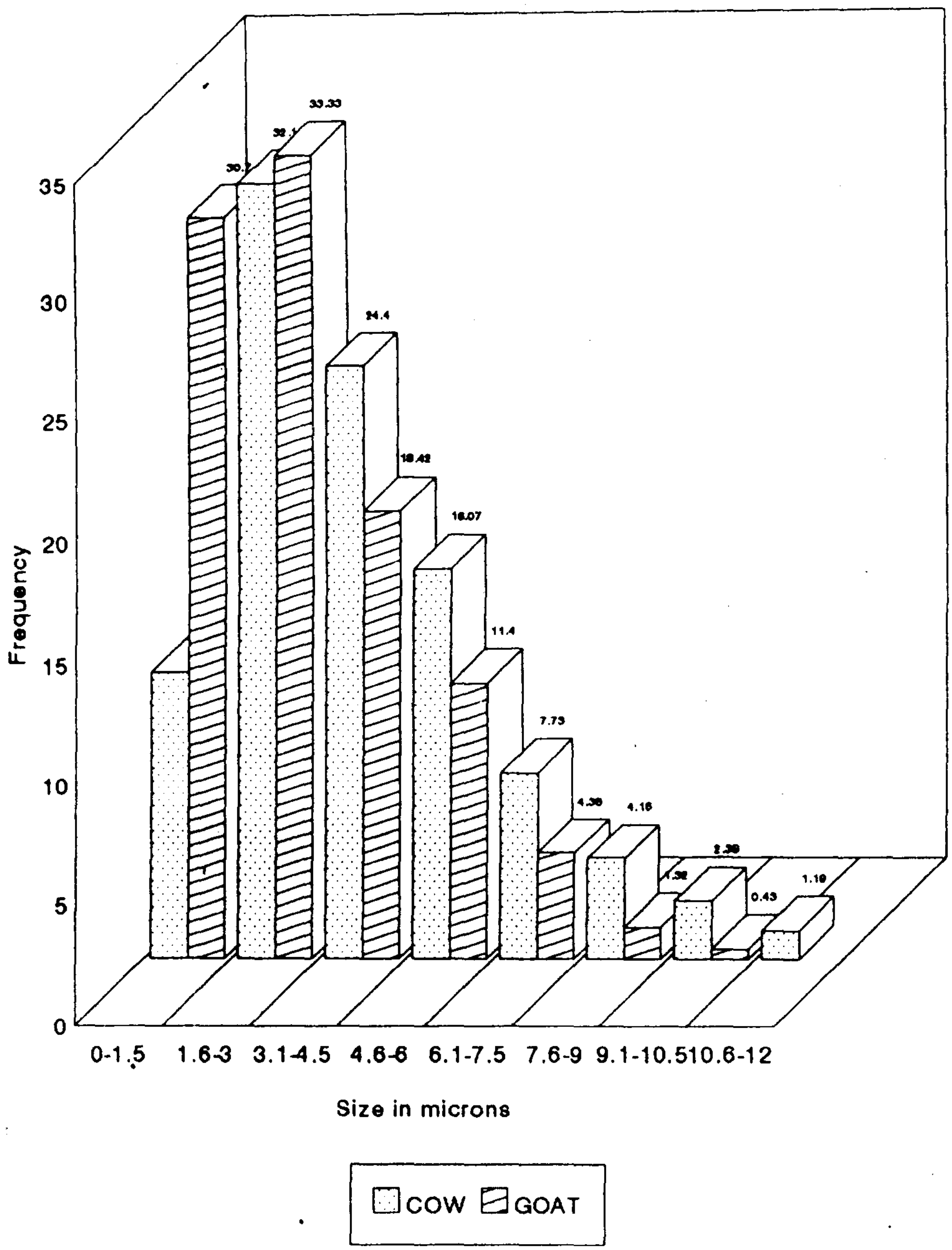


Table 3. Acid development in Mozzarella cheese during cooking process after cutting

	Percentage lactic acid		
Time in minutes	Control	Experimental I	Experimental II
0	0.122	0.122	0.122
15	0.131	0.122	0.122
30	0.148	0.131	0.140
45	0.166	0.148	0.157
60	0.183	0.166	0.175
75	0.210	0.183	0.201
90	0.236	0.218	0.227
105	0.262	0.245	0.253
120	0.306	0.280	0.297
135	0.358	0.323	0.332
150	-	0.376	0.385

* Averages of six trials

Fig.2 ACID DEVELOPMENT IN MOZZARELLA CHEESE DURING COOKING PROCESS

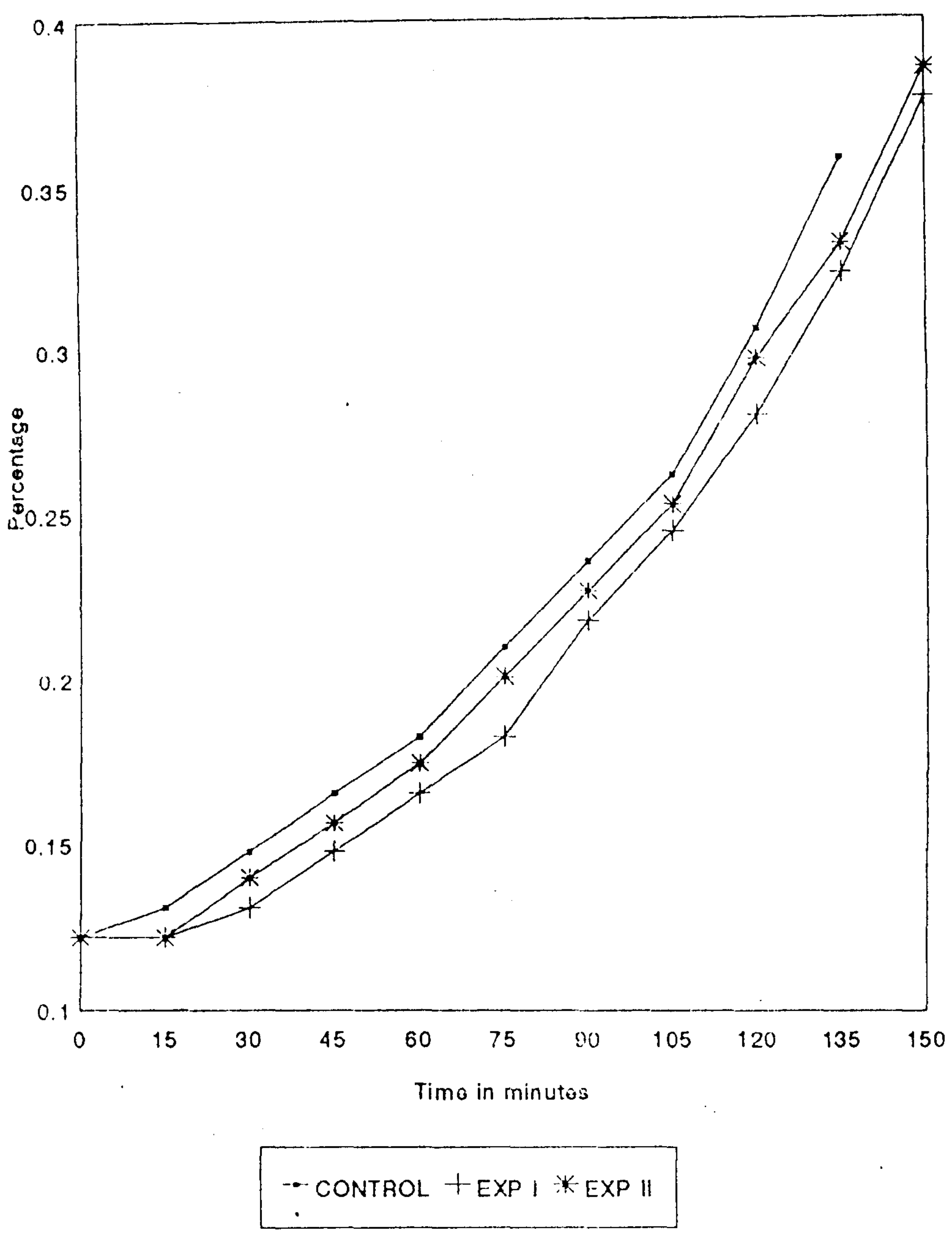


Table 4. Chemical composition of Mozzarella cheese prepared from cow milk (control).

	Percentage compositions						
Replication	Yield	Moisture	Fat	Protein	Total solid	PH	Acidity
1	13.46	48.76	22.00	22.71	51.24	5.63	0.324
2	13.60	48.92	23.00	22.45	51.08	5.62	0.324
3	13.86	49.12	22.00	22.62	50.88	5.60	0.360
4	13.50	48.67	23.00	21.96	51.33	5.63	0.324
5	13.72	49.16	22.00	22.20	50.84	5.61	0.324
6	13.28	48.32	22.00	22.69	51.68	5.64	0.324
Mean -	13.57 ±0.09	48.82 ±0.14	22.33 ±0.16	22.43 ±0.12	51.17 ±0.14	5.62 +0.00	0.333 ±0.00

Table 5. Chemical composition of Mozzarella cheese prepared from goat milk (experimental I)

	Percentage compositions						
Replication	Yield	Moisture	Fat	Protein	Total solid	PH	Acidity
1	11.72	52.18	20.00	18.88	47.82	5.61	0.324
2	11.20	51.83	21.00	18.62	48.17	5.60	0.360
3	11.56	52.77	22.00	18.37	47.23	5.62	0.360
4	11.26	52.22	20.00	18.11	47.78	5.62	0.324
5	10.96	51.92	21.00	18.62	48.08	5.63	0.360
6	11.64	52.64	20.00	18.43	47.36	5.60	0.324
Mean	11.39 $\pm$0.12	52.26 $\pm$0.15	20.33 $\pm$0.33	18.50 $\pm$0.12	47.74 $\pm$0.15	5.613 $\pm$0.00	0.342 $\pm$0.00

Table 6. Chemical composition of Mozzarella cheese prepared from cow and goat milk 1:1 ratio (experimental II)

	Percentage compositions						
Replication	Yield	Moisture	Fat	Protein	Total solid	PH	Acidity
1	12.40	50.36	22.00	20.67	49.64	5.63	0.324
2	12.82	50.24	21.00	20.41	49.76	5.60	0.360
3	12.64	49.84	21.00	20.16	50.16	5.62	0.324
4	12.50	50.48	22.00	20.72	49.52	5.61	0.324
5	11.94	49.78	21.00	20.72	50.22	5.60	0.360
6	12.24	50.63	21.00	20.56	49.37	5.64	0.324
Mean -	12.42 ±0.14	50.22 ±0.14	21.33 ±0.16	20.54 ±0.09	49.77 ±0.14	5.61 ±0.00	0.33 ±0.00

Table 7a. Analysis of Varience CRD for yield of Mozzarella cheese

Source of Variations	df	S.S	M.SS	F Value
Treatments	2	10.728255	5.364128	92.49 **
Error	15	0.869943	0.057996	
Total	17	11.591598		

** P< 0.01 CD = 0.2964

Table 7b. Analysis of Varience CRD for moisture of Mozzarella cheese

Source of Variations	df	S.S	M.SS	F Value
Treatments	2	11.762284	5.881142	149.90 **
Error	15	0.588493	0.039233	
Total	17	12.350777		

** P< 0.01 CD = 0.243747

Table 7c. Analysis of Varience CRD for fat of Mozzarella cheese

Source of Variations	df	S.S	M.SS	F Value
Treatments	2	5.873290	2.936645	22.59 **
Error	15	1.949851	0.129990	
Total	17	7.823141		

** P< 0.01 CD = 0.443680

Table 7d. Analysis of Varience CRD for protein of Mozzarella cheese

Source of Variations	df	S.S	M.SS	F Value
Treatments	2	23.467327	11.733664	334.52 **
Error	15	0.526146	0.035076	
Total	17	23.993473		

** P< 0.01 CD = 0.230474

Table 7e. Analysis of Varience CRD for total solids of Mozzarella cheese

Source of Variations	df	S.S	M.SS	F Value
Treatments	2	11.762284	5.881142	149.07 **
Error	15	0.591775	0.039452	
Total	17	12.354059		

** P< 0.01 CD = 0.244426

Table 7f. Analysis of Varience CRD for pH of Mozzarella cheese

Source of Variations	df	S.S	M.SS	F Value
Treatments	2	0.000211	0.000106	0.50
Error	15	0.003147	0.000210	
Total	17	0.003358		

NS Not significant

Table 7g. Analysis of Varience CRD for acidity of Mozzarella cheese

Source of Variations	df	S.S	M.SS	F Value
Treatments	2	0.001244	0.000622	1.67 NS
Error	15	0.005600	0.000373	
Total	17	0.006844		

NS Not significant

Fig. 3 CHEMICAL COMPOSITION AND YIELD OF MOZZARELLA CHEESE

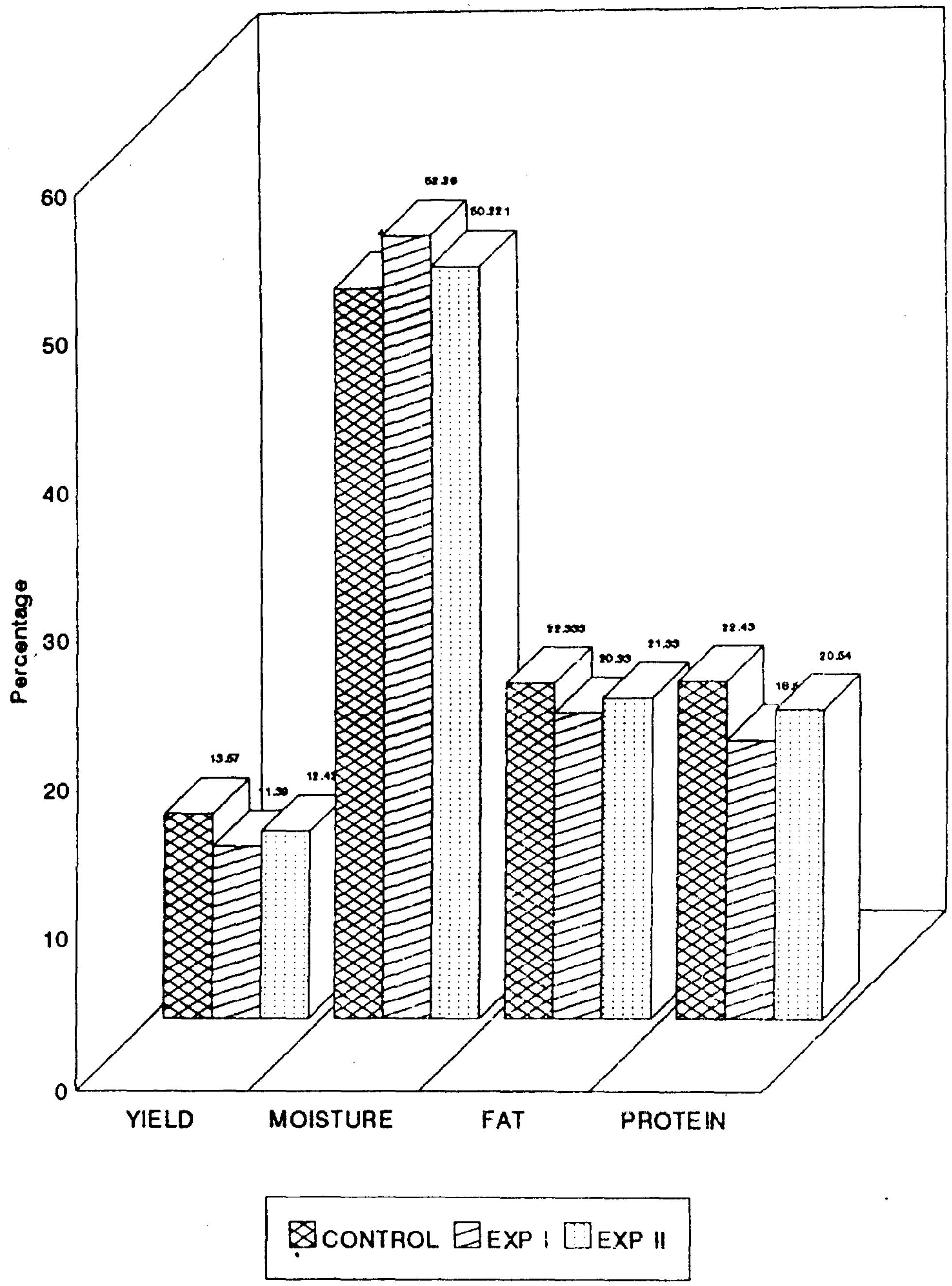


Table 8. Stretchability test for Mozzarella cheese using 5 points arbitrary scale.

Replication	Perfect	Control	Experimental I	Experimental II
1	5.00	4.85	3.80	4.42
2	5.00	4.76	3.90	4.40
3	5.00	4.89	3.95	4.36
4	5.00	4.67	3.75	4.28
5	5.00	4.86	3.85	4.42
6	5.00	4.63	3.78	4.32
Mean	5.00 0.00	4.776 ±0.04	3.838 ±0.03	4.366 ±0.01

Table 8a. Analysis of variance CRD for stretchability Mozzarella cheese

Source of Variations	df	S.S	M.SS	F Value
Treatments	2	2.655411	1.327706	191.55 **
Error	15	0.103973	0.006932	
Total	17	2.759384		

** $P < 0.01$ CD = 0.102454

Table 9. Sensory evaluation score of Mozzarella cheese

Replication	Perfect	Control	Experimental I	Experimental II
1	18.00	16.18	11.45	15.13
2	18.00	16.26	11.28	15.14
3	18.00	16.32	11.18	15.20
4	18.00	16.20	11.43	15.27
5	18.00	16.43	11.40	15.16
6	18.00	16.34	11.17	15.30
Mean	18.00 0.00	16.28 ±0.04	11.31 ±0.04	15.20 ±0.02

Table 9a. Analysis of variance CRD for sensory evaluation of Mozzarella cheese

Source of Variations	df	S.S	M.SS	F Value
Treatments	2	81.905419	40.952710	4134.19 **
Error	15	0.148588	0.009906	
Total	17	82.054007		

** P < 0.01 CD = 0.122479

Table 10. Chemical composition of whey

	Percentage Composition								
	Fat			Protein			Total solids		
Replication	Control	Exptl.I	Exptl.II	Control	Exptl.I	Exptl.II	Control	Exptl.I	Exptl.II
1	0.40	0.90	0.70	0.76	1.60	1.06	7.68	8.60	8.26
2	0.50	0.90	0.60	0.93	1.56	0.98	7.74	8.58	8.18
3	0.40	0.80	0.70	0.84	1.27	1.04	7.18	8.84	8.22
4	0.60	0.80	0.80	0.83	1.78	1.13	7.83	8.92	8.34
5	0.50	0.90	0.70	0.92	1.48	0.97	7.92	8.96	8.46
6	0.40	0.90	0.80	0.86	1.52	1.08	7.55	8.72	8.16
Mean	0.46 $\pm$0.03	0.86 $\pm$0.01	0.71 $\pm$0.03	0.85 $\pm$0.01	1.53 $\pm$0.05	1.04 $\pm$0.02	7.65 $\pm$0.12	8.77 $\pm$0.06	8.27 $\pm$0.05

Table 10a. Analysis of variance CRD for fat in whey

Source of Variations	df	S.S	M.SS	F Value
Treatments	2	4.525595	2.262798	57.77 **
Error	15	0.587522	0.039168	
Total	17	5.113117		

** P < 0.01 CD = 0.243546

Table 10b. Analysis of variance CRD for protein in whey

Source of Variations	df	S.S	M.SS	F Value
Treatments	2	10.208031	5.104016	69.37 **
Error	15	1.103685	0.073579	
Total	17	11.311716		

** P < 0.01 CD = 0.333804

Table 10c. Analysis of variance CRD for total solids in whey

Source of Variations	df	S.S	M.SS	F Value
Treatments	2	4.119933	2.059966	50.79 **
Error	15	0.608340	0.040556	
Total	17	4.728273		

** P < 0.01 CD = 0.247823

Table 11. Sensory evaluation score of whey drinks stored at refrigeration temparature (5±1°C) with pineapple flavour.

Replication	Control			Expt. I			Expt. II		
Storage	24 h	48 h	72 h	24 h	48 h	72 h	24 h	48 h	72 h
1	94.00	91.33	88.16	93.65	91.13	87.07	93.83	91.16	87.20
2	93.60	92.00	87.60	95.40	92.00	88.50	95.60	90.50	87.65
3	94.60	91.45	88.20	94.45	91.72	86.90	94.80	92.40	87.54
4	95.00	92.10	87.40	93.00	91.24	87.12	93.30	91.10	88.15
5	94.20	91.30	89.15	93.80	90.80	88.15	94.00	90.82	86.95
6	94.00	91.40	88.72	94.50	91.36	87.30	93.24	91.65	88.05
Mean	94.23 ±0.23	91.59 ±0.13	88.20 ±0.29	94.13 ±0.40	91.37 ±0.20	87.50 ±0.26	94.12 ±0.39	91.27 ±0.31	87.59 ±0.20

Fig. 4 SENSORY EVALUATION SCORE OF WHEY DRINKS STORED AT REFRIGERATION TEMPERATURE (5±1°C) : PINEAPPLE FLAVOUR

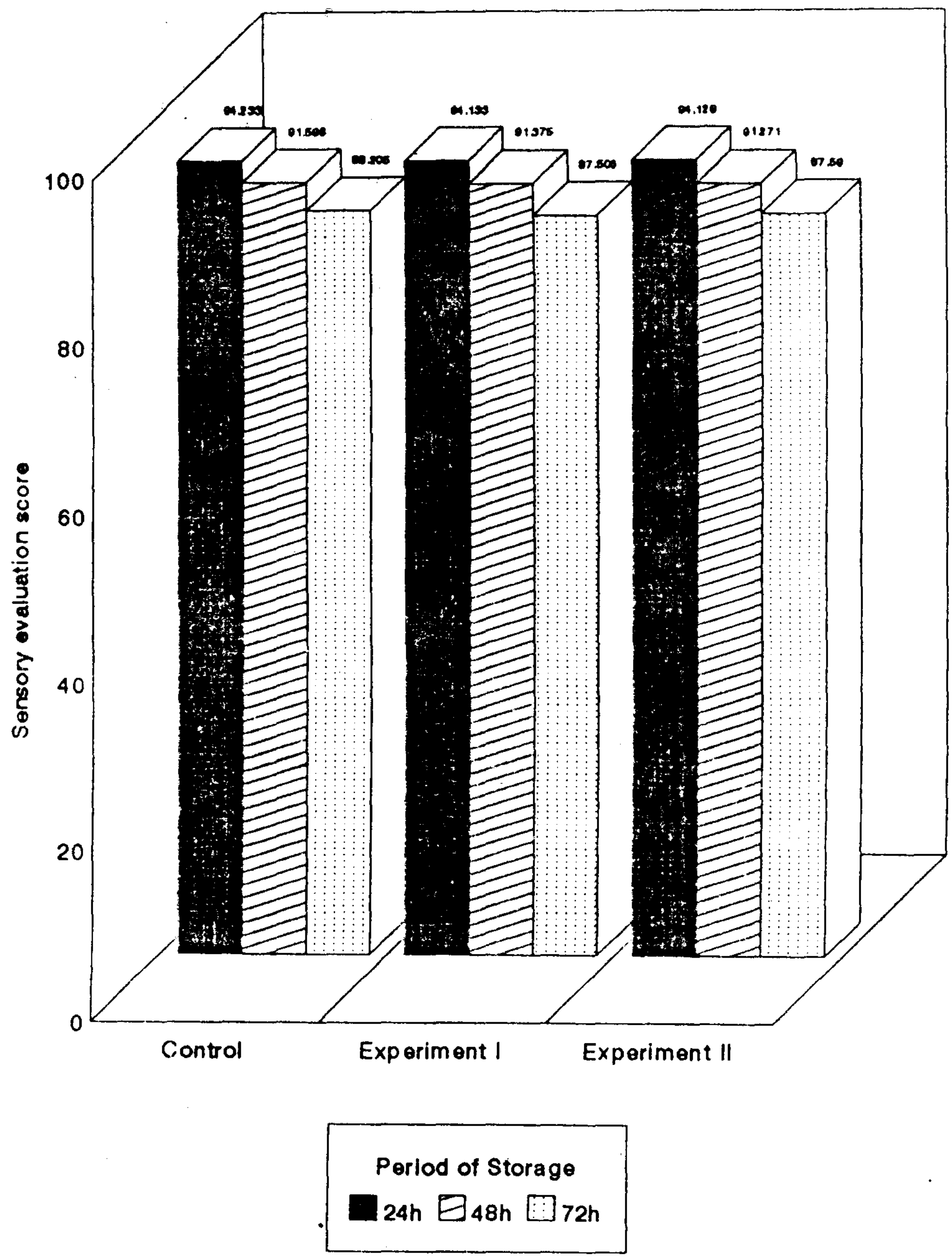


Table 12. Sensory evaluation score of whey drinks stored at refrigeration temparature (5±1 °C) with lemon flavour.

Replication	Control			Expt. I			Expt. II		
Storage	24 h	48 h	72 h	24 h	48 h	72 h	24 h	48 h	72 h
1	95.10	92.23	88.20	94.60	91.30	88.40	93.70	91.50	87.20
2	94.40	91.60	87.50	93.75	92.15	88.42	94.45	92.30	87.95
3	93.90	91.82	89.05	95.00	90.86	87.85	95.20	91.45	88.70
4	95.00	92.14	87.78	94.55	91.26	87.90	94.80	92.25	87.85
5	94.32	91.76	88.40	93.50	92.20	88.08	93.67	91.60	88.40
6	93.86	91.56	88.33	93.55	91.38	87.36	93.72	91.72	88.36
Mean	94.43 ±0.21	91.85 ±0.11	88.21 ±0.25	94.15 ±0.25	91.52 ±0.22	88.00 ±0.18	94.25 ±0.26	91.80 ±0.14	88.07 ±0.25

Fig. 5 SENSORY EVALUATION SCORE OF WHEY DRINKS STORED AT REFRIGERATION TEMPERATURE (5±1°C) : LEMON FLAVOUR

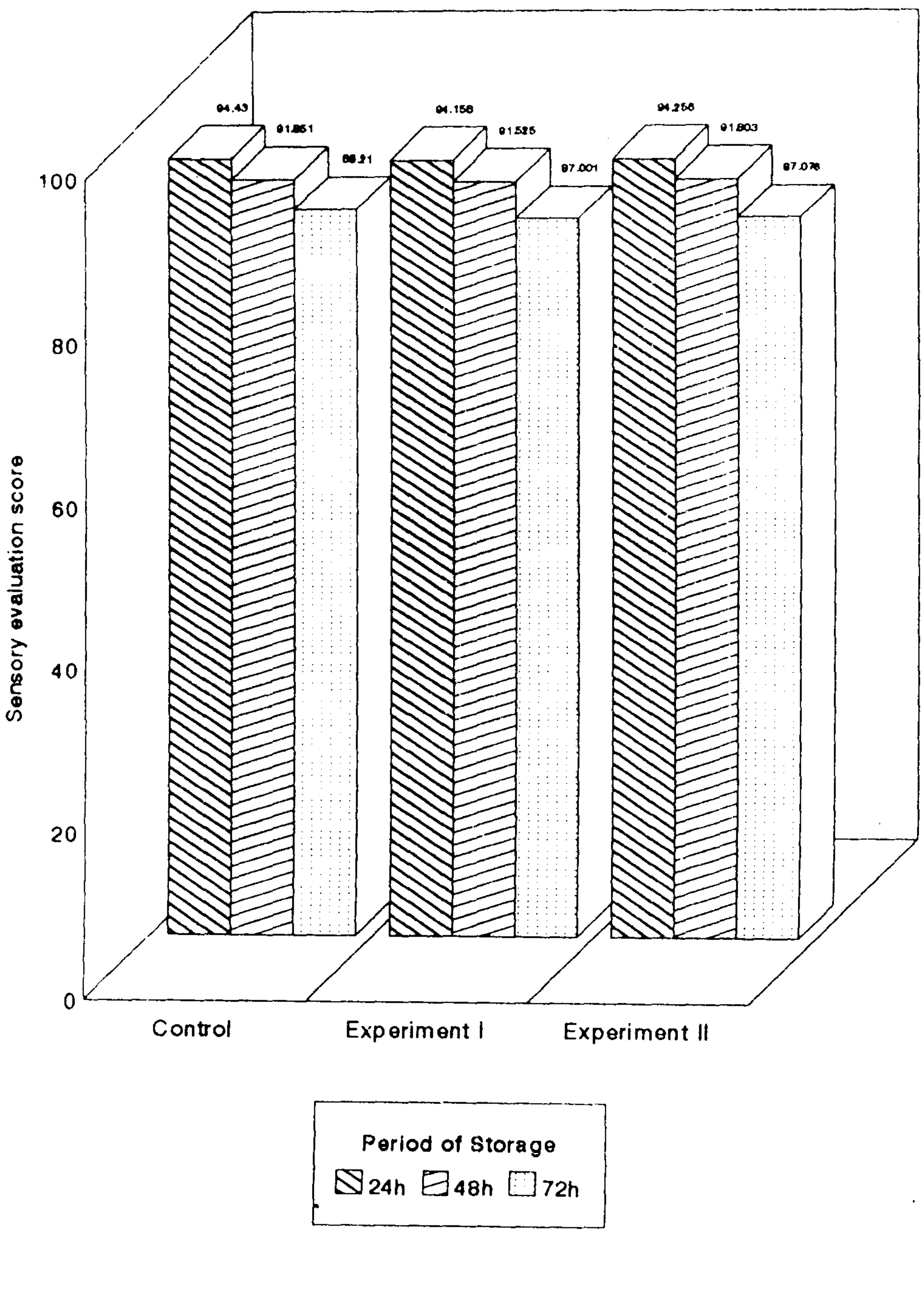


Table 13. Sensory evaluation score of carbonated whey drinks stored at room temparature (29°C) with pineapple flavour.

Replication	Control			Expt. I			Expt. II		
Storage	24 h	48 h	72 h	24 h	48 h	72 h	24 h	48 h	72 h
1	88.70	84.65	78.45	87.75	83.45	77.65	88.65	83.55	77.65
2	87.80	84.76	78.50	87.35	83.40	77.60	87.80	83.40	77.80
3	87.95	84.54	78.16	88.20	83.60	77.30	88.12	84.15	77.75
4	88.65	83.95	77.60	87.25	84.36	77.35	87.75	84.05	77.30
5	88.50	84.45	77.75	88.00	83.75	78.00	87.50	83.70	77.95
6	88.35	84.50	78.20	87.40	84.22	77.55	87.35	83.65	78.20
Mean	88.32 ±0.15	84.47 ±0.13	78.11 ±0.15	87.65 ±0.17	83.79 ±0.16	77.57 ±0.11	87.86 ±0.21	83.75 ±0.12	77.77 ±0.15

Fig.6 SENSORY EVALUATION SCORE OF CARBONATED WHEY DRINK STORED AT ROOM TEMPERATURE(29°C) : PINEAPPLE FLAVOUR

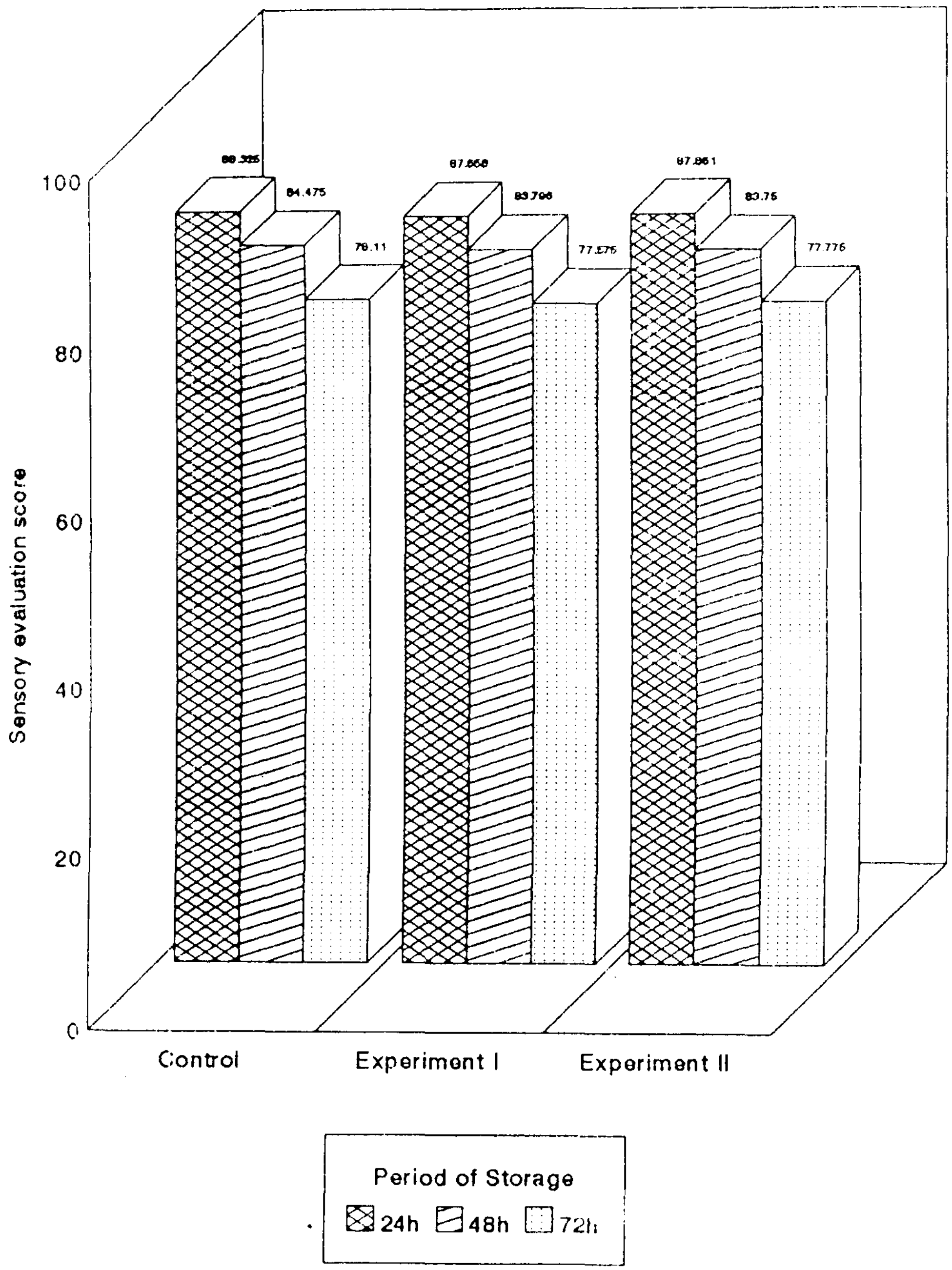


Table 14. Sensory evaluation score of carbonated whey drinks stored at room temparature (29 °C) with lemon flavour.

Replication	Control			Expt. I			Expt. II		
Storage	24 h	48 h	72 h	24 h	48 h	72 h	24 h	48 h	72 h
1	88.40	84.25	78.45	87.75	84.28	77.60	87.60	83.55	77.75
2	87.60	83.50	78.30	87.40	84.36	77.55	87.50	84.50	77.65
3	88.20	85.15	77.95	87.55	83.55	78.26	87.65	84.48	77.80
4	89.05	84.35	77.80	88.25	84.40	78.24	88.00	84.26	78.30
5	88.16	84.20	78.16	88.30	84.00	77.48	87.95	84.32	78.35
6	87.75	84.60	78.20	87.80	83.75	77.45	88.45	83.60	77.40
Mean	88.19 $\pm$0.24	84.34 $\pm$0.27	78.14 $\pm$0.10	87.84 $\pm$0.15	84.05 $\pm$0.14	77.76 $\pm$0.13	87.85 $\pm$0.16	84.11 $\pm$0.16	77.87 $\pm$0.16

Fig.7 SENSORY EVALUATION SCORE OF CARBONATED WHEY DRINK STORED AT ROOM TEMPERATURE(29°C) : LEMON FLAVOUR

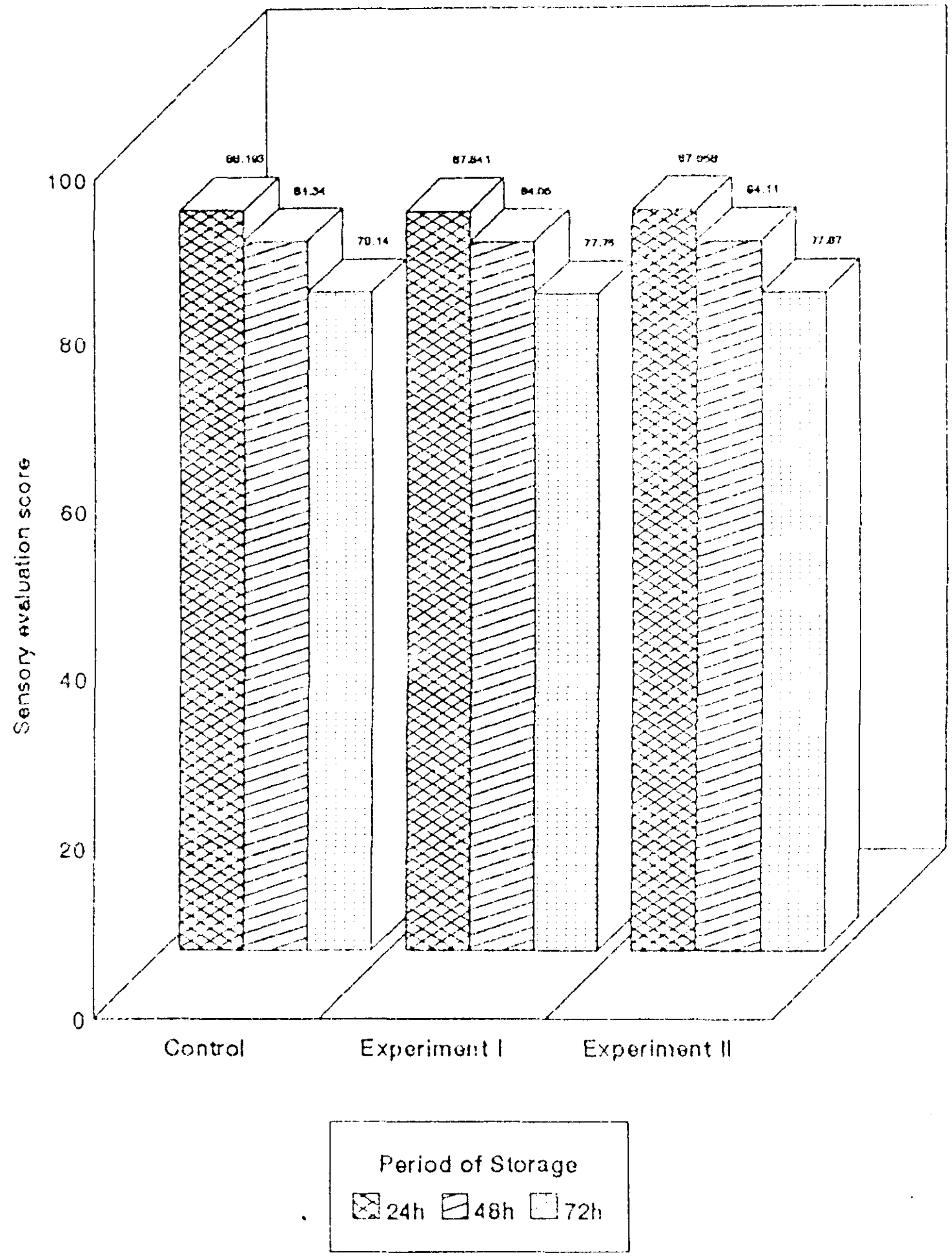


Table 15. Total bacterial counts in whey drinks stored at refrigeration temparature (5$\pm$1 °C)

	CFU / ml of whey drink								
Replication	Control			Expt. I			Expt. II		
Storage	24 h	48 h	72 h	24 h	48 h	72 h	24 h	48 h	72 h
1	$33x10^3$	$35x10^3$	$37x10^3$	$31x10^3$	$33x10^3$	$36x10^3$	$32x10^3$	$34x10^3$	$36x10^3$
2	$32x10^3$	$34x10^3$	$38x10^3$	$32x10^3$	$34x10^3$	$35x10^3$	$32x10^3$	$34x10^3$	$37x10^3$
3	$33x10^3$	$34x10^3$	$37x10^3$	$31x10^3$	$34x10^3$	$36x10^3$	$33x10^3$	$35x10^3$	$37x10^3$
4	$32x10^3$	$35x10^3$	$37x10^3$	$31x10^3$	$34x10^3$	$35x10^3$	$32x10^3$	$34x10^3$	$37x10^3$
5	$33x10^3$	$34x10^3$	$38x10^3$	$32x10^3$	$33x10^3$	$35x10^3$	$33x10^3$	$35x10^3$	$36x10^3$
6	$32x10^3$	$35x10^3$	$38x10^3$	$32x10^3$	$33x10^3$	$36x10^3$	$32x10^3$	$34x10^3$	$36x10^3$
Mean	$32.5x10^3$	$34.5x10^3$	$37.5x10^3$	$31.5x10^3$	$33.5x10^3$	$35.5x10^3$	$32.3x10^3$	$34.3x10^3$	$36.5x10^3$

Fig.8 TOTAL BACTERIAL COUNT IN WHEY DRINKS STORED AT REFRIGERATION TEMPERATURE(5±1°C)

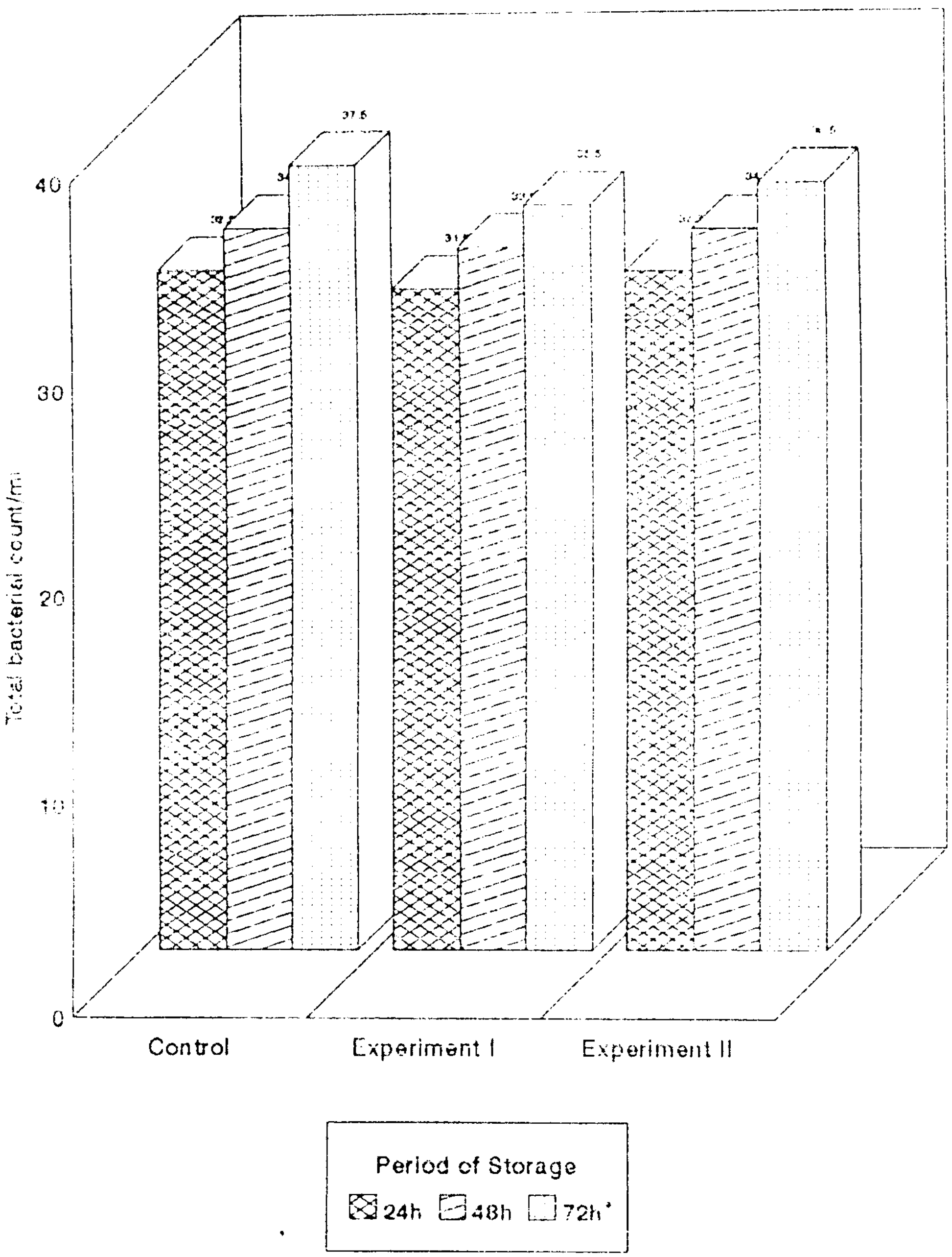
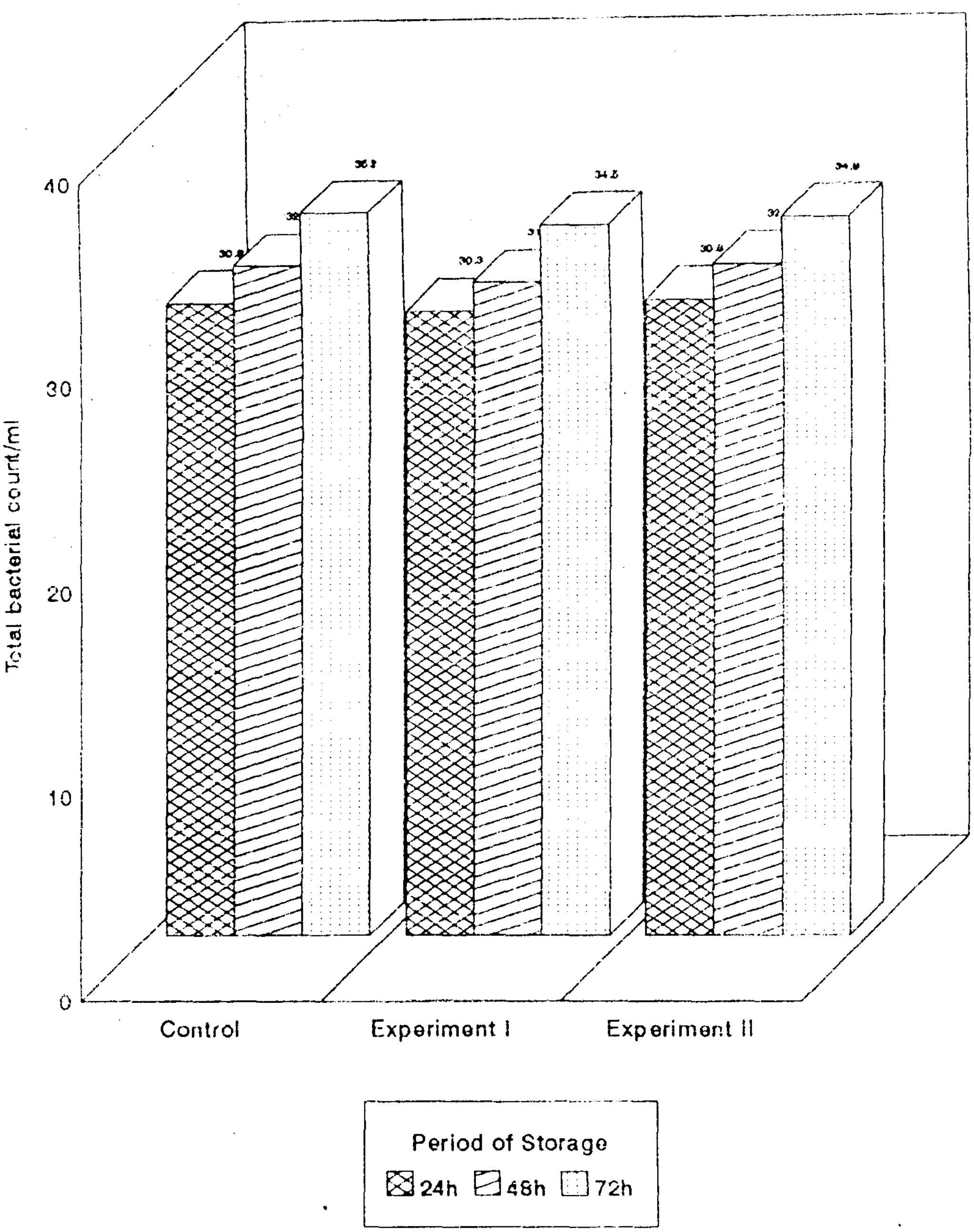


Table 16. Total bacterial counts in whey drinks stored at room temparature (29 °C)

	CFU / ml of whey drink								
Replication	Control			Expt. I			Expt. II		
Storage	24 h	48 h	72 h	24 h	48 h	72 h	24 h	48 h	72 h
1	31×10^{3}	33×10^{3}	35×10^{3}	30×10^{3}	31×10^{3}	34×10^{3}	31×10^{3}	32×10^{3}	35×10^{3}
2	31×10^{3}	32×10^{3}	35×10^{3}	31×10^{3}	32×10^{3}	35×10^{3}	31×10^{3}	33×10^{3}	35×10^{3}
3	31×10^{3}	32×10^{3}	36×10^{3}	30×10^{3}	32×10^{3}	34×10^{3}	31×10^{3}	32×10^{3}	34×10^{3}
4	31×10^{3}	33×10^{3}	35×10^{3}	30×10^{3}	31×10^{3}	35×10^{3}	31×10^{3}	32×10^{3}	35×10^{3}
5	31×10^{3}	33×10^{3}	35×10^{3}	30×10^{3}	31×10^{3}	35×10^{3}	31×10^{3}	32×10^{3}	35×10^{3}
6	30×10^{3}	33×10^{3}	35×10^{3}	31×10^{3}	31×10^{3}	34×10^{3}	31×10^{3}	33×10^{3}	35×10^{3}
Mean	30.8×10^{3}	32.6×10^{3}	35.2×10^{3}	30.3×10^{3}	31.7×10^{3}	34.5×10^{3}	30.8×10^{3}	32.5×10^{3}	34.8×10^{3}

Fig.9 TOTAL BACTERIAL COUNT IN WHEY DRINKS STORED AT ROOM TEMPERATURE(29°C)



Discussion

DISCUSSION

Everincreasing goat population and milk produced by them is certainly a challenge for technologists and manufacturers. In India demand for liquid milk is yet to be fulfilled. However, the goat milk is likely to be surplus as many people in India do not prefer goat milk because it possess a characteristic goaty odour. The use of goat milk for various dairy products are also not much appreciable except for few varieties of cheeses. The present study was therefore, undertaken to investigate the suitability of goat milk alone as well as in combination with cow milk for the manufacture of Mozzarella cheese. Whey, the by-product of cheese making was also utilized for the preparation of whey drinks. The results obtained are discussed in detail in the following text.

5.1 Chemical composition of cheese milk.

Mozzarella cheese was prepared from cow milk (control), goat milk (experimental - I) and combination of cow milk and goat milk at the ratio of 1:1 (experimental - II).

5.1.1 Fat

The average fat percentage of Mozzarella cheese milk under control, experimental I and II were 4.00, 4.10±0.22 and 4.10±0.01 respectively (Table 1). Mozzarella cheese milk having four per cent fat was found to be highly suitable for pizza making (Ghosh and Singh, 1990 b).

5.1.2 Protein

The average protein content of cheese milk used for preparation of Mozzarella cheese control, experimental I and II, respectively were 3.46±0.04, 3.76±0.07 and 3.62±0.06 per cent (Table 1). It was seen that protein content of experimental I and II cheese milk was higher than the control. This was because of the high protein content of goat milk used in the experiment. Devandra (1972) and Agarwal and Bhattacharya (1978) reported the protein content in goat milk to vary from 2.89 to 5.07 per cent.

5.1.3 Total solids

The cheese milk had an average total solids content of 12.84±0.04, 13.46±0.06 and 13.32±0.08 per cent respectively for control, experimental I and II (Table 1). A high total solids content was found in experimental I and II cheese milk than control, which was due to high total solids content in goat milk. The total solids content of 13.90 per cent in goat milk was reported by Devandra (1980). Whereas Quereshi *et al.* (1981) reported 13.26 per cent total solids. The present observation is in between the close range of these two.

5.1.4 Moisture content

The average moisture content of cheese milk was 87.16±0.04, 86.54±0.06 and 86.68±0.08 per cent respectively for control, experimental I and II (Table 1). This reflects the high total solids content in the goat milk used in the experimental cheese preparation.

5.1.5 pH

The average pH values of cheese milk were 6.58±0.05, 6.64±0.06 and 6.65±0.06 respectively for control, experimental I and II (Table 1). The value of pH in the cheese milk was found to be similar in all the samples of control, experimental I and II. This was in agreement with the normal pH value of 6.4 to 6.6 reported by De (1980).

5.1.6 Acidity

The average acidity (per cent lactic acid) were 0.166, 0.157 and 0.166 per cent, respectively for control, experimental I and II cheese milk (Table 1). The normal value of acidity in fresh drawn milk is 0.14 per cent lactic acid. The slight increase in acidity of the milk used in the present study may be due to the time lapse between milking and analysis of the milk.

5.2 Fat globule size and frequency distribution

The average size and percentage distribution of fat globule for both cow and goat milk are presented in Table 2. The average size of fat globule in cow milk was 4.55 microns and that of goat milk was 3.46 microns in diameter.

The frequency distribution of fat globule in both cow and goat milk are illustrated in Fig. 1. It was found that the percentage distribution of small size fat globule (0-1.5 and 1.6 - 3.0 microns diameter) was 11.90 percent and 32.14 per cent. This total comes to 44.04 per cent in cow milk. In the case of goat milk the corresponding values were 30.70 and 33.33 per cent, totaling to 64.03 per cent. The larger size fat globules (3.1 - 12.0 microns diameter) on cow milk was 55.96 per cent and in goat milk it was only 35.97 per cent.

The result obtained in the present study for average fat globule size and percentage of frequency distribution were similar to that reported by Fahmi et al. (1956).

5.3 Acid development in Mozzarella cheese during cooking process

The development of titratable acidity in Mozzarella cheese during cooking was observed at regular intervals (Table 3). The initial acidity were 0.166, 0.157 and 0.166 per cent lactic acid for control, experimental I and II cheese milk respectively (Table 1). Immediately after cutting, acidity came down to an average of 0.122 per cent lactic acid in control and experimental cheeses. Similar trends were reported by Anilkumar (1985), Mukundan (1989) and Johnson (1995).

The initial acidity at the start of cooking was similar in all the cases, thereafter slow and steady increase in acidity was observed. The control cheese obtained an ideal acidity of 0.35 per cent lactic acid in 135 minutes of cooking. Experimental I and II cheese samples took 150 minutes to reach an acidity 0.37 per cent and 0.38 per cent, respectively.

The rate of acid development in experimental I and II was observed to be slower than that of control. Therefore longer cooking period was employed to enhance the acid development required for stretching (Fig. 2). The slow acid development observed in the present study may be due to in corporation of goat milk which differ from cow milk in chemical composition (Parkash and Jenness, 1968, Anjaneyulu et al., 1985).

5.4. Chemical composition of Mozzarella cheese

5.4.1 Yield

The mean yield of Mozzarella cheese were 13.57±0.09, 11.39±0.012 and 12.42±0.14 per cent respectively for control, experimental I and II (Table 4, 5 and 6). Shukla and Ladkani (1989) reported that the yield of Mozzarella cheese ranged from 10.8 to 13.10 per cent from buffalo milk having 4 per cent fat.

In present study lowest yield was obtained in experimental I cheese prepared from goat milk alone which was in agreement with the opinion of Blattner and Gallmann (1980) based on rennet coagulation studies which showed that a lower yield could be expected in goat milk due to greater non protein nitrogen losses in whey.

It was seen that the yield decreases with the increased proportion of goat milk in the present study. The similar trend was observed by Lathasabikhi and Kanawjia (1992) in Mozzarella cheese prepared from buffalo milk, admixture of buffalo milk and goat milk at the ratio of 1:1 and 100 per cent goat milk. The lower yield in experimental I and II Mozzarella cheese may be due to increase proportion of goat milk having small size fat globule (Fahmi et al., 1956) and also may be due to loss of milk constituents into the whey as the goat milk has a weaker curd (Grandison, 1986).

5.4.2 Moisture content in Mozzarella cheese

Mozzarella cheese prepared from cow milk, goat milk and combination of cow and goat milk at the ratio of 1:1 contained 48.82±0.14, 52.26±0.15 and 50.22±0.14 per cent of moisture for control experimental I and II respectively (Table 4, 5 and 6).

The average moisture content of Mozzarella cheese ranged from 48.48 to 50.82 per cent from buffalo milk was reported by Ravisunder and Upadhyay (1990).

The moisture contents in the Mozzarella cheese prepared in the present study was found to contain similar moisture content reported by Lathasabikhi and Kanawjia (1992). It could be seen (Fig. 3) that the moisture content increases with the increase amount of goat milk. The experimental I cheese had higher moisture content but lower than the value of 54.45 per cent for goat milk Mozzarella cheese reported by Lathasabikhi and Kanawjia (1992). The low moisture content of goat milk cheese in the present study may be due to the extended period of cooking the curd at elevated temperature (40 - 42°C) to develop the required acidity for stretching. Similar observation was made by Johnson (1995).

5.4.3 Fat content of Mozzarella cheese

The average fat content of Mozzarella cheese prepared in the present study was 22.33$\pm$0.16, 20.33$\pm$0.33 and 21.33$\pm$0.16 per cent respectively for control, experimental I and II (Table 4, 5 and 6). Ravisunder and Upadhyay (1990) reported fat content from 21.76 to 27.95 per cent in Mozzarella cheese prepared from buffalo milk. Sukhla and Ladkani (1989) reported 23.95 per cent fat in Mozzarella cheese from buffalo milk having 4 per cent fat.

The lowest fat content of Mozzarella cheese obtained were 19.79, 18.49 and 19.26 per cent in milk acidulated with acetic, lactic and hydrochloric acid from admixture of goat and buffalo milk as reported by Lathasabikhi and Kanawjia (1993).

However, the fat percentage of Mozzarella cheese obtained in the present study was close to the range reported by Lathasabikhi (1992) and Ghosh and Singh (1992).

The fat content of Mozzarella cheese in the present study shows significant difference (Table 7c). The lower fat contents in experimental I and II Mozzarella cheese may be due to loss of fat in whey as a result of high cooking temperature for longer period of time and also may be due to larger amount of small size fat globules in goat milk.

5.4.4 Protein

The protein content of Mozzarella cheese were 22.43 ±0.12, 18.50±0.12 and 20.54±0.09 per cent respectively for control, experimental I and II (Table 4, 5 and 6).

Ravisundar and Upadhyay (1991 a) reported the protein content of 22.38 to 22.54 per cent from buffalo milk Mozzarella cheese in which the whey was obtained at 0.30 and 0.35 per cent acidity. Upadhyay et al. (1986) reported the protein content of 20.44 per cent in Mozzarella cheese using starter culture and 19.90 per cent from direct acid Mozzarella cheese manufactured from buffalo milk.

In the present investigation, significant difference has been observed in protein content of Mozzarella cheese. The protein content was in decreasing trend towards increasing proportion of goat milk in experimental I and II Mozzarella cheese. The lower content of protein in goat milk Mozzarella cheese may be due to escape of some casein into the whey as a result of weak curd formed in goat milk. Grandison (1986) also had the same opinion. According to him goat milk casein was observed to be less sensitive to rennet action and the curd formed is weak. The protein content in whey in the present study was found to be 0.85, 1.53 and 1.04 per cent respectively for control, experimental I and II Mozzarella cheese whey (Table 10) which shows more protein escape in to the whey with the increase amount of goat milk.

5.4.5 Total solids

The mean values obtained for total solids content in Mozzarella cheese were 51.71$\pm$0.14, 47.74$\pm$0.15 and 49.77 $\pm$0.14 per cent respectively for control, experimental I and II (Table 4, 5 and 6).

The average total solids content of Mozzarella cheeses in the present study was similar to the values obtained by Johnson (1995) who reported 51.16$\pm$0.39, 50.06$\pm$0.28 and 48.19$\pm$0.18 per cent respectively for cow milk and filled milk 50 and 100 per cent fat replaced (coconut fat) cow milk Mozzarella cheese. Kosikowski (1982) recommended 46 per cent of total solids content in commercial Mozzarella cheese and 53 per cent total solids content in low moisture Mozzarella cheese.

The lower value of total solids content in experimental I Mozzarella cheese (Table 5) made from goat milk alone may be due to higher moisture content in the respective Mozzarella cheese sample and also due to increased losses of milk solids into the whey.

5.4.6 pH of Mozzarella cheese

The mean values of pH recorded was 5.62, 5.61 and 5.61 for control, experimental I and II Mozzarella cheese respectively (Table 4, 5 and 6). Statistically, the pH values were not significantly different in the Mozzarella cheese in present study. The similar observations were made by Lathasabikhi and Kanawjia (1992) and Johnson (1995).

5.4.7 Acidity in Mozzarella cheese

The mean values of acidity obtained in Mozzarella cheese were 0.333, 0.342 and 0.336 per cent lactic acid for control, experimental I and II respectively (Table 4, 5 and 6). The titratable acidity of 0.357, 0.354 and 0.370 per cent lactic acid in Mozzarella cheese for buffalo milk and mixture of goat and buffalo milk and goat alone by direct acidification method was reported by Lathasabikhi and Kanawjia (1992). Some what similar values were reported by Johnson (1995). There was no significant difference noticed in the acidity of Mozzarella cheese in the present investigation.

5.5 Stretchability of Mozzarella cheese

Stretchability is a unique property of Mozzarella cheese. It was graded on a five point arbitrary scale where five represented the maximum score for the best product. The over all mean score of control, experimental I and II Mozzarella cheese was 4.77±0.04, 3.84±0.03 and 4.36±0.01 respectively (Table 8). Analysis of variance (Table 8a) showed significant differences ($P < 0.01$) between control and experimental Mozzarella cheese samples. Lathasabikhi and Kanawjia (1992) reported an average score of 4.07 for the cheese made from buffalo milk, 4.98 from admixture of buffalo and goat milk. Johnson (1995) also reported the value of 4.65±0.11, 4.6±0.09 and 4.41±0.13 from four per cent fat cow milk, filled milk and 50 per cent coconut fat filled milk.

The stretchability score of experimental I was lower than the control and experimental II. This can be attributed to the compositional difference in goat milk protein. Richardson *et al*. (1974) and Pellissier *et al*. (1976) reported that goat milk has consistently lower curd strength than those of cow milk. Singh and Gunguli (1977) and Jenness (1980) also reported that goat milk have more beta - casein concentration. However, goat milk lacks homologue of bovine alpha S_1 - casein the most abundant protein in cow milk . However which one of the caseins play an important role in stretching characteristic is not clearly understood.

In the present study stretchability of Mozzarella cheeses were graded on the 5 point arbitrary scale. Mozzarella cheese scored 4 to 5 represented the best, 3 to 4 represented satisfactory and below 3 was considered unsatisfacctory. Based on the stretchability scored it can be referred that satisfactory quality Mozzarella cheese can be prepared from goat milk.

5.6 Sensory evaluation of Mozzarella cheese

The average score of control, experimental I and II Mozzarella cheese were 16.28±0.04, 11.13±0.04 and 15.20 ±0.02 respectively (Table 9). Analysis of variance (Table 9a) showed significant difference ($P < 0.01$) between control and experimental Mozzarella cheese.

This is similar to the observation made by Lathasabkhi and Kanawjia (1992). They reported that total score of 14.54, 16.53 and 10.8 for buffalo milk admixture and 100 per cent goat milk Mozzarella cheese. Johnson (1995) also reported the total scores of 16.52 ±0.09, 15.67±0.10 and 15.37±0.09 respectively for cow milk, 50 and 100 per cent coconut fat filled milk Mozzarella cheese.

In the present study the results showed that the score was minimum for goat milk Mozzarella cheese. The result of the sensory evaluation of Mozzarella cheese in the present study are in agrement with the Lathasabikhi and Kanawjia (1992) who also reported a lowest score for goat milk Mozzarella cheese. According to them, flavour, weak and pasty body and texture defects were found of the cheese.

Patel et al. (1986) considered Mozzarella cheeses Those obtained less than 10 points were unacceptable. Therefore, the present study revealed that the goat milk Mozzarella cheese was acceptable as far as the organoleptic quality was concerned.

5.7 Chemical composition of whey

5.7.1 Fat

The fat content in whey samples were 0.46±0.03, 0.86±0.01 and 0.71±0.03 per cent in control, experimental I and II respectively (Table 10).

The fat contents of experimental cheese whey were significantly different from that of the control whey sample. The higher fat content in experimental I and II Mozzarella cheese may be due to increase loss of fat in the whey when the curd was cooked at higher temperature for extended period of time (Table 3). The higher percentage of smaller fat globules in goat milk is contributing much to this fact.

5.7.2 Protein

The average protein content in whey were found to be 0.85±0.01, 1.53±0.05 and 1.04±0.02 per cent respectively for control, experimental I and II (Table 10). The increased protein contents of the whey obtained in experimental I and II, are explainable as the protein content increases with increased proportion of goat milk.

The high amount of protein in cheese whey from goat milk in the present study may be attributed to large amount of whey protein in goat milk as reported by Jenness and Parkash (1968). Singh and Ganguli (1977) also reported large amount of beta-lactoglobulin and alpha-lactalbumin in goat milk which are usually known as whey proteins.

5.7.3 Total solids in whey

The mean total solids content in whey was 7.65±0.12 per cent for control, 8.77±0.06 and 8.27±0.05 per cent, respectively for experimental Iand II (Table 10). The total solids in whey in the present study was similar to the findings of the earlier workers viz., Lathasabikhi and Kanawjia (1992) and Johnson (1995).

It could be seen that total solids content of cheese whey from experimental I and II were significantly higher than that of control. The reasons for high total solids content of whey can be attributed to the escape of fat and protein from the curd during cooking process.

5.8 Sensory evaluation of whey drinks

Among the different flavours tried, it was found that pineapple and lemon flavour at the concentrations of 4 ml/ litre of whey gave optimum flavour score.

The average total score for pineapple flavoured whey drinks control were 94.23 ± 0.23, 91.59 ± 0.13 and 88.20 ± 0.29 respectively at the end of 24, 48 and 72 hours of storage at 5 ± 1°C. Similarly, experimental I whey drinks obtained a total score of 94.13 ± 0.40, 91.37 ± 0.20 and 87.50 ± 0.26 where as for experiemntal II whey drinks were 94.12 ± 0.39, 91.27 ± 0.31 and 87.59 ± 0.20 at the end of 24, 48 and 72 hours storage at 5 ± 1°C. The scores were illustrated in Fig. 4.

The average total scores for lemon flavoured cotrol whey drinks were 94.43 ± 0.21, 91.85 ± 0.11 and 88.21 ± 0.25 respectively at 24, 48 and 72 hours of storage at 5 ± 1°C. Similarly the total scores for experimental I lemon flavoured whey drinks were 94.15 ± 0.25, 91.52 ± 0.22 and 88.00 ± 0.18 respectively. The total score were 94.25 ± 0.26, 91.80$\pm$0.14 and 88.07$\pm$0.25 in experimental II whey drinks at the end of 24, 48 and 72 hour of storage at 5$\pm$1°C (Fig. 5).

It is seen from the Fig. 4 and 5 that the whey drinks prepared from control and experimental Mozzarella cheese whey were identical irrespective of flavouring agents. Similar observations were reported by Mini Jose (1992) and Johnson (1995). The whey drinks were graded using score card (Appendix - III) as per IS:7768 (1975) as **Excellent** at the end of 24 and 48 hours and **Good** at 72 hours of storage at 5$\pm$1°C for both pineapple and lemon flavoured whey drinks prepared from control and experimentals cheese whey. On further storage upto 96 hours, the physical appearance of the whey drinks was changed as they became slimy and the colour of the whey was almost vanishing.

The average total score for Pineapple flavoured carbonated whey drinks were 88.32$\pm$0.15, 84.74$\pm$0.13 and 78.11$\pm$0.15 for control whey drinks at the end of 24, 48 and 72 hours of storage at room temperature (29°C) in crown cork juice bottle. Similarly for experimental I and II whey drinks the scores obtained were 87.65$\pm$0.17, 83.79$\pm$0.16 and 77.57$\pm$0.11 as well as 87.86 $\pm$0.12, 83.75$\pm$0.12 and 77.77$\pm$0.15 respectively (Fig. 6).

Lemon flavoured carbonated whey drinks also had an average total scores of 88.19±0.24, 84.34±0.27 and 78.14±0.10 for control, 87.84±0.15, 84.05±0.14 and 77.76±0.13 for experiemntal I whey drinks and 87.85±0.16, 84.11±0.16 and 77.87±0.16 for experimental II at end of 24, 48 and 72 h of storage respectively (Fig. 7).

In this case, the average total score was less than that of non carbonated whey drinks. Carbonated whey drink at the end of 24 and 48 hours of storage were graded using score card (Appendix - III) as per IS:7768 (1975) as **Good** and at the end of 72 hour of it was **Fair** in both the control and experimental whey drinks in both flavouring agents used.

In the present study the carbonated whey drinks had scored less than that of non carbonated whey drinks, visible precipitates were noticed on the whey drink and quality was reduced. After 72 hours of storage at room temperature sensory evaluation was not done . These effects may be due to extensive protein in whey, as in the present study deproteinisation was not done. Jayaprakasha et al. (1986) reported the highest score of 90.00 for carbonated soft whey drinks prepared from clarified and deproteinized whey.

5.9 Total bacterial counts in whey drinks

The average total bacterial counts of the whey drink stored at 5±1°C for 24, 48 and 72 hours were 32.5 x 10^3 31.5 x 10^3, 33.5 x 10^3 for control whey drinks, 31.5 x 10^3, 33.5 x 10^3 and 35.5 x 10^3 for experimental I and 32.3 x 10^3, 34.3 x 10^3 and 36.5 x 10^3 for experimental II whey drinks (FIg. 8).

The average total bacterial count in carbonated whey drinks stored at room temperature for 24, 48 and 72 hours were 30.8 x 10^3, 32.6 x 10^3 and 35.2 x 10^3 in control whey drinks, 30.3 x 10^3, 31.7 x 10^3 and 34.5 x 10^3 in experimental I whey drinks and 30.8 x 10^3, 32.5 x 10^3 and 34.8 x 10^3 in experimental II whey drinks (Fig. 9).

In the present study, whey obtained was pasteurized at 70°C for 10 minutes prior to preparation of whey drink. This is to destroy the rennet enzyme present in the whey but the temperature employed is not sufficient enough to destroy bacterial spores. More over, chances are there for recontamination of pasteurized whey from flavouring and colouring substances added to the whey.

The count is slightly higher in control whey drinks stored at 5±1°C for 72 hours which may be due to higher bacterial load in cow milk. The count is some what lower in carbonated whey drinks stored at room temperature. It is believed that carbondioxide forms carbonic acid which along with lactic acid lower the pH which is unfavourable for growth of bacterial organisms.

5.10 Conclusion

Thus on the basis of present study there are ample reasons to assume that goat milk which is not liked by many people in this country due to presence of characteristic goaty odour can be benificialy utilized for the manufacture of Mozzarella cheese in combination with cow milk and also goat milk alone to a certain extent.

From the results, it was seen that increased amount of goat milk reduces the yield, fat content, protein content and total solids in the Mozzarella cheese. Cheese prepared from goat milk alone this was found in more intensity. Mozzarella cheese prepared from a combination of cow and goat milk in the ratio of 1:1 was almost similar to that of control prepared from cow milk. However, the acidity and pH of Mozzarella cheese was comparable. Stretching quality and sensory evaluation score were also lower in Mozzarella cheese made from goat milk alone but cheese from mixture of cow and goat milk was similar to that of control cheese.

Whey drinks prepared from control, experimental I and II Mozzarella cheese whey were found to be of **Excellent** quality at the end of 24 and 48 h and remained **Good** at the end of 72 hours of storage at 5$\pm$1°C. Carbonated whey drinks stored at room temperature (29°C) were graded as **Good** at the end of 24 and 48 hours and **Fair** at the end of 72 hours. Deproteinization of whey was not done in the present study of whey drinks. However, deproteinization seems to have an impact on the appearance and body of the whey drinks.

Available literature shows that the deproteinization of whey prior to carbonation have better impact on the appearance, body and texture of whey drinks. The whey drinks prepared were found to have only a shelf life of 3 days irrespective of the method of manufacture and temperature of storage.

Summary

SUMMARY

A study was carried out to assess the suitability of goat milk alone and combination of goat and cow milk for preparation of Mozzarela cheese and to compare with that prepared from cow milk. Fresh raw pooled milk of cow and goat was collected from the University Livestock Farm, Mannuthy. The milk was subjected to chemical analysis for fat, protein, moisture content, total solid, pH and acidity. Cow milk, goat milk and combination of cow and goat milk was standardized to have 4 per cent fat and casein to fat ratio of 1:0.7 in all the milk system.

The fat globules size of cow and goat milk were measured and on an average it was 4.55 micron 3.46 micron in diameter respectively. The frequency of small size fat globules 0 upto 3.0 microns was 64.03 per cent in goat milk and 44.04 per cent in cow milk. Acid development during cooking process in Mozzarella cheese was between 0.35 to 0.38 per cent. An ideal acidity for stretching was developed in 135 minutes in control cheese (cow milk) and in 150 minutes in experimental I (goat milk) and experimental II (goat milk + cow milk 1:1) cheese samples.

Mozzarella cheese samples were prepared from cow milk (control), goat milk (experimental I) and cow milk mix with goat milk at 1:1 ratio (experimental II) as per the procedure described by Kosikowski (1982). Milk was pasteurized, and inoculated with starter culture consisting of *Streptococcus thermophilus* and *Lactobacillus bulgaricus*. This was followed by renneting, cutting, cooking, stretching and moulding. The whey obtained were also used for preparation of whey drinks by adding sugar, flavour and colouring agents. The prepared cheese and whey drinks were subjected to chemical analysis and organoleptic evaluation. A total of six replications were carried out in the present study for all the parameters. The result obtained for the experimental cheese lots were compared with that of control sample.

The yield of control cheese was 13.57 ± 0.09 per cent and that of experimental I and II Mozzarella cheese was 11.39 ± 0.12 and 12.42 ± 0.14 per cent respectively. The yield of control, experimental I and II Mozzarella cheese were significantly different ($P < 0.01$) from each other.

The average moisture content of control, experiment I and II Mozzarella cheese were 48.82 ± 0.14, 52.26 ± 0.15 and 50.22 ± 0.14 per cent respectively.

The fat contents of control and experimental Mozzarella cheese samples were 22.33 ± 0.16, 20.33 ± 0.33 and

21.33±0.17 per cent respectively. Fat contents of Mozzarella cheese control, experimental I and II were significantly different ($P < 0.01$) from each other.

The mean protein content of Mozzarella cheese were 22.43±0.12, 18.50±0.12 and 20.54±0.09 per cent respectively for control, experimental I and II. The protein contents were significantly different ($P < 0.01$) between control and experemental Mozzarella cheese.

The total solids content of Mozzarella cheese control, experimental I and II were, 51.17±0.14, 47.74±0.15 and 49.77±0.14 percent respectively. Analysis of variance indicate a significant difference ($P<0.01$) in the total solids content of control and experimental Mozzarella cheese. The values of pH and acidity in control and experimental Mozzarella cheese were not significant.

The stretching quality of experimental II Mozzarella cheese was similar to that of control sample, where as experimental I Mozzarella cheese had lower stretching quality. however comes under satisfactory quality.

The sensory evaluation score of control Mozzarella cheese was 16.28±0.04 and that of experimental I and II was 11.31±0.04 and 15.20±0.02 respectively. The highest score was seen in control sample and lowest in experimental I sample where as experimental II sample is close to that of control. On statistical analysis, they were significantly different ($P < 0.01$) from each other.

The fat content, protein and total solids content of whey obtained from Mozzarella cheese preparation were determined and significant difference ($P < 0.01$) between control and experimental were noticed for each of the said parameters.

The pineapple and lemon flavoured whey drinks stored at 5±1°C were found to be of good quality on sensory evaluation studies by a panel of 5 judges, even after 72 hours of storage. At 96 hours of storage the samples developed sliminess and were defective in appearance.

The carbonated, pineapple and lemon flavoured whey drinks stored at room temperature (29°C), were found to be of good quality on sensory evaluation after 72 hours of storage. However, the sensory evaluation score were less than that obtained for the uncarbonated whey drinks stored at 5±1°C for the same storage period.

The whey drinks were subjected to bacteriological analysis. The total bacterial counts after interval of 24 hours during storage were found to be lower in carbonated whey drinks stored at room temperature (29°C) than that of uncarbonated whey drinks stored at 5±1°C.

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UTILIZATION OF GOAT MILK FOR PREPARATION OF MOZZARELLA CHEESE

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ABSTRACT OF A THESIS

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ABSTRACT

A study was carried out to assess the suitability of goat milk for the manufacture of Mozzarella cheese and to compare with that of cow milk. Cow and goat milks were subjected to chemical analysis prior to manufacture of cheese. The milks used were standardized to 4 per cent fat.

Cow milk, goat milk and combination of cow and goat milk 1:1 ratio were pasteurised at 72°C for 16 seconds and control, experimental I and II Mozzarella cheese samples were prepared respectively. A total of 6 replications were carried out.

The prepared cheese samples were subjected to chemical analysis. The yield, moisture content, fat, protien and total solids content were statistically analysed. Analysis of variance showed significant difference ($P<0.01$) between the samples.

The stretchability and organoleptic quality of experimental I Mozzarella cheese prepared from goat milk was lower, but experimental II Mozzarella cheese prepared from the mixture of cow and goat milk was comparable to control prepared from cow milk.

Mozzarella cheese whey was utilized for preparation of carbonated and non carbonated whey drinks using pineapple and lemon flavours. Carbonated whey drinks stored at room temparature (29°C) and non carbonated stored at 5 ± 1°C for 3 days were of good quality. Total bacterial counts of whey drinks during storage at 24 hours intervals were recorded.

The present study revealed that Mozzarella cheese prepared from combination of cow and goat milk is 1:1 ratio was comparable to control Mozzarella cheese prepared from cow milk. Goat milk Mozzarella cheese eventhough comes within the acceptable level was of low quality as compared to control samples. However, goat milk can be utilized for manufacture of Mozzarella cheese.