PREPARATION OF MOZZARELLA CHEESE USING SKIM MILK FILLED WITH COCONUT MILK

By

GNANA SELVA JOHNSON

THESIS

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Faculty of Veterinary and Animal Sciences
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Department of Dairy Science
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DECLARATION

I hereby declare that this thesis entitled **PREPARATION OF MOZZARELLA CHEESE USING SKIM MILK FILLED WITH COCONUT MILK** 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.

Mannuthy,
31-10-'94

G. GNANA SELVA JOHNSON

CERTIFICATE

I hereby declare that this thesis entitled **PREPARATION OF MOZZARELLA CHEESE USING SKIM MILK FILLED WITH COCONUT MILK** is a record of research work done independently by Sri. G. GNANA SELVA JOHNSON under my guidance and supervision and that it has not previously formed the basis for the award of any degree, fellowship, or associateship to him.

Mannuthy,

31-10-'94

Dr. M. MUKUNDAN,
Chairman, Advisory Committee,
Associate Professor,
Department of Dairy Science,
College of Veterinary & Animal
Sciences, Mannuthy.

CERTIFICATE

We the undersigned members of the Advisory Committee of Sri. G. GNANA SELVA JOHNSON is a candidate for the degree of Master of Veterinary Science in Dairy Science, agree that the thesis entitled **PREPARATION OF MOZZARELLA CHEESE USING SKIM MILK FILLED WITH COCONUT MILK** may be submitted by Sri. G. GNANA SELVA JOHNSON in partial fulfilment of the requirement for the degree.

Dr. M. MUKUNDAN,
Chairman, Advisory Committee,
Associate Professor,
Department of Dairy Science,
College of Veterinary & AnimalSciences,
Mannuthy.

Dr.K. PAVITHRAN
Professor & Head
Department of Dairy Science
College of Veterinary
& Animal Sciences,
Mannuthy.
(Member)

Sri.R.RAJENDRAKUMAR
Associate Profeeessor
Department of Dairy Science
College of Veterinary
& Animal Sciences,
Mannuthy.
(Member)

Dr.N. KUNJUKUTTY
Professor
Department of Animal Nutrition
College of Veterinary
& Animal Sciences,
Mannuthy.
(Member)

EXTERNAL EXAMINER

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G. GNANA SELVA JOHNSON

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INTRODUCTION

Dairying occupies a place of pride in the Indian Economy. India has emerged as the second largest milk producer in the world, next to the U.S.A. with an annual production of 54.9 million tonnes of milk. Milk produced in the country is far short of the requirement as the nutritional demand amounts to 65 million tonnes. Per capita consumption of milk in our country is 178 grams/day, which does not meet the minimum quantum of 280 grams/day recommended by the Nutritional Advisory Committee of the Indian Council of Medical Research (Aneja, 1992).

Milk consumption pattern in India reveals that 45.7 per cent of the total milk produced is consumed as liquid milk. This leaves only 54.3 per cent of the total milk for the preparation of various dairy products. It also shows that 34 per cent of the milk produced goes for the manufacture of fat rich product like butter.

The major manufacturers of dairy products in India like Amul, Vijay and Sagar are forced to reduce the production of dairy products as a measure to increase the availability of fluid milk for consumption. The use of whole milk for the preparation of Indigenous milk products like Paneer, Chhana, Rasagolla etc. is also to be reduced. Butter and Ghee industry yield large quantity of skim milk

which is highly nutritive, largely containing solids-not-fat (SNF) This leaves an opportunity to economically utilize these by-products.

While buttermilk is consumed as a refreshing drink, only a small portion of skim milk obtained is effectively utilized. Unfortunately, the facilities available in our country for production of skim milk powder is limited and hence ~~the major~~ a/ portion of skim milk obtained has been wasted. In surplus season skim milk will be available in plenty which is not properly utilized. Attempts are yet to be made for economic utilization of skim milk (Aneja,1992).

On the other hand, any product made out of skim milk is not properly relished by Indians as they prefer fat rich products. Milk fat is an important constituent of all dairy products and has marked influence on consumer acceptance of these products.

Depending on the product, important quality characteristics contributed by fat are flavour, colour, richness, mouth feel, softness, smoothness etc.

The high cost of milk unfortunately has made dairy products a luxury item, which can not be afforded by people of low income group of the developing countries including Milk fat being highly expensive, its substitution with cheaper fats can substantially reduce the cost of the product.

Attempts were made, in these circumstances to produce an imitation product which have resemblance with milk or cream and this was achieved by blending skim milk with any fat or oil other than milk fat. These products were named as filled milk products. In other words filled milk products are those products which are made by combining fats or oils other than milk fat with skim milk. In India, Vanaspathi has been reported to be used to prepare filled cheese, filled chhana and rasogolla and filled ice cream.

In order to produce filled milk products at a lower cost than natural milk products, cheaper and easily available vegetable fat have to be selected. As far as Kerala is concerned, coconut is a valuable food crop important in the general economy of the state and is available in plenty, with 58.7 per cent of total coconut production in India (Thampan,1975). Coconut milk extracted from grated coconut approximates in nutritive properties of the consumption of rich natural cream. Pleasant and sweet, it is endowed with an agreeable flavour. A comparison of cow milk with the coconut milk prepared from an equal quantity of water and gratings has shown that coconut milk is richer in fat and poorer in protein and sugar content. The above qualities make coconut fat an ideal substitute for milk fat for the preparation of filled milk products.

Cheese is a highly nutritious dairy product, which provides many dietary elements that are essential for human system. Even then cheese industry is not flourishing in India as it requires large investment for cold storage and also huge expenditure for maintaining the curing room.

The dairy situation in India does not allow to divert more milk for the manufacture of Mozzarella cheese. To meet the demand for Mozzarella cheese and also to utilize the skim milk in a better way, manufacture of cheese from skim milk fortified with vegetable fat is the need of the day. The available literature indicates that no systematic study has thus far been carried out in India to prepare Mozzarella cheese from skim milk filled with coconut fat. From the foregoing information it is evident that studies on the utilization of skim milk filled with coconut fat for Mozzarella cheese preparation will yield data of technological importance.

Mozzarella cheese was originated in Italy and was traditionally manufactured from buffalo milk. But now it is made all over Europe and USA from cow milk. Mozzarella cheese is an unripened variety of cheese gaining importance all over the world. Its melting and stretching properties are highly suitable for pizza manufacture. With the arrival f 'pizza' in India and the mushrooming of pizza

parlours in the large cities of our country, the demand for Mozzarella cheese is ever increasing.

Whey is the by-product of cheese and paneer industry. It contains 6-7 per cent of total solids in the form of lactose, proteins, fats, mineral and water soluble Vitamins. Total amount of whey produced in India is more than 0.016 million metric tonnes annually from cheese industry alone. World wide production of whey appears in the order of 1.5 million metric tonnes per annum (Shilpa and Gandhi, 1993).

Whey contains nearly 42-44 per cent of total solids of milk. Liquid whey contains 5.8-6.8 per cent dry matter, of which 4.2-4.7 per cent is lactose, 0.8-1.0 per cent albumin, 0.2-0.4 per cent fat and 0.6-0.7 per cent ash. In the light of its nutritional value and realising the importance of whey solids in human food system, it is logical to use this secondary product of cheese production in newer food systems.

In the present study, an attempt has been made to convert skim milk into a value added product, by adding coconut milk and the filled milk thus prepared has been used for the preparation of Mozzarella cheese with the following objectives:-

1. To assess the suitability of skim milk, filled with coconut milk for the preparation of Mozzarella cheese.

2. To compare the quality of Mozzarella cheese prepared from 50 and 100 per cent vegetable (coconut) fat substituted milk with that of control prepared from cow milk.

3. Preparation of whey drinks from whey obtained from the above experiments and to assess the keeping quality at refrigerator temperature, and at room temperature with carbonation.

Review of Literature

REVIEW OF LITERATURE

So far, no work has been reported on the utilization of skim milk filled with coconut milk for manufacturing Mozzarella cheese. However, there is little published literature available regarding replacement of cow milk fat with coconut fat for use in the preparation of dairy products.

Substitution of milk

Medora (1971) defined filled milk as the product made from skim milk powder and vegetable oils, added to it in the same proportion as the butter fat removed from the whole milk. It was also discussed that certain filled milk products like filled ice cream and butter margarine mixture were made from milk and vegetable fats, especially coconut fat.

Bhandari et al. (1976) prepared flavoured filled milk having 3.5 per cent fat and 8.5 per cent SNF using coconut oil and low heat spray dried skim milk powder as the major ingredients. The technological procedure adopted resulted in a product which showed resemblance with natural flavoured milk in terms of homogenicity and body.

Rajor and Gupta (1982) manufactured soft-serve ice-cream from soybean and butter milk. They recommended a soy-

solids to butter milk-solids ratio of 1.3:1, fat level of 9 per cent and sugar concentration of 15 per cent.

Garikipati et al. (1983) studied the effect of partial replacement of cow milk by soy milk in the preparation of cheddar cheese with and without adjusting casein-fat ratio. Replacement of cow milk with soy milk (without adjusting casein-fat ratio) at 10 per cent level and upto 20 per cent level was found to be satisfactory for the manufacture of cheese and were comparable with cow milk cheese. The cheese made from modified milk containing 10 and 20 per cent soy milk (with adjusted casein-fat ratio) was comparable with that of cow milk right from the initial stage.

Sanchez and Rasco (1984) used coconut milk as a cow's mil extender in the manufacture of yoghurt. Formulations were prepared using various combinations of coconut milk and dried skim milk. A control without coconut milk was also prepared. The 50 per cent coconut milk and 50 per cent dried skim milk combination approached the desired pH, acidity and viscosity necessary for high quality yoghurt.

A cheese like product named Soy cheese spread, has been developed by Singh and Mittal (1984), using a blend of soybean and milk solids. The desired flavour is associated with relatively low rate of acid development and controlled proteolysis. Soy cheese spread resulting from this

formulation contains about 35 per cent total solids, 18 per cent fat, 11 per cent protein, 2 per cent sodium chloride and 3 per cent ash.

Nielsen and Pihl (1985) made cheese with a mixture of vegetable oils of similar fatty acids composition to that of milk fat, containing 40 per cent coconut oil, 50 per cent palm oil and 10 per cent rape seed oil, was successfully used to produce Havarti and Danish Blue cheese with acceptable quality and reduced costs.

Sanchez and Rasco (1986) utilized coconut in white soft cheese production. As coconut milk percentage increased, the cheese fat content increased, while moisture, protein and salt content decreased. Similarly yield decreased as percentage of coconut milk increased.

Singh and Ganesh (1988) prepared filled rasogolla by utilizing sweet cream butter milk, skim milk powder and hydrogenated vegetable oil which was comparable in appearance, body, texture, flavour and overall quality to the conventional one.

Meena Grover and Tyagi (1989) developed a process for the manufacture of soy paneer from defatted soy flour using organic acids. A total solids content of 7.58 per cent and temperature of 95°C were found to be the optimum for the coagulation of soy slurry.

Umesh et al. (1989) utilized Vanaspathi in the preparation of filled soft serve ice cream without sacrificing the quality of the finished product, by replacing milk fat with vegetable fat by using Vanaspathi at levels of 40, 50 and 60 per cent. Vanilla and chocolate flavours were used. Results of organoleptic evaluation have revealed that Vanaspathi could be used to replace milk fat in the manufacture of soft serve ice cream upto 60 per cent.

Kanawjia et al. (1990) prepared filled paneer using skim milk and vegetable oils/Vanaspathi. The paneer thus developed contains 16-18 per cent protein, 22-23 per cent vegetable fat and 55-56 per cent moisture. The cost of the production was considerably reduced.

Rajasekaran and Rajor (1990) developed yoghurt like product of an acceptable consistency, body, texture and flavour, from soybean and skim milk. The effect of the addition of three different levels of total solids Viz. 9,11, and 13 per cent in the ratio of soy solids:skim milk solids:50:50 and stabilizer about 0.3 per cent Viz. sodium alginate, gelatin and starch were investigated. The standardized product obtained had a composition of crude protein 4.46, fat 2.4, ash 0.49, carbohydrates 4.26 and total solids 11.61 per cent.

Cheema and Arora (1991) manufactured filled ice cream using vegetable oils (groundnut, soybean and maize) and it

was compared with control ice cream manufactured from milk fat. The values of surface tension, relative viscosity, melting rate and pH of all types of filled ice cream/mixes were similar to those of the control.

Prajapati et al. (1991) used a 50:50 blend of hydrogenated fat (melting point 29.9°C) and soybean oil for preparing a low-fat butter flavoured spread. The product was fairly close to table butter.

Katara and Bhargava (1992) concluded that buffalo milk with 2-3 per cent fat when admixed with 20 per cent soymilk could produce chhana of most acceptable quality, which resembled closely with cow milk chhana but had a significantly lower fat content. Incorporation of soymilk in milk increased both the moisture retention and protein content in chhana.

Babje et al (1992) studied the possibility of blending soy milk with buffalo milk for obtaining good quality paneer. Addition of soy milk to buffalo milk upto 20 per cent had no adverse effect on quality of paneer and the product resembled that of milk paneer in taste, colour and springiness. However, the paneer prepared by blending soy milk showed higher protein content.

Mini Jose (1992) concluded that good quality paneer, rasogolla and whey drinks could be prepared from coconut fat filled skim milk.

Morton and Kettyle (1993) described a process for producing a vegetable fat cream and a cheese product from it. The process comprises forming a mixture of vegetable fat and whey in a weight ratio of 1:1.5 to 1:9 where in the vegetable fat comprises by weight at least 70 per cent unsaturated fatty acids . The mixture was blended to form an artificial cream, and the artificial cream was mixed with milk to form a filled milk and that a cheese product was prepared from it.

Use of coconut milk in filled milk processing

As per the figures reported in Philippines, coconut milk contained 56.3 per cent moisture, 43.7 per cent total solids(1.2 per cent ash, 33.4 per cent fat, 4.1 per cent protein and 5.0 per cent invert sugar). A comparison of the coconut milk prepared from an equal quality of water and gratings with cow's milk has shown that while the coconut milk is richer in fat, it is poorer in protein and sugar content (Thampan, 1975).

Lupke (1979) has described a new product, 'creamed coconut' a hundred per cent coconut product without any additives. Possible uses in the dairy industry included preparation of desserts, milk shakes, cream and semi finished products.

Krishnamurthy and Chandrasekhara (1983) studied the composition of coconut lipids. Fractionation indicated that they were composed of 94.3 per cent neutral, 5.5 per cent glyco and 0.2 per cent phospho lipids. Mono-galactosyl diglyceride was the predominant glycolipid and the major components of lipids were phosphatidyl choline and phosphatidyl ethanolamine and phosphatidyl inositol. But glyco and phospholipids were rich in unsaturated fatty acids and had iodine value of 41.6 and 58.3 respectively. Linoleic acid was present in total (0.5 %) as well as in glycolipids (2.5 %).

Nair and Geevarghese (1988) succeeded in preparing a dairy analogue - Kera Cream. Coconut milk blended with milk was used to prepare Kera Cream which resembled ice cream.

Agrawal et al. (1991) prepared 'coconut milk' which is the product made from non-fat milk solids either of liquid or powder origin, in which vegetable fats or oil have been incorporated in approximately the same proportion as in the butter fat of fresh milk. Vitamins are normally added to make up for those lost in the extracted fat. The idea of preparing coconut milk was originally thought to have arisen due to economic factor. The milk extracted had a fat content of 37-38 per cent and average total solids content of 48 per cent.

Analysis of coconut milk has shown that it contained 41.0 per cent moisture, 5.8 per cent protein, 38-40 per cent fat, 6.2 per cent minerals and 9-11 per cent carbohydrates (Mini Jose, 1992).

Standardization of milk

Standardization of milk is one of the important steps in cheese making for its composition to conform to legal standards, optimized yield, reduced milk solids losses, maintain uniformity in day to day production and to obtain product of desired body and texture characteristics.

Ravi Sundar 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, Fat in dry matter (FDM) and protein contents of the cheese were significantly affected by C:F ratio of the milk, fat and FDM values being highest, and protein values lowest in cheese made from milk with C:F ratio of 0.5. Yield of cheese (kg/100 kg of milk) decreased from 16.47 to 13.75 as C:F ratio increased from 0.5 to 0.9.

Ghosh and Singh (1990b) standardized the manufacturing technique using different fat levels in milk (3,4 and 5 per cent). They used starter cultures Streptococcus thermophilus and Lactobacillus bulgaricus in the ratio of 1:1 and 2:1. They observed that Mozzarella cheese from

four per cent fat was highly suitable for pizza making. The cheese from three per cent fat milk was coarse and hard, where as that from five per cent fat milk yielded too soft a product and excessive fat leakage was noticed during pizza preparation. The fat levels did not have any significant effect on stretchability of cheese.

Latha Sabikhi (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 found 3.0 per cent fat milk to give the best Mozzarella cheese. The yield of cheese increased with increase in fat content. The retention of moisture was inversely related to the fat content.

Pasteurization of milk

Mozzarella cheese from whole milk pasteurized at 71.95°C (161.5°F) for 15 sec, was first made by Kosikowski (1951). He observed that the flavour, yield and other physical properties of cheese were inferior in the case of raw milk than the pasteurized milk cheese.

Kosikowski (1982) further recommended pasteurization of milk at 72°C for 16 Sec and cooling to 32.2°C for all types of Mozzarella cheese.

Ghosh and Singh (1990a) made Mozzarella cheese from raw, pasteurized (63°C/30 minutes) and high temperature heated

(71°C/30 minutes) buffalo milk standardized to four per cent fat. Cheese prepared from raw and pasteurized milk cheese was superior to those prepared from milk heated to high temperature. The flavour characteristics of pasteurized milk cheese was superior to that of raw milk cheese.

Direct acidification of milk

Breene et al. (1964) acidified two per cent fat milk at 40°F to pH 5.6 with lactic, acetic and hydrocholoric acids. The cheese exhibited good melting and stringing properties when baked. Excessive fat leakage could be corrected by single stage homogenisation (500 psi) of the whole milk used for standardization.

Patel et al. (1986) obtained Mozzarella cheese by direct acidification method using milk standardized to 3.0 and 6.0 per cent fat and concluded that a high fat in milk resulted significantly higher fat and lower protein in cheese than those made from low fat milk.

Anis and Ladkani (1988) concluded that the cheese milk acidified either by using hydrochloric acid or phosphoric acid did not have significant effect on the solids not fat percentage of the resultant cheese but fat percentage was found to be lower when hydrochloric acid rather than phosphoric acid was used.

Shukla and Ladkani (1990) prepared Mozzarella cheese by direct acidification method in milk standardized to 2.0, 3.0 and 4.0 per cent fat acidified to different pH levels.

Shukla and Ladkani (1989) optimized the process of manufacture of direct acid Mozzarella cheese from buffalo milk. It was observed that 1.6 to 3.5 ml hydrochloric acid or 2.0 to 4.0 ml acetic acid was required to obtain the desired pH at 6-8°C and 0.9 to 1g calf or 0.4-0.5 g meito rennet per 100 litres of milk gives satisfactory curd at 35°C. Stirring curd for 20 to 30 minutes after cutting and soaking of curd in whey for 30 minutes gave optimum composition and excellent melting and stretching properties.

Latha Sabiki and Kanawjia (1993) were studied the effect of different acids, Viz., acetic, lactic and hydrochloric acid on sensory, physico - chemical rheological and textural properties of Mozzarella cheese. The study revealed that hydrochloric acid was the most suitable acidulant for the production of good quality Mozzarella cheese.

Tariq Masud et al. (1993) made an attempt to use buffalo milk for the preparation of Mozzarella cheese by using direct acidification technique, with gradual addition of 10 per cent (W/V) lactic acid solution with constant stirring to obtain a pH 5.2. The cheese prepared had a

higher fat percentage (23.50 per cent) than protein (20.15). They concluded that by using this technology, buffalo milk can be converted into valuable Mozzarella cheese which can be used as in the baking industry.

Homogenization of milk

Homogenization of cheese milk, in general is found to be beneficial in relation to yield, appearance, flavour and baking qualities of cheese. The effects of homogenization condition on the textural and baking characteristics of buffalo milk Mozzarella cheese was studied by Jana and Upadhyay (1991b). They homogenized buffalo milk at 25 or 50 kg/cm^2 pressure and 50°C temperature resulted in Mozzarella cheeses which were superior to controls with regard to flavour and fat leakage, but inferior in stringiness, textural properties and meltability of cheese.

Jana and Upadhyay (1992a) further recommended homogenization of buffalo milk for Mozzarella cheese making since it leads to a significant increase in moisture, moisture-in-fat-free substances, Fat-in-Dry Matter content and cheese yield with improved fat and protein recovery. Acceptable quality can be obtained if buffalo milk homogenized either at 25 or 50 kg/cm^2 pressure at 50 or 60°C.

Jana and Upadhyay (1993) compared the quality of Mozzarella cheese obtained from unhomogenized and homogenised buffalo milks. Homogenised milk cheeses had significantly higher yield on a gross-weight basis (kg cheese/100 kg of milk) than control. When used as topping on pizza, the homogenised milk cheeses exhibited superior flavour characteristics and controlled fat leakage.

Addition of starter culture

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

Upadhyay et al. (1986) prepared Mozzarella cheese from buffalo milk using two per cent (1:1) starter cultures (S. thermophilus and L. bulgaricus).

Ghosh and Singh (1990) studied the effect of fat levels and starter cultures on sensory and rheological properties of buffalo milk Mozzarella cheese. They concluded that S. thermophilus and L. bulgaricus at 1:1 ratio produced cheese with the best flavour and textural quality. The yield and moisture retention were higher in cheese made from 1:1 ratio cultures than that from 2:1 ratio cultures.

Ravi Sundar and Upadhyay (1990) standardized casein/fat ratio for Mozzarella cheese composition and cheese making efficiency by using two per cent (V/W) 1:1 S. thermophilus.: L. bulgaricus starter.

Ghosh and Singh (1991) developed a new method for vegetarian Mozzarella cheese from buffalo milk. They advocated 1:1 S. thermophilus : L. bulgaricus starter culture.

Renneting of milk

Mozzarella cheese was made experimentally by direct acidification using varying amounts of commercial single strength rennet (2.5, 5.0, 7.5, 10.0 or 15.0 ml rennet) for 45.4 kg of milk. Mean yield, composition and properties of cheese were not affected by the amount of enzyme, except for a limited number of characteristics (Micketts and Olson 1974).

Kosikowski (1982) stated that addition of 60 to 80 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 1:40 with pure cold water just before addition to milk.

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.

Cooking

The cooking of the curd should be started after about 10 to 15 min of cutting (Kosikowski, 1982). He also recommended final cooking temperature of 105°F in 35 min or 118°F in 45 min depending upon the desired moisture level of low moisture cheese.

Ravi Sundar and Upadhyay (1990) employed a cooking temperature of 40°C until it developed an acidity of 0.42 per cent.

Drainage of whey

Ravi Sundar and Upadhyay (1991) concluded that high levels of whey acidity yielded cheese with significantly higher titratable acidity, lower pH, marked reduction in calcium and phosphorus, but not of ash. It resulted in higher milk solids losses reflecting significantly on yield beyond 0.40 per cent whey acidity. Regulation of whey acidity at draining can be used to improve the cheese making efficiency and quality of cheese, latter being best at 0.40 per cent whey acidity.

Ravi Sundar and Upadhyay (1992) studied the influence of whey acidity at draining on cheese baking, rheological and sensory characteristics. Their result showed that maximum springiness was noted in cheese made by draining at 0.40 per cent acidity. Stretchability of curd was severely impaired at extremes of whey acidity used. Organoleptically, 0.40 per cent whey acidity cheese had a superior flavour, body-texture and total score, where as 0.50 per cent WA cheese scored the least.

Stretching and Moulding

Stretching, one of the most important physical properties of Mozzarella cheese is governed by optimum acid development and temperature of hot water. After the optimum level of acidity is reached, the curd is immersed in hot water. 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). The curd was then stretched using a wooden paddle or revolving blender until a smooth, white, plastic mass resulted.

Jana and Upadhyay (1992b) stretched the curd at 85°C to 90°C for 1-3 min., which yielded satisfactory stretching of the curd.

SALTING

This essential step serves the following purposes,

(i) to control the growth of undesirable micro organisms,

(ii) to retard acidity development by controling the growth of lactic acid organisms and

(iii) to give cneese an appealing taste.

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

Latha Sabikhi and Kanawjia (1992b) immersed the moulded cheese balls in brine solution of 20 per cent (w/w) concentration at 8±1°C for 3 to 4 hrs.

Packaging

The shelf life of a product is to a large extent, dependent on its packaging. The high moisture content in Mozzarella cheese makes it susceptible to spoilage due to microbial attack and moisture loss. Therefore, a cheese packaging material should possess oxygen barrier and moisture barrier properties.

Kosikowski (1982) advocated that the cheese should be dried for some time and wrapped in parchment, saran or vacuum packaged in cryovac, polyethylene or cellophane pouches, followed by refrigerated storage.

Ghosh and Singh (1991) suggested that Mozzarella cheese could be packaged in food grade polyethylene pouches of 300 gauge thickness, sealed with aluminium clips.

Storage

The packaged cheese samples were stored in the refrigerator (8±1°C) until used (Patel et al., 1986; Ghosh and Singh, 1991).

Yield of cheese

Kosikowski (1982) reported that the average yield of commercial Mozzarella cheese was 11.5 per cent containing 53.6 per cent moisture made from 3.0 per cent fat cow milk.

Ghosh and Singh (1990) found that yield, fat and total solids recovery were significantly higher in case of cheese made from pasteurized milk as compared to raw milk, whereas the yield was more and fat and total solids recovery were less in the case of high heated milks.

Latha Sabikhi and Kanawjia (1992b) observed the yield of 15.44 per cent Mozzarella cheese containing 47.28 per cent fat in dry matter basis.

Utilization of whey

Dordevic and Kolev (1967) outlined the process of refreshing beverages from whey. The process included the removal of proteins, deodorization, addition of natural flavourings, filtration, deaeration, pasteurization, and filling with carbonation. This process gave a clear drink.

Patil et al. (1984) prepared a low cost nutritious beverage from soybean and milk whey which can be utilized in Institutional feeding programme of developing countries like India.

Technology, processing and marketing of whey drinks have described in detail by Prendergast (1985). Production methods based on fermentation and on direct acidification, carbonation, shelf life and packaging of whey drinks were discussed.

Dyachenko and Suares-solis (1985) have adopted one procedure to manufacture fruit/whey beverages. The procedure included, filtration of fresh whey, cooling to 4-6°C, addition of recipie ingredients, pasteurization of the mixture at 74±2°C for 16 seconds and the product had a guaranteed shelf - life of upto 5 days at 4-6°C and retained its organoleptic quality for upto 8 days.

Gargrani et al. (1987) prepared fruit flavoured whey beverage from whey free of proteins and fat with an acidity of 0.5 per cent and flavoured with orange, pineapple, guava and mango fruit juices at 10, 15, 20 and 25 per cent of whey. Sensory evaluation showed that whey beverage prepared from mango juice with 15 per cent of whey was superior to others.

According to Gupta and Mathur (1989) full utilization of whey has not been achieved in India, inspite of considerable technologies being evolved. The authors suggested the utilization of whey solids by combining with newly emerged fruit juice for the manufacture of beverages consisting of plain, carbonated, alcoholic and fruit flavours.

Paul (1990) described a wide range of nutritive beverages for products diversification and to enhance economic returns. According to the author, these types of beverages have several nutritional and therapeutic attributes. The utilization of whey for the manufacture of refreshing beverages also abates the problem of their economic disposal and permits reduction of the B.O.D. loads on sewerage.

Krishnaiah et al. (1991) developed three categories of whey beverages for human consumption (i) whey beverage was

prepared by the addition of 10 per cent sugar and 0.2 per cent citric acid to deproteinated whey. Orange essence to taste and orange colour to pleasing appearance were added and mixed vigorously (ii) By mixing three parts of acid whey with pH 6.8, one part of toned milk and sugar at 10 per cent level and pine apple essence and yellow colour and (iii) By mixing three parts of acid whey with pH 6.8, one part of toned milk and sugar at 10 per cent level and banana essence and lemon yellow colour were formulated. On sensory evaluation the second and third categories of beverages were more acceptable than the first due to added toned milk.

Methods for preparation of whey Beverages

Guy et al. (1968) developed an acceptable tasting, low cost, citrus flavoured, proteinaceous beverage by combining soy flour with either sweet or cottage cheese whey, then adding sugar or artificial sweetener, citric acid, stabilizer and flavouring. These ingredients were combined, homogenized and concentrated.

Bambha et al. (1972) produced a nourishing soft drink 'whevit'. The manufacturing process consisted of steaming of whey, cooling and filtering, addition of citric acid, sugar syrup, colour and yeast culture, (Saccharomyces cerevisiae) 0.5-1 per cent, incubation, addition of flavour, bottling and pasteurization and storage at low temperature. pH of the drinks were 4.2 to 4.3.

Gandhi (1984) made an attempt to convert surplus whey into a palatable, refreshing and economic acidophilus whey drink fermented by Lactobacillcus acidophilus and named as Acido whey. Fat free whey was strained, cooled, filtered, inoculated with L. acidophilus and incubated at 39±1°C for 20-24 hours. Acidophilus whey was again filtered and sugar and pineapple flavour were added. The contents were mixed thoroughly and packed in bottles, pasteurized and then were stored at low temperature Organoleptic tests of the product gave satisfactory results.

Jayaprakasha et al. (1986) made whey drinks by deproteinising and clarifying whey from cheese, chhana or acid casein, adding 6-12 per cent sugar, 0.02 to 0.4 per cent citric acid and flavourings at 0.15 to 0.45 ml/litre whey, then in-bottle pasteurizing or sterilizing with or without carbonation. Optimum levels were 10 per cent sugar for all wheys; 0.2, 0.25 and 0.4 citric acid for acid casein, chhana and cheese whey respectively; orange, pineapple, mango or raspberry flavouring at 0.34, 0.4, 0.25 or 0.3 ml/litre respectively. Carbonated whey drink were the most acceptable and had the highest average sensory score of 90 (max.100)

Hamad et al. (1987) have developed a chocolate-flavoured drink from equal parts of whole milk and sweet whey from manufacture of white soft cheese. The whey was

boiled to inactivate chymosin, and coagulated whey proteins were removed by straining through a cheese cloth, 103 g of date puree was added to 900 ml whey and the mix was homogenized and strained through cheese cloth. Whole milk 900 ml and dry ingredients 48 g sugar, 30 g cocoa powder, 1 g stabilizer and 0.2 g vanilla flavourings were mixed with the filtrate and the volume made to 2 litres with whey:milk (50:50). After heating at 85 °C for 30 minutes and cooling , the drink was evaluated by a taste panel. The drink was stable at 4° °C for 10 days and had a pH of 6.5 - 6.6 and contained 16.5 per cent TS, 2.20 per cent fat and 3.70 per cent protein.

Reddy et al. (1987) manufactured a sterilized whey beverage containing deproteinised cheddar cheese whey, lemon juice and sugar. They indicated that acceptable quality of sterilized beverage could be manufactured with the addition of 8 per cent lemon juice and 14 per cent sugar to whey.

Materials and Methods

MATERIALS AND METHODS

Mozzarella cheese and whey drinks were prepared using cow's milk as per the procedure described below. Filled milk was prepared using coconut milk as the source of fat and products were prepared as from cow's milk. Six replication were done for each item and all the samples were subjected for various analysis. The data obtained were statistically analysed to arrive at a conclusion.

3.1. Analysis of Milk

3.1.1. Collection of Milk Samples

Fresh raw milk, received from the University Livestock Farm, Mannuthy was used in Mozzarella cheese preparation. The following analysis were carried out.

3.1.2. Estimation of Fat

The fat per cent of milk was determined according to IS:1224, Part I (1977)

3.1.3. Estimation of total solids

The total solids percentage of milk was estimated by Gravimetric method (IS: 1479-part II, 1961).

3.1.4. Estimation of Titratable acidity

The titratable acidity of milk was determined according to IS:1479 part I (1961).

3.1.5. pH Value

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

3.1.6. Standardization of cheese milk

3.1.6.1. Control cheese

Five litres of cow's milk was preheated to 32°C and cream was separated by using an Alpha-Laval cream separator. Milk was standardized to 4.0 per cent fat by mixing skim milk and cream in the required quantity according to the Pearson's square method. The standardized milk was used to prepare control samples of Mozzarella cheese and whey drink.

3.1.6.2. Experimental Cheese I (50 per cent of milk fat replaced with coccnut fat)

Five litres of cow's milk were standardized to 2 per cent fat. Coconut milk was added to this, so as to prepare filled milk with four per cent fat and was used to prepare experimental cheese with 50 per cent coconut fat.

3.1.6.3. Experimental Cheese II (100 per cent of milk fat replaced with coconut fat)

To five litres of skim milk, 500 ml of coconut milk was added, so as to prepare filled milk with four per cent fat and used to prepare experimental cheese with 100 per cent coconut fat.

3.1.7. Starter culture

Stock cultures of Streptococcus thermophilus and Lactobacillus bulgaricus procured from Dairy Microbiology Division, National Dairy Research Institute, Karnal was used in the preparation of Mozzarella cheese.

3.1.8. Rennet

Microbial rennet (Rennilase) procured from M/s Hansens' Laboratory Ltd, Denmark was used in the preparation of mozzarella cheese @ 1 g/50 kg of milk.

3.2. Analysis of Coconut Milk

3.2.1. Collection of coconuts.

Mature coconuts (nuts of cocos nucifera) required for the preparation of coconut milk were collected from Kerala Agricultural University Farm, Mannuthy.

3.2.2. Extraction of coconut milk

The selected coconuts were dehusked and broken into two halves. The kernel was grated and the coconut milk was extracted by pressing it under a screw press. After the first extraction of coconut milk, the coconut kernel was kneaded with water (30 per cent W/W) and was again pressed under the screw press for extracting the milk. The coconut milk extracted by the first and second extractions was mixed together.

3.2.3. Estimation of fat in coconut milk

Five grams of well mixed coconut milk was weighed in a butyrometer. Ten ml of Gerbers' sulphuric acid was mixed with ten ml of distilled water in a beaker and while hot poured about 18 ml of the mixture into the butyrometer. One ml of amyl alchol was added and mixed well. After placing the rubber stopper in position the butyrometer with the contents were centrifuged at 1100 rpm for five minutes. The length of fat column obtained was the fat percentage of coconut milk.

3.3. Mozzarella cheese preparation

Mozzarella cheese (both ccntrol and experimental) was prepared as per the procedure outlined by Kosikowski (1982) with slight modifications.

The milk was standardized to the required fat percentage and was pasteurized at 72°C for 15 seconds and it was cooled to 30°C. Active starter cultures (consisting of Streptococcus thermophilus and Lactobacillus bulgaricus, in 1:1 ratio) was added to the milk at the rate of two per cent V/V. The culture was mixed thoroughly. The milk was allowed to ripen at 30°C for 15 minutes and was renneted using microbial rennet at the rate of 11ml of one per cent rennet solution per litre of milk with a setting time of 45 minutes. The curd was cut into one cm cubes and

allowed to stand undisturbed for 10 minutes. Then the cubes were made free from the sides and bottom of the vat. The temperature was enhanced at the rate of 1°C for every five minutes till the ccoking temperature of 40°C were reached. With continuous agitation the curd was cooked at 40°C till the acidity of whey reached 0.32 per cent lactic acid. The strechability test was done in accordance with Kosikowski (1982) 'stretch test' to make sure the stretching of the curd. As soon as the acidity of the whey reached 0.32 per cent the curd was separated from the whey. After that sufficient hot water at 80-85°C was added to cover the curd. After 1-2 minutes of warming up, the curd was 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 about 4-5°C for2 hours. The cheese was removed from the water and kept in the refrigerator for the draining out of the water.

3.4. Analysis of Mozzarella cheese

3.4.1. Sampling of cheese.

An approximately 100 g portion of the 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.

3.4.2.Chemical analysis

3.4.2.1. Total solids

Total solids percentage of cheese was estimated by IS:2785, (1964).

Clean stainless steel dishes with 20 g of prepared sand and a stirring rod were heated in the oven for 1 hour. Then it was cooled in a desiccator and three g of prepared sample of cheese was added into the dish. The sand was saturated by the careful addition of few drops of distilled water. The wet sand was mixed with cheese with the glass rod. The dish ccntents were dried by placing on a boiling water bath for 20-30 min. Then it was transferred to a well ventilated oven maintained at 102°C±1°C with the glass rod. After four hours the dish was removed and transferred immediately to the desiccator. Weighed the dish after 30 minutes. This procedure was repeated until consecutive weighing agreed to within 0.5 mg. Lowest weight was noted. Percentage of the total solids was calculated.

3.4.2.2. Estimation of fat in cheese

Fat content of Mozzarella cheese was determined by the method given in IS:1224, part II (1977). Ten ml of sulphuric acid (90-91 per cent) was transferred into the butyrometer and warm water (30 to 40°C) was added to form a

layer about 6 mm on the top of acid. Then 3 g of cheese sample was added to the butyrometer. One ml of amyl aclhol was added and added warm water (30 to 40°C) until the butyrometer was filled to about 5 mm below the shoulder. The butyrometer neck was closed with the stopper, contents were mixed thoroughly and was transferred into a water bath having a temperature of 65±2°C for three to 10 minutes. Then it was centrifuged for five minutes. After that it was transferred into a water bath like the previous one and the fat percentage was noted.

3.4.2.3. Estimation of protein in cheese

Method used for the determination of total protein in cheese samples was essentially that of Kosikowski (1982).

Reagents

1. Acetic acid solution

   Glacial acetic acid 25 ml in 100 ml distilled water.

2. Catalyst mixture

   Potassium sulphate 80 g + copper sulphate 20.g.

3. Mixed indicator

   Two parts of 0.2 per cent alcoholic methyl red mixed with one part of 0.2 per cent alcoholic methylene blue solution.

2.5 g of grated cheese was ground well with a small amount of acetic acid solution and the volume was made upto 50ml with same solution. After keeping in a water bath at 50°C for 15 minutes, 4 ml. aliquot (equivalent to 200 mg of cheese) was transferred to Kjeldahl flask to which was added one gram catalyst mixture and 10 ml of concentrated sulphuric acid. The mixture was digested under moderate heat (80 to 90°C) for three to four hours. The digested sample was rinsed with 20 ml of distilled water and transferred to the boiling flask of Kjeldahl distillation unit to which was also added 15 to 20 ml. of 50 per cent NaOH solution. Dry steam was then turned on and the mixture was boiled vigorously. About 40 ml distillate was collected in 10 ml saturated boric acid containing one or two drops of the mixed indicator. It was titrated against N/35 H_2SO_4 to a faint pink colour as the end point. Similar procedures were followed for blank using distilled water as sample. The total percentage of protein was calculated using the formula,

$$\text{Percentage of protein} = \frac{(\text{ml of } H_2SO_4 \text{ used for sample} - \text{ml of } H_2SO_4 \text{ used for the blank}) \times \text{Normality of } H_2SO_4 \text{ used} \times 0.014 \times 6.38 \times 100}{\text{Weight of cheese sample}}$$

3.4.2.3 Titratable acidity

For determining the titratable acidity of cheese, 10g cheese was mixed with 100 ml distilled water at 40° - 50°C to obtain a homogenous suspension, which was then filtered through whatman filter paper No. 40. Ten ml of filtrate was titrated against 0.1 N NaOH using phenolphthalein as an indicator and acidity expressed in per cent lactic acid.

3.4.2.4 pH

pH of cheese was determined by a digital pH meter, using homogenous cheese paste prepared by mixing cheese and distilled water (1:1).

3.5 **Stretchability test**

Stretchability test was carried out as per the principles of 'stretch test' described by Kosikowski (1982). About 10g of cheese was taken in 250 ml beaker containing 3/4th of its volume of hot water maintained at 80-82°C in a water bath. It was kept in the beaker for about 3 min. 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 formation was observed when the rod was being gradually lifted. The length of the thread was 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 best stretchable characteristics.

3.6 Sensory Evaluation

Mozzarella cheese was evaluated organoleptically for different quality attributes such as appearance, body and texture and flavour. An 18 point score card, developed by Duthie et al. (1980) was used for this purpose. Average score obtained from five judges for each replication was used for statistical analysis.

Proforma of score card for judging the organoleptic quality of Mozzarella cheese was as follows:-

SCORE CARD FOR MOZZARELLA CHEESE

Date	Code number for each sample		
Panelist	1	2	3
APPEARANCE DEFECTS (Packages and Colour) Excellent score=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	
Lipolyzed	
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 = 3)	Slight	Definite	Pronounced
Acid-cut (dull, faded or bleached-colored blotches)	-1	-2	-3
Misshapen (deformed from normal shape)	-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 spots or areas)	-2	-3	-3
Soiled surface (Discoloration 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 holes)	-1	-2	-3
Weak (soft but not sticky)	-1	-3	-4

FLAVOR (Excellent score=10

Acid (distinct sour taste)	-1	-3	-5
Bitter (distasteful, strong, lingering aftertaste)	-5	-7	-10
Flat (lacks 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 vomit odor 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 flavor)	-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

3.7 Preparation of Whey drinks

Whey drink was prepared according to the method suggested by Gandhi (1984) with slight modifications, using the whey obtained from Mozzarella cheese preparation. The whey was collected, and sugar added at 10 per cent level into the whey. Then it was heated to 70°C for 10 minutes to destroy the residual rennet enzyme and filtered using a muslin cloth. Whey was then cooled to room temperature and the flavours were added.

Initially whey drinks with different flavours viz., pineapple, Orange, Lemon and Mango were prepared. Suitable colours like orange, yellow, Apple green etc., at the rate of 4 ml (one per cent aqueous solution) per litre were added to whey drinks. After preparation the whey drinks were stored in the refrigerator at a temperature of 5±1°C before serving.

Consumer acceptance studies were carried out to determine the acceptable flavour and colour of the whey drink. The whey drink which came first through consumer acceptance studies was selected and prepared for further studies.

In the case of carbonated whey drink, the whey drink filled in bottles were carbonated, sealed and stored at room temperature.

3.7.1. Sensory Evaluation of whey drink

The keeping quality of whey drink was evaluated for its sensory quality on 24, 48, and 72 hrs of storage at 5±1°C and at room temperature for carbonated whey drinks by the score card proposed in IS:7768-1975.

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		
		suspi-cion	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

3.8. Statistical Analysis

The results obtained were subjected to statistical analysis using Analysis of variance techique (CRD) and 't' test (Snedecor and Cochran, 1968) for comparing the control and experimental samples of cheese, whey and whey drinks respectively.

Results

RESULTS

Mozzarella cheese and whey drinks were prepared from cows' milk and filled milk (skim milk added with coconut milk), standardized to four per cent fat. They were subjected to chemical analysis and sensory evaluation tests. The percentage yield, moisture, fat, protein, Total solids, stretchability, acidity and pH of Mozzarella cheese were estimated.

Experimental Mozzarella cheese prepared were subjected to sensory evaluation and the Appearance, Body/Texture Flavour etc., were compared with that of control Mozzarella cheese prepared in the present study. Appearance, odour, Flavour and Body of whey drinks were also compared. Evaluation were carried out by a panel of five judges on the basis of 18 point and 100 point score card respectively for Mozzarella cheese and whey drinks. The total scores awarded by different judges were tabulated and averaged.

Whey obtained as a by-product was also analysed for its fat, protein, total solids and moisture content. The values were tabulated and averaged.

The data presented in the case of analysis of control and experimental cheese milk represent the average of six trials for each of the parameters studied. In the case of Mozzarella cheese, whey and whey drinks the data obtained

for all the six replications are presented in Tables. The analysis of variance technique was used to compare the different parameters of control and experimental samples of Mozzarella cheese. The data on whey and whey drinks were compared statistically with the help of 't'-test.

In the case of 't' test comparison were made between control-experiment I and control-experiment II samples of whey and whey drinks.

4.1. Chemical analysis of cheese milk

Cow milk from which the fat was replaced at 0, 50 and 100 per cent level with coconut fat were used respectively, for the preparation of control, experiment I, and experiment II Mozzarella cheese in the present study.

4.1.1. Fat

The fat percentage of the milk used for the preparation of Mozzarella cheese were presented in the Table 1, 2 and 3. The milk used in the preparation of control sample was to contain a fat per cent of 4.1 (average of six trails), where as that used for the experiment I and experiment II samples respectively, were 4.1 and 4.0 (Tables 1,2 and 3).

4.1.2. Protein

The cheese milk had an average protein percentage of 3.34, 4.32 and 5.04 (average of six trials) respectively,

for control, experiment I and experiment II. Experiment I and II Cheese milk were found to have higher protein percentage than control cheese milk (Tables 1, 2 and 3).

4.1.3. Total solids

The average (6 trials) total solid content of control cheese milk was 12.98 per cent, where as in the case of experiment I and II cheese milk were 14.62 and 15.58 per cent respectively. A high total solids contents were observed in experiment I and II cheese milk (Tables 1, 2 and 3).

4.1.4. Moisture

The moisture content of cheese milk had an average value of 87.02, 85.38 and 84.42 per cent respectively, for control, experiment I and II Mozzarella cheese (Tables 1, 2 and 3).

4.1.5. pH

The average pH value of the milk were found to be 6.70, 6.72 and 6.74, respectively, for that used in control, experiment I and II Mozzarella cheese (Tables 1, 2 and 3).

4.1.6. Acidity

It was found that the average acidity of control, experiment I and II cheese milk were the same i.e. 0.14 per cent lactic acid (Table 1, 2, and 3).

The cheese milk of the above said composition were used in the preparation of control, experiment I and II Mozzarella cheese as per the method given by Kosikowski (1982). The prepared cheese was subjected to physical, chemical and organoleptic analyses. The data were presented in Tables 4 to 26.

4.2 Acid development in Mozzarella Cheese during Cooking (per cent Lactic Acid)

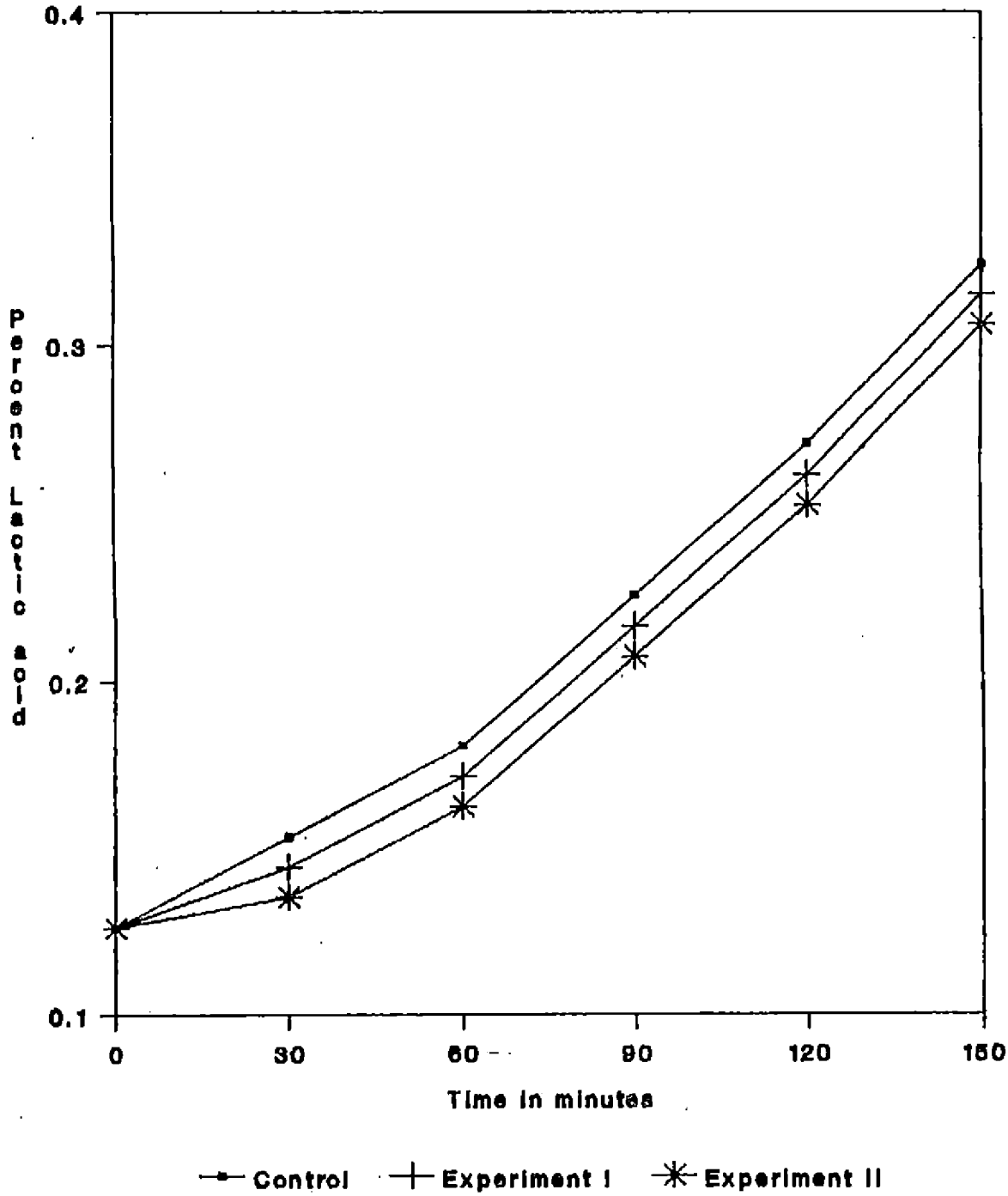
Table 4 shows the acid development in control, experiment I and II Mozzarella cheese during cooking. The average values obtained were 0.126, 0.126 and 0.126 per cent; 0.153, 0.144 and 0.135 per cent; 0.180, 0.171 and 0.162 per cent; 0.225, 0.216 and 0.207 per cent; 0.270, 0.261 and 0.252 per cent; 0.324, 0.315 and 0.306 per cent respectively, for control, experiment I and II Mozzarella cheese, at the end of 0, 30, 60, 90, 120 and 150 minutes of cooking.

4.3 Analysis of Mozzarella Cheese

4.3.1 Yield

The yield of Mozzarella cheese is furnished in Table 5. The mean yield of control, experiment I and II cheese were 14.28±0.15 (range 13.82 to 14.75), 12.75±0.16 (range 12.24 to 13.20) and 12.20±0.09 (range 11.88 to 12.54) per cent respectively. The maximum yield of Mozzarella cheese was

Fig.1 ACID DEVELOPMENT IN MOZZARELLA CHEESE DURING COOKING

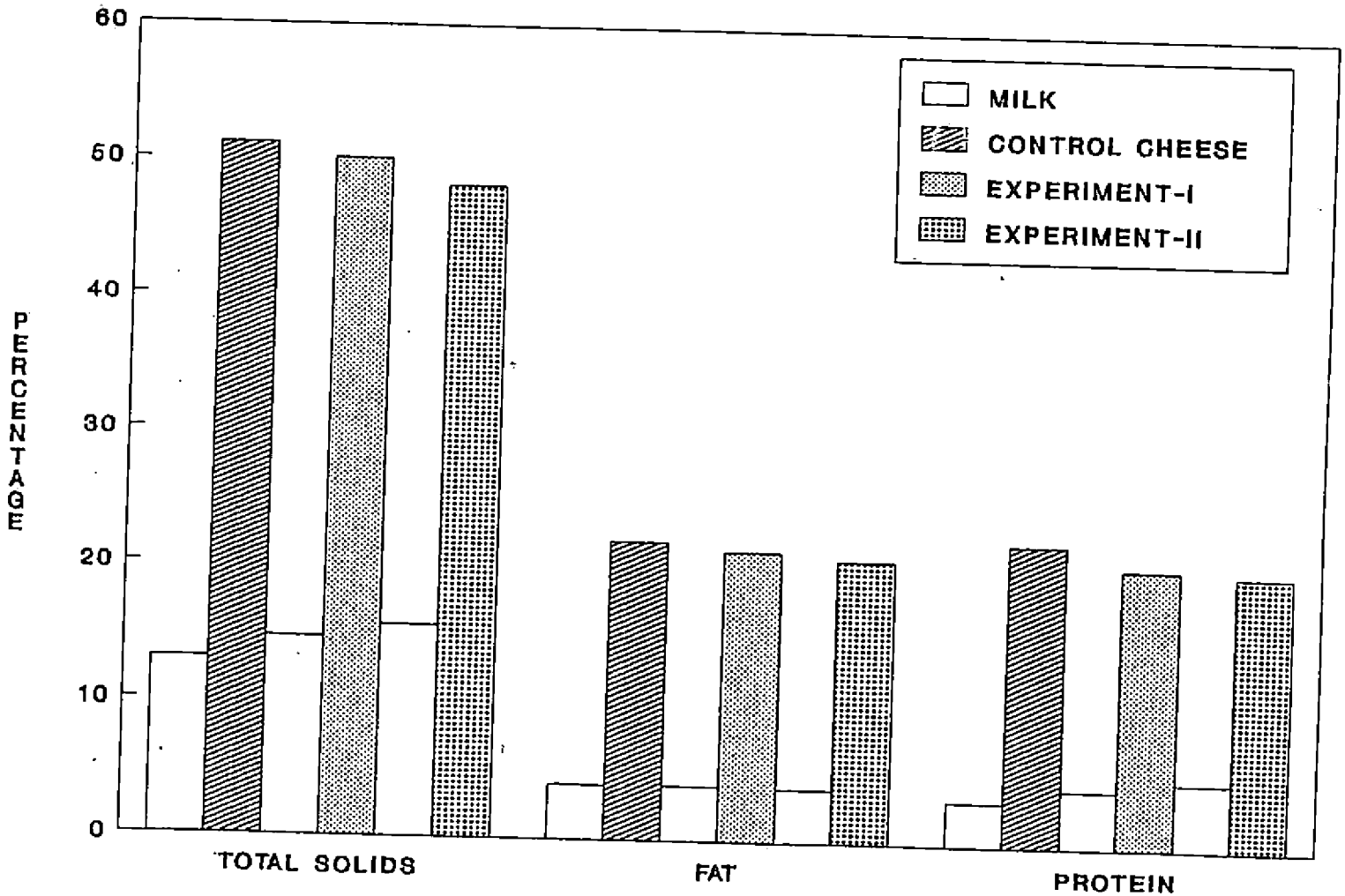


14.75 per cent and minimum of 11.88 per cent. On statistical analysis (Table 5a) the yield of control Mozzarella cheese was found to be significantly ($P<0.01$) higher than the yield of experiment I and II Mozzarella cheese (CD=0.402) i.e. the difference between the mean values of control and experiment I was 1.53 and between control and experiment II was 2.08, indicates control and experimentals were different. Whereas the difference between the experiment I and II was 0.550, also revealed difference.

4.3.2 Moisture content

Results in Table 7 shows the moisture percentage of control, experiment I and II Mozzarella cheese. The mean values obtained were 48.84 ± 0.39, 49.94 ± 0.28 and 51.81 ± 0.18 per cent respectively. Individually experiment II Mozzarella cheese had the maximum moisture content of 52.25 per cent and control had the minimum of 47.08 per cent. Significant difference (Table 7a) was observed between the control and experimental Mozzarella cheese (CD=0.893), ($P<0.01$) i.e. the difference between the mean values of control and experiment I was 1.10 and between control and experiment II was 2.97, indicates control and experimentals were different. Whereas the difference between the experiment I and II was 1.87 also indicates difference.

Fig.6 Chemical analysis of cheese milk and cheese



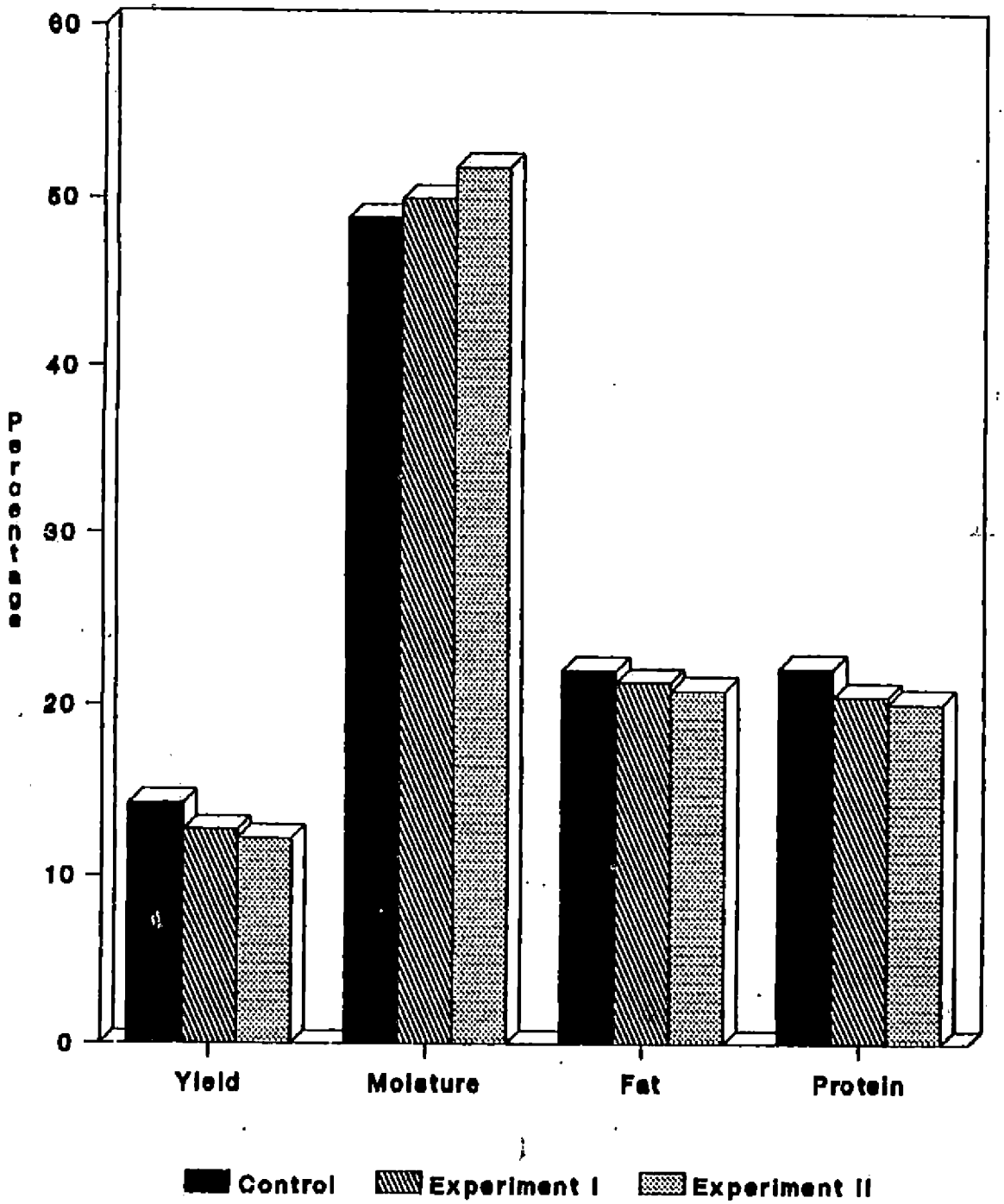
4.3.3 Fat content

The fat percentage of control, experiment I and II Mozzarella cheese is given in Table 9. The mean values obtained were 22±0.26 (range 21.00 to 23.00), 21.33±0.21 (range 21.00 to 22.00) and 20.83±0.17 (range 20.00 to 21.00) per cent, respectively. The maximum fat percentage was 23 and the minimum was 20. The analysis of variance (Table 9a) revealed that there was significant difference ($P<0.01$), (CD = 0.648) i.e. the difference between the mean vlaues of control and experiment I was 0.670 and between the control and experiment II was 1.17 which indicates that control and experimentals were different, whereas the difference between the experiment I and II was 0.50 indicating no difference.

4.3.4 Protein Content

The mean protein contents of cheese were 22.13±0.36 (range 21.28 to 23.21), 20.53±0.19 (range 19.82 to 21.18) and 20.16±0.16 (range 19.78 to 20.68) per cent respectively, for control experiment I and II Mozzarella cheese. The maximum value was 23.21 per cent and minimum value was 19.78 per cent (Table 11). The analysis of variance (Table 11a) shows that there was significant difference ($P < 0.01$), (CD=0.755) i.e. the difference between the mean values of control and experiment I was 1.60, and between control and experiment II was 1.97, which indicates that control and experimentals were different, whereas the difference

Fig.2 THE YIELD, MOISTURE, FAT AND PROTEIN CONTENT OF MOZZARELLA CHEESE



between the experiment I and II was 0.370, indicating no difference.

4.3.5 Fat in Dry Matter (FDM) Content

The mean FDM content of control cheese was 43±0.58 per cent with a standard deviation of 1.42, whereas experiment I and II were 42.62±0.42 and 43.23±0.34 per cent, respectively with a standard deviation of 1.03 and 0.83. The maximum FDM content was 44.78 per cent and minimum was 41.03 per cent (Table 13). Analysis of variance (Table 14) shows there was no significant difference between the FDM content of control and experimental Mozzarella cheese.

4.3.6 Total solids content

Results presented in Table 15 shows the total solids of control and experimental cheese, the mean values obtained were 51.16±0.39 (range 50.28 to 52.92), 50.06±0.28 (range 48.80 to 50.72) and 48.19±0.18 (range 47.75 to 49.04) per cent respectively. The maximum TS content was 52.92 per cent and minimum was 47.75 per cent. Analysis of variance (Table 15 a) indicates there was significant difference between treatments ($P < 0.01$), (CD=0.893) i.e. the difference between the mean values of control and experiment I was 1.10 and between control and experiment II was 2.97, which indicates that control and experimentals were different. Whereas the difference

between experiment I and II were 1.87 also indicating difference

4.3.7. pH

Table 17 shows that the mean values of pH recorded were 5.615, 5.615 and 5.617, respectively, for control, experiment I and II Mozzarella cheese. Statistically the difference was not significant (Table 18).

4.3.8 Acidity of Mozzarella Cheese

The mean values obtained were 0.327, 0.329 and 0.33 per cent lactic acid for control, experiment I and II Mozzarella cheese respectively (Table 19). Analysis of variance indicates no significant difference between treatments with regard to acidity (Table 20).

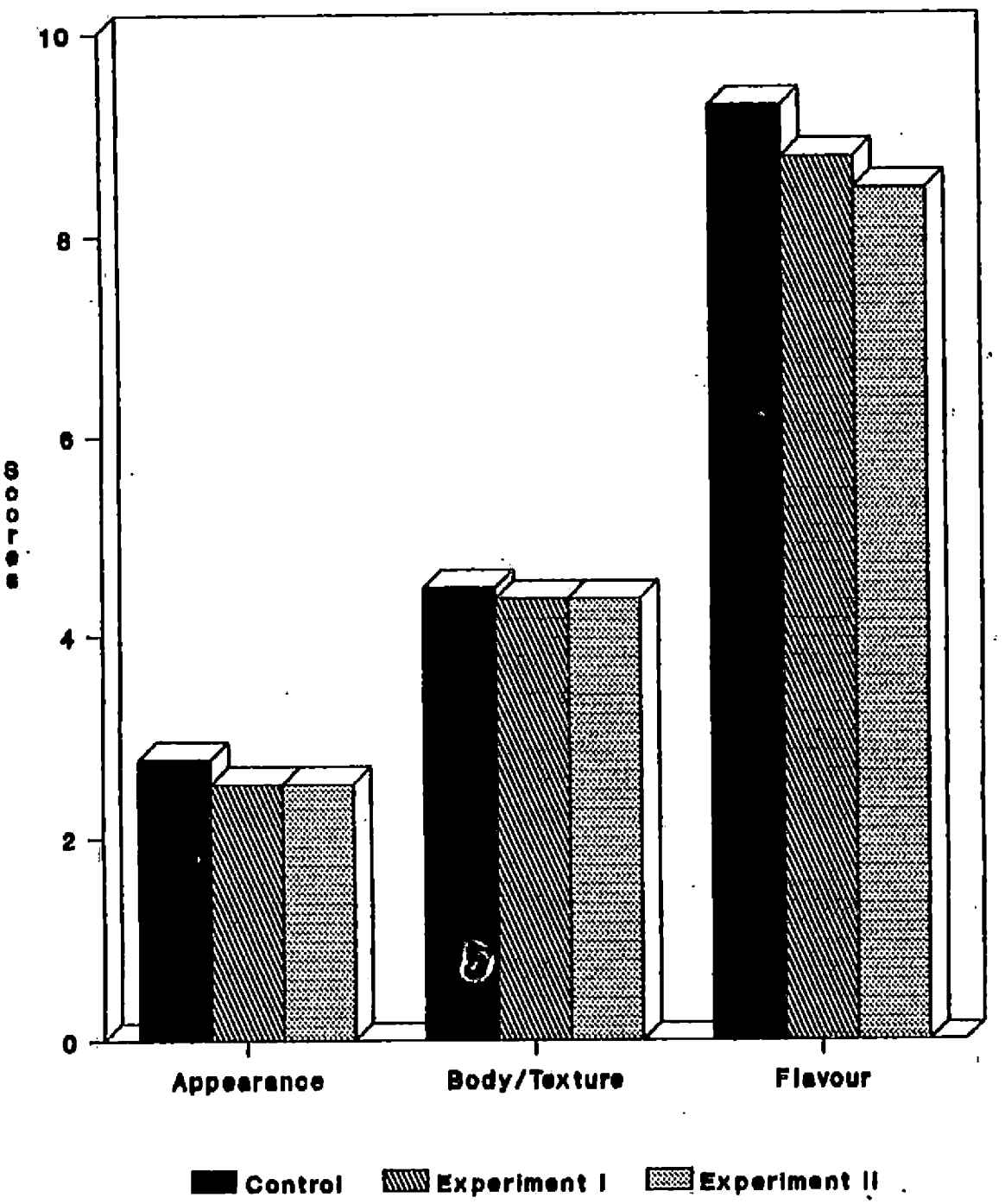
4.4 Stretchability of Mozzarella Cheese

The stretchability of control Mozzarella cheese was the highest, obtaining a mean score of 4.65±0.11, as against 4.46±0.09 and 4.41±0.13 for experiment I and II Mozzarella cheese, respectively (Table 21). There was no significant variation in the stretchability of all kinds of Mozzarella cheese (Table 22).

4.5 Sensory Evaluation

The overall mean score and total score for appearance, body/texture and flavour of control, experiment I and II

Fig.3 SENSORY EVALUATION SCORE OF MOZZARELLA CHEESE



Mozzarella cheese are presented in Tables 23, 25, 27 and 29. The mean score obtained for appearance were 2.77±0.06, 2.53±0.07 and 2.53±0.07. Mean score obtained for body/texture were 4.48±0.04, 4.37±0.06 and 4.37±0.06. Mean values obtained for flavour were 9.27±0.09, 8.77±0.14 and 8.47±0.10. The overall mean total score were 16.52±0.09, 15.67±0.10 and 15.37±0.09, respectively.

The analysis of variance for appearance body/texture, flavour and total score of Mozzarella cheese are presented in Tables 24, 26, 28 and 30. The tables indicate that significant differences were exhibited in appearance ($P < 0.05$), flavour ($P < 0.01$) and Total score ($P < 0.01$) between control and experimental Mozzarella cheese. The differences in regard to body/texture of Mozzarella cheese was found to be not significant.

4.6 Chemical analysis of whey

The percentage of fat, protein, TS and moisture in the whey of control, experiment I and II are tabulated in Tables 31 and 32.

4.6.1 Fat

The fat content in whey on an average was 0.22±0.016 (range 0.2 to 0.3), 0.28±0.016 (range 0.2 to 0.3) and 0.33±0.021 (range 0.3 to 0.4) per cent in control, experiment I and II whey. Significant difference was

observed between the fat content of control and experimental whey.

4.6.2 Protein

The mean protein content in whey was found to be 0.84±0.02 (range 0.79 to 0.90), 1.00±0.03 (range 0.92 to 1.12) and 1.30±0.06 (range 1.14 to 1.48) per cent respectively for control, experiment I and II whey. Experiment II whey had the highest protein percentage of 1.48 and the minimum value of 0.79 was found in control whey.

Statistical analysis of the data showed that there was significant difference between the protein percentage of control and experimental whey.

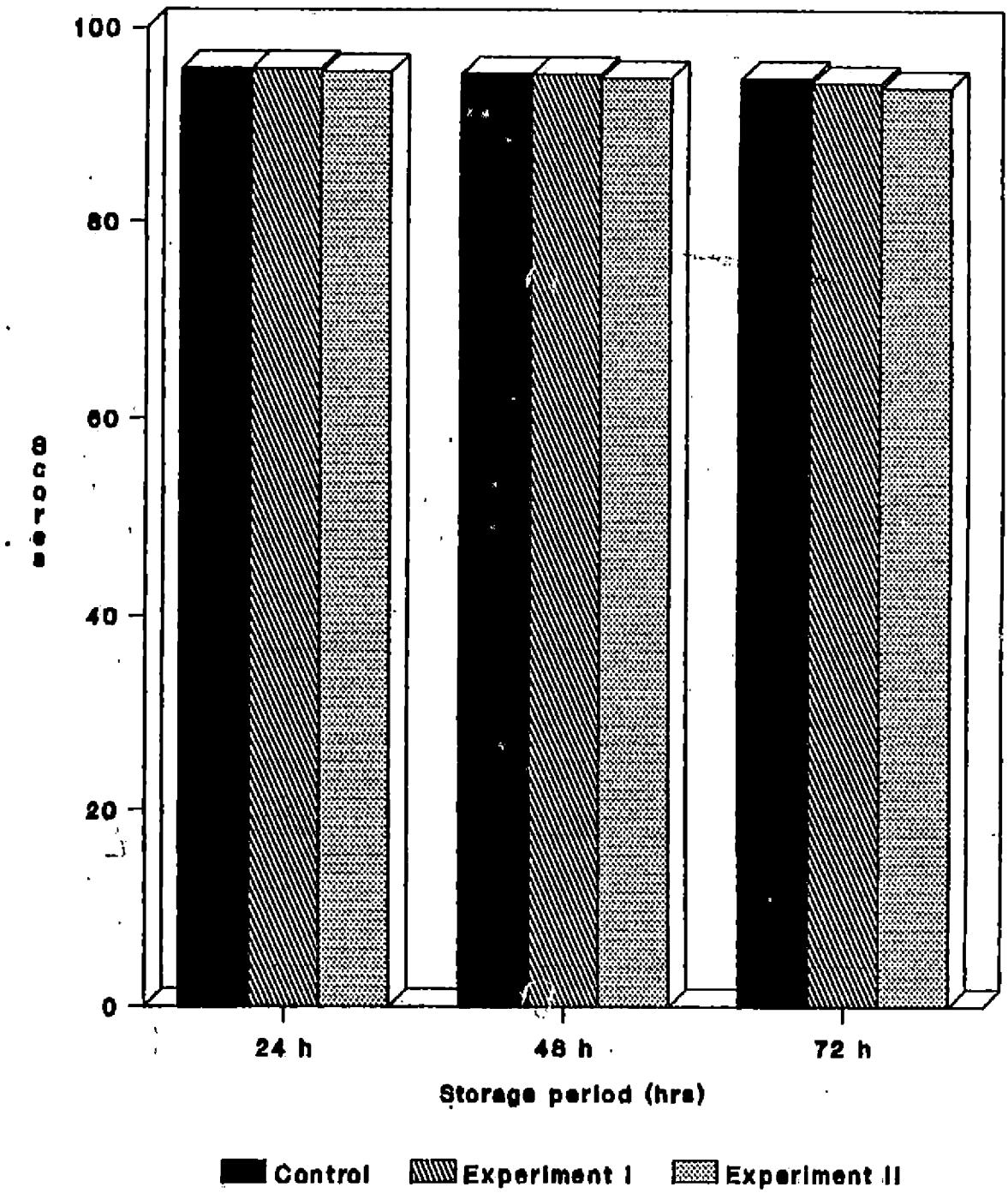
4.6.3. TS content

The mean total solids in whey were 7.72±0.12 (range 7.18 to 7.97), 8.29±0.07 (range 8.16 to 8.60) and 8.79±0.08 (range 8.42 to 8.98) per cent, respectively for control and experimental whey. There was significant difference between the TS content of control and experimental whey on statistical analysis.

4.6.4 Moisture Content

The mean moisture content in whey was 92.28±0.12 (range 92.03 to 92.82), 91.71±0.07 (range 91.40 to 91.84)

Fig.4 SENSORY EVALUATION SCORE OF WHEY DRINKS : PINEAPPLE FLAVOUR



and 91.21±0.08 (range 91.02 to 91.58) per cent, respectively for control, experiment I and II whey. Statistical analysis revealed that there was significant difference in the moisture content of whey from control, experiment I and II.

4.7. Sensory Evaluation of Whey Drink

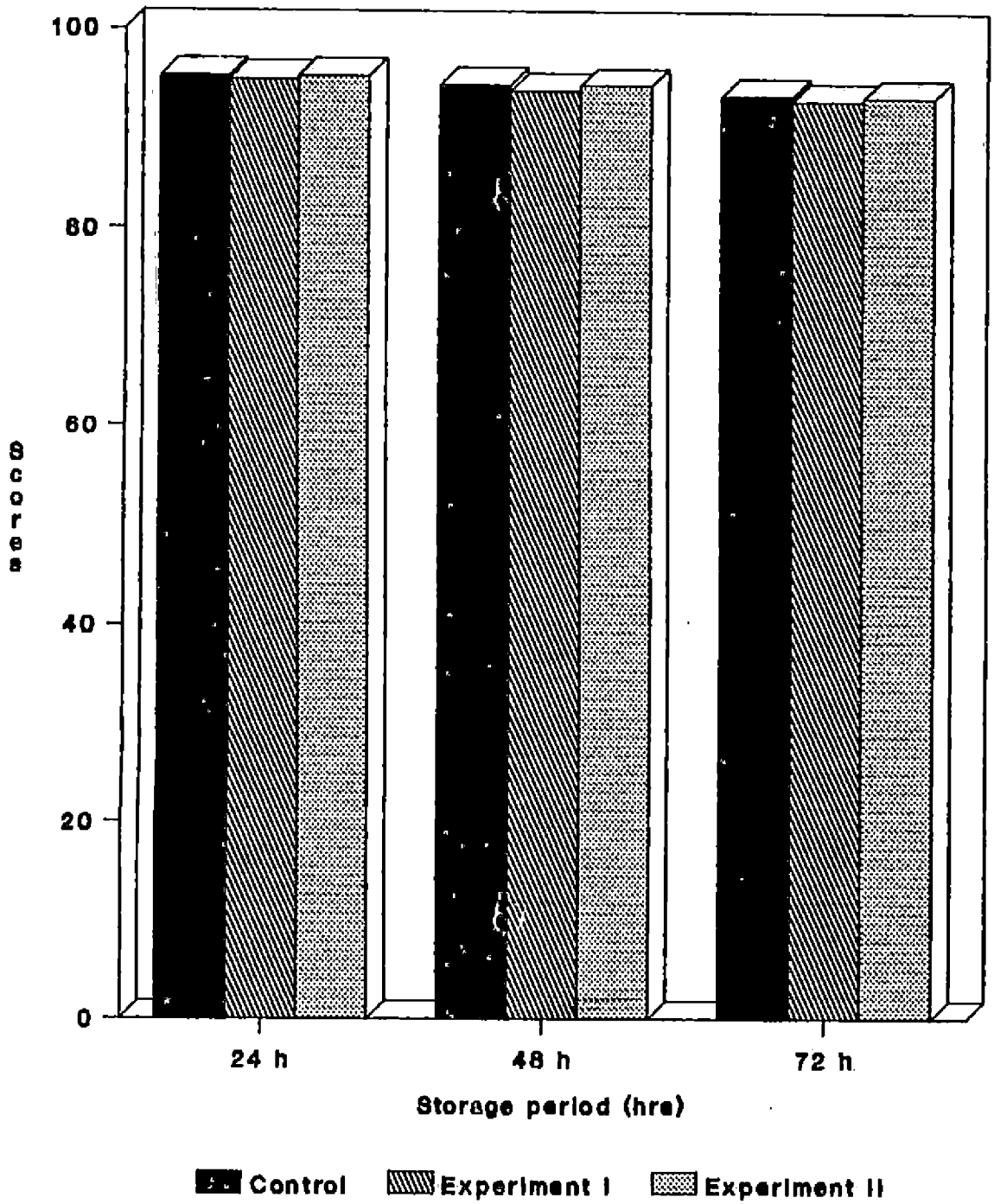
Among the different flavours tried, pineapple and lemon flavours were found to be good. The study was carried out with these two flavours later.

The overall total scores obtained in sensory evaluation of pineapple flavoured control, experiment I and II whey drinks were compared. The mean total score obtained for pineapple flavoured whey drinks on the 24, 48 and 72 hours of storage were 95.87±0.27, 95.87±0.37 and 95±0.49; 95.3±0.34, 95.3±0.24 and 94.97±0.45; 94.93±0.41, 94.47±0.20 and 93.97±0.36 respectively (Tables 33 and 34).

The over all total scores of lemon flavoured control, experiment I and II whey drinks had a mean value of 95.30±0.29, 95.00±0.56 and 95.33±0.30 ; 94.43±0.26, 93.83±0.54 and 94.40±0.29 ; 93.43±0.20, 92.93±0.61 and 93.27±0.33 respectively (Tables 35 and 36).

Both pineapple and lemon flavoured whey drink were found to be similar, on statistical analysis. They were found to have good keeping quality and consumer acceptance for 72 hours under storage at refrigeration temperature.

Fig.5 SENSORY EVALUATION SCORE OF WHEY DRINKS : LEMON FLAVOUR



Carbonation of whey drinks were tried with crown cork bottles. During the carbonation of whey drinks excessive foaming was noticed and the entire liquid was coming out. The crown cork bottle was found to be unsuitable for carbonation of whey drinks and the study was discontinued.

4.8. Total bacterial count of whey drinks

Table 37 shows the total bacterial count of control and experimental whey drinks during storage at 5 ± 1°C for three days.

It may be seen from the Table 37 that the average total bacterial count in whey drinks were 3.2×10^4, 3.4×10^4 and 4.4×10^4; 4.1×10^4, 4.3×10^4 and 4.9×10^4; 4.2×10^4, 4.5×10^4 and 5.2×10^4 CFU/ml of whey drink respectively at the end of 24, 48 and 72 hours of storage for control, experiment I and II whey drinks.

Table 1. Composition of milk used in the preparation of Mozzarella cheese: Control.

Sl. No.	Attributes	Per cent * (W/W)
1	Fat	4.10
2	Protein	3.34
3	T.S.	12.98
4	Moisture	87.02
5	pH	6.70
6	Acidity	0.14

* Average of six trials

Table 2. Composition of milk used in the preparation of Mozzarella cheese: Experiment I

Sl. No.	Attributes	Per cent * (W/W)
1	Fat	4.10
2	Protein	4.32
3	T.S.	14.62
4	Moisture	85.38
5	pH	6.72
6	Acidity	0.14

* Average of six trials

Table 3. Composition of milk used in the preparation of Mozzarella cheese: Experiment II

Sl. No.	Attributes	Per cent * (W/W)
1	Fat	4.00
2	Protein	5.04
3	T.S.	15.58
4	Moisture	84.42
5	pH	6.74
6	Acidity	0.14

* Average of six trials

Table 4. Acid development in Mozzarella cheese during cooking (per cent lactic acid)

Time (in minutes)	Control	Experiment I	Experiment II
0	0.126	0.126	0.126
30	0.153	0.144	0.135
60	0.180	0.171	0.162
90	0.225	0.216	0.207
120	0.270	0.261	0.252
150	0.324	0.315	0.306

Average of six trials

Table 5. Yield of Mozzarella cheese (in percentage)

Replication	Control	Experiment I	Experiment II
1	13.96	12.24	11.88
2	13.82	12.28	12.18
3	14.20	12.86	12.25
4	14.60	13.20	12.54
5	14.75	12.92	12.12
6	14.32	12.84	12.20
Mean	14.28	12.72	12.20
SD	0.36	0.38	0.21
SE	0.15	0.16	0.09

Table 5a. Analysis of variance (CRD)-Yield of Mozzarella cheese

Source	df	SS	MSS	F-Value
Treatment	2	14.026	7.013	65.723**
Error	15	1.601	0.107	
Total	17	15.627		

** P < 0.01 CD = 0.402

Table 6. Comparison of the yield of Experiment I and II Mozzarella cheese

Replication	Experiment I	Experiment II
1	12.24	11.88
2	12.28	12.18
3	12.86	12.25
4	13.20	12.54
5	12.92	12.12
6	12.84	12.20
Mean	12.72	12.20
t-Value	2.960*	

* Significant at 5 % level

Table 7. Moisture percentage in Mozzarella cheese.

Replication	Control	Experiment I	Experiment II
1	48.82	50.12	51.76
2	47.08	49.87	52.08
3	49.58	49.53	52.25
4	49.20	51.20	51.92
5	48.64	49.65	51.88
6	49.72	49.28	50.96
Mean	48.84	49.94	51.81
SD	0.96	0.68	0.45
SE	0.39	0.28	0.18

Table 7a. Analysis of variance (CRD)-Moisture percentage of Mozzarella cheese

Source	df	SS	MSS	F-Value
Treatment	2	27.018	13.509	25.615**
Error	15	7.911	0.527	
Total	17	34.929		

** P < 0.01 CD = 0.893

Table 8. Comparison of the moisture percentage of experiment I and II Mozzarella cheese

Replication	Experiment I	Experiment II
1	50.12	51.76
2	49.87	52.08
3	49.53	52.25
4	51.20	51.92
5	49.65	51.88
6	49.28	50.96
Mean	49.94	51.81
t-Value	5.610**	

** Significant at 1% level

Table 9. Fat percentage of Mozzarella cheese.

Replication	Control	Experiment I	Experiment II
1	21.00	21.00	21.00
2	22.00	22.00	20.00
3	22.00	22.00	21.00
4	22.00	21.00	21.00
5	23.00	21.00	21.00
6	22.00	21.00	21.00
Mean	22.00	21.33	20.83
SD	0.63	0.52	0.41
SE	0.26	0.21	0.17

Table 9a. Analysis of variance (CRD)-Fat percentage of Mozzarella cheese

Source	df	SS	MSS	F-Value
Treatment	2	4.111	2.056	7.400**
Error	15	4.167	0.278	
Total	17	8.278		

** P < 0.01 CD = 0.648

Table 10. Comparison of fat percentage of Experiment I and II Mozzarella cheese

Replication	Experiment I	Experiment II
1	21.00	21.00
2	22.00	20.00
3	22.00	21.00
4	21.00	21.00
5	21.00	21.00
6	21.00	21.00
Mean	21.33	20.83
t-Value	1.860 NS	

NS Not-significant

Table 11. Protein percentage of Mozzarella cheese.

Replication	Control	Experiment I	Experiment II
1	22.82	20.62	19.78
2	23.21	20.47	20.46
3	21.28	20.24	20.32
4	22.70	20.85	20.68
5	21.46	21.18	19.80
6	21.31	19.82	19.92
Mean	22.13	20.53	20.16
SD.	0.87	0.47	0.38
SE	0.36	0.19	0.16

Table 11a. Analysis of variance (CRD)-Protein percentage of Mozzarella cheese

Source	df	SS	MSS	F-Value
Treatment	2	13.156	6.578	17.452**
Error	15	5.654	0.377	
Total	17	18.809		

** P < 0.01 CD = 0.755

Table 12. Comparison of protein percentage of Experiment I and II Mozzarella cheese

Replication	Experiment I	Experiment II
1	20.62	19.78
2	20.47	20.46
3	20.24	20.32
4	20.85	20.68
5	21.18	19.80
6	19.82	19.92
Mean	20.53	20.16
t-value	1.493 NS	

NS Not-significant

Table 13. Fat in Dry Matter (FDM) of Mozzarella cheese (percentage)

Replication	Control	Experiment I	Experiment II
1	41.03	42.10	43.53
2	41.57	43.88	41.74
3	43.55	43.59	43.98
4	43.31	43.03	43.68
5	44.78	41.71	43.64
6	43.75	41.40	42.82
Mean	43.00	42.62	43.23
SD	1.42	1.03	0.83
SE	0.58	0.42	0.34

Table 14. Analysis of variance (CRD)-Fat in Dry Matter (FDM) of Mozzarella cheese

Source	df	SS	MSS	F-Value
Treatment	2	1.150	0.575	0.460 NS
Error	15	18.750	1.250	
Total	17	19.900		

NS - Not-significant

Table 15. Total solids in Mozzarella cheese (percentage)

Replication	Control	Experiment I	Experiment II
1	51.18	49.88	48.24
2	52.92	50.13	47.92
3	50.42	50.47	47.75
4	50.80	48.80	48.08
5	51.36	50.35	48.12
6	50.28	50.72	49.04
Mean	51.16	50.06	48.19
SD	0.96	0.68	0.45
SE	0.39	0.28	0.18

Table 15a. Analysis of variance (CRD)-Total solids in Mozzarella cheese

Source	df	SS	MSS	F-Value
Treatment	2	27.018	13.509	25.615**
Error	15	7.911	0.527	
Total	17	34.929		

** P < 0.01 CD = 0.893

Table 16. Comparison of Total solids content of experiment I and II Mozzarella cheese

Replication	Experiment I	Experiment II
1	49.88	48.24
2	50.13	47.92
3	50.47	47.75
4	48.80	48.08
5	50.35	48.12
6	50.72	49.04
Mean	50.06	48.19
t-value	5.610**	

** Significant at 1% level

Table 17. pH of Mozzarella cheese

Replication	Control	Experiment I	Experiment II
1	5.62	5.62	5.62
2	5.60	5.61	5.60
3	5.61	5.61	5.63
4	5.62	5.62	5.62
5	5.62	5.61	5.61
6	5.62	5.62	5.62
Mean	5.615	5.615	5.617
SD	0.01	0.01	0.01
SE	0.004	0.004	0.004

Table 18. Analysis of variance (CRD)-pH of Mozzarella cheese

Source	df	SS	MSS	F-Value
Treatment	2	0.000	0.000	0.081 NS
Error	15	0.001	0.000	
Total	17	0.001		

NS Not-significant

Table 19. Acidity of Mozzarella cheese (per cent lactic acid)

Replication	Control	Experiment I	Experiment II
1	0.324	0.324	0.333
2	0.333	0.333	0.324
3	0.324	0.333	0.333
4	0.324	0.324	0.333
5	0.333	0.333	0.333
6	0.324	0.324	0.324
Mean	0.327	0.329	0.330
SD	0.00	0.00	0.00
SE	0.0	0.0	0.0

Table 20. Analysis of variance (CRD)-Acidity of Mozzarella cheese

Source	df	SS	MSS	F-Value
Treatment	2	0.000	0.000	0.600NS
Error	15	0.000	0.000	
Total	17	0.000		

NS Not-significant

Table 21. Stretchability of Mozzarella cheese (5 point Arbitrary Scale)

Replication	Control	Experiment I	Experiment II
1	4.67	4.44	4.44
2	4.44	4.22	4.00
3	4.33	4.22	4.11
4	5.00	4.44	4.56
5	4.89	4.78	4.44
6	4.56	4.67	4.89
Mean	4.65	4.46	4.41
SD	0.26	0.23	0.32
SE	0.11	0.09	0.13

Table 22. Analysis of variance (CRD)-Strechability of Mozzarella cheese

Source	df	SS	MSS	F-Value
Treatment	2	0.193	0.096	1.301 NS
Error	15	0.110	0.074	
Total	17	1.303		

NS Not-significant

Table 23. Sensory Evaluation score of Mozzarella cheese - Appearance score (Max.3)

Replication	Control	Experiment I	Experiment II
1	2.80	2.60	2.40
2	3.00	2.80	2.80
3	2.60	2.40	2.60
4	2.80	2.40	2.60
5	2.60	2.60	2.40
6	2.80	2.40	2.40
Mean	2.77	2.53	2.53
SD	0.15	0.16	0.16
SE	0.06	0.07	0.07

Table 24. Analysis of variance (CRD)-Sensory evaluation score of Mozzarella cheese-Appearance score (Max.3)

Source	df	SS	MSS	F-Value
Treatment	2	0.218	0.109	4.298*
Error	15	0.380	0.025	
Total	17	0.598		

* P < 0.05 CD = 0.194

Table 25. Sensory Evaluation score of Mozzarella cheese - Body / Texture score (Max.5)

Replication	Control	Experiment I	Experiment II
1	4.40	4.20	4.40
2	4.50	4.40	4.20
3	4.60	4.60	4.60
4	4.40	4.40	4.20
5	4.40	4.40	4.40
6	4.60	4.20	4.40
Mean	4.48	4.37	4.37
SD	0.10	0.15	0.15
SE	0.04	0.06	0.06

Table 26. Analysis of variance (CRD)-Sensory evaluation score of Mozzarella cheese-Body/Texture score (max.5)

Source	df	SS	MSS	F-Value
Treatment	2	0.054	0.027	1.485 NS
Error	15	0.275	0.018	
Total	17	0.329		

NS Not-significant

Table 27. Sensory Evaluation score of Mozzarella cheese - Flavour score (max.10)

Replication	Control	Experiment I	Experiment II
1	9.20	9.20	8.80
2	9.20	8.20	8.60
3	9.60	8.60	8.20
4	9.40	9.00	8.40
5	9.20	8.80	8.20
6	9.00	8.80	8.60
Mean	9.27	8.77	8.47
SD	0.21	0.34	0.24
SE	0.09	0.14	0.10

Table 28. Analysis of variance (CRD)-Sensory evaluation score of Mozzarella cheese-Flavour score (Max.10)

Source	df	SS	MSS	F-Value
Treatment	2	1.960	0.980	13.364**
Error	15	1.100	0.073	
Total	17	3.060		

** P < 0.01 CD = 0.332

Table 29. Sensory Evaluation score of Mozzarella cheese - Total score (max.18)

Replication	Control	Experiment I	Experiment II
1	16.40	16.00	15.60
2	16.70	15.40	15.60
3	16.80	15.60	15.40
4	16.60	15.80	15.20
5	16.20	15.80	15.00
6	16.40	15.40	15.40
Mean	16.52	15.67	15.37
SD	0.22	0.24	0.23
SE	0.09	0.10	0.09

Table 30. Analysis of variance (CRD)-Sensory evaluation score of Mozzarella cheese-Total score (Max.18)

Source	df	SS	MSS	F-Value
Treatment	2	4.270	2.135	39.294**
Error	15	0.815	0.054	
Total	17	5.085		

** P < 0.01 CD = 0.286

Table 31. Analysis of Whey-control and Experiment I

Sample	Replication	Moisture	Fat	Protein	TS
Control	1	92.17	0.20	0.79	7.83
	2	92.26	0.20	0.82	7.74
	3	92.08	0.20	0.86	7.92
	4	92.03	0.30	0.82	7.97
	5	92.32	0.20	0.85	7.68
	6	92.82	0.20	0.90	7.18
Mean		92.28±0.12	0.22±0.02	0.84±0.02	7.72±0.12
Sample	Replication	Moisture	Fat	Protein	TS
Experiment I	1	91.40	0.2	0.99	8.60
	2	91.74	0.3	0.97	8.26
	3	91.82	0.3	1.04	8.18
	4	91.66	0.3	0.12	8.34
	5	91.84	0.3	0.92	8.16
	6	91.78	0.3	0.94	8.22
Mean		91.71±0.07	0.28±0.02	1.00±0.03	8.29±0.07
t-value		4.27**	2.83*	4.63**	4.27**

* Significant at 5% level P < 0.05
** Significant at 1% level P < 0.01

Table 32 Analysis of whey -control and experiemnt II

Sample	Replication	Moisture	Fat	Protein	TS
Control	1	92.17	0.20	0.79	7.83
	2	92.26	0.20	0.82	7.74
	3	92.08	0.20	0.86	7.92
	4	92.03	0.30	0.82	7.97
	5	92.32	0.20	0.85	7.68
	6	92.82	0.20	0.90	7.18
Mean		92.28±0.12	0.22±0.02	0.84±0.02	7.72±0.12
Sample	Replication	Moisture	Fat	Protein	TS
Experiment II	1	91.08	0.30	1.22	8.92
	2	91.16	0.40	1.48	8.84
	3	91.58	0.40	1.14	8.42
	4	91.14	0.30	1.20	8.86
	5	91.28	0.30	1.32	8.72
	6	91.02	0.30	1.46	8.98
Mean		91.21±0.08	0.33±0.02	1.30±0.06	8.79±0.08
t-Value		7.50**	4.34**	7.73**	7.50**

** Significant at 1% level (P < 0.01)

Table 33. Sensory Evaluation score of Whey Drink-control and experiment-I Maximum score:100 Flavour: pineapple (storage period in hours)

	Control		
Replication	24	48	72
1	96.6	96.2	96.0
2	96.0	96.2	96.2
3	96.2	95.0	95.0
4	94.8	94.2	94.0
5	96.2	95.6	94.6
6	95.4	94.6	93.8
Mean	95.87±0.27	95.3±0.34	94.93±0.41
	Experiment I		
1	97.2	96.0	94.6
2	95.2	95.6	95.2
3	95.6	94.6	94.6
4	96.8	95.8	94.0
5	95.2	95.0	94.6
6	95.2	94.8	93.8
Mean	95.87±0.37	95.3±0.24	94.47±0.20
t-Value	0.000^{NS}	0.000^{NS}	1.021^{NS}

NS Not-significant

Table 34. Sensory Evaluation score of whey Drink-control and Experiment II Maximum score: 100 Flavour: Pineapple (storage period in hours)

Replication	Control 24	Control 48	Control 72
1	96.6	96.2	96.0
2	96.0	96.2	96.2
3	96.2	95.0	95.0
4	94.8	94.2	94.0
5	96.2	95.6	94.6
6	95.4	94.6	93.8
Mean	95.87±0.27	95.3±0.34	94.93±0.41
	Experiment II		
1	94.8	95.0	93.8
2	94.0	93.2	92.6
3	95.6	94.8	93.8
4	97.6	96.4	95.2
5	95.8	95.8	94.6
6	95.2	94.6	93.8
Mean	95.5±0.49	94.97±0.45	93.97±0.36
t-Value	0.653^{NS}	0.086^{NS}	1.776^{NS}

NS Not-significant

Table 35. Sensory Evaluation score of whey Drink-Control and Experiment I Maximum score: 100 Flavour: Lemon (Storage period in hours)

Replication	Control		
	24	48	72
1	94.8	94.4	93.2
2	95.2	93.8	94.0
3	95.8	94.0	92.8
4	94.2	94.0	93.4
5	95.8	95.2	94.0
6	96.0	95.2	93.2
Mean	95.30±0.29	94.43±0.26	93.43±0.20
	Experiment I		
1	94.0	92.6	92.6
2	94.2	93.4	92.8
3	96.8	96.0	95.0
4	95.2	93.4	93.6
5	93.4	92.8	90.4
6	96.4	94.8	93.2
Mean	95.00±0.56	93.83±0.54	92.93±0.61
t-Value	0.476^{NS}	1.012^{NS}	0.775^{NS}

NS Not-significant

Table 36. Sensory Evaluation score of whey Drink-Control and Experiment II Maximum Score: 100 Flavour: Lemon (Storage period in hours)

Replication	Control 24	Control 48	Control 72
1	94.8	94.4	93.2
2	95.2	93.8	94.0
3	95.8	94.0	92.8
4	94.2	94.0	93.4
5	95.8	95.2	94.0
6	96.0	95.2	93.2
Mean	95.3±0.29	94.43±0.26	93.43±0.20
	Experiment II		
1	94.2	93.0	92.2
2	96.0	94.8	93.8
3	94.8	94.6	93.6
4	96.0	94.6	93.4
5	95.2	94.4	92.4
6	95.8	95.0	94.2
Mean	95.33±0.30	94.40±0.29	93.27±0.33
t-Value	0.080^{NS}	0.086^{NS}	0.439^{NS}

NS Not-significant

Table 37. Total bacterial Count of control and experimental whey drinks stored at 5±1°C

Period of storage (hrs)	* Counts /ml whey drink		
	Control	Experiment I	Experiment II
24	3.2×10^4	3.4×10^4	4.4×10^4
48	4.1×10^4	4.3×10^4	4.9×10^4
72	4.2×10^4	4.5×10^4	5.2×10^4

* Average of six trials

Discussion

DISCUSSION

The valuable skim milk which finds limited use can be effectively utilized for developing vegetable fat filled milk and in turn can be converted in to valuable products.

An attempt has been made in the present study to compare the quality of Mozzarella cheese and whey drinks prepared using skim milk filled with coconut fat. It was compared with the similar products prepared from cow milk. Results of the findings are discussed in this chapter in detail.

5.1 Chemical Analysis of Milk

Cheese was prepared from cow milk and used as control. In experiment I and II Mozzarella cheese were prepared from cow milk, in which the fat was replaced to 50 per cent and 100 per cent, respectively, with coconut fat.

5.1.1. Fat

The average values for percentage of fat in milk under control, experiment I and II were 4.1, 4.1 and 4.0 per cent respectively (Table 1, 2 and 3). Ghosh and Singh (1990) reported that Mozzarella cheese from 4 per cent fat was highly suitable for pizza making.

5.1.2. Protein

The average protein percentage of milk under control was 3.34. Under experiment I a value of 4.32 was observed and under experiment II the value obtained was 5.04 per cent (Tables 1, 2 and 3). The cheese milk in which the milk fat was completely replaced with coconut milk had the higher protein content than the control cheese milk. Mini Jose (1992) reported a value of 5.8 per cent protein in coconut milk. This higher protein content of coconut milk might have contributed to the increased protein content of experiment I and II cheese milk. The experiment II cheese milk had the highest protein content among the three milks.

5.1.3. Total solids

The cheese milk had an average total solids content of 12.98, 14.62 and 15.58 per cent respectively, for control, experiment I and II (Tables 1, 2 and 3). A higher total solids content were found in experiment I and II cheese milk than control. The reason was found to be the higher solids content of coconut milk. Agrawal (1991) observed that the milk extracted from coconut had a fat content of 37-38 per cent and an average total solids content of 48 per cent.

5.1.4. Moisture

The average moisture contents of cheese milk were found to be 87.02, 85.38 and 84.42 per cent respectively, for control, experiment I and II Mozzarella cheese (Tables 1, 2 and 3). The moisture content of cheese milk showed a decreasing trend, as the quantity of coconut milk in the blend increased. The control cheese milk had the highest moisture content.

5.1.5. pH

The average pH of cheese milk under control was 6.70. Under experiment I a value of 6.72 was observed and experiment II the value obtained was 6.74 (Tables 1,2 and 3). The pH of cheese milk were found to be almost similar.

5.1.6. Acidity

The average value of acidity in control, experiment I and II cheese milk were found to be similar, the value being 0.14 per cent lactic acid (Tables 1, 2 and 3).

5.2. Acid development in Mozzarella cheese during cooking (per cent Lactic acid)

Acid development in Mozzarella cheese during cooking was observed at regular intervals (Table 4). The increase in acidity in the case of control was from 0.126, 0.153, 0.180, 0.225, 0.270 and 0.324 per cent lactic acid from 0,

30, 60, 90, 120 and 150 minutes of cooking. Corresponding values for experiment I were 0.126, 0.144, 0.171, 0.216, 0.261 and 0.315 per cent lactic acid and for experiment II the same were 0.126, 0.135, 0.162, 0.207, 0.252 and 0.306 per cent lactic acid. The initial acidity at the starting of cooking was similar in all the cases of cheese. Thereafter a slow and steady increase in acidity was observed. This observation was found to be in agreement with the observations made by Mukundan (1989).

The rate of acidity increase in experiment I and II cheese was found slow when compared to control Mozzarella cheese. Hence the cooking period employed was longer to attain the required acidity (Table 4) of 0.32 per cent lactic acid. The slow acid development observed in the present study may be due to the slow growth of the culture organisms in the vegetable fat filled milk.

5.3. Analysis of Mozzarella cheese

5.3.1. Yield

The overall mean yield of Mozzarella cheese were 14.28±0.15, 12.72±0.16 and 12.20±0.09 per cent when prepared from control, experiment I and II cheese milk (Table 5). Latha Sabikhi and Kanawjia (1993) reported the cheese yield of 13.8, 14.52 and 14.40 per cent from a mixture of Goat and Buffalo milk in the ratio of 1:1 using Acetic, Lactic and Hydrochloric acid. Shukla and Ladkani (1989) also reported

the yield of Mozzarella cheese in the range of 10.8 to 13.1 per cent from four per cent fat buffalo milk. The level of casein in the three milks were found to be similar. The low yield of cheese in experiment I and II may be due to poor entrapment of solids in the curd matrix and smaller size of fat globule in coconut milk used for fat replacement. This is in agreement with the findings of Latha Sabikhi and Kanawjia (1992b). They reported an average cheese yield of 11.8 per cent from Goat milk standardized to four per cent fat. The size of the fat globule of Goat milk is smaller than that of the cow's milk.

Statistical analysis showed that the yield of control Mozzarella cheese was significantly higher than the yield of cheese in experiment I and II. This is in agreement with the findings of Sanchez and Rasco (1986), who reported that the yield of cheese decreased as the percentage of coconut milk increased. Comparison made between the yield of cheese in experiment I and II (Table 6), Shows significant difference between the two ($P < 0.05$). However, the yield of cheese was lower that reported by (16.37 ± 0.33) Ghosh and Singh (1990).

5.3.2. Moisture Content

The Mozzarella cheese prepared using cow milk as well as 50 and 100 per cent vegetable fat substituted milk on an

average contained 48.84±0.39, 49.94±0.28 and 51.81±0.18 per cent moisture respectively, for control, experiment I and II (Table 7). The moisture contents in cheeses acidified to a pH of 5.6 reported by Shukla and Ladkani (1989) was 49.0 per cent from four per cent fat buffalo milk. Latha Sabikhi and Kanawjia (1992b) reported low yield (11.80 per cent) with higher moisture content (54.74 per cent) from Goat milk Mozzarella cheese, when compared to control cheese made from four per cent fat buffalo milk. Katara and Bhargava (1992) observed that incorporation of soymilk in milk increase the moisture retention in chhana. Thus, the higher moisture content in experiment I and II Mozzarella cheese might be due to the moisture retention property of vegetable milk.

The moisture content of cheese obtained in the present study is similar to that reported by Ravi Sundar and Upadhyay (1992). The moisture content was 50.23 and 50.07 from standardized (fat/casein, 1:0.7±0.01) buffalo milk, when the whey was drained at 0.30 and 0.35 per cent lactic acid respectively.

Analysis of variance (Table 7a) showed significant difference between treatments (CD=0.893). Comparison made between experiment I and II, showed significant difference (Table 8). The moisture content was lowest in the cheese from cow's milk. The moisture content of control cheese was

lower than the corresponding value reported by Ghosh and Singh (1992).

5.3.3. Fat content

The fat content was 22.00±0.26, 21.33±0.21 and 20.83±0.17 per cent respectively, for control, experiment I and II Mozzarella cheese (Table 9). Latha Sabikhi and Kanawjia (1993) reported a fat percentage of 19.79, 18.49 and 19.26 in Mozzarella cheese from a mixture of Goat and Buffalo milk in the ratio of 1:1 using Acetic, Lactic and Hydrochloric acids, respectively. The fat percentage obtained in the present study was higher than the above findings. However, Ghosh and Singh (1992) reported a fat percentage of 21.7±0.41 which is in agreement with the present study. Upadhyay et al. (1986) also reported a fat percentage of 21.69.

The low fat percentage in experiment II Mozzarella cheese may be due to the highest fat loss in whey, since the melting point of coconut fat is low as compared to cow milk fat. Similar report was made by Mini Jose (1992).

5.3.4. Protein content

The mean protein contents of cheese were 22.13±0.36, 20.53±0.19 and 20.16±0.16 per cent (Table 11) respectively, for control, experiment I and II Mozzarella cheese. Ravi Sundar and Upadhyay (1992) reported protein content of

22.38, 22.54 per cent from four per cent fat buffalo milk in which the whey was drained at 0.30 and 0.35 per cent acidity respectively.

The analysis of variance (Table 11a) showed that there was significant difference between treatments but there was no significant difference between experiment I and II Mozzarella cheese in the protein content (Table 12) i.e., the protein contents were lower in experiment I and II than control but the protein contents were same in experiment I and II.

The protein content of the cheese in the present investigation is in agreement with the findings of Upadhyay et al. (1986), Ravi Sundar and Upadhyay (1991) and Latha Sabikhi and Kanawjia (1993) who reported values of 20.44, 22.38 and 20.72 per cent respectively.

5.3.5. Fat in Dry Matter (FDM) content

The mean FDM content of control Mozzarella cheese was 43.00±0.58 per cent, where as for experiment I and II the same were 42.62±0.42 and 43.23±0.34 per cent, respectively (Table 13) Dianda (1982) observed the dry matter contents of 40.00 per cent and Fat in Dry Matter of 35.00 per cent in commercial Mozzarella cheese sold in Argentina.

Analysis of variance (Table 14) showed no significant difference between the FDM content of control,

experiment I and II Mozzarella cheese. There are no legal standards prescribed for this variety of cheese in India and also no data are available on FDM content of cow milk Mozzarella cheese for comparison. FDM content of over 40 per cent is a must for Mozzarella cheese (Ravi Sundar and Upadhyay, 1990).

5.3.6. Total Solids Content

The mean values obtained for total solids content of Mozzarella cheese were 51.16±0.39, 50.06±0.28 and 48.19±0.18 per cent respectively, for control, experiment I and II (Table 15). Kosikowski (1982) recommended 46 per cent total solids in commercial Mozzarella cheese and 53 per cent total solids in low moisture-Mozzarella cheese.

Analysis of variance (Table 15a) indicates that there was significant difference between treatments (CD=0.893) Comparison made between the total solids content of experiment I and II Mozzarella cheese, showed that there was significant difference between them (Table 16). Eventhough the fat and casein ratio is the same, the yield and total solids were low in experiment I and II. This might be due to the poor entrapment of solids in the curd matrix.

5.3.7. pH

The mean values of pH recorded were 5.615, 5.615 and 5.617 respectively for control, experiment I and II

Mozzarella cheese (Table 17). Statistically the difference was not significant. This observation was in accordance with that reported by Latha Sabikhi and Kanawjia (1992b).

5.3.8. Acidity of Mozzarella Cheese

The mean values obtained were 0.327, 0.329 and 0.330 per cent lactic acid for control, experiment I and II Mozzarella cheese respectively (Table 19). Similar values were observed by Patel et al. (1986). Analysis of variance indicates no significant difference between treatment with regards to acidity of cheese (Table 20). This is expected as the cheese was plasticized at the same acidity.

5.4. **Stretchability of Mozzarella cheese**

Stretchability was graded on a five point arbitrary scale where five represented the maximum score for the best product. The overall mean score of control Mozzarella cheese was 4.65±0.11, as against 4.46±0.09 and 4.41±0.13 respectively, for experiment I and II (Table 21). Latha Sabikhi and Kanawjia (1992b) had reported an average arbitrary score of 4.07 in the cheese made from four per cent fat buffalo milk and 4.98 from the 1:1 admixture of Goat and Buffalo milk.

There was no significant difference in the stretchability of control and experimental Mozzarella cheese (Table 22). There are no reports available on

stretchability of Mozzarella cheese from vegetable fat filled milk for comparison.

5.5 Sensory Evaluation

The overall mean score and total score for appearance, body/texture and flavour of control, experiment I and II Mozzarella cheese are presented in Tables 23, 25, 27 and 29. The mean score obtained for appearance were 2.77±0.06, 2.53±0.07 and 2.53±0.07. Mean score obtained for body/texture were 4.48±0.04, 4.37±0.06 and 4.37±0.06. Mean value obtained for flavour were 9.27±0.09, 8.77±0.14 and 8.47±0.10. The over all mean total score were 16.52±0.09, 15.67±0.10 and 15.37±0.09, respectively.

The analysis of variance (Tables 24, 26, 28 and 30) indicates that there was significant difference in appearance, flavour and total score of Mozzarella cheese between treatments. Both experiment I and II had the same value for appearance and body/texture. Body/texture score of experiment I and II Mozzarella cheese was comparable with that of control cheese. Patel et al. (1986) reported that those Mozzarella cheeses that scored less than 10 points were considered to be unacceptable. As all the Mozzarella cheese scored more than 85 per cent of the total score, the product made from all kinds of cheese milk were acceptable.

The low score obtained for flavour of experiment I and II Mozzarella cheese may be due to natural flavour of

coconut fat, which is unnatural for original Mozzarella cheese.

5.6. Chemical Analysis of Whey

5.6.1. Fat

The fat contents in the whey samples were 0.22±0.016, 0.28±0.016 and 0.33±0.021 per cent in control, experiment I and II cheese milk respectively. Significant difference was observed between the fat content of whey (Tables 31 and 32). Lower fat per cent in whey was observed in control cheese whey than experiment I and II cheese whey. From the Tables 9, 31 and 32, it was observed that higher the fat content in cheese, the lower the fat in whey vice-versa This might be due to the higher melting point of milk fat as compared to coconut fat.

5.6.2. Protein

The mean protein content in whey was found to be 0.84±0.02, 1.00±0.03 and 1.30±0.06 per cent respectively, for control, experiment I and II cheese. The increased protein content of the whey obtained from experiment II Mozzarella cheese is explainable. As the percentage of the fat replacement increased, more coconut milk was added to the skim milk. This resulted in an increase in the protein content of the milk used in the experiment II. A major portion of the excess protein might have escaped in

to the whey due to higher fat to protein ratio in the cheese milk.

Statistical analysis showed (Tables 31 and 32) significant difference between the protein content of control, experiment I and II whey.

5.6.3. Total Solids content

The mean total solids found in whey was 7.72±0.12 per cent for control, 8.29±0.07 per cent for experiment-I and 8.79+0.08 per cent for experiment II. Latha Sabikhi and Kanawjia (1992b) reported 7.56 and 8.23 per cent total solids in whey from four per cent fat Buffalo milk and Goat milk respectively.

There was significant difference between the TS content of control, experiment I and II whey on statistical analysis (Tables 31 and 32). A higher total solids in experiment I and II whey were observed. This might be due to the chemical nature of protein and fat that lead to heavier loss of milk solids in the whey.

5.6.4. Moisture content

The mean moisture content in whey was 92.28±0.12, 91.71±0.07 and 91.21±0.08 per cent respectively, for control, experiment I and II cheese whey. Statistical analysis revealed that there was significant difference in

the moisture content of whey from control experiment I and II (Tables 31 and 32). This is expected as the total solids content in higher in experiment I and II cheese whey.

5.7. Sensory Evaluation of whey drinks

The overall total scores obtained in sensory evaluation of pineapple flavoured control, experiment I and II whey drinks were compared. Pineapple flavoured control whey drinks obtained a total score with a mean value of 95.87±0.27, 95.3±0.34 and 94.93±0.41 respectively, at the end of 24, 48 and 72 hours of storage at 5±1°C. Similarly experiment I whey drink obtained a total mean value of 95.87±0.37, 95.3±0.24 and 94.47±0.20 and experiment II whey drink obtained a total mean value of 95.0±0.49, 94.97±0.45 and 93.9±0.36 (Table 33). Both control, experiment I and II whey drinks were graded excellent on 24, 48 and 72 hours of storage. Similar observation was reported by Mini Jose (1992).

Lemon flavoured control whey drink obtained a total mean value of 95.3±0.29, 94.43±0.26 and 93.4±0.20 respectively, at the end of 24, 48 and 72 hours of storage at 5±1°C. Similarly experiment I whey drink obtained a total mean score of 95.0±0.56, 93.83±0.54 and 92.93±0.61 and experiment II whey drink obtained a total mean value of 95.3±0.30, 94.4±0.29 and 93.27±0.33 respectively (Table 35&36). The whey drink were graded as excellent on 24, 48 and 72

hours of storage. Similar observation was reported by Mini Jose (1992).

Statistical analysis revealed that both pineapple and lemon flavoured whey drinks were not significantly different from each other. They were found to have good keeping quality and consumer acceptance for 72 hours of storage under refrigerated condition (5±1°C). Ropiness was noticed after 96 hours of storage in all samples and hence the samples were not subjected to sensory evaluation.

5.8. Total Bacterial Count of Whey Drinks

The average total bacterial count in whey drinks were 3.2×10^4, 3.4×10^4 and 4.4×10^4; 4.1×10^4, 4.3×10^4 and 4.9×10^4; 4.2×10^4, 4.5×10^4 and 5.2×10^4 CFU/ml of whey drink respectively at the end of 24, 48 and 72 hours of storage for control, experiment I and experiment II whey drinks (Table 37).

A higher count was observed in experiment I and II whey drinks. Arumughan et al. (1993) reported a total count of 10^4 to 10^5/ml in fresh coconut milk and 10^2 to 10^3/ml in pasteurized samples. Bacillus was present in all the samples. So the higher count in experiment I and II might have contributed by coconut milk, which involves various process.

The temperature and time employed for heating of whey drink was 70°C for 10 minutes. This would not be sufficient to destroy all the vegetative bacteria and spore formers.

5.9. Conclusion

From the foregoing results it was found that acceptable good quality of Mozzarella cheese and whey drinks could be prepared from skim milk. This method can be recommended for utilizing skim milk efficiently.

Addition of coconut milk to skim milk decreased the yield, protein and fat in the experiment I and II Mozzarella cheese. The products prepared in experiment I and II were found to be similar in their protein and fat content. However, the yield of cheese was higher in 50 per cent fat replaced milk than that of 100 per cent fat replaced milk. The Mozzarella cheese prepared in the experiment work was found to be of good quality and comparable with the control Mozzarella cheese. No significant difference was observed in FDM, acidity, pH and stretchability between control, experiment I and II Mozzarella cheese.

On sensory evaluation, experiment I and II Mozzarella cheese had secured low score for appearance and flavour

than control Mozzarella cheese, but body/texture resembled that of control Mozzarella cheese. The total solids recovery was the maximum and losses through whey were minimum in control Mozzarella cheese than experiment I and II Mozzarella cheese.

Whey drinks prepared from control, experiment I and II whey were found to be 'Excellent' on sensory evaluation. Pineapple and lemon flavoured experiment I and II whey drinks were found to resemble control whey drinks, when evaluated at the end of 24, 48 and 72 hours of storage at 5±1°C.

Summary

SUMMARY

. A detailed study was carried out to determine the quality of vegetable fat (Coconut fat) filled milk for the preparation of mozzarella cheese and whey drinks. The chemical and organoleptic quality of mozzarella cheese, composition of whey and sensory evaluation of whey drinks prepared by using 50 per cent and 100 per cent vegetable fat filled-skim milk were compared to those prepared from whole cow milk.

Control, experiment I and Experiment II cheese milk samples were analysed for fat, protein, total solids, moisture, pH and acidity. Mozzarella cheese were prepared as per the procedure given by Kosikowski (1982). Filled milk prepared by mixing skim milk with cream and coconut fat (1:1 ratio) and 100 per cent coconut fat standardized to four per cent fat was used for the preparation of experiment I and II samples of mozzarella cheese. The whey obtained were converted to whey drinks by adding sugar, colour and flavour. A total of six trials were carried out in the present experimental studies.

The following analyses in cheese were carried out: yield, moisture, fat, protein, FDM, total solids, pH and acidity etc. Acid development in cheese during cooking and stretchability of cheese were also estimated. The

prepared products were also subjected to sensory evaluation and compared with the control sample.

The average values for percentage of fat in milk under control, experiment I and II were 4.1, 4.1 and 4.0 per cent respectively. Protein percentage of milk under control was 3.34, 4.32 in experiment I and 5.04 per cent in experiment II cheese milk. The cheese milk had an average total solids content of 12.98, 14.62 and 15.58 per cent respectively, for control, experiment I and II.

The average pH of cheese milk under control was 6.70, 6.72 in experiment I and 6.74 in experiment II. The average value of acidity in control, experiment I and II cheese milk were found to be similar, the value being 0.14 per cent lactic acid.

Acid development in Mozzarella cheese during cooking were observed. The average values obtained were 0.126, 0.126 and 0.126 per cent; 0.153, 0.144 and 0.135 per cent; 0.180, 0.171 and 0.162 per cent; 0.225, 0.216 and 0.207 per cent; 0.270, 0.261 and 0.252 per cent; 0.324, 0.315 and 0.306 per cent respectively, for control, experiment I and II mozzarella cheese, at the end of 0, 30, 60, 90, 120 and 150 minutes of cooking.

The overall mean yield of cheese were 14.28$\pm$0.15, 12.75$\pm$0.16 and 12.20$\pm$0.09 per cent respectively, for control,

No significant difference were noticed between control, experiment I and II mozzarella cheese with regard to their FDM, pH, Acidity and stretchability.

The mean values obtained for total solids content of mozzarella cheese were 51.16±0.39, 50.06±0.28 and 48.19±0.18 per cent respectively, for control, experiment I and II. Analysis of variance indicates that there was significant difference between treatments ($P < 0.01$), (CD = 0.893||. Comparison between experiment I and II showed significant difference in their total solids content.

On sensory evaluation, the mean score obtained for appearance were 2.77±0.06, 2.53±0.07 and 2.53±0.07; 4.48±0.04, 4.37±0.06 and 4.37±0.06 for body/texture; 9.27±0.09, 8.77±0.14 and 8.47±0.10 for flavour; 16.52±0.09, 15.67±0.10 and 15.37±0.09 for mean total score respectively, for control, experiment I and II cheese samples. Both experiment I and II mozzarella cheese got low score for flavour, but the cheese made from all kinds of cheese milk were found acceptable.

The mean fat percentage of whey samples were 0.22±0.016, 0.28±0.016 and 0.33±0.021 per cent in control, experiment I and II respectively. Statistical analysis showed significant difference between treatments.

The mean protein content in whey was 0.84±0.02 for control, 1.00±0.03 for experiment I and 1.30±0.06 per cent for experiment II. Statistical analysis showed significant different between the protein content of control, experiment I and II whey samples.

The mean total solids in whey was 7.72±0.12 per cent for control, 8.29±0.07 per cent for experiment I and 8.79±0.08 per cent for Experiment II. There was significant difference between the TS content of control, experiment I and II whey.

The mean moisture content in whey was 92.28±0.12, 91.71±0.07 and 91.21±0.08 per cent respectively, for control, experiment I and II whey. Statistical analysis revealed that there was significant difference in moisture content of whey from control, experiment I and II.

Whey drinks were prepared using pineapple and lemon flavour from control, experiment I and II whey. Pineapple flavoured control whey drink obtained a mean total score of 95.87±0.27, 95.3±0.34 and 94.93±0.41, similarly experiment I whey drinks obtained a mean total score of 95.87±0.37, 95.3±0.24 and 94.47±0.20 and experiment II whey drink obtained a mean total score of 95.0±0.49, 94.97±0.45 and 93.9±0.36 respectively, on the 24, 48 and 72 hours of storage at 5±1°C.

Lemon flavoured control whey drink obtained a mean total score of 95.3±0.29, 94.43±0.26 and 93.4±0.20, similarly experiment I whey drink obtained a mean total score of 95.0±0.56, 93.83±0.54 and 92.93±0.61 and experiment II whey drink obtained a mean total score of 95.3±0.30, 94.4±0.29 and 93.27±0.33 respectively, on the 24, 48 and 72 hours of storage at 5±1°C

Control, experiment I and II whey drinks were graded as 'excellent' on the 24, 48 and 72 hours of storage. Statistical analysis revealed that both pineapple and lemon flavoured whey drinks were not singnificantly different from each other.

The average total bacterial count in whey drinks were 3.2×10^4, 3.4×10^4 and 4.4×10^4; 4.1×10^4, 4.3×10^4 and 4.9×10^4; 4.2×10^4, 4.5×10^4 and 5.2×10^4 CFU/ml of whey drink respectively, for control, experiment I and II whey drinks at the end of 24, 48 and 72 hours of storage at 5±1°C.

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*** Originals not seen**

PREPARATION OF MOZZARELLA CHEESE USING SKIM MILK FILLED WITH COCONUT MILK

By

GNANA SELVA JOHNSO

ABSTRACT OF A THESIS

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Kerala Agricultural University

Department of Dairy Science
COLLEGE OF VETERINARY AND ANIMAL SCIENCES
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ABSTRACT

A detailed study was carried out to determine the quality of coconut fat filled milk for the preparation of Mozzarella cheese and whey drinks. Literatures based on filled milk products has been reviewed, apart from the preparation of cheese and whey drinks.

The control samples of Mozzarella cheese and whey drinks were prepared using cow's milk. Experiment I products were prepared from milk in which 50 per cent of milk fat was replaced with coconut fat. Experiment II products were prepared from cheese milk in which 100 per cent of milk fat was replaced with coconut fat. All the samples of milk were standardized to 4 per cent fat. A total of 6 trials were carried out to obtain reliable data for statistical analysis.

The acidity, pH, stretchability and FDM content were found to be similar in control, experiment I and II Mozzarella cheese. Eventhough, the control Mozzarella cheese were found to have slightly higher yield, protein, fat and lower moisture content, the experiment I and II. Mozzarella cheese also satisfied the requirements for good quality Mozzarella cheese.

The control Mozzarella cheese got maximum score on sensory evaluation than the experiment I and II Mozzarella cheese.

Pineapple and Lemon flavoured control, experiment I and II whey drinks were found to be equally acceptable with no difference on storage studies ar 5±1oC. Total bacterial count on whey drinks were also made.

The studies revealed that the cow milk in which the milk fat replaced to the extend of 50 per cent and 100 per cent with coconut fat can be effectively utilized for preparation of Mozzarella cheese. The quality of such cheese is comparable with that made from cow milk.