USE OF COCONUT CREAM IN FLAVOURED FILLED YOGHURT

By

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THESIS
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DECLARATION

I here by declare that the thesis entitled **'USE OF COCONUT CREAM IN FLAVOURED FILLED YOGHURT'** 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 of any degree, diploma, associateship, fellowship or other similar titles, of any other university or society.

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Dedicated to my family members,
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LIST OF ABBREVIATIONS

BIS	Bureau of Indian Standards
CD	Critical difference
cp	Centipoise
CT	Curd tension
cfu	Colony forming units
g	Gram
h	Hours
MSNF	Milk solids not fat
mg	Milligram
Min	Minimum
Max	Maximum
NPN	Non protein nitrogen
NS	Not significant
NFDM	Non fat dry milk
p	Poise
SA	Sodium alginate
SE	Standard error
SNF	Solids not fat
TS	Total solids
WPC	Whey protein concentrate

Introduction

1. INTRODUCTION

High quality nutrients of milk can be preserved by fermentation process. The preparation of fermented milks are achieved by the action of lactic acid bacteria, inoculated to milk as starter cultures. The fermented milk has become more popular due to its appealing taste as well as extended shelf-life. The survival of pathogenic microflora in fermented milks are decreased due to its low pH.

Yoghurt- the western counterpart of curd, is one of the fermented milks, which is being associated with several health benefits. Consumption of yoghurt is recommended as a remedy for gastrointestinal disorders and for lactose intolerant people. It is also recommended in immune system stimulation, cancer suppression (Buttriss, 1997) and blood cholesterol reduction (Rao *et al.*, 1981).

The nutritional attributes of yoghurt is worth mentioning. The protein in yoghurt is twice as digestible than milk and it contains increased level of free amino acids as compared to milk (Deeth and Tamine, 1981). It is an excellent source of calcium, phosphorus and potassium. In yoghurt, bioavailability of copper, calcium, iron, zinc, manganese and phosphorus are high as compared to milk (Sherwood, 1990). It is also packed with significant quantities of several vitamins and hence it is a valuable adjunct to any healthy diet.

India secures first place in world milk production with an output of 74.3 million metric tonnes per annum. However the per capita milk availability is 214 g, which is lower than the ICMR recommendation of 220 g per day. Out of the total-milk produced in India 27.5 per cent is converted to ghee, 6.5 per cent to makkhan, 6.9 per cent to dahi, 6.5 per cent to khoa and condensed milk, 3.7 per cent to milk powder, 1.9 per cent to paneer, channa and cheese, 0.6 per cent to ice-cream and kulfi, 0.2 per cent to cream and 0.5 per cent to other products. (Gupta, 1997). Eventhough the dairy products preparation are in full swing, many products are out of reach to the common man, due to their high cost. Consequently to liberalisation policy implemented by the Government, many multinationals are entering the growing dairy sector in India for bulk production of dairy products. So, in future the availability of fluid milk may further be reduced eventhough the Government is controlling the situation by imposing rules such as Milk and Milk Product Order, 1992 (MMPO).

The availability of fluid milk can be increased, if by products from various sources other than milk are used in the manufacture of dairy analogues. Moreover, substitution of expensive milk fat with cheaper fats can reduce the cost of production of dairy foods. Thus these nutritious products can be made available to the weaker sections of the community. If the milk fat and SNF are spared, it can be used in the manufacture of baby foods and other vital food items. Thus the production of yoghurt in which milk fat is partially and fully replaced by vegetable fat is worth mentioning.

A dairy product analogue is a substitute, in which the general composition, appearance and characteristics intended to simulate milk or milk product and the milk solid constituents are wholly or partly replaced with non-dairy ingredients (Kaushik *et al.*, 1997).

In India, coconut possesses a documented history of about 3000 years. The crop is extensively grown in the Western and Eastern coasts and has a profound influence on the economy of many South Indian states. Presently, India ranks first position in world coconut production with an annual production of 13,300 million nuts (Thampan, 1997). It is estimated that 55 per cent of coconut produced in the country is used for culinary preparation and 36 per cent is converted into oil, which is utilised for industrial purposes and that minor fraction infact determines the price of coconut in Kerala and neighbouring states. More often, the price of coconut oil is depend on the price of other edible oils, their internal production and import to the country. The liberalised import policy implemented by the Government has aggravated the situation. Such uncertainty in prices are likely to adversely affect the crop production and economy of the South Indian states. The problems associated with price fluctuation can be over come to some extent by finding diversified uses for coconut.

Scientists and physicians attributed several nutritional and medicinal properties for coconut. It contains organic iodine which can prevent goitre. It is also used to cure constipation, dysentery and intestinal inflammation.

Coconut oil and Kernel are used in 'Ayurveda' (Warrier, 1994) to relieve burning sensation and to heal lesions. It subsides the heat, clears blood impurities and promotes sexual potency. Coconut oil and kernel is also used in 'Homoeopathy' to treat eruptive fevers, convalescence after gastric problems, carcinoma etc. (Vidya prakash, 1994). Several beneficial properties are attributed to coconut oil and kernel by naturopaths also (Ulpalakshan, 1994).

Reports are there regarding the use of coconut cream in the preparation of dairy analogues such as paneer and rasogolla (Mini Jose, 1992), mozzarella cheese (Johnson 1994) and icecream (Geevarghese 1996). The possibility of developing filled yoghurt is worth considering. The organoleptic and textural qualities of any filled product is an important criteria as far as consumer acceptance is concerned. Reports are available regarding the use of stabiliser, flavour and colour in improving the above attributes. These additives were also tried while making the product. Successful development of a flavoured filled yoghurt will definitely reduce the cost and there by increase its availability. This study will also increase the diversified use and demand of coconuts which will be beneficial for the coconut growers of the South Indian states. The main objective of the study was to asses the feasibility of incorporating coconut cream in place of milk fat and to study its physico-chemical, micro-biological and organoleptic qualities of the flavoured filled yoghurt.

Review of literature

2. REVIEW OF LITERATURE

Coconut (cocos nucifera L.) is a cherished, delicious food in many parts of the world. The main objective of incorporating coconut cream in place of milk fat in filled yoghurt is to reduce the cost. Literature on coconut cream incorporated yoghurt is limited. However, a review is attempted here, with available literatures regarding the physico-chemical, micro-biological and organoleptic properties of yoghurt in which various dairy and non-dairy products are incorporated.

2.1 Differentiation of coconut cream and coconut milk

Coconut cream and coconut milk are differentiated by their composition. The term coconut cream unless otherwise modified shall refer exclusively to the aqueous coconut product expressed from disintegrated moist solid coconut endosperm. Coconut cream contains minimum 18.5 per cent coconut fat and maximum 77.6 per cent water. It should have a minimum of 25 per cent total solids. On the other hand coconut milk have 11.5, 86.1 and 15.0 percentage of fat, water and total solids respectively (APCC 1992).

2.2 Composition of coconut cream

Walker (1906) reported that coconut cream contained 56.3 per cent water, 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 total sugar as invert sugar. The values presented by Jaganathan (1970) were 50 per cent moisture, 40 per cent fat, 3 per cent protein, 1.5 per cent ash and 5.5 per cent carbohydrate.

Analysis of Philippine coconut milk revealed that it contained 46.5 per cent water, 53.5 per cent total solids and 10.1 per cent SNF (Banzon, 1978). The analysis of coconut cream at Central Food Technological Research Institute, Mysore revealed that composition containing 41 per cent water, 5.8 per cent protein, 38.40 per cent fat 6.2 per cent minerals and 9.11 per cent carbohydrates (Thampan, 1984).

The composition reported by Geevarghese (1996) were (in percentage) 47.71 moisture, 52.29 total solids, 38.95 fat, 5.771 protein, 6.549 carbohydrate and 1.02 ash.

2.3 Composition of dairy ingredients

According to Indian Standards Institution (IS : 1165, 1967) the skim milk powder should contain 95.3 per cent total solids (per cent weight) and less than 1.5 per cent fat whereas Prevention of Food Adulteration Act -1954 specification is less than 5 per cent moisture, less than 1.5 per cent fat for skim milk powder, not less than 0.5 per cent fat, minimum 8.7 per cent SNF for skim milk and not less than 25 per cent for cream respectively.

Hall and Hedrick (1971) reported that skim milk powder contains (percentage) 0.8 fat, 3.0 moisture, 35.9 protein, 52.3 lactose. Sukumar De (1980) reported that milk cream contains (percentage) 45.45 moisture, 50 fat, 1.69 protein, 2.47 lactose, 54.55 total solids. Webb *et al.*, (1987) reported that skim milk contains (percentage) 90.5 moisture, 0.1 fat, 3.6 protein, 5.1 lactose. Shakeel-Asgar and Thompkinson (1994) reported that milk cream contains 58-62 per cent fat.

2.4. Addition of non-dairy ingredients in yoghurt

2.4.1 Oat

Donald (1996) supplemented hydrolysed oat flour in skim milk to prepare low fat filled milk with good texture and taste and was utilised for use in the preparation of low fat yoghurt and other low fat dairy products to reduce blood cholesterol level.

2.4.2 Soyabean

The qualities of yoghurt and Zabadi were evaluated by EL-Soda *et al.*, (1979) and Schmidt *et al.*, (1980) by fortification of cow milk with oil seed proteins (peanut flour, soy protein isolate and cotton seed flour). They observed that the texture of yoghurt coagulum was improved by heating the fortified milk to 90°C. The addition of stabilisers was recommended for milk fortified with peanut flour for improving the texture of yoghurt. They observed that the addition of high levels of cotton seed flour resulted in yoghurt with a salty flavour, weak texture, yellowish discolouration and slow acid production.

The addition of soya milk to buffalo milk at concentrations of 0,10,20 or 30 per cent prior to manufacture of Zabadi (Egyptian yoghurt) was investigated by EL-Sayed *et al.*, (1988). Results showed that addition of soya milk to the buffalo milk decreased the pH values throughout the incubation period. Titratable acidity increased with the addition of 10 per cent soya milk and decreased with higher concentrations of soya milk.

Cheng *et al.*, (1990) prepared two sogurt products by making a formulation containing soya milk, 0.15 per cent calcium acetate, 0.5 per cent gelatin and lactose (0 or 2 per cent) with *L. caesi* and *S. thermophilus*. Commercial plain yoghurt was used as a control. Sogurts were evaluated for aroma, taste, texture, titratable acidity, pH and colour. They had 'beany' and 'raisin' aromas, more bitter and astringent tastes than yoghurt and a slightly sandy mouth-feel. Sogurt and yoghurt did not differ significantly ($P < 0.05$) in intensity of butter aroma. Sogurt with lactose did not differ ($P < 0.05$) from yoghurt in acidity.

2.4.3 Cotton seed protein

Moharram *et al.*, (1992) prepared a type of yoghurt - Zabadi by incorporating cotton seed flour. They reported that zabadi with satisfactory chemical and sensory properties could be made from cow milk fortified with cotton seed flour added at 5 to 15 per cent levels.

2.4.4 Groundnut protein

Syoei (1974) reported that pealed groundnut cotyledons were heated under pressure in saturated sodium chloride solution and was ground with hydrated dextrin sugar and casein prior to powdering and it was used in the yoghurt preparation.

2.4.5 Sunflower protein

Bilani *et al.,* (1989) studied the effect of replacing milk proteins with sunflower concentrate at the level of 0 to 20 per cent for maintaining the total protein content in yoghurt at 4 per cent. The results indicated that sunflower protein had no gel forming ability in normal condition and it interacted with caesin micelles and produced a softer gel.

2.4.6 Coconut milk

Sanchez and Rasco (1984) used coconut milk as a cow's milk extender in the manufacture of yoghurt. Formulations were prepared by using various combinations of coconut milk and dried skim milk. The 50 per cent coconut milk and 50 per cent dried skim milk combination approached the desired pH, acidity and viscosity necessary for a good quality yoghurt.

Davide (1985) reported that yoghurt can be prepared by blending milk and coconut flavoured with fruits. The resultant product was very much acceptable. Davide *et al.,* (1990) developed a pineapple flavoured yoghurt 'Niyogurt' from blends of water extracted coconut milk and skim milk powder. The gross composition of 'Niyogurt' was similar to that made from cow's milk. It had 4.36 per cent protein, 1.07 per cent total ash, 1.9 per cent fat, 23.99 per cent total solids, 1.386 per cent acidity and 3.92 pH. "Niyogurt' was highly acceptable to 97.93 per cent consumers who tasted the product. This study also revealed that coconut milk as a fat carrier, can be used as a substitution for butter fat in the preparation of cheese and yoghurt from skim milk powder thus providing appropriate technologies for new dairy foods.

Mini Jose (1992) prepared indigenous dairy products such as Paneer, Rasogolla and Whey drink from skim milk filled with coconut milk and found that addition of coconut milk resulted in an increase of total protein in the filled milk, over and above that of cow's milk.

Johnson (1994) prepared mozzarella cheese using skim milk filled with coconut milk and found that the protein content increased from 3.34 to 5.04 per cent in the final product.

2.5 Factors responsible for quality of yoghurt

2.5.1 Quality of milk

Acid production by various lactic cultures in cow and buffalo milk was reported by Thomas *et al.*, (1966). They found that a marked increase in acid production in buffalo milk as compared to cow milk.

Iyengar *et al.*, (1967) reported that mixed cultures of *S. thermophilus* and *L. bulgaricus* produced more acid in buffalo milk than in cow milk.

Rangappa and Achaya (1973) reported that the initial acidity and physical properties of milk has a considerable effect on the texture and taste of dahi and yoghurt. Milk stored for too long, before seeding often gives rise to broken curd of poor taste.

Singh and Singh (1980) studied the influence of somatic cell count in buffalo milk on the quality of fermented milk. They found that dahi and yoghurt prepared form high somatic cell count milk had low acidity even after 8 h of incubation. Poor body and texture with unsatisfactory flavour characteristics and wheying - off tendency were evident in the above dahi and yoghurt.

2.5.2 Homogenization

Pette (1964) emphasized the need for homogenization to improve the firmness of curd. Efficient homogenization prevents butter fat separation on storage, lowers the curd tension and results in the formation of soft finely divided curd.

Mulder and Walstra (1974) showed that homogenization process splitted the fat globules, increased the density and reduced their tendency to agglutinate. The fat got evenly and permanently dispersed through the liquid and did not separate out during incubation.

Tamine and Deeth (1980) found that homogenization caused an increased coagulum stability and viscosity of yoghurt. It also improved the organoleptic quality of the product.

Homogenization is the process by which the fat globules in milk or cream are broken down into smaller size by mechanical force. Due to reduction in globule diameter there will be an increase in the surface area of fat globule by 4 to 6 times. The increased surface area contributed to the higher viscosity and whiter appearance of the product. The small sized globules would have less tendency for clumping and rising to the surface of the product (Tamine and Robinson, 1988).

2.5.3 Inoculation and incubation of the mix

Lal *et al.*, (1978) found that for successful preparation of yoghurt a proper symbiotic growth between *S. thermophilus* and *L. bulgaricus* is required. They reported that the combinations of *S. thermophilus* and *L. bulgaricus* in the ratio of 1:2 and 1:1 gave best results.

Tamine and Robinson (1985) prepared yoghurt mix after pasteurization and later cooled to 42°C and inoculated with 3 per cent yoghurt mixed culture of *Streptococcus thermophilus* and *Lactobacillus bulgaricus* and then incubated at 42°C for 3 ½ h till the acidity of the product reached 0.7 to 0.75 per cent.

Patel and Chakraborty (1985) reported that when buffaloes' skim milk was inoculated with two per cent yoghurt culture and incubated at 42°C, the rate of acid production and final acidity decreased with increasing total solid content.

2.5.4 Total solids

Marshall (1982) recommended that the temperature during vacuum condensation should be less than 70°C to avoid protein denaturation,. By this method whey can be condensed to 50 to 60 per cent total solids.

Yoghurt was prepared by using butter milk condensed to a total solids ranging from 10 to 45 percentage. When the total solids increased beyond 25 percentage in the condensed product, the organoleptic properties decreased and the optimal composition was obtained when the product contained 15 per cent total solids (Builova *et al.*, 1983).

Abou-Dawood *et al.*, (1984) added whey protein concentrate (WPC) to cow milk to enhance the SNF by 0.5, 1, 1.5 or 2 per cent. Yoghurt was prepared from this fortified milk using 3 per cent starter (*S. themophilus, L. bulgaricus* 1:1) and incubated at 45°C for 3.5 h. Results showed that the addition of WPC to gave an extra one per cent SNF in milk yielded an acceptable yoghurt.

Caric *et al.*, (1985) prepared yoghurt with reconstituted milk containing 11 to 14 per cent total solids mixed in various proportions with partially skimmed milk. Results showed that reconstituted milk with 11 per cent total solids produced good quality yoghurt. Tamine and Robinson (1985) studied the relationship between the level of solids in the milk and the consistency of yoghurt. They observed that by increasing the level of total solids from 12 to 20 per cent improved the textural quality of yoghurt and also best results were obtained when the total solids content was 15 to 16 per cent. They also observed that an increase in the level of solids-not-fat in the yoghurt mix, tend to increase the titratable acidity and reduce the coagulation time due to the buffering action of the additional protein, phosphates, citrates, lactate and other miscellaneous constituents. The recommended level of addition of skim milk powder to increase SNF was 3 to 4 per cent.

EL-Gazzar and Hafez (1990) prepared yoghurt from cow skim milk (control) and soya milk enriched with 0 to 10 per cent dried skim milk, using 3 per cent yoghurt starter culture and incubated at 40°C for 4 h. Results showed that, with an increasing level of dried skim milk in soya milk, total solids and total protein of yoghurt increased form 7.64 to 16.02 per cent, 3.92 to 7.54 per cent respectively. Moisture, fat and pH decreased from 92.36 to 82.98 per cent, 1.82 to 1.45 per cent and 6.85 to 4.40 respectively. Corresponding values for yoghurt (control) were 11.5 per cent total solids, 3.75 per cent protein, 88.5 per cent moisture and 0.5 per cent fat and 4.5 pH.

Jayanta and Rajorhia (1990) studied the effect of milk solids-not-fat (MSNF) content in the preparation of misti dahi. The results showed that the average initial acidity of the mix increased with increasing MSNF content. The rate of acid development was lowered with increasing MSNF content

Mohamed *et al.*, (1991) studied the effect of incorporating different levels of whey protein concentrate WPC on the quality of yoghurt. The whey protein concentrate was mixed with buffalo milk at the rate of 0,10,20 or 30 per cent for the preparation of yoghurt. They found that WPC could be added to buffalo milk upto 20 per cent without affecting the quality of yoghurt.

2.5.5 Sweetening agents

Tramer (1973) reported that the rate of acid development in concentrated milk was reduced as the sugar content increased from 6 to 12 per cent. It was also shown that *S. thermophilus* was more tolerant in high sugar concentration than *L. bulgaricus*.

Singh (1982) studied the effect of sugar and fruits on the activity of yoghurt starter cultures in producing acid and acetaldehyde. The addition of eight per cent sugar into the milk did not affect the activity of mixed culture for the yoghurt preparations. However, further increase in the concentration of sugar lowered the acidity and acetaldehyde values.

Effect of sweetness on the quality and acceptability of yoghurt was studied by Mc Gregor and White (1986). They found that as the amount of sweetener increased the time required to get the pH of 4.4 was increased. Mean flavour scores were significantly ($P < 0.01$) higher for yoghurt sweetened at 4 per cent level than at 0,2 or 6 per cent levels regardless of the sweeteners used.

Jayanta and Rajorhia (1990) studied the effect of different levels of cane sugar in the preparation of mist dahi. They observed that production of diacetyl and acetyl methyl carbinol was adversely affected by increasing concentration of sugar. The highest scores were given to the product containing 14 per cent sugar, 13 per cent MSNF, and 5 per cent fat.

Venkateshaiah *et al.*, (1996) studied the influence of incorporating different levels of whey solids in place of skim milk powder in the preparation of yoghurt. The addition of whey powder at 3 per cent level increased the lactose content of the mix besides essential amino acids which helped to increase the acid production.

2.5.6 Stabiliser

Miloslav (1979) reported that additives such as modified starches, alginates, gelatin etc. are used to stabilise yoghurt. These agents improved the texture, firmness and prevented syneresis.

Modler *et al.*, (1983) reported that the presence of stabilisers significantly affected the physical and sensory properties of yoghurt. They found that addition of sodium alginate at the rate of 1.5 per cent increased the gel strength but the product was not smooth in texture and had a coarser appearance than gelatin stabilised yoghurt.

Hrabova and Hylmar (1984) studied the effect of stabilisers on rheological properties of fruit yoghurt and found that addition of pectin, CMC and frimulsion significantly improved the viscosity of the product.

Jamrichova (1985) reported the effect of maize starch stabiliser, added at the rate of 20 g/l milk before pasteurization. It had pronounced effect on the rheological properties of the coagulum as compared to control (av. 9. 340 poise for stabilised Vs 2.440 poise for control).

Shukla *et al.*, (1985) concluded that the addition of stabilisers and additives improved the quality of yoghurt, caused a decrease in the production of flavour compounds like diacetyl and volatile fatty acids.

Shukla and Jain (1986) studied the effect of various additives on the quality of yoghurt and reported that the use of gelatin at 0.2 to 0.3 per cent level not only improved the quality of yoghurt but also controlled the problem of wheying - off. The use of sodium hexametaphosphate, gum acacia, pectin and sodium alginate at levels of 0.2 - 0.3, 0.2, 0.2 and 0.2 per cent respectively was found to improve the quality of yoghurt. However, the use of gum acacia was not appreciated as it imparted slightly unpleasant flavour in the finished product.

Shukla *et al.*, (1988) reported the effect of various additives viz., gelatin, sodium hexametaphosphate gum acacia, CMC, pectin and sodium alginate improved the quality of yoghurt but gelatin was found to be the best among them.

Jogdand *et al.*, (1991 a) worked on the quality of dahi prepared from cow milk by the addition of stabilisers like gelatin and sodium alginate at 0.1, 0.2 and 0.3 per cent levels. Curd tension and viscosity increased while titratable acidity decreased with increasing levels of either gelatin or sodium alginate. Sodium alginate in all cases had greater effect than the corresponding level for gelatin.

Jogdand *et al.*, (1991 b) incorporated additives like starch, sodium alginate and gelatin at 0.1, 0.2 and 0.3 per cent levels respectively, to fresh cow milk used for dahi preparation. Results indicated that curd tension and viscosity increased while titratable acidity and total volatile acids decreased with increasing levels of additives. Sodium alginate had the greatest effect while starch had the least effect in all cases.

Addition of 0.4 per cent gelatin or 0.08 per cent dariloid (a mixture of guar gum, xanthan and locust bean gum) to the milk prior to homogenization reduced whey separation and improved body, texture and appearance of the goat milk yoghurt (Kamaly *et al.*, 1992).

Yadav *et al.*, (1994) prepared soyoghurt using soy milk and additives. Soyoghurt made from buffalo milk supplemented with soy milk in the ratio 65:35 was rated acceptable by sensory panels. Addition of sodium alginate at the level of 0.2 per cent improved textural characteristics like appearance, body as compared to CMC and control (without any stabiliser).

2.5.7 Flavour for yoghurt

Misra and Kuila (1994) incorporated orange juice, grape juice, pineapple flavour or carrot juice in the preparation of Biogarde (yoghurt-like product) and Bifighurt.

Sensory evaluation studies showed that pineapple flavoured biogarde was ranked first on the preference scale followed by fruit biogarde, carrot biogarde, normal biogarde and lastly bifighurt as it was too sour in taste due to comparatively higher acidity produced by *L. acidophilus.*

Desai *et al.,* (1994) studied the suitability of different fruits for the preparation of fruit yoghurt. They found that yoghurt incorporating mango pulp was rated as the best, on the basis of sensory quality, followed by pineapple yoghurt. Kokum and sapota yoghurts were inferior to plain yoghurt. The lowest acceptability score was obtained by papaya yoghurt.

2.6 Physico-chemical properties of yoghurt

2.6.1 Acidity

The lactic acid produced during fermentation process provides sharp acid taste and typical flavour to yoghurt.

Speck and Hansen (1983) studied the properties of non fat yoghurt flavoured with vanilla, chocolate or coffee and reported that highest score was obtained for samples with low titratable acidity (0.28 to 0.38 per cent lactic acid) while the lowest score for higher acidity (0.76 to 1.25 per cent) samples. Shankar *et al.,* (1983) reported the percentage of titratable acidity in yoghurt increased from 0.86 to 0.96 (percentage lactic acid) after 16 h of refrigerated storage.

Gopalakrishnan *et al.,* (1984) reported that the acidity and pH of yoghurt ranged from 0.19 to 0.28 per cent and 6.28 to 6.60.

Tamine and Robinson (1985) reported that the yoghurt coagulum of desirable firmness could be achieved by incubating the mix to a pH of 4.6 to 4.7.

Chandrasekar *et al.,* (1987) studied the mean titratable acidity of dahi and yoghurt during storage. They found that the mean titratable acidity values of yoghurt and dahi varieties during storage at ambient and refrigeration temperatures increased but the rate of increase was more in samples stored at ambient temperature.

The most important fermentative reaction used in dairy processing is the homofermentative conversion of lactose to lactic acid. For the preparation of high quality fermented products including yoghurt requires rapid and consistent rate of lactic acid production (Frank and Marth 1988). The optimum level of acidity (around one per cent) is also found to be important to prevent the growth of pathogens (Schaak and Marth, 1988).

Mehanna and Mehanna (1989) studied the effect of adding different levels of stabiliser- gelodan in the preparation of yoghurt. Results revealed that the addition of stabiliser slightly increased the rate of acid development from initial acidity of 0.17,0.18, 0.18 and 0.19 per cent to 0.74, 0.80, 0.82and 0.84 per cent after 240 minutes at 42°C when stabiliser were added at 0,0.2, 0.35 and 0.5 per cent respectively but no significant effect was noticed on total solids, fat, volatile fatty acids, total nitrogen, NPN or tryptophan content of yoghurt. Sensory scores increased with stabiliser level of upto 0.35 per cent but addition of 0.5 per cent resulted in an inferior flavour especially in stored yoghurt.

Cho-Ah-Ying *et al.,* (1990) observed that there was no significant interaction between the temperature of incubation and style of yoghurt (stirred or set yoghurt) for the characteristics such as titrable acidity, pH and viscosity. However, the stirred yoghurt had a significantly higher titratable acidity (1.3 per cent lactic acid) and low pH (4.03) than set yoghurt (1.12 to 1.17 per cent lactic acid and 4.13 pH).

Prasad (1990) studied the effect of different milk samples preserved by different methods used for the preparation of yoghurt. It was found that the yoghurt made by using pasteurized milk and lactoperoxidase activated milk had initial acidity of 0.14 per cent. But the values gradually increased to 0.15 per cent in yoghurt prepared from pasteurized milk and 0.16 per cent in yoghurt prepared from lactoperoxidase activated milk at the end of storage period of 72 h. An increased titratable acidity in yoghurt prepared from lactoperoxidase activated milk can be attributed to the increased multiplication of bacteria.

Mistry and Hassan (1992) prepared non fat yoghurt from a high milk protein powder. They reported that the final product had a pH of 4.6, protein 5.6 percent, total solids 14 per cent and titratable acidity (as percentage lactic acid) ranged from 1.03 to 1.25 and produced good quality yoghurt.

Desai *et al.*, (1994) found that the plain yoghurt had a titratable acidity of 0.784 per cent which was significantly increased due to addition of fruit pulp / juice such as mango, sapota, papaya, pineapple and kokum yoghurt. The higher acidity levels in fruits ranging from 0.28 to 2.5 per cent contributed to the increase in acidity levels in fruit blended yoghurt.

Baig (1994) studied the effect of incorporation of condensed cheese whey to replace non fat dry milk (NFDM) on the titratable acidity of set yoghurt. He found that the titratable acidity of condensed whey incorporated yoghurt ranged from 0.93 to 0.96 (as per cent lactic acid)

2.6.2 pH

Manfred (1975) suggested that for good quality yoghurt a final pH of 4.1 to 4.2 after normal souring is optimal and above 4.5 produced weak coagulum.

The relationship between initial acidity of plain yoghurt and the changes in acidity during refrigerated storage was investigated by Salji and Ismail (1983). The results indicated that the samples with low initial acidity showed relatively the highest titratable acidity during one week of storage at 4°C. The initial acidity of 3 samples were (in percentage) 0.79, 1.01 and 1.38 and the pH were 4.89, 4.18 and 3.82 after one week of storage at 4°C the titratable acidity increased to 0.96, 1.10 and 1.48 and pH values decreased to 4.27, 4.12 and 3.81.

There was no significant difference in pH values of yoghurt mix when different heating systems like vat, HTST and UHT treatments were employed (Parnell - Clunies *et al.*, 1986). The pH values of yoghurt for all treatments ranged between 4.16 to 4.28.

Gupta *et al.*, (1997) observed a difference in the pH of normal yoghurt and acidophilus yoghurt. Normal yoghurt had a pH of 4.10 $\pm$ 0.08, where as acidophilus yoghurt had a pH of 4.40 $\pm$ 0.07.

2.6.3 Protein

Storgards (1964) reported that heat treatments which cause denaturation of the protein increased the NPN substances and give rise to an improvement in the firmness and consistency of yoghurt.

Growth of starter organisms on some nitrogenous constituents of cow's milk was studied by Shankar *et al.*, (1983). They found that after 5 h fermentation of milk by *S,. thermophilus* and *L. bulgaricus*. The percentage of casein, whey protein nitrogen, and NPN were 89.8, 3.4 and 7.8 but after refrigerated storage for 16 h the level changed to 88.8, 3.3 and 8.9 respectively.

Davide *et al.*, (1990) prepared 'Niyogurt' by using coconut milk and skim milk powder. It had the composition of (in percentage) 4.36 protein, 1.386 acidity, 23.99 total solids and pH of 3.92.

Malarkannan (1996) used condensed coconut water to replace milk solids not fat (MSNF) partially in yoghurt preparation. He found that the protein content of filled yoghurt decreased as compared to control because of lower protein content of coconut water and the NPN content of filled yoghurt was increased as compared to control because of higher level of NPN (21.0 mg per cent) in the coconut water.

2.6.4 Non protein nitrogen

NPN content increased in all Swedish fermented products during fermentation (Alm, 1982). He found that the NPN level of milk used for product preparation ranged from 30 to 40 mg / 100 g before fermentation but after fermentation and storage the level increased from 40 to 120 per cent and 70 to 140 per cent in first and eleventh day respectively.

Prasad (1990) reported an increase in the content of NPN in yoghurt prepared from raw milk than the yoghurt prepared from pasteurized milk. The mean values mg/100 g were 55.91 $\pm$ 7.99 and 30.25 $\pm$ 1.34 respectively. This increase was attributed to the presence of psychrotrophic bacterial enzymes in the stored raw milk.

Manjunath and Bhat (1990) studied the native proteinase activity in composite cow and buffalo milk incubated at 37^{0}C for 5 days. They found that the increase in NPN was more in cow milk (6.87 mg / l) than in buffalo milk (55.10 mg / l).

Baig (1994) reported that the NPN content of yoghurt prepared by fortification with whey protein dispersion was significantly higher than that of yoghurt with condensed cheese whey at 100 per cent replacement level.

2.6.5 Curd tension

Chandrasekhara *et al.*, (1957) developed a simple curd tension meter for determining the curd tension of milk. The curd tension was recorded by using on 'H' shaped instrument and it was observed that boiling of milk and addition of citrates and phosphates bring about a reduction in the curd tension of cow milk and buffalo milk.

The effect of homogenization pressure on curd tension of buffalo milk were studied by Prasad *et al.*, (1974). They found that the average reduction in curd tension was 73 per cent and 72.7 per cent for single and double stage homogenization respectively.

Patel and Chakraborty (1985) conducted a comparative study on the curd tension values of (i) fresh skim milk (control) (ii) Reconstituted skim milk (iii) Fresh butter milk (iv) Diluted concentrated skim milk inoculated with 2 per cent culture and incubated for 4 to 5 h. The curd tension values (g) were 98.8, 59, 47.6 and 82.1 respectively indicating that fresh butter milk had very low curd tension.

Curd tension of misti dahi increased with an increase in homogenization pressure (Jayanta and Rajorhia, 1990). They found that it was due to the result of casein fat globule membrane interaction and protein- protein interaction which increased water binding capacity of protein system.

Rathi *et al.*, (1990) reported that curd tension values of fresh dahi ranged from 34.34 to 36.67 g and reconstituted dahi ranged from 3.80 to 5.23 g.

Abd.-EL-Salam *et al.*, (1991) reported that curd tension values ranged from 19.0 to 24.0 g for yoghurt fortified with whey protein concentrate. Desai *et al.*, (1994) compared plain yoghurt with fruit yoghurt prepared by incorporating mango, sapota, papaya, pineapple and kokum juice at 0,10,15 and 20 per cent levels. The results indicated that yoghurt prepared with mango, sapota, papaya and pineapple had higher curd tension values of 27.29, 27.6, 26.1 and 26.78 g respectively, whereas kokum yoghurt had a lower curd tension value of 25.09 g than plain yoghurt (26.9 g). They found that curd tension values progressively increased as total solids increased.

Effect of different levels of SNF on the curd tension and viscosity of yoghurt was studied by Chawla and Balachandran (1994). It was shown that higher concentration of SNF in milk caused an increase in the curd tension and stirred viscosity significantly. Milk containing 3.0 per cent fat and 10.0 per cent SNF was found to be optimum for the preparation of yoghurt based on sensory evaluation.

The influence of different compositional and processing parameters on curd tension of fruit flavoured filled bioyoghurt was studied by Shakeel-Asgar and Thompkinson (1994). The results indicated that different levels of SNF, fat and homogenization pressure had significantly affected the curd tension while holding time at 90°C had no significant effect. The product with higher fat (4.5 per cent) and SNF (18.0 per cent) levels, homogenized at 140.6/35.2 kg/cm^2 and heated at 90°C for 30 minutes was found to have improved body and texture with highest curd tension value of 39 g.

2.6.6 Viscosity

Jacquelin *et al.*, (1979) reported that the viscosity value of normal yoghurt varied from 224 to 632 poise.

Viscosity was influenced mainly by protein content and acidity (Builova *et al.*, 1983). Greig and Harris (1983) utilised whey protein concentrates prepared by ultra-filtration at the levels of 0,10 and 40 per cent to liquid milk in a standard yoghurt formulation. Viscosity values measured at 6°C ranged from 135 to 346 poise. The results revealed that there was a significant reduction in viscosity when SNF was replaced with WPC at 40 per cent level.

Chawla and Balachandran (1986) prepared yoghurt incorporating 0 to 2 per cent potato starch. They found that viscosity was maximum at 1.5 per cent level of incorporation of potato starch.

Becker and Puhan (1989) reported that the viscosity of stirred yoghurt was positively correlated with SNF content of milk. Rohm (1989) reported that an increase in apparent viscosity of stirred yoghurt was due to whey protein denaturation and dry matter content.

Gassem and Frank (1990) reported a viscosity value of 356 cp for the normal yoghurt. Dargan and Savello (1990) studied the effect of UHT treatment of skim milk and low fat milk on yoghurt quality. They reported that yoghurt prepared with milk heated at 116^{0}C to 127^{0}C gave highest stirred viscosity than skim milk yoghurt. But yoghurt prepared with low fat milk had the lowest gel strength and viscosity.

Farooq and Haque, (1992) reported that the viscosity values ranged from 8.3 to 8.7 x 10^7 cp for high milk protein yoghurt. Ramaswamy and Basak (1992) studied the influence of various levels of pectin (0.0 to 0.5 per cent) and rasberry concentrate (0 to 10 per cent) on the rheological characteristics of commercial stirred yoghurt using a computer - controlled rotational viscometer. The results showed that the apparent viscosity continuously increased with increasing levels of pectin and rasberry concentrate.

Ibrahim *et al.*, (1992) prepared ice cream like yoghurt from a mixture of buffalo milk with cooked sweet potato at the ratio of 77.5 : 0 to 66 : 17.5 to which sweetener and stabiliser was blended. It was shown that sweet potato tendered to improve the viscosity but decreased the whippability of the product.

Rodarte *et al.*, (1993) reported that the viscosity values ranged from 1600 to 4400 cp for yoghurt prepared from fortification with reconstituted skim milk powder.

Chawla and Balachadran (1994) studied the effect addition of different levels of (9.0 to 15.0 per cent) SNF in buffalo milk for the manufacture of yoghurt. They found that with higher concentration of SNF in milk caused an increase in the curd tension and viscosity.

2.6.7 Proteolysis by starter organisms

Dutta *et al.,* (1971) studied some of the biochemical changes produced in curd by selected cultures of lactic acid bacteria. It was found that *S. lactis, S. diacetylactis, S. fecalis* and *S. cremoris* produced 0.31, 0.27 to 0.36, 0.26 to 0.36 and 0.26 to 0.34 mg of tyrosine per g of curd in 24 h respectively.

Singh and Ranganathan (1977) reported a tyrosine value of 350 microgram per ml for different strains of lactobacillus in milk.

While studying the effect of fermentation process on proteins of Swedish fermented milk products Alm (1982) observed that the degree of proteolysis depended on the intensity of heat treatments of milk before inoculation, the buffering capacity of milk used for fermentation , the types and amounts of proteolytic enzymes excreted by the starters. He also found that the proteolytic activities of *L. thermophilus, L. bulgaricus, L. acidophilus* and *L.bifidus* were comparatively high, resulting in relatively more free amino acids in acidophilus, bifidus milk and yoghurt as compared to other fermented milk products.

Abou-Donia *et al.,* (1984) found that the tyrosine value in commercial samples of yoghurt (Zabadi) ranged form 28 to 48 mg / ml.

Tamine and Robinson (1985) reported that the range of products released by proteolysis is dependent on two main factors such as components of the milk protein fraction and types of proteolytic - enzymes that the yoghurt organisms may possess.

Proteolysis of casein by starter culture is important for optimum flavour and textural characteristics of yoghurt. *L. bulgaricus* would hydrolyse casein, whereas *S. thermophilus* showed significant peptidase activity for breaking down the products of casein hydrolysis. The proteolytic activities of 2 starter culture organisms complement each other and release the free amino acids. The maximum proteolytic activity was recorded when the ratio of *S. thermophilus* to *L. bulgaricus* was 1:1 (Frank and Marth, 1988).

Slocum *et al.,* (1988 a) reported that addition of 15 per cent sucrose to milk inhibited proteolysis and acid production during last 2 h of incubation. Slocum *et al.,* (1988 b) reported that the proteolytic activity was dependent on total solids concentration of milk. The minimum and maximum proteolytic activity was noticed at 10 and 14.5 per cent total milk solids.

Abraham *et al.,* (1993) pointed out that proteolytic system of *L. bulgaricus* was complex and observed that the specific proteolytic activity (SPA) was maximum when grown at 34 to 38^{0}C in milk with low soluble nitrogen. Increasing the temperature above 40^{0}C decreased the specific proteolytic activity.

Hari *et al.,* (1997) reported that the tyrosine values of short - set, long-set and acidophilus yoghurt samples were 0.21, 0.21 and 0.29 respectively.

2.7 Coliform and yeast / mould count

Indian standards (IS : 7035, 1973) has specified the limits of coliform count and yeast /mould count in fermented milk products as less than 10 cfu / ml and 100 cfu/ ml respectively.

Mohanan *et al.,* (1984) studied the characters of dahi prepared under household conditions of Bangalore. It was observed that total viable count in dahi ranged from 56 to 500 million / ml, yeast and mould counts ranged from 700 to 5000 / ml and coliform count ranged from 0 to 100 / ml respectively.

Lalas and Mantes (1986) analysed 30 samples of homogenized gel type yoghurt for its micro-biological quality. The content of lactic acid bacteria ranged from 1.5 to 450 million / g, yeast and mould 25 - 250 / g, coliform< 0.3/g.

Salgi *et al.*, (1987) observed initial coliform counts of < 1 cfu / ml in yoghurt which remained constant throughout 14 days of storage at 7°C, 10°C or 15°C.

Al-Hadethi *et al.*, (1992) studied the incidence of coliform bacteria in yoghurt of Mosul city. The results revealed that the average coliform count was 5×10^4/g of yoghurt.

2.8 Sensory evaluation

Parnell-Clunies *et al.*, (1986) compared the physical and sensory properties of yoghurt prepared by vat, HTST and UHT means of processing. Scores for all the three types were different in sensory properties. Firmness was highest for yoghurt heated in vat, but the texture was grainy.

Mehanna and Mehanna (1989) studied the effect of stabiliser-gelodan on the quality of cow milk yoghurt. Results showed that sensory scores increased with increase in the level of stabiliser upto 0.35 per cent but addition of 0.5 per cent resulted in undesirable flavour especially in stirred yoghurt.

Sensory evaluation studies showed that pineapple flavoured biogarde was ranked first on the performance scale, followed by fruit biogarde, carrot biogarde, normal biogarde and lastly bifigurt (Misra and Kuila, 1994).

Desai *et al.*, (1994) reported that yoghurt prepared from mango pulp as the best on the basis of sensory quality and it was closely followed by pineapple yoghurt. Kokum and sapota yoghurts were inferior to plain yoghurt. The lowest score was obtained by papaya yoghurt.

Organoleptic evaluation revealed that regular yoghurts and acidophilus yoghurts were almost identical with respect to colour, flavour, appearance, texture and body characteristics and overall acceptability with a score ranging from 7.4 to 7.8 on the 9 point hedonic scale (Gupta *et al.*, 1997).

2.9 Standards for flavoured yoghurt

2.9.1 Indian standards (IS 12898 : 1989 and IS 7035 : 1973)

These standards applies fermented milk products, where cultures of *Lactobacillus bulgaricus* and *Streptococcus thermophilus* are mainly employed for the fermentation process. In addition the yoghurt may also contain cultures of *Bifidobacterium bifidus* and *Lactobacillus acidophilus* and if added, the declaration to this effect shall be made on the label. The flavoured plain yoghurt complying with minimum fat content of 3.0 per cent with the addition of permitted flavouring and colouring materials with or without the addition of sweetening agents. The following are the essential raw materials for the manufacture of yoghurt.

1. Milk

Toned, recombined or concentrated or a combination of two or more of these products.

2. Bacterial culture

Cultures of *Lactobacillus bulgaricus* and *Streptococcus thermophilus* at the rate of 2 to 3 per cent shall be used for the fermentation of yoghurt.

3. Optional ingredients

(a) Milk powder, skimmed milk powder, unfermented butter milk, concentrated whey, whey powder, whey proteins, whey protein concentrate, water - soluble milk proteins, edible casein, caseinates manufactured from pasteurized products and lactase enzyme preparation.

(b) Sugars, corn syrup or glucose syrup in case of sweetened, flavoured and fruit yoghurt.

(c) Fruits - fruit (fresh, canned, quick frozen and powdered), fruit pulp, jam, fruit syrup, fruit juice etc.

(d) Permitted colour in flavoured and fruit yoghurt only.

4. Stabilisers

Stabilisers are permitted under PFA Act, 1954 may be used in the manufacture of yoghurt upto a maximum limit of 0.5 per cent. It is recommended to obtain the satisfactory consistency and viscosity of yoghurt by using adequate technical and technological measures rather than by using stabilisers.

Requirements for flavoured yoghurt (IS 12898 :1989)

1.	Total milk solids, per cent by mass (min.)	13.5
2.	Milk fat, per cent by mass (min.)	3.0
3.	Sugar, per cent by mass (min.)	6.0
4.	Titratable acidity	0.8 - 1.2
5.	Protein, per cent by mass (min.)	3.2
6.	pH	between 3.8 to 4.6
7.	Yeast and mould count per gram (max.)	100
8.	Coliform count per gram (max.)	10
9.	Phosphatase test	Negative

Materials & methods

3. MATERIALS AND METHODS

This experiment was carried out to find out the feasibility of incorporating coconut cream to replace milk fat and to study the physico-chemical, micro-biological and organoleptic qualities of the flavoured filled yoghurt. The experiments were carried out in the Department of Dairy Science, College of Veterinary and Animal Sciences, Mannuthy, utilising the facilities of the Kerala Agricultural University Dairy Plant. The data obtained in six replications were analysed by approved statistical methods (Snedecor and Cochran, 1980).

3.1 Materials

These are divided into dairy and non-dairy ingredients.

3.1.1 Dairy ingredients.

3.1.1.1. Skim milk.

Fresh pooled cow milk was collected from the Kerala Agricultural University Dairy Plant, Mannuthy, Thrissur, which was skimmed using an $\propto$ - laval cream separator.

3.1.1.2 Skim milk powder

Spray dried skim milk powder (Anikspray, Brooke Bond Lipton (I) Ltd. Calcutta - 700 001) was used to adjust the milk solids not fat in yoghurt.

3.1.1.3 Milk cream

Fat percentage of yoghurt was adjusted with fresh cream collected during skimming.

3.1.1.4 Starter cultures

Ampoules of freeze dried culture of *streptococcus salivarius* subsp *thermophilus* and *Lactobacillus delbrueckii* subsp *bulgaricus* were obtained form National Collection of Dairy Cultures, National Dairy Research Institute, Karnal, Haryana.

3.1.2 Non-dairy ingredients

3.1.2.1 Coconut cream

The coconuts (cocos nucifera L.) used were collected from Government Agricultural Central Farm, Mannuthy. Mature coconuts were dehusked and broken into two halves. The kernel was grated and the coconut cream was extracted by using screw press. The pressed liquor was sieved through a muslin cloth to remove the solid particles to get the coconut cream and the fat percentage was adjusted to 30 per cent level by adding distilled water.

3.1.2.2 Sugar

Cane sugar purchased from local market was used in the experiments.

3.1.2.3 Stabiliser

Alginate D_2 (SA) manufactured by Davars M.P Organics, Tansen Road, Gwalior - 474002 was used.

3.1.2.4 Flavour

Liquid synthetic pineapple flavour manufactured by Bush Boake Allen (India) Ltd, Cathedral Garden Road, Nungambakkam , Madras was used in the experiments.

3.1.2.5 Colour

Synthetic food colour(Lemon yellow powder) contained sodium chloride, tartrazine (dye content is 21.9 per cent) (ISI 5346) manufactured by Mallya Fine-chem Pvt. Ltd, C - 331 and 332 II nd stage Peenya Industrial Estate, Bangalore- 560 058. The colour solution was prepared by mixing four gram of powder in 100 ml of distilled water.

3.1.2.6 Violet Red Bile Agar

Violet Red Bile Agar (Himedia laboratories private Ltd, Bombay - 400 086) was used for enumeration of coliform count in set yoghurt.

3.1.2.7 Potato Dextrose Agar.

Potato Dextrose Agar (Himdeia laboratories private Ltd, Bombay - 400 086) was used for enumeration of yeast/mould count in set yoghurt.

3.2 Methods

3.2.1 Analysis of coconut cream

3.2.1.1 Fat

The fat content in the coconut cream was estimated by using the mojonnier fat extraction apparatus using diethyl ether and light petroleum ether as solvents (IS: SP 18 - part XI, 1981).

3.2.1.2 Total solids

Total solids in coconut cream was estimated by Gravimetric method (IS: 1479 - part II, 1961).

3.2.1.3 Non protein nitrogen

For the estimation of NPN, 20 g of coconut cream was taken in a 100ml volumetric flask. The content was diluted to the mark with 15 per cent trichloroacetic acid (TCA) and mixed well. The precipitate was allowed to settle and filtered through what man No: 40 filter paper. The filterate was collected in a dry flask. The NPN contents were further determined by Kjeldahl method, as described in IS: 1479, part II(1961).

3.2.2 Analysis of skim milk and cream.

3.2.2.1 Fat

Fat percentage in skim, milk and cream were determined by Gerber method described in IS: 1224, part I (1977).

3.2.2.2 Total solids

The total solids in milk and cream were determined by Gravimetric method (IS:1479, part 11, 1961).

3.2.2.3 Non protein nitrogen

As per the procedure given in 3.2.1.3

3.2.3 Analysis of skim milk powder.

3.2.3.1 Fat

The procedure described in IS:SP 18 part XI, 1981 was followed for the estimation of fat percentage in skim milk powder.

3.2.3.2 Total solids

The method described in IS: 18 part XI, 1981 was followed for the estimation of total solids percentage in skim milk powder.

3.2.4 Maintenance of starter culture

Pure cultures of *S.thermophilus* and *L.bulgaricus* were maintained separately in sterile skim milk and subcultured at weekly interval. The starter cultures were tested periodically for their purity and activity.

3.2.5 Plan of experiment

The experiment was aimed to study the effect of incorporation of different levels of coconut cream to replace milk fat at 25,50,75 and 100 per cent levels and to evaluate the merits of adding sodium alginate in improving the physical properties. The feasibility of adding flavour and colour were also undertaken during the course of the study. The proportionate quantity of different ingredients for the preparation of yoghurt were derived by linear programming model and are presented in table 1 together with its cost. The computer programme for the above is appended in Appendix- I.

3.2.5.1 Control (TC)

Yoghurt was prepared to contain 14 per cent MSNF, three per cent fat and six per cent sugar using cultures of *Streptococcus thermophilus* and *Lactobacillus bulgaricus* at the rate of 1:1 involving in the following steps. Calculated quantity of cream and skim milk powder were added to skim milk so as to increase the milk solids to 17 per cent and to this mixture cane sugar was added at the rate of six per cent to enhance the total solids to 23 per cent. The mix thus prepared was preheated 55 to 60°C and homogenized at 210 Kg/ cm^2 and 35 Kg/ cm^2 respectively. The mix was then pasteurized at 85°C for 30 minutes in a double jacketed vat and was subsequently cooled at 42°C. It was inoculated with three per cent yoghurt culture, 0.5 per cent flavour, 0.5 per cent colour solution.

The inoculated yoghurt mix was transferred to cups and incubated at 42 ± 1°C and was monitered periodically for pH. When the desired pH of 4.6 was attained, the cups were transferred to the refrigerator at 4-5°C and kept for 12 hours before evaluation for physico - chemical, micro-biological and organoleptic properties. The process flow chart for the preparation of flavoured filled yoghurt is presented in Fig1.

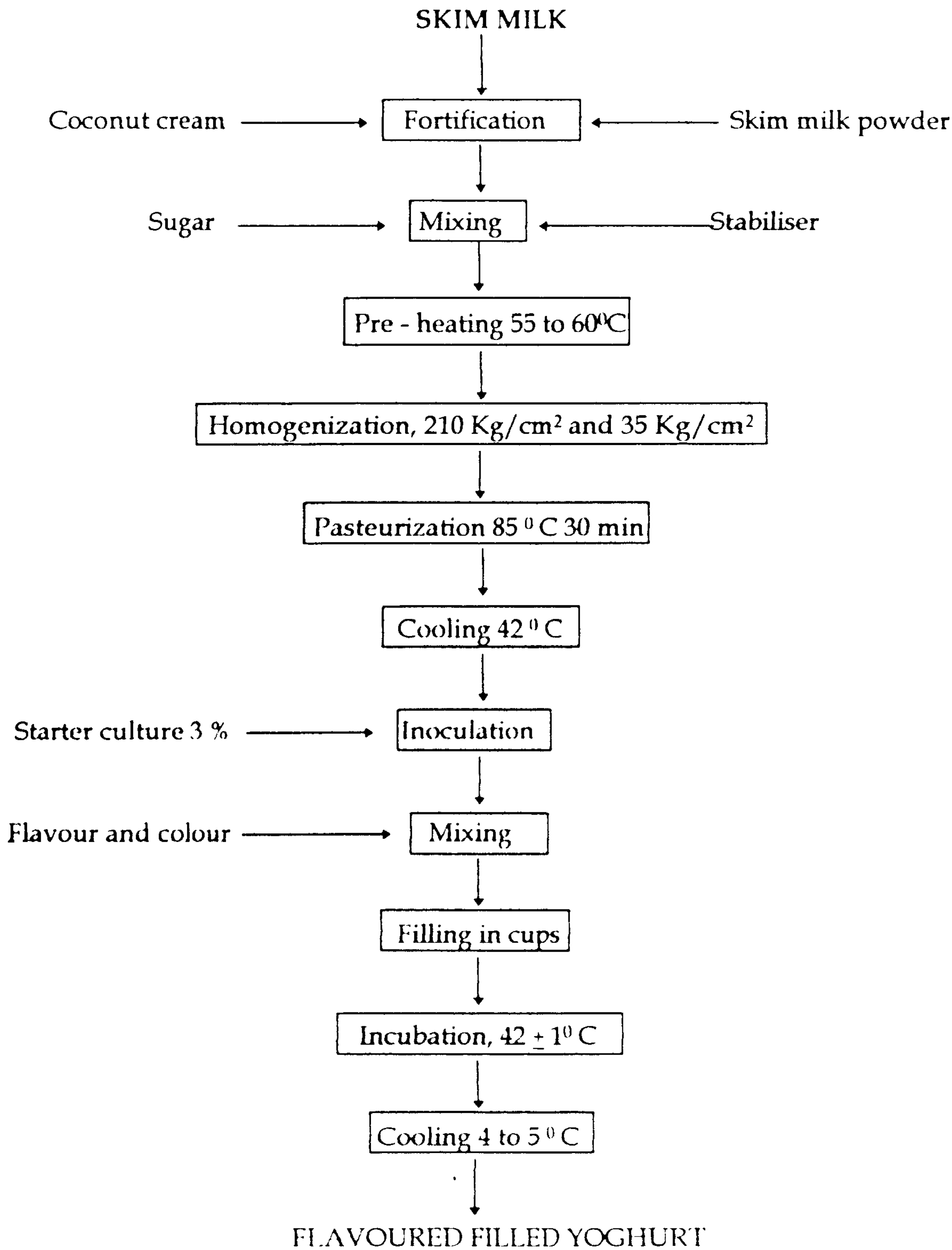


Fig.1. Process flow chart for the preparation of flavoured filled yoghurt

The procedure as described above was followed in the preparation of experimental yoghurt samples. Modifications were only in replacement of milk fat and solids partially or fully and addition of stabiliser. The following treatments were conducted.

3.2.5.2 Treatment 2(T2)

Milk fat was replaced at 25 per cent level with fat from coconut cream so as to maintain the fat level at 3 per cent.

3.2.5.3 Treatment 3 (T3)

Milk fat was replaced at 50 percent level with fat from coconut cream, so as to maintain the fat level at 3 per cent.

3.2.5.4 Treatment 4 (T4)

Milk fat was replaced at 75 per cent level with fat from coconut cream so as to maintain the fat level at 3 per cent.

3.2.5.5 Treatment 5(T5)

Milk fat was replaced at 100 per cent level with fat from coconut cream so as to maintain the fat level at 3 per cent.

3.2.5.6 Treatment 6,7,8,and 9 (T6,T7,T8,T9)

The treatment T6,T7,T8 and T9 will contain 0.2 per cent sodium alginate as stabiliser in the respective treatment groups of T2,T3,T4 and T5.

Table.1: Quantity of ingredients and their costs for 100 g of yoghurt mixes

Ingredients	Tc	T2	T3	T4	T5*	T6	T7	T8	T9*
Skim milk powder	5.760	5.889	6.017	6.146	6.255	5.682	5.811	5.946	6.049
Cost	0.749	0.766	0.782	0.799	0.813	0.739	0.755	0.772	0.786
Milk cream	4.648	3.446	2.231	1.022	-	3.442	2.233	1.024	-
Cost	0.465	0.344	0.223	0.102	-	0 .344	0 .223	0.102	-
Coconut cream	-	2.500	5.000	7.500	9.614	2.500	5.000	7.500	9.619
Cost	-	0.058	0.116	0.174	0.224	0.058	0.116	0.174	0.224
Skim milk	83.592	82.172	80.752	79.331	78.130	82.176	80.756	79.336	78.132
Cost	0.669	0.657	0.646	0.635	0.625	0.657	0.646	0.635	0.625
Sugar	6.000	6.000	6.000	6.000	6.000	6.000	6.000	6.000	6.000
Cost	0.096	0.096	0.096	0.096	0.096	0.096	0.096	0.096	0.096
Stabiliser	-	-	-	-	-	0.200	0.200	0.200	0.200
Cost	-	-	-	-	-	0.027	0.027	0.027	0.027
Flavour	-	-	-	-	-	-	-	-	-
Cost	0.040	0.040	0.040	0.040	0.040	0.040	0.040	0.040	0.040
Colour	-	-	-	-	-	-	-	-	-
Cost	0.080	0.080	0.080	0 .080	0.080	0.080	0.080	0.080	0.080
Total	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00
Cost	2.098	2.041	1.984	1.926	1.877	2.042	1.984	1.927	1.877

*** Coconut fat replacement in treatment T5 and T9 are only 2.89 per cent out of 3 per cent fat in yoghurt and the remaining 0.11 per cent met from skim milk powder and skim milk.**

- Cost in Rupees.

3.2.6 Analysis of yoghurt mix

3.2.6.1 Titratable acidity

The procedure described in IS: SP : 18 (part XI, 1981) was followed for the estimation of titratable acidity of yoghurt mix.

3.2.6.2 pH

The pH of yoghurt mix was determined by pH scan 2 (MERCK) pH meter.

3.2.6.3 Total solids

Total solids in yoghurt mix was determined by following the procedure described by Tamine and Robinson (1985), using vacuum drying in which sodium hydroxide was used as a moisture absorbent.

3.2.7 Analysis of yoghurt

Samples of set flavoured filled yoghurt after cooling were analysed for bio-chemical and micro-biological characters.

3.2.7.1 Bio - chemical analysis of yoghurt

Samples of set yoghurt from control and experimental groups were analysed for the following bio-chemical properties.

3.2.7.1.1 Setting time

The time taken to reach the pH of 4.6 was taken as setting time (Baig, 1994)

3.2.7.1.2 Acidity

The acidity of yoghurt was measured by using the procedure described by Tamine and Robinson (1985). 20g of yoghurt was diluted in 10 ml of distilled water and titrated with 0.1 N sodium hydroxide solution using two ml of one per cent phenolphthalein as indicator.

$$\text{Acidity (percentage of lactic acid)} = \frac{\text{Amount of NaOH used} \times 0.009}{\text{Weight of sample (g)}} \times 100$$

3.2.7.1.3 pH

pH of the samples during incubation and after cooling was recorded by pH scan 2 (MERCK) pH meter.

3.2.7.1.4 Fat

The percentage of fat in yoghurt was determined by modified Gerber method using 11.3 g of yoghurt in a milk butyrometer (Tamine and Robinson, 1985).

3.2.7.1.5 Total protein

The total protein in yoghurt was determined as per the procedure described in IS: 1479, part II (1961) .

3.2.7.1.6 Non protein nitrogen (NPN)

As per the procedure given in 3.2.1.3

3.2.7.1.7 Curd tension

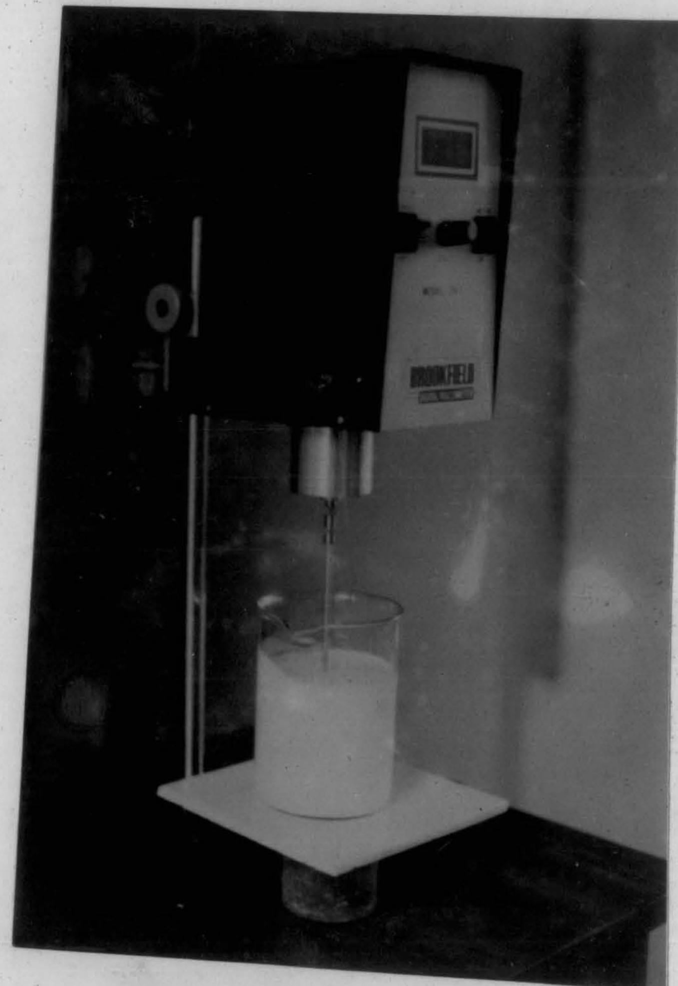
The curd tension values of yoghurt samples were measured according to the method described by Chandrasekhara *et al.*, (1957). The curd tension meter consisted of three sharp stainless steel blades of 1" x ¼" welded in the form of "H". A thin vertical rod was attached to the centre of the middle blade. The other end of the rod was bend in the form of a hook which was attached to the thread carrying the pan over a frictionless pully. After heat treatment 50ml of yoghurt mix was poured in a 100ml glass beaker in which the welded "H" shape blade was inserted. After incubation and cooling, the hook was attached to a pan in which weights were added slowly until the blade come out of the sample. The result is expressed in grams.

3.2.7.1.8 Viscosity

The apparent viscosity values of the samples were measured with a Brook Field Viscometer Model DV - 1 (plate - 1 and 2) using 400g of sample refrigerated over night.

PLATE 1 & 2 BROOK FIELD VISCOMETER

1. After Standardisation



2. During Measurement

After standardizing the equipment the spindle was allowed to rotate and then the spindle was immersed into the sample slowly to avoid channelling effect. Reading's were taken at 20°C after 10 minutes of spindle rotation (speed 2.5 revolution /min, spindle number 4). The report model is appended in appendix -II

3.2.7.1.9 Tyrosine value

The tyrosine value of set yoghurt was determined by the method of Lowery *et al.*, (1951) yoghurt sample (5g) was taken in a beaker to which equal volume of 12 per cent TCA was added. After vigorous mixing it was allowed to stand for 15 minutes. The mixture was then filtered through a what man No. 42 filter paper. One ml of the filtrate was mixed with 5 ml of alkaline reagent (48 ml of 2 per cent sodium carbonate + 1ml of 1 per cent sodium potassium tartrate + 1 ml of 0.5 per cent copper sulphate). The contents were mixed well and incubated at 37°C for 20 minutes in the same water bath. The blue colour developed was measured at 660 nm in a Spectronic - 20 Spectrophotometer set against a reagent blank. The blank was prepared by mixing 1ml of distilled water with 5 ml of the alkaline reagent. The tyrosine value was calculated from the standard curve. The standard curve was prepared with 0.1 to 0.6 mg/ml of L-tyrosine and the proteolytic activity was expressed as mg of tyrosine liberated per gram of yoghurt sample.

3.2.7.2 Microbiological analysis

3.2.7.2.1 Preparation of diluents

Normal saline was used for serial dilution of samples. One ml of flavoured filled yoghurt sample was transferred aseptically into 9ml of sterile saline. One ml of appropriate dilution (10^1) was used for coliform count and yeast/mould count.

3.2.7.2.2 Coliform count

The coliform counts in samples of set yoghurt for control and treatments were enumerated by using Violet Red Bile Agar(IS 5401, 1969).

3.2.7.2.3 Yeast / mould count

Yeast and mould counts in set yoghurt under control and treatments were enumerated by using Potato - Dextrose Agar (IS 5403, 1969).

3.2.8 Sensory evaluation

The samples of control and yoghurt were subjected to sensory evaluation by a panel of six judges using the score card adopted by Pearce and Heap (1974). The guidelines reported by Shakeel-Ur-Rehman *et al.,* (1994) is followed during sensory evaluation of the resulted products. Average score obtained from six members of the panel for each replication was used for statistical analysis. Score card adopted for evaluation of yoghurt is appended in appendix III .

3.2.9 Cost estimation

The cost of 100g control and treatment yoghurt samples were calculated from the linear programming model. The cost of ingredients were as follows (Table 2).

Sl.No	Ingredients	Cost (Rs/Kg)
1.	Skim milk powder	130.00
2.	Cream	100.00
3.	Coconut cream	23.25
4.	Skim milk	8.00
5.	Sugar	16.00
6.	Stabiliser	136.00
7.	Flavour	85.00
8.	Colour	400.00

3.2.10 Statistical analysis

The experiment was carried out with 6 replications. The data obtained were subjected to statistical analysis (Snedecor and Cochran, 1980). Completely randomised design(CRD) was selected to test the significance between the control and treatments.

Results

4. RESULTS

The data generated together with statistical analysis and the results during the course of the experiment are presented in the following section.

4.1 Analysis of coconut cream

The mean fat and total solids percentage (Table-3) of coconut cream were 40.76, 53.01. The NPN content in coconut cream also analysed and it was found 1.41 g per 100 ml.

4.2 Analysis of dairy ingredients

The mean fat and total solids (percentage) (Table 3.) contained in skim milk powder, skim milk and cream were 0.56, 97.37, 0.13, 8.62,62.78 and 76.02 respectively. The NPN content in milk cream also analysed and it was found 0.84 g per 100 ml.

4.3 Analysis of control and experimental yoghurt mixes

The physico-chemical properties of control and experimental yoghurt mixes were studied and the results obtained are presented in Table 4 to 6.

4.3.1 Titratable acidity

Analysis of the data presented in Table 4 with regard to titratable acidity of yoghurt mix revealed no significant difference between control and treatments. The mean titratable acidity ranged from 0.20 to 0.23 among the control and various treatments. The mean $\pm$ SE values were 0.21 $\pm$ 0.003, 0.21 $\pm$ 0.004, 0.20 $\pm$ 0.003, 0.21 $\pm$ 0.004, 0.22 $\pm$ 0.002, 0.22 $\pm$ 0.005, 0.22 $\pm$ 0.003, 0.21 $\pm$ 0.003 and 0.22 $\pm$ 0.003 for the control and treatments T2 to T9 respectively, indicating that addition of coconut cream at 25, 50, 75 and 100 per cent levels with or without the addition of sodium alginate does not produce any significant change in the titratable acidity of yoghurt mixes.

4.3.2 pH

Data with regard to pH (Table 5) of yoghurt mix revealed no significant difference between the control and treatments as well as among the treatments. The mean ±SE for the control and treatments were 6.212 ± 0.01, 6.220 ± 0.01, 6.195 ± 0.01, 6.187 ± 0.01, 6.207 ± 0.01, 6.202 ± 0.01, 6.198 ± 0.02, 6.215 ± 0.02 and 6.227 ± 0.01 respectively, indicating that addition of coconut cream at 25,50, 75 and 100 per cent levels with or without the addition of sodium alginate does not produce any significant change in the pH of yoghurt mixes.

4.3.3 Total solids

Analysis of the data presented in Table 6, with regard to total solids (g percentage) revealed no significant difference between the control and treatments, when analysed statistically. The mean ±SE for control and treatment yoghurt mixes were 23.07 ± 0.12, 22.98 ± 0.03, 22.62 ± 0.19, 23.04 ± 0.06, 22.99 ± 0.04, 22.98 ± 0.06, 22.96 ± 0.04, 23.09 ± 0.12 and 22.98 ± 0.15 respectively.

4.4 Analysis of yoghurt

4.4.1 Analysis for physico-chemical properties

4.4.1.1 Setting time

Data with regard to setting time (h) of yoghurt mix are presented in Table 7 and fig 2. The mean ± SE for control and treatments were 3.57± 0.09, 4.09 ± 0.01, 4.11 ± 0.01, 4.21 ± 0.01,4.27 ± 0.02, 4.17 ± 0.02, 4.19 ± 0.01, 4.25 ± 0.01 and 4.32 ± 0.01 respectively. The highest mean setting time of 4.32 was recorded in T9 but it was comparable with T5 & T8. A significant difference ($p<0.01$) existed between control (3.57) and treatments when the means were compared using critical difference. The setting time at different replacement levels in the treatment groups were comparable as compared to its corresponding pairs with the stabiliser. There is a gradual increase in setting time as the replacement level increased and addition of stabiliser does not have any influence in the setting time.

4.4.1.2 Titratable acidity.

Analysis of the data with regard to titratable acidity (as percentage lactic acid) of the yoghurt are presented in Table 8. The mean $\pm$ SE for control and treatments were 0.91 $\pm$ 0.10, 1.03 $\pm$ 0.009, 1.05 $\pm$ 0.005, 1.04 $\pm$ 0.014, 1.06 $\pm$ 0.007, 1.04 $\pm$ 0.008, 1.05 $\pm$ 0.006, 1.06 $\pm$ 0.005 and 1.06 $\pm$ 0.005 respectively. Statistical analysis of the data revealed that there is significant difference ($p<0.01$) between control and treatments, indicating that titratable acidity gradually increased as the percentage replacement increases. The treatment means when compared using critical difference revealed that control and T2 were comparable and replacement at 50,75 and 100 per cent level with or without sodium alginate are homogenous, which indicated that the substitution levels does not influence the titratable acidity of the yoghurt samples.

4.4.1.3 pH

Analysis of the data presented in Table 9 with regard to pH of yoghurt samples revealed no significant difference between the control and treatments, indicating that incorporation of coconut cream at 25,50, 75 and 100 per cent levels with or without addition of sodium alginate does not produce any change in the pH. The mean $\pm$ SE for control and treatments were 4.56 $\pm$0.01, 4.55 $\pm$ 0.00, 4.57 $\pm$ 0.01, 4.56 $\pm$ 0.00, 4.57 $\pm$ 0.00, 4.56 $\pm$0.00, 4.57 $\pm$ 0.01, 4.57 $\pm$ 0.00 and 4.56 $\pm$ 0.00 respectively.

4.4.1.4 Fat

The fat percentage (mean ± SE) of control and treatment samples are presented in Table 10. Analysis of variance showed no significant difference among the treatments as well as between the control and treatments. The mean ± SE fat of yoghurt (percentage) for control and treatments were 3.00 ± 0.06, 2.98 ± 0.05, 3.00 ± 0.04, 3.00 ± 0.06, 3.02 ± 0.05, 3.02 ± 0.06, 2.98 ± 0.05, 3.00 ± 0.06 and 3.03 ± 0.07 respectively.

4.4.1.5 Protein

Data with respect to protein (g/100 ml) (mean ± SE) in yoghurt for control and treatments presented in Table 11 (Fig 3) were 5.255 ± 0.08, 5.358 ± 0.06, 6.107 ± 0.02, 6.652 ± 0.05, 7.158 ± 0.04, 5.393 ± 0.05, 6.157 ± 0.02, 6.777 ± 0.04 and 7.162 ± 0.24 respectively. Statistical analysis of the data revealed that there is significant difference ($p<0.01$) between control and treatments and among the treatments. The protein content in treatments showed an increasing trend as the replacement level increased. When the means were compared using critical difference it revealed that the protein content in treatment 2 (T2) only comparable with control and the protein percentage in 25, 50, 75 and 100 per cent replacement was comparable with their counterpart, containing stabiliser.

4.4.1.6 Non Protein Nitrogen (NPN)

The data with regard to NPN (mg /100 ml) content are presented in Table 12 and Fig 4. The NPN values of the control and treatments (mean ± SE) were 43.12 ± 2.44, 46.84 ± 2.21, 51.67 ± 1.79, 58.94 ± 1.70, 68.27 ± 1.04, 47.96 ± 2.22, 52.78 ± 1.79, 60.40 ± 1.80 and 70.27 ± 0.93 respectively. Analysis of variance revealed significant difference ($p<0.01$) between the control and treatments and among the treatments. There is a progressive increase in NPN content as the replacement level increased. The highest mean NPN was recorded for T5 and T9 where 100 per cent milk fat was replaced with coconut fat. The comparison of treatment and control means using critical difference revealed that treatment T2 and T6 (25 per cent replacement with or without stabiliser) were comparable with control. Similarly T3 & T7, T4 & T8, T5 & T9 were homogeneous indicating that addition of sodium alginate had no effect on the NPN content.

4.4.1.7 Curd Tension

The data with respect to curd tension (g) values in yoghurt for control and treatments are presented in Table 13 and Fig 5. The mean $\pm$ SE for control and treatments were 28.73 $\pm$ 1.07, 30.89 $\pm$ 1.19, 33.55 $\pm$ 1.35, 35.84 $\pm$ 1.18, 38.44 $\pm$ 0.91, 32.77 $\pm$ 0.98, 35.73 $\pm$ 1.35, 38.39 $\pm$ 0.76 and 40.60 $\pm$ 0.91 respectively. Statistical analysis showed that there is significant difference ($p<0.01$) between control and treatments. There was a progressive increase in curd tension, as the percentage replacement increased, irrespective of addition of sodium alginate. The highest curd tension mean value was recorded in T9 (40.60 $\pm$0.91) and lowest in control (TC) (28.73 $\pm$ 1.07) which was comparable with T2 (25 per cent replacement without sodium alginate). A little increase in the curd tension was noticed in T6, T7, T8 and T9 when compared to their pairs T2, T3, T4 and T5 but they were statistically insignificant, when treatment means were compared using critical difference. The results indicated that the curd tension values increased as replacement of milk fat with coconut fat increased and the contribution of stabiliser in increasing curd tension was not significant.

4.4.1.8 Viscosity

The viscosity values (p) for control and treatments are presented in Table 14 and Fig 6. Statistical analysis of the data showed that there is a significant difference ($p<0.01$) between control and treatments. The mean $\pm$ SE for control and treatments were 247.18 $\pm$ 4.30, 256.23 $\pm$ 4.31, 263.69 $\pm$ 4.63, 273.76 $\pm$ 4.21, 283.44 $\pm$ 3.90, 267.68 $\pm$ 6.32, 273.62 $\pm$ 4.96, 286.74 $\pm$ 6.04 and 297.71 $\pm$ 5.32 respectively. There is progressive increase in the viscosity values as the replacement level increased irrespective of stabiliser addition.

Highest viscosity values were observed for T8 and T9 which were identical when the treatments were compared using critical difference. Lowest viscosity was recorded in control group but is comparable with T2. However treatments T2 & T6, T3 & T7, T4 & T8 were comparable, indicating that upto 75 per cent replacement with or without sodium alginate had no influence on the viscosity values. Treatments with 25 (T2) and 50 (T3) per cent replacement levels were comparable with 25 (T6) per cent replacement with sodium alginate. Similarly 75 and 100 per cent replacement levels were comparable with its corresponding pair with stabiliser. The results indicated that viscosity values at replacement levels upto 75 percentage is not influenced with addition of sodium alginate or not. The viscosity values followed almost similar trend as with the curd tension.

4.4.1.9 Tyrosine value

The tyrosine value for control and treatments (mg/g of yoghurt) are presented in Table 15 and Fig 7. The mean $\pm$ SE for the control and treatments were 0.325 $\pm$0.01, 0.308 $\pm$ 0.00, 0.336 $\pm$ 0.01, 0.355 $\pm$ 0.01, 0.315 $\pm$ 0.01, 0.298 $\pm$ 0.00, 0.328 $\pm$ 0.00, 0.348 $\pm$ 0.01 and 0.363 $\pm$ 0.01 respectively. Statistical analysis revealed significant difference ($p<0.01$) between the control and treatments. The highest values were recorded for T4, T5 and T9 which were comparable when treatment means are compared using critical difference. Similarly control and treatments T2, T3, T6 and T7 were also comparable, indicating that the tyrosine values upto 50 per cent replacement with or without sodium alginate is identical with the control. Treatments T4 & T8 were also homogenous. A gradual increase in tyrosine value was recorded as replacement level increased irrespective of stabiliser addition.

4.4.2 Microbiological quality of yoghurt

4.4.2.1 Coliform Count

The coliform count (cfu/ml) data with range, mean $\pm$ SE are presented in Table 16. The mean $\pm$ SE for control and treatments were 5.83 $\pm$ 0.60, 5.33 $\pm$ 0.56, 5.00 ± 0.52, 5.33 ± 0.67, 6.33 ± 0.80, 7.67 ± 0.42, 5.83 ± 0.79, 5.83 ± 0.31 and 6.83 ± 0.48 respectively. Analysis of variance showed no significant difference between control and treatments indicating addition of coconut cream at 25,50,75 and 100 per cent levels with or without addition of sodium alginate does not produce any statistically significant change in the coliform count of the set yoghurt.

4.4.2.2 Yeast / mould count

Analysis of the data (Table 17) with regard to yeast/mould count (cfu/ml) showed no significant difference between control and treatments. The mean ±SE for the control and treatments were 10.50 ± 0.67, 10.30 ± 0.66, 11.00 ± 0.80, 11.83 ± 0.80, 12.33 ± 1.20, 11.50 ± 0.67, 12.16 ± 0.48, 12.5 ± 0.71 and 12.6 ± 0.33 respectively. The results indicated that addition of coconut cream at 25, 50, 75 and 100 per cent levels with or with out sodium alginate does not produce any change in the yeast/mould count of the set yoghurt.

4.5 Sensory Evaluation

Marketing and consumer acceptability of yoghurt is mainly dependent upon the sensory qualities of the product. The sensory qualities such as appearance, body and texture and flavour of control and treatment yoghurt were evaluated by a panel of six judges.

4.5.1 Appearance and colour score

The data with range, mean ± SE with respect to appearance & colour are presented in Table 18 and Fig 8. The mean scores obtained for control and treatments were 4.14 ±0.16, 4.23 ± 0.13, 4.22 ± 0.08, 4.11 ± 0.11, 4.04 ±0.09, 4.11 ± 0.12, 4.17 ± 0.12, 4.16 ± 0.13 and 3.98 ± 0.11 respectively. The lowest mean score was obtained for T9, however analysis of variance showed no significant difference among the treatments as well as between the control and treatments.

4.5.2 Body and Texture Score

The mean $\pm$ SE for body and texture score were 3.90 $\pm$ 0.13, 4.09 $\pm$ 0.09, 4.24 $\pm$ 0.06, 4.28 $\pm$ 0.08, 4.32 $\pm$ 0.06, 4.12 $\pm$ 0.10, 4.34 $\pm$ 0.08, .4.24 $\pm$ 0.11 and 4.33 $\pm$ 0.07 respectively. Body and texture score (Table 19 and Fig 8) showed significant difference ($p<0.05$) between control and treatments. The body and texture mean scores showed an increasing trend as compared to control irrespective of the addition of sodium alginate. Treatment means when compared using critical difference revealed that T3, T4, T5, T6, T7, T8 and T9 were comparable. Hence, it is observed that for improving body and texture qualities at 50, 75 and 100 per cent replacement levels stabiliser addition has no influence. Body and texture attributes of samples with 25 per cent replacement with or without stabiliser, was comparable to control.

4.5.3 Flavour Score

The flavour score for control and treatments are presented in Table 20 and Fig 8. The mean $\pm$ SE were 8.50 $\pm$ 0.15, 8.36 $\pm$ 0.12, 8.61 $\pm$ 0.23, 8.61 $\pm$ 0.20, 8.37 $\pm$ 0.17, 8.21 $\pm$ 0.11, 8.29 $\pm$ 0.19, 8.48 $\pm$ 0.13 and 8.21 $\pm$ 0.08 for control and treatments respectively. Statistical analysis of the data revealed no significant difference between control and treatments as well as among the treatments, indicating that neither coconut cream nor stabiliser produces any effect on the flavour of yoghurt.

4.5.4 Total Scores

The total scores for control and treatments are presented in Table 21 and Fig 8. The mean $\pm$ SE total score for control and treatments T2,T3,T4,T5,T6,T7,T8 and T9 were 16.55 $\pm$ 0.31, 16.67 $\pm$ 0.29, 17.07 $\pm$ 0.27, 16.99 $\pm$ 0.29, 16.73 $\pm$0.16, 16.43 $\pm$ 0.21, 16.80 ± 0.30, 16.89 ±0.24 and 16.52 ± 0.22 respectively. With regard to the total score no significant difference between the control and treatments could be observed, indicating that incorporation of coconut cream to replace milk fat at 25,50,75 and 100 per cent levels with or without addition of sodium alginate does not produce significant change in the total score of the product, when organoleptic evaluation of the product was done by panel of judges.

4.6 Cost Estimation

The cost of 100 g of control and experimental yoghurt was calculated based on the ingredient cost (Table 2). The cost of ingredients for 100 g control was Rs. 2.098 where as for the treatments T2, T3,T4,T5,T6,T7,T8 and T9 were Rs. 2.041/- Rs. 1.984/-, Rs. 1.926/-, Rs. 1.877/-, Rs. 2.042/-, Rs. 1.984/-, Rs. 1.927/- and Rs. 1.877 respectively. The saving in cost was 2.72 per cent, 5.43 per cent, 8.20 per cent, 10.53 per cent, 2.67 per cent 5.43 per cent, 8.15 per cent and 10.53 per cent for treatments T2,T3,T4,T5,T6,T7,T8 and T9 respectively as compared to control.

Tables

Table:3. Mean fat, total solids of skim milk powder, skim milk ,milk cream and coconut cream

Ingredients	Fat %	Total solids %
Skim milk powder	0.56	97.37
Skim milk	0.13	8.62
Milk cream	62.78	76.02
Coconut cream	40.76	53.01

Table 4. Titratable acidity of yoghurt mix (as percentage lactic acid)

Trails	Tc	T2	T3	T4	T5	T6	T7	T8	T9
1	0.20	0.21	0.21	0.22	0.22	0.21	0.22	0.22	0.22
2	0.22	0.23	0.20	0.23	0.22	0.23	0.22	0.22	0.21
3	0.20	0.21	0.20	0.22	0.23	0.23	0.20	0.21	0.22
4	0.20	0.22	0.22	0.21	0.21	0.21	0.21	0.20	0.22
5	0.21	0.20	0.21	0.20	0.22	0.20	0.22	0.21	0.21
6	0.20	0.20	0.21	0.21	0.22	0.21	0.22	0.21	0.22
Range	0.20 - 0.22	0.20- 0.23	0.20- 0.22	0.20- 0.23	0.21- 0.23	0.20- 0.23	0.20- 0.22	0.20- 0.22	0.21- 0.22
Mean $\pm$ SE	0.21 $\pm$0.003	0.21 $\pm$0.004	0.20 $\pm$0.003	0.21 $\pm$0.004	0.22 $\pm$0.002	0.22 $\pm$0.005	0.22 $\pm$0.003	0.21 $\pm$0.003	0.22 $\pm$0.003

ANOVA

Source	df	ss	mss	F-value
Between	8	0.037	0.005	1.447 NS
Within	45	0.145	0.03	
Total	53	0.183		

NS - Not Significant

Table 5. pH value of yoghurt mix

Trails	Tc	T2	T3	T4	T5	T6	T7	T8	T9
1	6.18	6.20	6.22	6.18	6.22	6.20	6.26	6.28	6.21
2	6.28	6.29	6.18	6.17	6.20	6.22	6.18	6.24	6.24
3	6.20	6.21	6.17	6.18	6.18	6.17	6.17	6.19	6.19
4	6.21	6.21	6.18	6.19	6.20	6.20	6.17	6.19	6.22
5	6.20	6.20	6.22	6.22	6.26	6.20	6.19	6.19	6.24
6	6.20	6.21	6.20	6.18	6.18	6.22	6.22	6.20	6.26
Range	6.18-6.28	6.20-6.29	6.17-6.22	6.17-6.22	6.18-6.26	6.17-6.22	6.17-6.26	6.19-6.28	6.19-6.26
Mean $\pm$ SE	6.212 $\pm$0.01	6.220 $\pm$0.01	6.195 $\pm$0.01	6.187 $\pm$0.01	6.207 $\pm$0.01	6.202 $\pm$0.01	6.198 $\pm$0.02	6.215 $\pm$0.02	6.227 $\pm$0.01

ANOVA

Source	df	ss	mss	F-value
Between	8	0.008	0.001	1.140 NS
Within	45	0.039	0.001	
Total	53	0.046		

NS - Not Significant

Table 6. Total solids of yoghurt mix.(percentage)

Trials	Tc	T2	T3	T4	T5	T6	T7	T8	T9
1	23.15	23.07	22.63	23.00	23.80	22.70	22.90	23.10	22.40
2	22.82	23.05	23.10	22.90	23.02	22.94	22.80	22.98	23.72
3	23.60	22.88	22.98	22.96	23.10	23.07	23.11	23.65	22.78
4	22.90	22.95	23.02	23.00	23.03	23.07	23.00	22.82	23.02
5	23.00	22.92	22.98	23.05	23.01	23.00	22.92	22.97	23.42
6	22.93	23.00	23.02	23.03	23.00	23.12	23.02	23.00	23.06
Range	22.82-23.60	22.88-23.07	22.63-23.10	22.90-23.05	23.00-23.80	22.70-23.12	22.80-23.11	22.82-23.65	22.40-23.42
Mean $\pm$ SE	23.07 $\pm$0.12	22.98 $\pm$0.03	22.62 $\pm$0.19	23.04 $\pm$0.06	22.99 $\pm$0.04	22.98 $\pm$0.06	22.96 $\pm$0.04	23.09 $\pm$0.12	22.98 $\pm$0.15

ANOVA

Source	df	ss	mss	F-value
Between	8	0.420	0.053	1.775^{NS}
Within	45	1.332	0.030	
Total	53	1.752		

NS - Not Significant

Table 7. **Setting time of yoghurt (h)**

Trials	Tc	T2	T3	T4	T5	T6	T7	T8	T9
1	3.52	4.13	4.13	4.25	4.30	4.24	4.20	4.28	4.34
2	3.55	4.10	4.12	4.22	4.29	4.17	4.18	4.27	4.32
3	4.00	4.06	4.10	4.20	4. .31	4.20	4.22	4.26	4.35
4	3.53	4.12	4.13	4.23	4.25	4.20	4.20	4.27	4.32
5	3.40	4.09	4.10	4.18	4.25	4.14	4.16	4.22	4.30
6	3.44	4.05	4.08	4.16	4.22	4.09	4.15	4.21	4.31
Range	3.40 - 4.00	4.05 - 4.13	4.08 - 4.13	4.16 - 4.25	4.22 - 4.31	4.09 - 4.24	4.15 - 4.22	4.21 - 4.28	4.30 - 4.35
Mean ± SE	3.57^{f} ± 0.09	4.09^{e} ± 0.01	4.11^{de} ± 0.01	4.21^{bc} ± 0.01	4.27^{ab} ± 0.02	4.17^{cde} ± 0.02	4.19^{bcd} ± 0.01	4.25^{abc} ± 0.01	4.32^{a} ± 0.01

ANOVA

Source	df	ss	mss	F-value
Between	8	2.366	0.296	47.962**
Within	45	0.277	0.006	
Total	53	2.643		

** indicating significant difference at 1 % level ($p < 0.01$)
Means bearing the common letters as super script are statistically not significant.

Table 8. Titratable acidity of yoghurt (as percentage lactic acid)

Trials	Tc	T2	T3	T4	T5	T6	T7	T8	T9
1	0.92	0.99	1.04	1.06	1.07	1.03	1.04	1.06	1.08
2	0.91	1.03	1.06	1.01	1.08	1.01	1.06	1.07	1.07
3	0.89	1.04	1.03	0.99	1.03	1.07	1.07	1.04	1.04
4	0.91	1.04	1.03	1.07	1.06	1.04	1.03	1.05	1.06
5	0.88	1.02	1.06	1.07	1.06	1.03	1.06	1.07	1.06
6	0.95	1.06	1.05	1.06	1.07	1.03	1.05	1.07	1.07
Range	0.91 - 0.95	0.99 - 1.06	1.03 - 1.06	0.99 - 1.07	1.03 - 1.08	1.01 - 1.07	1.03 - 1.07	1.04 - 1.07	1.04 - 1.08
Mean $\pm$ SE	0.91^{c} ± 0.010	1.03^{b} ± 0.009	1.05^{ab} ± 0.005	1.04^{ab} ± 0.014	1.06^{a} ± 0.007	1.04^{b} ± 0.008	1.05^{ab} ± 0.006	1.06^{a} ± 0.005	1.06^{a} ± 0.005

ANOVA

Source	df	ss	mss	F-value
Between	8	0.924	0.115	33.605**
Within	45	0.155	0.003	
Total	53	1.078		

** indicating significant difference at 1 % level ($p < 0.01$)
Means bearing the common letters as super script are statistically not significant.

Table 9. pH value of yoghurt

Trials	Tc	T2	T3	T4	T5	T6	T7	T8	T9
1	4.55	4.56	4.56	4.57	4.55	4.56	4.56	4.57	4.56
2	4.56	4.53	4.55	4.55	4.56	4.55	4.55	4.56	4.57
3	4.58	4.55	4.60	4.56	4.58	4.57	4.56	4.57	4.56
4	4.56	4.56	4.57	4.55	4.57	4.56	4.60	4.57	4.55
5	4.58	4.55	4.56	4.55	4.58	4.56	4.55	4.56	4.56
6	4.53	4.56	4.57	4.56	4.56	4.55	4.57	4.56	4.55
Range	4.53 - 4.58	4.53 - 4.56	4.55 - 4.60	4.55 - 4.57	4.55 - 4.58	4.55 - 4.57	4.55 - 4.60	4.56 - 4.57	4.55 - 4.57
Mean $\pm$ SE	4.56 $\pm$ 0.01	4.55 $\pm$ 0.00	4.57 $\pm$ 0.01	4.56 $\pm$ 0.00	4.57 $\pm$ 0.00	4.56 $\pm$ 0.00	4.57 $\pm$ 0.01	4.57 $\pm$ 0.00	4.56 $\pm$ 0.00

ANOVA

Source	df	ss	mss	F-value
Between	8	0.001	0.000	1.075^{NS}
Within	45	0.007	0.000	
Total	53	0.008		

NS - Not Significant

Table 10. Fat percentage of yoghurt

Trials	Tc	T2	T3	T4	T5	T6	T7	T8	T9
1	3.2	3.1	3.0	3.2	3.0	3.2	3.1	3.2	3.2
2	3.0	3.1	2.9	3.0	3.1	3.0	3.0	3.1	3.2
3	3.1	3.0	3.1	3.1	3.2	3.1	3.1	3.0	3.1
4	2.8	2.9	3.0	2.9	3.0	2.8	2.9	3.0	3.0
5	2.9	2.8	2.9	3.0	3.0	3.1	2.8	2.8	2.9
6	3.0	3.0	3.1	2.8	2.8	2.9	3.0	2.9	2.8
Range	2.8 - 3.2	2.8 - 3.1	2.9 - 3.1	2.8 - 3.2	2.8 - 3.2	2.8 - 3.2	2.8 - 3.1	2.8 - 3.2	2.8 - 3.2
Mean $\pm$SE	3.00 $\pm$ 0.06	2.98 $\pm$ 0.05	3.00 $\pm$ 0.04	3.00 $\pm$ 0.06	3.02 $\pm$ 0.05	3.02 $\pm$ 0.06	2.98 $\pm$ 0.05	3.00 $\pm$ 0.06	3.03 $\pm$ 0.07

ANOVA

Source	df	ss	mss	F- value
Between	8	0.034	0.004	0.085^{NS}
Within	45	2.284	0.051	
Total	53	2.318		

NS - Not Significant

Table No. 11. Protein content of yoghurt (g /100 ml)

Trials	Tc	T2	T3	T4	T5	T6	T7	T8	T9
1	5.34	5.39	6.11	6.65	7.10	5.41	6.20	6.88	7.09
2	5.52	5.58	6.15	6.73	7.34	5.60	6.23	6.70	7.24
3	5.12	5.21	6.09	6.76	7.14	5.24	6.11	6.79	7.16
4	5.31	5.39	6.03	6.40	7.07	5.41	6.09	6.65	7.10
5	5.26	5.39	6.15	6.67	7.17	5.44	6.17	6.17	7.18
6	4.98	5.19	6.11	6.70	7.13	5.26	6.14	6.85	7.20
Range	4.98-5.52	5.19-5.58	6.09-6.15	6.40-6.76	7.07-7.34	5.24-5.60	6.09-6.23	6.17-6.88	7.09-7.24
Mean $\pm$SE	5.255^{e} $\pm$ 0.08	5.358^{de} $\pm$0.06	6.107^{c} $\pm$0.02	6.652^{b} $\pm$0.05	7.158^{a} $\pm$0.04	5.393^{d} $\pm$0.05	6.157^{c} $\pm$0.02	6.777^{b} $\pm$0.04	7.162^{a} $\pm$0.24

ANOVA

Source	df	ss	mss	F-value
Between	8	27.823	3.478	273.411**
Within	45	0.572	0.013	
Total	53	28.398		

** Indicating significant difference at 1 % level (p< 0.01)

Means bearing the common letters as superscript are statistically not significant.

Table 12. Non protein nitrogen content of yoghurt (mg/100 ml)

Trial	Tc	T2	T3	T4	T5	T6	T7	T8	T9
1	40.32	44.80	50.46	59.48	70.56	45.92	51.64	61.60	71.68
2	38.08	42.56	48.16	54.58	64.96	43.60	49.20	56.60	67.20
3	35.84	40.30	45.92	53.76	66.08	41.44	47.04	53.88	68.32
4	44.80	47.04	52.34	60.48	69.64	48.16	53.26	62.72	72.28
5	50.40	52.60	56.00	60.38	67.20	53.76	57.22	61.52	69.44
6	49.30	53.76	57.12	64.96	71.20	54.90	58.24	66.08	72.72
Range	35.84 - 50.40	40.30 - 53.16	45.92 - 57.12	53.76 - 64.96	64.96 - 71.20	41.44 - 54.90	47.04 - 58.24	53.88 - 66.08	67.20 - 72.72
Mean ±SE	43.12^{e} ± 2.44	46.84^{de} ± 2.21	51.67^{cd} ± 1.79	58.94^{b} ± 1.70	68.27^{a} ± 1.04	47.96^{cde} ± 2.22	52.78^{c} ± 1.79	60.40^{b} ± 1.80	70.27^{a} ± 0.93

ANOVA

Source	df	ss	mss	F-value
Between	8	4345.213	543.152	26.895**
Within	45	908.792	20.195	
Total	53	5254.005		

** Indicating significant difference at 1 % level (p< 0.01)
Means bearing the common letters as superscript are statistically not significant.

Table 13. Curd tension values of yoghurt (g)

Trials	Tc	T2	T3	T4	T5	T6	T7	T8	T9
1	30.80	32.85	36.90	38.88	40.60	34.22	38.70	40.20	42.90
2	32.90	35.90	38.50	39.97	41.50	37.00	40.90	41.20	43.10
3	28.20	29.12	30.73	33.78	35.58	31.25	32.85	39.94	37.00
4	27.80	30.00	31.84	34.05	37.95	32.05	33.15	36.80	40.25
5	26.00	28.28	31.00	33.10	36.82	31.10	34.00	38.12	39.88
6	26.70	29.18	32.30	35.28	38.17	31.00	34.80	37.10	40.48
Range	26.00 - 32.90	28.28 - 35.90	30.73 - 38.50	33.10 - 39.97	35.58 - 41.50	31.00 - 37.00	32.85 - 40.90	36.80 - 41.20	37.00 - 43.10
Mean $\pm$SE	28.73^{e} $\pm$ 1.07	30.89^{de} $\pm$ 1.19	33.55^{cd} $\pm$ 1.35	35.84^{bc} $\pm$1.18	38.44^{ab} $\pm$ 0.91	32.77^{cd} $\pm$ 0.98	35.73^{bc} $\pm$ 1.35	38.39^{ab} $\pm$ 0.76	40.60^{a} $\pm$ 0.91

ANOVA

Source	df	ss	mss	F Value
Between	8	715.317	89.415	12.412**
Within	45	324.175	7.204	
Total	53	1039.493		

** Indicating significant difference at 1 % level ($p < 0.01$)
Means bearing the common letters as superscript are statistically not significant.

Table 14 Viscosity values of yoghurt (p)

Trials	Tc	T2	T3	T4	T5	T6	T7	T8	T9
1	251.68	262.28	271.68	280.92	289.78	276.08	282.36	295.08	308.20
2	253.50	264.38	270.92	280.86	290.76	289.28	285.32	308.26	312.72
3	239.00	247.80	254.38	264.10	273.00	253.18	264.76	273.10	289.00
4	242.22	251.50	259.85	269.83	280.98	260.10	262.00	281.78	287.17
5	234.20	242.28	248.12	260.72	271.24	250.24	261.20	269.12	282.16
6	262.47	269.12	277.20	286.10	294.10	277.20	286.10	293.12	306.98
Range	234.20 - 262.41	242.28 - 269.12	248.12 - 277.20	260.72 - 286.10	271.24 - 294.10	250.24 - 289.28	261.20- 286.10	269.12 - 308.26	282.16- 312.72
Mean $\pm$SE	247.18^{e} $\pm$ 4.30	256.23^{de} $\pm$ 4.31	263.69^{cd} $\pm$ 4.63	273.76^{bc} $\pm$ 4.21	283.44^{b} $\pm$ 3.90	267.68^{cd} $\pm$ 6.32	273.62^{bc} $\pm$ 4.96	286.74^{ab} $\pm$ 6.04	297.71^{a} $\pm$ 5.32

ANOVA

Source	df	ss	mss	F- value
Between	8	11800.605	1475.076	10.022**
Within	45	6623.365	147.186	
Total	53	18423.970		

** Indicating significant difference at 1 % level ($p< 0.01$)
Means bearing the common letters as superscript are statistically not significant.

Table 15 Tyrosine value of yoghurt (mg/g)

Trials	Tc	T2	T3	T4	T5	T6	T7	T8	T9
1	0.31	0.30	0.33	0.35	0.38	0.29	0.32	0.34	0.37
2	0.28	0.29	0.32	0.33	0.35	0.28	0.31	0.33	0.34
3	0.33	0.32	0.36	0.38	0.39	0.31	0.35	0.37	0.38
4	0.32	0.30	0.32	0.34	0.36	0.29	0.32	0.33	0.34
5	0.37	0.33	0.35	0.37	0.39	0.32	0.34	0.37	0.38
6	0.34	0.31	0.34	0.36	0.38	0.30	0.33	0.35	0.37
Range	0.28 - 0.37	0.29 - 0.33	0.32 - 0.36	0.33 - 0.38	0.35 - 0.39	0.28 - 0.32	0.31 - 0.35	0.33 - 0.37	0.34 - 0.38
Mean $\pm$SE	0.325^{ef} $\pm$ 0.01	0.308^{fg} $\pm$ 0.00	0.336^{cde} $\pm$ 0.01	0.355^{abc} $\pm$ 0.01	0.375^{a} $\pm$ 0.01	0.298^{g} $\pm$ 0.00	0.328^{def} $\pm$ 0.00	0.348^{bcd} $\pm$ 0.01	0.363^{ab} $\pm$ 0.01

ANOVA

Source	df	ss	mss	F- value
Between	8	0.031	0.004	11.048**
Within	45	0.016	0.000	
Total	53	0.046		

** Indicating significant difference at 1 % level ($p< 0.01$)
Means bearing the common letters as superscript are statistically not significant.

Table 16. Coliform count of yoghurt (cfu/ml)

Trials	Tc	T2	T3	T4	T5	T6	T7	T8	T9
1	5	4	3	4	4	8	7	6	5
2	8	7	6	5	7	6	6	5	6
3	4	7	5	6	5	7	8	6	7
4	6	5	4	3	5	8	4	7	8
5	7	4	6	7	9	8	3	5	7
6	5	5	6	7	8	9	7	6	8
Range	4 - 8	4 - 7	3 - 6	3 - 7	4 - 9	6 - 9	3 - 8	5 - 7	5 - 8
Mean ± SE	5.83 ± 0.60	5.33 ± 0.56	5.00 ± 0.52	5.33 ± 0.67	6.33 ± 0.80	7.67 ± 0.42	5.83 ± 0.79	5.83 ± 0.31	6.83 ± 0.48

ANOVA

Source	df	ss	mss	F- value
Between	8	1.399	0.175	1.850^{NS}
Within	45	4.253	0.095	
Total	53	5.652		

NS - Not Significant

Table 17. Yeast/mould count of yoghurt (cfu/ml)

Trials	Tc	T2	T3	T4	T5	T6	T7	T8	T9
1	10	8	9	12	11	13	11	12	13
2	9	11	10	13	12	13	14	10	12
3	10	9	10	11	8	10	13	14	13
4	12	10	13	9	13	9	12	12	12
5	9	12	14	15	17	12	12	15	14
6	13	12	10	11	13	12	11	12	12
Range	9 - 13	8 - 12	9 - 14	9 - 15	8 - 17	9 - 13	11 - 14	10 - 15	12 - 14
Mean $\pm$SE	10.50 $\pm$ 0.67	10.30 $\pm$ 0.66	11.00 $\pm$ 0.80	11.83 $\pm$ 0.80	12.33 $\pm$ 1.20	11.50 $\pm$ 0.67	12.16 $\pm$ 0.48	12.50 $\pm$ 0.71	12.66 $\pm$ 0.33

ANOVA

Source	df	ss	mss	F- value
Between	8	0.794	0.099	1.382^{NS}
Within	45	3.234	0.072	
Total	53	4.028		

NS - Not Significant

Table 18. Sensory evaluation of yoghurt (Appearance and colour score)

Trials	Tc	T2	T3	T4	T5	T6	T7	T8	T9
1	4.00	3.85	4.43	3.71	3.85	4.00	4.28	4.28	3.59
2	3.89	3.83	3.94	3.81	3.83	3.72	3.78	3.50	3.78
3	3.86	4.43	4.40	4.43	4.14	3.86	4.43	4.29	4.00
4	4.86	4.29	4.29	4.29	4.00	4.28	3.80	4.36	4.00
5	4.00	4.57	4.14	4.14	4.43	4.29	4.40	4.29	4.23
6	4.25	4.78	4.13	4.25	4.00	4.50	4.31	4.25	4.25
Range	3.86 - 4.86	3.83 - 4.78	3.94 - 4.43	3.71 - 4.43	3.83 - 4.43	3.72 - 4.50	3.78 - 4.43	3.50 4.29	3.59 - 4.25
Mean $\pm$ SE	4.14 $\pm$ 0.16	4.23 $\pm$ 0.13	4.22 $\pm$ 0.08	4.11 $\pm$ 0.11	4.04 $\pm$ 0.09	4.11 $\pm$ 0.12	4.17 $\pm$ 0.12	4.16 $\pm$ 0.13	3.98 $\pm$ 0.11

ANOVA

Source	df	ss	mss	F- value
Between	8	0.317	0.040	0.474^{NS}
Within	45	3.762	0.084	
Total	53	4.079		

NS - Not Significant

Table 19. Sensory evaluation of yoghurt (Body and texture score)

Trials	Tc	T2	T3	T4	T5	T6	T7	T8	T9
1	3.42	3.71	4.14	4.00	4.10	4.00	4.20	4.73	4.40
2	3.67	4.05	4.12	4.50	4.42	4.22	4.16	4.22	4.06
3	4.00	4.02	4.20	4.14	4.20	4.04	4.56	4.07	4.38
4	4.00	4.07	4.21	4.29	4.50	3.79	4.50	4.00	4.20
5	4.00	4.29	4.29	4.28	4.43	4.14	4.14	4.29	4.43
6	4.31	4.38	4.50	4.44	4.28	4.50	4.50	4.13	4.50
Range	3.42 - 4.31	3.71 - 4.38	4.12 - 4.50	4.00 - 4.50	4.10 - 4.50	4.00 - 4.50	4.14 - 4.56	4.07 - 4.73	4.06 - 4.50
Mean + SE	3.90^{c} + 0.13	4.09^{bc} + 0.09	4.24^{ab} + 0.06	4.28^{ab} + 0.08	4.32^{ab} + 0.06	4.12^{abc} + 0.10	4.34^{a} + 0.08	4.24^{ab} + 0.11	4.33^{ab} + 0.07

ANOVA

Source	df	ss	mss	F- value
Between	8	1.024	0.128	2.749*
Within	45	2.100	0.047	
Total	53	3.124		

* Indicating significant difference at 5 % level ($p < 0.05$)
Means bearing the common letters as superscript are statistically not significant.

Table 20. Sensory evaluation of yoghurt (Flavour score)

Trials	Tc	T2	T3	T4	T5	T6	T7	T8	T9
1	8.29	8.30	9.42	8.29	8.86	8.08	8.00	8.29	8.19
2	8.00	8.20	8.10	8.12	7.90	7.91	7.88	7.98	8.00
3	8.70	8.00	8.40	8.14	8.29	8.14	8.06	8.57	8.29
4	8.28	8.28	8.57	9.14	8.00	8.71	8.10	8.86	8.00
5	8.86	8.86	9.14	9.14	8.29	8.29	8.57	8.57	8.29
6	8.88	8.50	8.00	8.80	8.88	8.13	9.13	8.63	8.50
Range	8.00 - 8.88	8.00 - 8.86	8.00 - 9.42	8.12 - 8.88	7.90 - 8.88	7.91 - 8.71	7.88 - 9.13	7.98 - 8.86	8.00 - 8.50
Mean $\pm$SE	8.50 $\pm$ 0.15	8.36 $\pm$ 0.12	8.61 $\pm$ 0.23	8.61 $\pm$ 0.20	8.37 $\pm$ 0.17	8.21 $\pm$ 0.11	8.29 $\pm$ 0.19	8.48 $\pm$ 0.13	8.21 $\pm$ 0.08

ANOVA

Source	df	ss	mss	F- value
Between	8	1.126	0.141	0.919^{NS}
Within	45	6.892	0.153	
Total	53	8.018		

NS - Not Significant

Table 21. Sensory evaluation of yoghurt (Total score)

Trials	Tc	T2	T3	T4	T5	T6	T7	T8	T9
1	15.71	15.86	17.99	16.00	16..81	16.08	16.48	17.30	16.18
2	15.56	16.08	16.16	16.43	16.15	15.85	15.82	15.70	15.84
3	16.56	16.45	17.00	16.71	16.63	16.04	17.05	16.93	16.67
4	17.14	16.64	17.07	17.72	16.50	16.78	16.40	17 .22	16.20
5	16.86	17.72	17.57	17.56	17.15	16.72	17.11	17.15	16.95
6	17.44	17.26	16.63	17.49	17.16	17.13	19.94	17.01	17.25
Range	15.56 - 17.44	15.86 - 17.72	16.16 - 17.99	16.00 - 17.72	16.15 - 17.16	15.85 - 17.13	15.82 - 19.94	15.70 - 17.30	15.84 17.25
Mean $\pm$SE	16.55 $\pm$ 0.31	16.67 $\pm$ 0.29	17.07 $\pm$ 0.27	16.99 $\pm$ 0.29	16.73 $\pm$ 0.16	16.43 $\pm$ 0.21	16.80 $\pm$0.30	16.89 $\pm$ 0.24	16.52 $\pm$ 0.22

ANOVA

Source	df	ss	mss	F- value
Between	8	2.288	0.286	0.716^{NS}
Within	45	17.981	0.400	
Total	53	20.269		

NS - Not Significant

Figures

Fig. 2 Setting time of Yoghurt

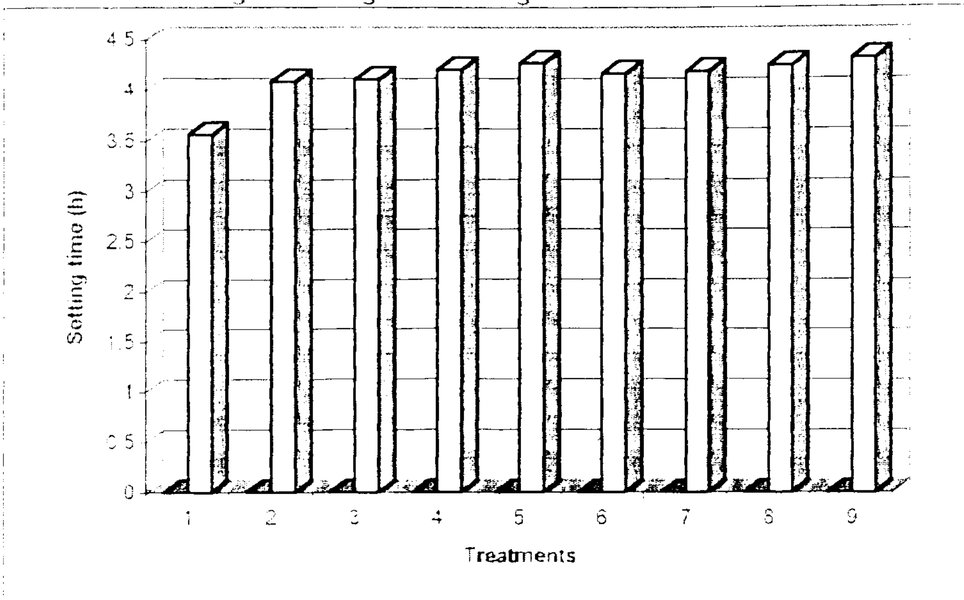


Fig. 3 Protein Percentage of Yoghurt

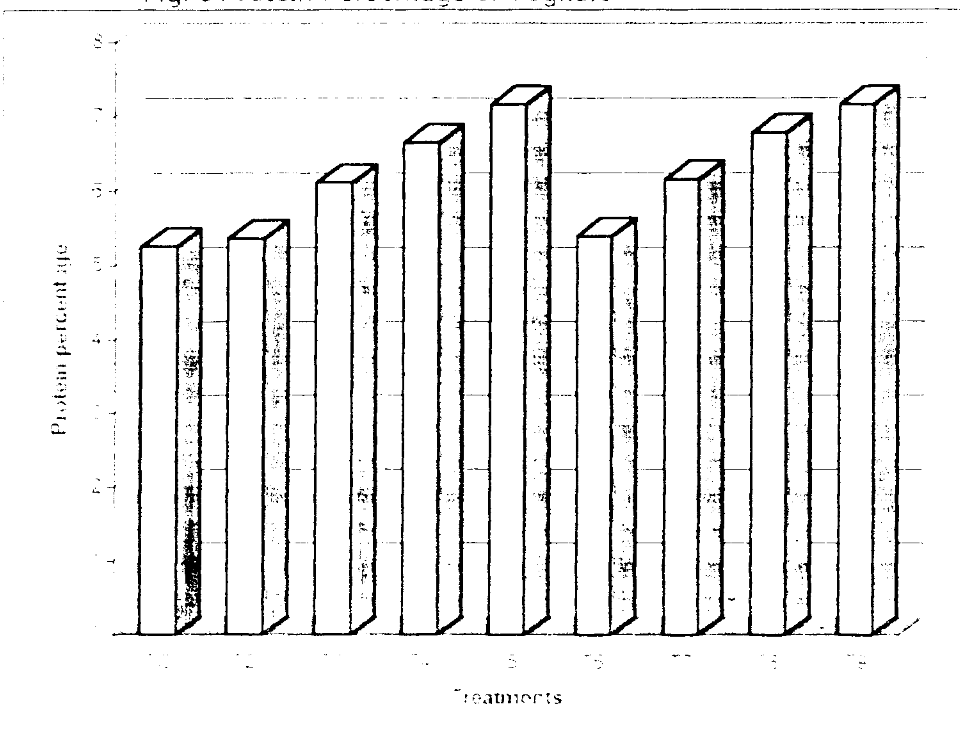


Fig. 4, Non protein ni trogen percentage

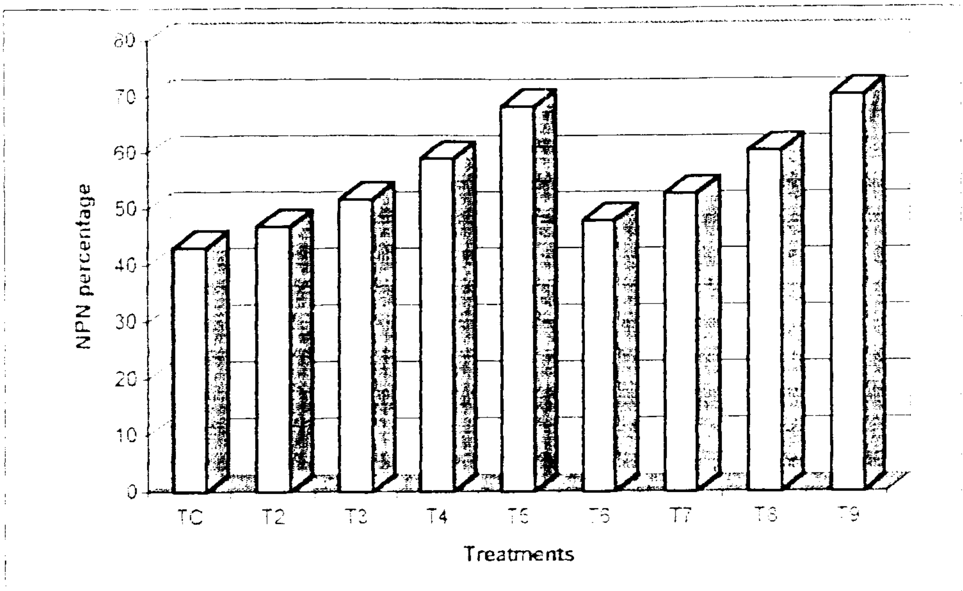


Fig. 5 Curd tension of yoghurt

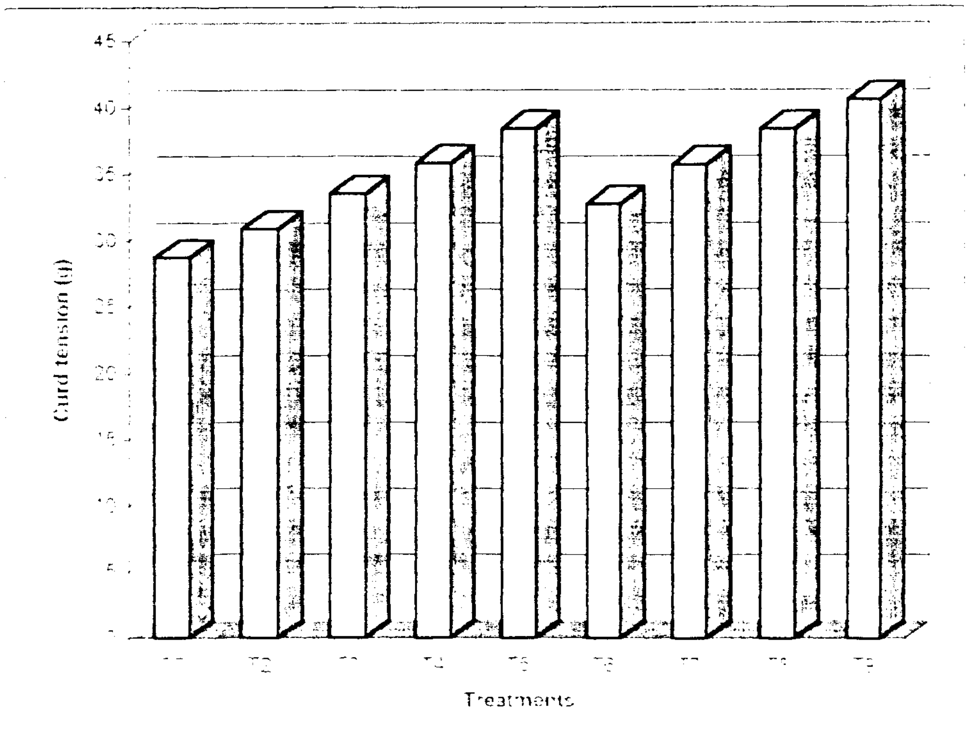


Fig. 6 Viscosity of yoghurt

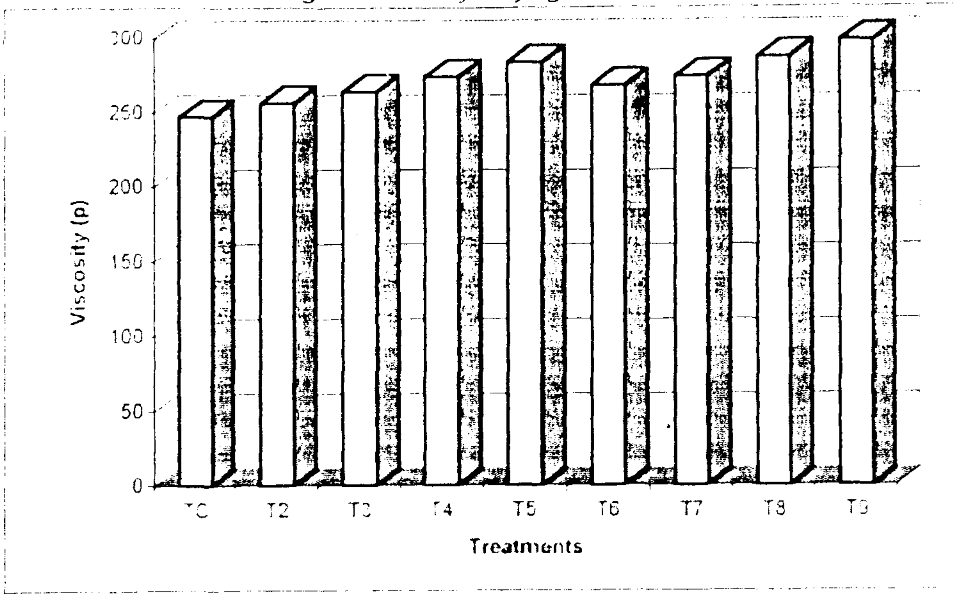


Fig. 7 Tyrosine value of yoghurt

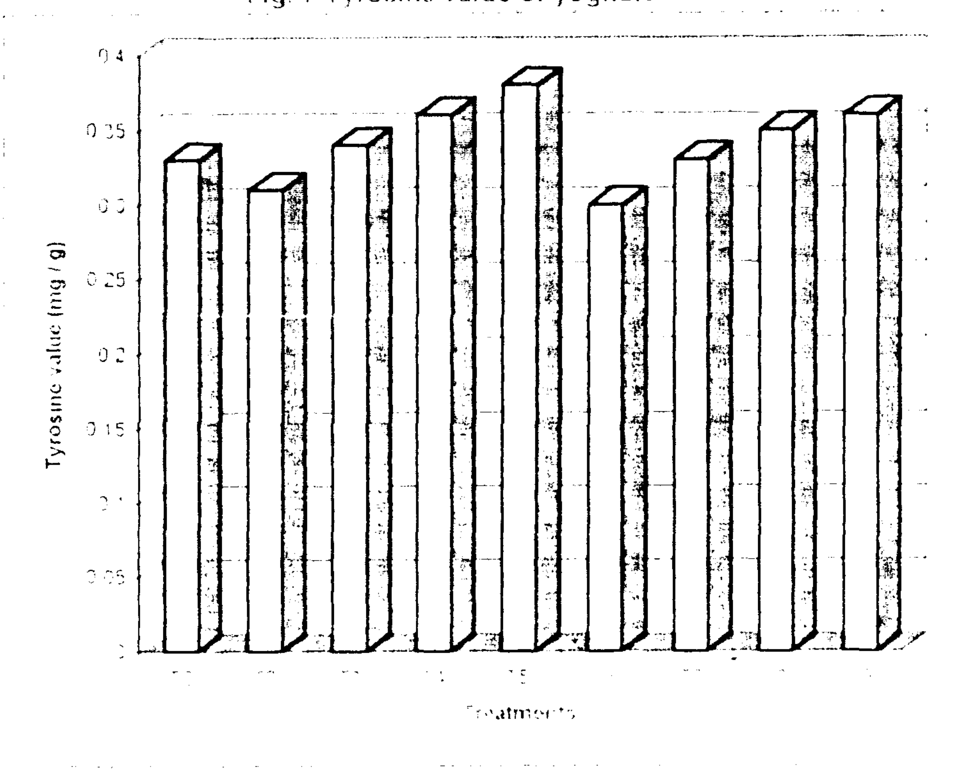
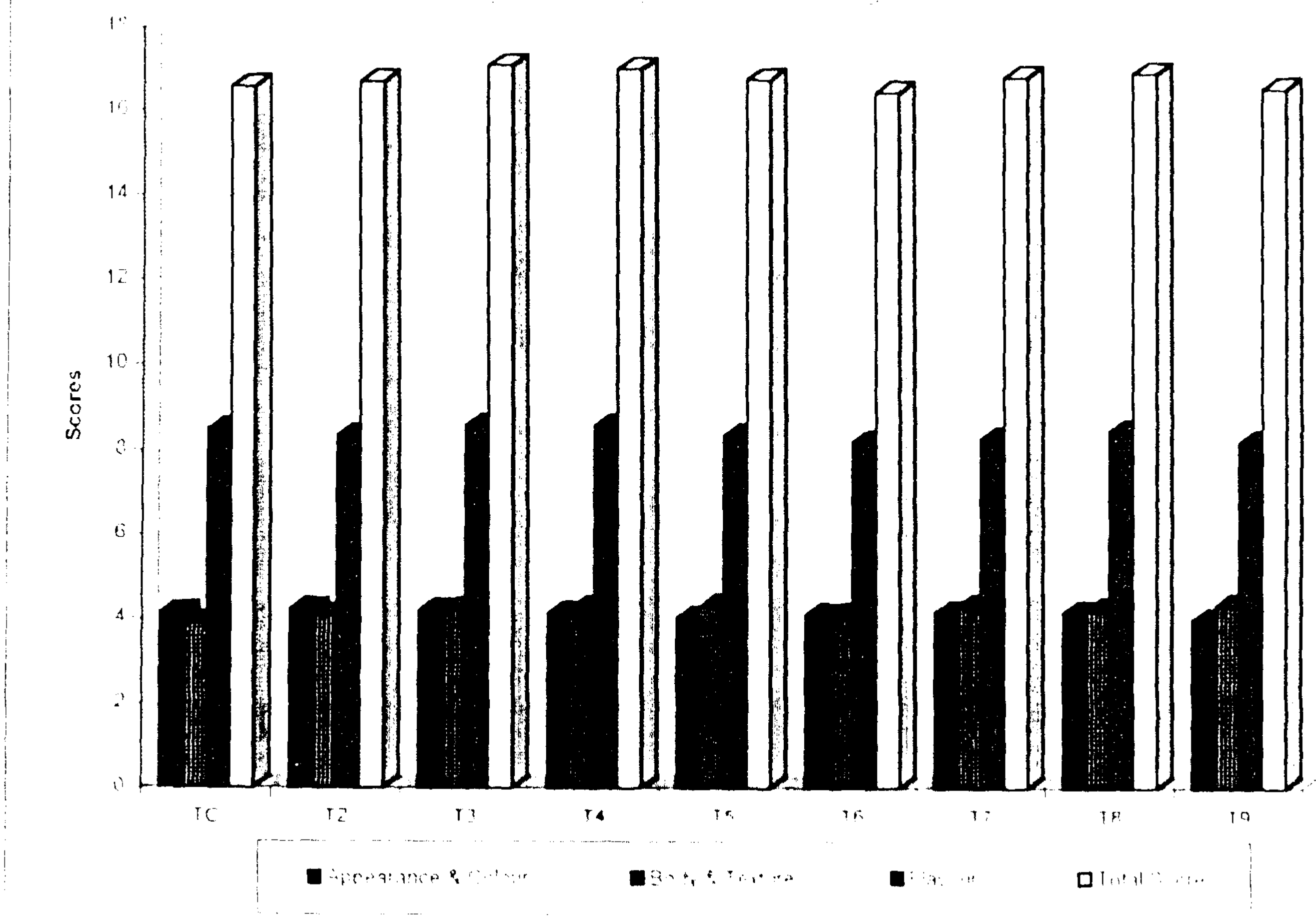


Fig. 8. Sensory evaluation of yoghurt



Discussion

5. DISCUSSION

Yoghurt is a fermented milk product having better nutritional and therapeutic value compared to milk. This study was undertaken to explore the feasibility of using coconut fat in the form of coconut cream, to replace milk fat at different levels in the manufacture of filled yoghurt. The product prepared was analysed for physico-chemical properties and subjected to sensory evaluation and was compared to normal yoghurt. The effect of sodium alginate in improving the textural characters of yoghurt was also undertaken. The results of the findings are discussed in this chapter.

5.1 Analysis of coconut cream

The mean composition of coconut cream extracted for various replications are presented in Table. 3. The mean fat percentage in coconut cream was 40.76, which was comparable to the value of 38 to 40 reported by Thampan (1984) and 40 reported by Jaganathan (1970). The mean total solids percentage in coconut cream was 53.01 which was in close agreement with the values of 50 and 53.5 reported by Jaganathan (1970) and Banzon (1978). The mean NPN content in coconut cream was 1.41 g/100ml.

5.2 Analysis of dairy ingredients

The dairy ingredients such as skim milk powder, skim milk and cream used in the preparation of yoghurt were analysed for fat and total solids(Table 3). The values obtained for the skim milk powder was in close agreement with the report of Hall and Hedrick (1971) and it is within the limits prescribed by Bureau of Indian Standards (IS : 1165, 1967) and Prevention of Food Adulteration Act. - 1954. The fat and total solids recorded for the skim milk were closer to the report of Webb *et al.*, (1987) and also within the limits of PFA Act - 1954. Recorded values for milk cream was in close agreement with the report of Sukumar De (1980), Shakeel-Asgar and Thompkinson (1994) and also within the limits of PFA Act - 1954. The NPN content in the milk cream was 0.84 g/100 ml. Manjunath and Bhat (1990) reported that the NPN content in the milk as 68.7 mg/ l.

5.3 Analysis of yoghurt mix

5.3.1 Titratable acidity

The titratable acidity with range, mean ± SE for control and treatment yoghurt mixes are presented in Table 4. The mean titratable acidity (as percentage lactic acid) for control was 0.21 and for treatments T2, T3, T4, T5, T6, T7, T8 and T9 were 0.21, 0.20, 0.21, 0.22, 0.22, 0.22, 0.21 and 0.22 respectively. Statistical analysis of the data showed no significant difference between control and treatments, indicating that addition of coconut cream to the yoghurt mix in partial or complete replacement of milk fat does not produce any significant change in the titratable acidity. The acidity in yoghurt mix reported by earlier workers ranged from 0.19 to 0.28 (Gopalakrishnan *et al.*, 1984), 0.14 to 0.185 (Chawla and Balachandran, 1994) and 0.17 to 0.19 (Malarkannan, 1996). In the present investigation the acidity ranged from 0.20 to 0.23 in the control and treatments and were in close agreement to the reports of Gopalakrishnan *et al.*, (1984), Chawla and Balachandran (1994), and Malarkannan (1996).

5.3.2 pH

The data with regard to pH including range, mean ± SE are presented in Table 5. The pH for the control was 6.212 whereas for the treatments it ranged from 6.187 to 6.227. Statistical analysis revealed no significant difference between control and treatments, indicating that addition of coconut cream to the yoghurt mixes does not produce any significant change in the pH. The earlier researchers reported pH values ranging from 6.28 to 6.60 (Gopalakrishnan *et al.*, 1984), 6.4 to 6.58 (Chawla and Balachandran, 1994) and 6.19 to 6.33 (Malarkannan, 1996) in yoghurt. The pH recorded in the present experiment are in unison with the reports of Gopalakrishnan *et al.*, (1984), Chawla and Balachandran (1994) and Malarkannan (1996).

5.3.3 Total solids

The data with range, mean $\pm$ SE for total solids (percentage) in yoghurt mix are presented in Table 6. The mean total solids in the control and treatments ranged from 22.62 to 23.09and the contribution by MSNF, fat and sugar were 14, three and six per cent respectively. Statistical analysis revealed no significant difference between the control and treatments. Identical total solids percentage could be achieved in all treatments since figuring of the mix was carried out employing linear programming model. Tamine and Robinson (1985) opined that the consistency and quality of the yoghurt are mainly dependant on the total solids and observed that increasing the level of total solids from 12 to 20 per cent improved the textural qualities of the yoghurt. Shakeel-Asgar and Thompkinson (1994) suggested 22.5 percentage of total solids in bioyoghurt, whereas the values ranged from 23.12 to 23.66 in yoghurt prepared by using condensed coconut water Malarkannan (1996) and Baig (1994) prepared good quality yoghurt incorporating whey solids with 20.86 to 22 per cent total solids. The total solids level maintained in the control and treatments were in close agreement with the reports of Shakeel-Asgar and Thompkinson (1994) and Malarkannan (1996).

5.4 Analysis of yoghurt

5.4.1 Analysis for physico-chemical properties

5.4.1.1 Setting time

The pH of 4.6 was taken as the cut off point in the fermentation process which was reported to be optimum for the production of good quality yoghurt. The data with respect to setting time (h) for the control and treatments are presented in Table 7 and Fig 2. Perusal of the data revealed a significant increase ($p < 0.01$) in setting time as the percentage replacement increased irrespective of addition of sodium alginate as compared to the control. The mean setting time for the control was 3.57 as compared to 4.27 and 4.32 in treatments T5 and T9 respectively. A setting time of 3.5 to 4 h and 4.0 to 4.3 h was reported for the yoghurt fortified with condensed skim milk by Patel and

Chakraborty (1985) and Shukla and Sandhu (1985). Prasad (1990) reported the setting time (h) of 3.15 to 4.30, 3.30 to 4.30 and 3.55 to 4.55 for yoghurt prepared from raw, pasteurized and lactoperoxidase activated cow milk. Malarkannan (1996) reported a setting time of 3.40 to 3.52 for normal yoghurt where as it ranged from 4.09 to 4.32 for yoghurt prepared by using condensed coconut water. The setting time recorded in the present study was in close agreement with the reports of the above researchers.

5.4.1.2 Titratable acidity

The data with regard to titratable acidity for the control and treatments (as percentage lactic acid) are presented in Table 8. The lowest mean titratable acidity of 0.91 was recorded in the control which gradually increased to 1.06 in 100 per cent replacement levels (T5 and T9). A significant difference ($p < 0.01$) existed between the control and treatments with respect to titratable acidity. The titratable acidity of normal yoghurt reported by earlier researchers were 1, 0.5, 1.16, 0.95 to 1.23 and 0.84 by Iyengar *et al.*, (1967), Marshal (1982), Mehanna and Mehanna (1989), Prasad (1990) and Chawla and Balachandran (1994). Baig (1994) reported values ranging from 0.93 to 0.96 in yoghurt prepared from condensed cheese whey. Misra and Kuila (1994) reported that with one, two and three per cent inoculum of *L. acidophilus*, *B. bifidum* and *L. bulgaricus* (1:1:3) in biogarde, the acidity developed was 0.99, 1.03 and 1.09 per cent respectively. Mistry and Hassan (1992) recommended an acidity level of 1.03 to 1.25 for yoghurt prepared by using high protein milk powder. Goodenough and Kleyn (1975) reported an acidity of 1.37 in commercial yoghurt having a carbohydrate content of 5.94 per cent. Anantakrishnan *et al.*, (1994) recommended the acidity around 1.2 to 1.4 per cent in good quality yoghurt. Malarkannan (1996) reported that the acidity ranged from 0.96 to 1.07 in yoghurt prepared using condensed coconut water. The acidity recorded in the present investigation for the control and treatments were closer to the values reported by Iyengar *et al.*, (1967), Marshal (1982), Prasad (1990), Baig (1994), Mistry and Hassan (1992) Anantakrishnan *et al.*, (1994) and Malarkannan (1996).

5.4.1.3 pH

The mean pH for the control was 4.56 and it ranged from 4.55 to 4.57 in treatments. Statistical analysis of the data presented in Table 9, revealed no significant difference between control and treatments, indicating that replacement of milk fat with coconut fat and addition of stabiliser did not have any influence on the pH of the products. Marshal (1982) and Tamine and Robinson (1985) recommended a pH of 4.4 to 4.6 and 4.6 to 4.7 for maintaining desirable body, texture and proper balance of *S. thermophilus* and *L. bulgaricus*. Similarly Gopalakrishnan *et al.*, (1984), Mistry and Hassan (1992), Baig (1994) reported that withdrawing of incubation process at a pH of 4.5 to 4.7 is required to produce good quality yoghurt, when whey protein concentrate, high milk protein powder and condensed cheese whey respectively were incorporated in yoghurt. In the present investigation the pH values were more or less similar to the values reported by the above scientists. Moreover the fermentation process was cut off when the pH was around 4.6. For obtaining good quality yoghurt Chawla and Balachandran (1994) and Shakeel -Asgar and Thompkinson (1994) recommended a cut of point of pH 4.6. Recorded values in the control and treatments were also within the range of 3.8 to 4.6 as suggested by Bureau of Indian Standards (IS 12898 : 1989).

5.4.1.4 Fat

The mean fat percentage in control yoghurt was 3.00 and for treatments it ranged from 2.98 to 3.03 (Table 10). Statistical analysis showed no significant difference between control and treatments. With regard to fat percentage in the yoghurt Alm, 1982 (for Swedish fermented milk products), Baig, 1994 (for yoghurt fortified with condensed cheese whey), Chawla and Balachandran, 1994 (for buffalo milk yoghurt), Shakeel-Asgar and Thompkinson, 1994 (for fruit flavoured filled bioyoghurt) and Desai *et al.*, 1994 (for fruit yoghurt) suggested that the ideal fat percentage in yoghurt for obtaining good flavour and mouth feel was 3.0. Bureau of Indian Standards (IS 12898: 1989) also recommended a fat percentage of 3.0 per cent for flavoured yoghurt. The fat percentage maintained in the control and treatments were in close agreement with the reports of the above scientists.

5.4.1.5 Protein

The body and textural qualities of yoghurt is mainly dependant on the protein content. The range and mean ± SE for protein are presented in Table 11 and Fig 3. The minimum mean protein (g/100 ml) of 5.255 was observed in control and the maximum was in treatments T5 (7.158) and T9 (7.162). Statistical analysis showed a significant difference ($p<0.01$) between the control and treatments. The protein content reported by earlier workers in yoghurt were 4.4 to 5.3 g per cent (Jacquelin *et al.*, 1979) for commercial yoghurt, 3.92 to 7.54 g per cent (EL - Gazzar and Hafez, 1990) for whey protein fortified yoghurt, 3.88 to 4.44 g per cent (Prasad, 1990) for normal yoghurt and 5 g per cent (Dargan and Savello, 1990) for yoghurt prepared from ultrafiltered skim milk. The protein content ranging from 4.98 to 10.96 was reported by Mistry and Hassan, (1992). Mini Jose (1992) prepared indigenous dairy products such as Paneer, Rosagolla and Whey drink, found that addition of coconut milk resulted in an increase of 0.3 per cent total protein. Johnson (1994) prepared Mozzarella cheese using skim milk filled with coconut milk and found that when milk fat is replaced with coconut fat the protein content increased from 3.34 to 5.04 per cent in the final product. The findings in the present investigation was in close agreement with the values reported by Jacquelin *et al.* (1979), El-Gazzar and Hafez (1990), Prasad (1990), Dargan and Savello (1991) and Mistry and Hassan (1992). In the treatments an increasing trend in the protein content was observed when the replacement level of coconut cream increased. This can be corroborated with the higher protein content in the coconut cream. Walker (1906), Thampan (1984) and Geevarghese (1996) reported that the protein percentage in coconut cream was 4.1, 5.8 and 5.771 respectively whereas Sukumar De (1980) reported a protein content of 2.54 per cent in milk cream. Higher level of incorporation of skim milk powder

(Table 1) in the treatments might also have favoured for this increased protein content in treatments.

5.4.1.6 Non protein nitrogen (NPN)

The data pertaining to the NPN content (mg/100 ml) in control and treatments are presented in Table 12 and Fig 4. The NPN content in control ranged from 35.84 to 50.40 and in the treatments it ranged from 40.30 to 72.72. The minimum NPN content of 43.12 was recorded in the control (TC) and the maximum in T9 (70.29). Statistical analysis of the data revealed a significant difference ($p<0.01$) between control and treatments. Alm (1982) reported an NPN content (mg / 100 ml) of 45 for normal yoghurt whereas Prasad (1990) reported values ranging from 17.0 to 42.0. When dairy by-products such as whey protein dispersion and condensed cheese whey (50 and 100 per cent levels) were added the mean values were 60.69, 52.53 and 46.69 mg / 100 ml (Baig, 1994). Abd-EL-Salam *et al.,* (1991) reported a value of 47.0 to 63.0 mg / 100 ml for yoghurt prepared from whey protein concentrate. The observations in the present study was in close agreement with earlier reports of Prasad (1990), Abd-AL-Salam *et al.,* (1991), Baig (1994) and Malarakannan (1996). However, a progressive increasing trend in NPN content was recorded in the treatments as compared to control. Analysis of coconut cream revealed that it contained 1.41 g/100 ml of NPN as compared to a value of 0.84 g/100ml in milk cream. This might have resulted in an increased NPN content in the treatments as compared to control. Temperature of heat treatment and fermentation process influence the protein breakdown which leads to formation of NPN, peptides and amino acids. Some of the liberated amino acids and peptides were utilised by the starter bacteria while others get accumulated in the medium which showed high NPN content. The Increase in NPN content in the treatments can also be corroborated with an increase in tyrosine value also (Prasad, 1990).

5.4.1.7 Curd tension

The data with range, mean $\pm$ SE with regard to curd tension value (g) of control and treatments are presented in Table 13 and Fig 5. The mean curd tension was 28.73 for the control and it progressively increased as percentage replacement increased. At 100 per cent replacement level the curd tension recorded were 38.44 and 40.60 for treatments T5 and T9. Statistical analysis revealed a significant difference ($p<0.01$) between control and treatments. The curd tension (g) values recorded by earlier workers in fermented products were 34.34 to 36.67 for freeze dried dahi (Rathi *et al.*, 1990), 19 to 24 for yoghurt fortified with whey protein concentrate (Abd-EL-Salam *et al.*, 1991), 26.9 for plain yoghurt (Desai *et al.*, 1994) and 31.4 to 33.5 for bioyoghurt (Shakeel - Asgar and Thompkinson 1994 a). Chawla and Balachandran (1994) reported that higher concentrations of SNF (13 percentage) in milk increased the curd tension value to 42.5 g as compared to 39.3 g when it contained 10 per cent SNF. Shakeel - Asgar and Thompkinson (1994 b) also reported that curd tension values increased as SNF level increased. They recorded a value of 1.5 per cent SNF and 3 per cent fat. Malarkannan (1996) reported a mean curd tension value of 26.0 to 32. 0 g for normal yoghurt and 11.0 to 21.5 g for yoghurt prepared by using condensed coconut water. The curd tension recorded in the present study was within the range or closer to the values reported by earlier workers such as Rathi *et al.*, (1990), Chawla and Balachandran (1994), Shakeel-Asgar and Thompkinson (1994 a,b). The progressive increase in curd tension value recorded in the treatments may be attributed to the higher protein in the treatments (Table 11) as compared to the control. Effect of stabilisers on improving the textural properties and curd tension were reported by Miloslav (1979), Molder *et al.*, (1983), Hrabova and Hylmar (1984), Jamrichova (1985), Shulka and Jain (1986), Shulka *et al.*, (1988), Kamaly *et al.*, (1992) and Yadav *et al.*, (1994). It was reported by Jogdand *et al.* (1991 a, b), Rathi *et al.*, (1990), Malarkannan (1996) that curd tension value of the yoghurt was increased with incorporation stabiliser. In the present study an increasing trend in curd tension was observed in treatments T6 and T9 containing 0.2 per cent sodium alginate as compared to their counterparts without stabiliser . However the increase was not statistically significant.

5.4.1.8 Viscosity

The observations with respect to viscosity (p) are presented in Table 14 and Fig 6. The mean viscosity for the control was 241.18 which increased progressively to 256.23, 263.69. 247.76 and 283. 45 at replacement levels of 25,50,75 and 100 per cent respectively. Corresponding values were 267.68, 273.62, 286.74 and 297.71 for treatments wherein sodium alginate was incorporated. Statistical analysis showed a significant difference ($p<0.01$) between control and treatments. Viscosity values reported by earlier scientists were 224 to 632 p (Jacquelin *et al.*, 1979), 550 - 568 cp (Parnell - Clunies 1986), and 3500 cp (Gassen and Frank 1990) for normal yoghurt. The viscosity values of 136 to 346 poise (Greig and Harris, 1983), 800 to 980 cp (Rathi *et al.*, 1990), 8.7 x 10^7 cp (Farooq and Haque, 1992), 1600 to 4400 cp (Rodarte *et al.*, 1993) and 90.35 to 197.30 (Malarkannan, 1996) for yoghurt fortified with whey protein concentrate, freeze dried dahi, high milk protein powder, reconstituted skim milk powder and condensed coconut water respectively were reported. The viscosity values recorded in the present experiment was more or less similar to the reports of earlier workers such as Jacquelin *et al.*, (1979) and Greig and Harris (1983) for yoghurt and yoghurt incorporating whey protein concentrate respectively. There was a steady increase in the viscosity values as replacement level increased. This can be attributed to a progressive increase in protein content in the treatments as compared to control (Table 1). Builova *et al.*, (1983) reported that the viscosity was influenced mainly by protein content in yoghurt . Perusal of the data with regard to viscosity in treatments with or without stabiliser revealed that the values were higher in treatments containing sodium alginate as compared to their corresponding pair. It was reported by Hrabova and Hylmar (1984), Jogdand *et al.*, (1991 a, b) and Ibrahim *et al.*, (1992) that viscosity of the yoghurt was increased with incorporation of stabiliser. However, when the viscosity values were compared using critical difference no significant difference was revealed between the pairs with or without stabiliser.

5.4.1.9 Tyrosine value

The data pertaining to the tyrosine value (mg/g) of yoghurt are presented in Table 15 and Fig 7. The mean tyrosine value for control was 0.325 and for treatments T2 to T9 were 0.308, 0.336, 0.355, 0.375, 0.298, 0.328, 0.348 and 0.363 respectively. Statistical analysis of the data revealed a significant difference ($p < 0.01$) between control and treatments. Maximum tyrosine values were recorded in T4 and T5 (75 and 100 per cent replacement) and T9 (100 per cent replacement with sodium alginate) which were identical when means were compared. Dutta *et al.*, (1971) reported a tyrosine value of 0.26 to 0.34 mg/g of curd by employing selected strains of *streptococcus* and *lactobacillus*. Similarly Singh and Ranganathan (1977) recorded a tyrosine value of 350 mg/ml for different strains of lactobacillus in milk. Shankar *et al.*, (1983) reported a tyrosine value of 23.1 mg/ 100 g of curd. Prasad (1990) observed tyrosine values of 0.36 to 0.49 and 0.27 to 0.29 for yoghurt prepared from raw and pasteurized cow milk. Baig (1994) reported mean tyrosine values of 0.18, 0.20, 0.17 and 0.24 mg/g for yoghurt prepared from non fat dry milk, condensed cheese whey (50 and 100 per cent replacement levels) and whey protein dispersion. Sharma and Prasad (1986), Malarkannan (1996) and Hari *et al.*, (1997) reported values of 0.41, 0.28 to 0.39 and 0.21 mg/g for skim milk, normal yoghurt and short-set yoghurt respectively. The tyrosine values in control and treatments recorded were in close agreement with the values reported by Dutta *et al.*, (1971), Prasad (1990), Baig (1994) and Malarkannan (1996). The progressive increase in tyrosine value recorded for the treatments at 50,75 and 100 per cent replacement levels may be due to higher protein content. Alm (1982) reported that the degree of proteolysis will be depending on the degradation level of proteins. In the above treatments more protein might have degraded during heat treatment which resulted in more surface area for the action of bacterial enzymes leading to higher tyrosine value. This is evidenced by the fact that the tyrosine value followed a similar increase as the protein content increased in the treatments. The increased level of protein in the treatments might have come from either coconut cream or more of skim milk powder incorporated in the treatments as compared to the control.

5.4.2 Microbial quality of yoghurt

5.4.2.1 Coliform count

The coliform count (cfu/ml) data with range, mean ± SE are presented in Table 16. The mean coliform count in control was 5.83 and in the treatments were 5.33, 5.00, 5.33, 6.33, 7.67, 5.83, 5.83 and 6.83 for T2, T3, T4, T5, T6, T7, T8 and T9 respectively. Statistical analysis revealed no significant difference between control and treatments and among the treatments. A coliform count of 0 to 100 cfu/ml for dahi prepared under household conditions in Bangalore city (Mohanan *et al.*, 1984), 0.3/g for homogenized gel yoghurt (Lalas and Mantes, 1986), 5 x 10^4 for yoghurt sold in the retail market of Mosul city (AL - Hadethi *et al.*, 1992) were reported earlier. Baig (1994) recorded a mean count of 3.33 for yoghurt prepared from condensed cheese whey. Malarkannan (1996)reported a mean count of 3.17 for normal yoghurt and 4.33 to 4.83 for yoghurt prepared from condensed coconut water. Bureau of Indian Standards (IS: 7035; 1973) has specified the limits of coliform count in yoghurt as less than 10 cfu/ml. In this study the coliform count is within this limit and closer to the values reported by Mohanan *et al.*, (1984) and Malarkannan (1996).

5.4.2.2 Yeast / mould count

The yeast/mould count of control (cfu/ml) and treatments are presented in Table 17. Statistical analysis of the data revealed no significant difference between control and treatments. Mohanan *et al.*, (1994) and Lalas and Mantes (1986) reported the count of 700 to 5000/ml and 25 to 100/g for dahi and homogenized gel yoghurt respectively. Baig (1994) reported mean counts of 3.33/ml and 11.66/ml for yoghurt prepared from condensed cheese whey at 50 and 100 per cent replacement levels. Malarkannan (1996) reported a mean count of 11.83 for normal yoghurt and 16.50 to 17.50 for yoghurt prepared from condensed coconut water. Bureau of Indian Standards (IS: 7035; 1973) has specified the limits of yeast and mould could in yoghurt as less than 100 cfu/g. In this investigation the count is within the limit, and closer to the observations of Baig (1994), Malarkannan (1996) and Lalas and Mantes (1986).

5.5 Sensory evaluation

The sensory qualities such as appearance and colour, body and texture, flavour and total scores of control and treatments were evaluated by a panel of six judges.

5.5.1 Appearance and colour score

The appearance and colour score for the control and treatments are presented in Table 18 and Fig 8. The mean appearance and colour score for control was 4.14 and for the treatments were 4.23, 4.22, 4.11, 4.04, 4.11, 4.17, 4.16 and 3.98. The minimum mean score was observed in T9 (3.98) maximum mean was in T2 (4.23). Statistical analysis showed no significant difference between control and treatments. Mehanna and Mehanna (1989) and Shakeel-Asgar and Thompkinson (1994) reported a score of 4.25 and 3.55 for cow and buffalo milk yoghurt, 3.75 and 4.0 for dahi prepared from milk concentrated by reverse osmosis. Prasad (1990) reported a score of 4.32 for pasteurized cow milk yoghurt and Baig (1994) reported scores of 4.28, 3.74,4.27 and 4.46 for yoghurt prepared from non fat dry milk, condensed cheese whey (50 and 100 per cent replacement levels) and whey protein dispersion. Malarkannan (1996) recorded a mean score of 4.21 for normal yoghurt and 3.91 to 4.3 for yoghurt prepared using condensed coconut water incorporated at 25 and 50 per cent levels with or without gelatin. The results of the present investigation are in close agreement with the reports of Prasad (1990), Baig (1994), Shakeel-Asgar and Thompkinson (1994) and Malarkannan (1996).

5.5.2 Body and texture

Body and texture scores for control and treatments are presented in Table 19 and Fig 8. Statistical analysis revealed a significant difference ($p<0.05$) between control and treatments. The minimum mean body and texture scores was observed in control (3.90) and the maximum in T9 (4.33). A progressive increase in body and texture scores were recorded as the percentage replacement increased irrespective of addition of stabiliser. A score of 4.13, 3.26 and 3.37 for body and texture were reported for normal yoghurt (Prasad, 1990), buffalo milk yoghurt (Chawla and Balachandran, 1994) and dahi (Desai *et al.,* 1994) respectively. Baig (1994) recorded a mean score of 4.18, 3.90, 3.90 and 4.50 for yoghurt prepared from non fat dry milk, condensed cheese whey (50 and 100 per cent replacement levels) and whey protein dispersion. Shakeel - Asgar and Thompkinson (1994) reported a mean score of 3.40 for bioyoghurt. Malarkannan (1996) recorded a mean score of 4.38 for normal yoghurt and 3.40 to 4.18 for yoghurt prepared from condensed coconut water incorporated at 25 and 50 per cent levels without and with gelatin. The scores obtained for body and texture in the present investigation were in close agreement with the reports of Prasad (1990), Chawla and Balachandran (1994), Desai at al. (1994), Shakeel - Asgar and Thompkinson (1994), Baig (1994) and Malarkannan (1996).

There is a steady increase in the body and texture score of the treatments as percentage replacement increased irrespective of addition of stabiliser. Mean body and texture scores for T3 to T9 were comparable when treatment means are compared irrespective of the addition of stabiliser. Shakeel-Asgar and Thompkinson (1994) reported that there is a correlation between curd tension and body and texture characters. In the present study the curd tension values increased progressively (Table 13) as the level of replacement increased and the increase in body and texture score can be corroborated with this increase. Storgards (1964) reported that heat treatment which cause denaturation of the proteins give rise to an increased NPN contents, and presence of heat denatured whey proteins stabilise the coagulum. In the treatments the concentration of NPN was recorded as higher than the control which confirms that denaturation has taken place in the treatments. An increase in protein content might have also helped in improving consistency as reported by Chawla and Balachandran (1994). Addition of stabiliser has produced a slight improvement in the body and textural characters of yoghurt as reported by Mehanna and Mehanna (1989), Jogdand *et al.,* (1991 a, b) but it was not statistically significant.

5.5.3 Flavour score

The flavour score for control and treatments are presented in Table 20 and Fig 8. The minimum mean flavour score was observed in T6 and T9 (8.21) and maximum in T3 and T4 (8.61). Analysis of variance revealed no significant difference between the control and treatments. Mehanna and Mehanna (1989) reported a score of 5.5 for yoghurt stabilised with gelodan. Prasad (1990) and Chawla and Balachandran (1994) recorded a score of 8.43 and 9.0 for normal yoghurt and buffalo milk yoghurt respectively. Baig (1994) reported a mean flavour score of 8.75, 8.43, 8.55 and 8.81 for yoghurt prepared from non fat dry milk, condensed cheese whey (incorporated at 50 and 100 per cent levels) and whey protein dispersion where as Malarkannan (1996) recorded a mean flavour score of 8.12 for normal yoghurt and 6.47 to 7.86 for yoghurt prepared from condensed coconut water with and without gelatin. The flavour scores obtained in the present investigation were in accordance with the reports of Mehanna and Mehanna (1989), Prasad (1990), Baig (1994) and Chawla and Balachandran (1994).

5.5.4 Total score

The total scores for control and treatment yoghurt samples are presented in Table 21 and Fig 8. Statistical analysis showed no significant difference between control and treatments. The minimum mean total score was observed in T6 (16.43) and maximum in T3 (17.07). Gupta *et al.,* (1997) observed almost identical total scores for normal yoghurt and acidophilus yoghurt, on a nine point hedonic scale. Hari *et al.,* (1997) observed total sensory scores of 8.4, 8.1 and 7.4 out of 10 for short-set, long-set and acidophilus yoghurt samples. Baig (1994) reported a mean total scores of 17.23, 16.11, 16.36 and 17.80 for yoghurt prepared by using non fat dry milk, condensed cheese whey (incorporated at 50 and 100 per cent levels) and whey protein dispersion. Prasad (1990) obtained a mean score of 17.02 for normal yoghurt. Malarkannan (1996) recorded a mean score of 16.71 for normal yoghurt and 14.70 to 16.02 for yoghurt prepared by using condensed coconut water at 25 and 50 per cent replacement levels. The results of the present study was in close agreement with the reports of Prasad (1990), Baig (1994) and Malarkannan (1996).

From the foregoing discussion it can be reasonably concluded that the use of coconut fat as coconut cream to replace milk fat upto 100 percentage in the preparation of yoghurt had more or less similar organoleptic properties except body and texture as compared to the control. It is also concluded that addition of stabiliser have no effect in improving the organoleptic characters.

5.6 Cost estimation

The cost of 100 g each of control and experimental yoghurt samples presented in Table 1, indicated that when replacement level increased, the cost of ingredients of yoghurt decreased. When the replacement level was at 25, 50, 75 and 100 per cent, the percentage reduction in cost were 2.72, 5.43, 8.20 and 10.53 respectively as compared to control yoghurt. The savings in cost (in percentage) were 2.67, 5.43, 8.15 and 10.53 respectively in treatments with sodium alginate as compared to control. There is no difference in the cost at 50 and 100 per cent replacement levels with or without addition of sodium alginate. The reduction in the cost for experimental yoghurt samples could be attributed to the lower cost of coconut cream as compared to milk cream. From the over all assessment of the data during the course of present investigation, revealed that there is no significant difference between the control and treatments for the properties like pH, total solids, fat, coliform count, yeast and mould count and sensory evaluation scores except body and texture score. A gradual increase in acidity, setting time, protein, NPN, curd tension, viscosity, and tyrosine value could be noted as the replacement level increased. The addition of stabiliser has not produced any significant change in the setting time, curd tension, viscosity as compared to the treatments, without sodium alginate, indicating that sodium alginate has no influence in improving the above parameters and hence of no use. A savings in the cost of upto 10.53 per cent can be achieved by 100 per cent replacement of milk fat with coconut fat with or without sodium alginate. Hence, it could be reasonably concluded that coconut fat can be replaced at 100 per cent level with the advantage of cost saving, increased protein, NPN, curd tension and tyrosine value. Even at 100 per cent replacement level over all total organoleptic scores were comparable with control.

Summary

6. SUMMARY

A detailed investigation was carried out to assess the feasibility of incorporating of coconut fat as coconut cream to replace milk fat at 25, 50,75 and 100 per cent levels with or without stabiliser in the preparation of filled yoghurt. The products were analysed for physico-chemical properties, micro-biological and organoletptic qualities using standard analytical procedures and compared with normal yoghurt.

Coconut cream was extracted form mature coconuts using a screw press and analysis of coconut cream revealed 40.76 per cent fat, 53.01 per cent total solids and 1.41 g.100ml of NPN. The mean fat and total solids (percentage) contained in skim milk powder, skim milk and cream were 0.56, 97.37,0.13, 8.58, 62.76 and 76.02 respectively. NPN content in milk cream was estimated to be 0.84 g/100 ml.

Standard procedures were followed for the preparation of control and treatment yoghurt samples using coconut fat in the form of coconut cream to replace milk fat at 25, 50,75 and 100 per cent levels with or without sodium alginate. The properties of the treatment yoghurt samples designated as T2, T3, T4, T5, T6, T7, T8 and T9 were compared with control yoghurt (TC). The proportionate quantity of ingredients to be added in the control and treatment mixes to obtain three per cent fat, fourteen per cent MSNF, six per cent sugar making to 23 per cent total solids were derived by the linear programming model.

The yoghurt mixes (control and treatments) prepared were analysed for titratable acidity (as percentage lactic acid), pH and total solids. The mean acidity of the yoghurt mixes (control and treatments) ranged from 0.20 to 0.23 per cent, pH from 6.17 to 6.29 and total solids form 22.40 to 23.80 per cent. The above three properties revealed no significant difference between control and treatments and were more or less similar to the reports of earlier workers.

The mean setting time for control was 3.57 (h) as compared to a time of 4.32 for treatment 9 (T9) and the difference were statistically significant ($p<0.01$). It was concluded that, as the replacement level increased the setting time also increased. Titratable acidity of yoghurt (as percentage lactic acid) revealed significant difference ($p< 0.0.1$) between control and treatments and among the treatments. The mean titratable acidity of control and treatment yoghurt samples ranged from 0.91 to 1.06 per cent which is considered to be within the normal range reported by earlier workers.

pH values showed no significant difference between control and treatments. The values were 4.56 for control and it ranged from 4.53 to 4.57 for the treatments and the above values were within the normal range of 4.4 to 4.6 recommended to produce good quality yoghurt. The mean fat percentage of control and treatments ranged between 2.98 to 3.03, which is considered to be ideal for the medium fat yoghurt .

Protein content in yoghurt revealed an increasing trend as replacement of milk fat with coconut fat increased and there was a significant difference ($p< 0.01$) between control and treatments. Mean protein content in control (TC) was 5.255 per cent where as for 100 per cent replacement without (T5) and with (T9) sodium alginate were 7.158 and 7.162 per cent respectively. This increase can be attributed mainly due to the higher level of protein in coconut cream. The non-protein nitrogen content also showed an increasing trend as replacement of milk fat with coconut fat increased and were statistically significant ($p< 0.01$). The highest mean NPN content of 70.27 mg per cent was recorded in T9 whereas in control it was 43.12 mg per cent. The progressive increase in NPN content in the treatments can be attributed to higher level of NPN content in coconut cream.

The curd tension of yoghurt was measured with curd tension meter. Analysis of the data with respect to the curd tension (g) indicated that it increased as the percentage substitution of coconut fat increased. The progressive increase in the curd tension value recorded in the treatments may be attributed to the higher protein The mean curd tension value of 28.73 (g) was recorded in control and in treatments T5 and T9 it was 38.44 and 40.60 respectively and the difference was statistically significant ($p < 0.01$). The viscosity (p) value of yoghurt was measured with Brook field viscometer. Similar to curd tension as increasing trend was observed in viscosity as the percentage replacement increased and a significant difference ($p < 0.01$) was observed between control and treatments. The highest mean viscosity of 286.74, 297.71 was recorded in T8 and T9 respectively.

With respect to tyrosine value (mg/g curd) significant difference ($p<0.01$) observed between control and treatments. The minimum tyrosine value was in control (0.325) and T2 (0.298) whereas highest was in T5 (0.375) and T9 (0.363) respectively.

The coliform count ranged from 3 to 9 (cfu/ml) and yeast/mould count ranged from 8 to 17 (cfu/ml) in control and treatments. The maximum count recommended by Bureau of Indian Standards (BIS) is 10 cfu/ml for coliform and 100 cfu/ml for yeast/mould count. The counts recorded in the present investigation were within the range prescribed under BIS.

Organoleptic qualities of the products were assessed by sensory evaluation with respect to attributes like appearance and colour, body and texture, flavour and total score. Analysis of the data with regard to appearance and colour showed no significant difference between control and treatments, where as body and texture scores revealed a significant difference ($p<0.05$). The minimum mean body and texture score awarded for control was 3.90 and maximum was in T5 (4.28) and T9 (4.33) respectively. Flavour and total score for control and treatments showed no significant difference.

A saving of 10.53 per cent in cost can be achieved as compared to control by 100 per cent replacement of milk fat with coconut fat in the form of coconut cream with or without sodium alginate.

Taking into consideration the results obtained in the present investigation it could be concluded that coconut fat can be replaced at 100 per cent level in flavoured filled yoghurt preparation with the advantage of cost saving, increased protein, NPN, curd tension and tyrosine value. The organoleptic scores of the product were comparable with control. There is no material gain by the addition of stabiliser as far as the physico-chemical and organoleptic properties of the product.

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USE OF COCONUT CREAM IN FLAVOURED FILLED YOGHURT

By

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ABSTRACT OF A THESIS
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ABSTRACT

A trial was conducted to assess the suitability of incorporating coconut fat as coconut cream in flavoured yoghurt at various levels and the properties of the product were studied. A detailed review of literature on the various physico-chemical properties of yoghurt has been presented.

The treatments were divided in to TC (control without stabiliser) T2, T3, T4,T5 (25, 50, 75 and 100 per cent replacement level of milk fat respectively using coconut cream, without stabiliser), T6, T7, T8, T9 (25, 50, 75 and 100 per cent replacement level of milk fat respectively using coconut cream, with stabiliser 0.2 per cent) and the physico - chemical, micro-biological and organoleptic properties of the treatments were studied .

Experimental yoghurt mixes prepared were analysed for titratable acidity, pH and total solids. Statistical analysis revealed no significant difference between control and treatments of the above characters.

No significant difference was noticed in pH and fat between the control and treatment yoghurt samples whereas a significant difference ($p < 0.01$) in titratable acidity, protein, NPN, curd tension and viscosity was observed between control and treatments. Protein, NPN, curd tension and viscosity showed an increasing trend with increasing level of replacement. In treatments T6, T7, T8 and T9 sodium alginate produced slight improvement in curd tension and viscosity but it was not statistically significant. Tyrosine value increased at replacement level of 50 per cent onwards as compared to control. Coliform and yeast/mould count showed no significant difference between control and treatments.

Organoleptic quality of the products revealed no significant difference between control and treatments except for body and texture scores which showed a

significant ($p < 0.05$) difference. Stabiliser sodium alginate produced little improvement in the body and texture score but was statistically not significant as compared to their corresponding pair. The results of the experiment revealed that coconut fat can be replaced upto 100 per cent level in the yoghurt preparation with an advantage of cost saving, increased protein, NPN, curd tension and tyrosine value. Even upto 100 per cent replacement level overall total organoleptic scores were comparable with control.

Appendices

```
10 'SIMPLEX LINEAR PROGRAMMING
15 'CALCULATION OF YOGHURT COMPOSITION
20 CLS : CLEAR
30 DIM C(20, 40), D(20, 40), VALY(20), Y(20), PRDT(20), AMT(20), VALX(20), X(40), RVLX(40)
40 DIM X1$(40), Y1$(40), CON$(40), ING(20), Q(20), INGS(20), RES(20), OM(20, 40)
50 PRINT "      LINEAR PROGRAMMING FOR OPTIMUM MIX ": PRINT
60 INPUT "LEVEL (%) MILK FAT REPLACEMENT REQUIRED ?  ", A: B = 3 * A / 100
70 READ N, M, VP
80 PRINT : PRINT "CONSTRAINTS", "TOT. VARIABLES", "INGREDINTS POSITON": PRINT
90 PRINT N, M, , VP: PRINT
100 FOR I = 1 TO N: FOR J = 1 TO M: READ C(I, J): NEXT J: NEXT I
110 FOR J = 1 TO M: READ VALX(J): NEXT J
120 FOR I = 1 TO N: READ PRDT(I): NEXT I
130 PRINT : PRINT "CONSTRAINTS ": PRINT
140 FOR I = 1 TO N: PRINT "C"; I; "="; PRDT(I), : NEXT I: PRINT
150 FOR J = 1 TO M: READ X1$(J): NEXT J
160 FOR I = 1 TO N: READ CON$(I): NEXT I
165 PRINT
170 PRINT : PRINT "VARIABLES ": PRINT
180 FOR J = 1 TO M: PRINT "X"; J; "="; X1$(J), : NEXT J
190 PRINT : PRINT "VARIABLE", "INGREDIENT", "COST(Rs/kg)": PRINT
195 FOR J = VP TO M: PRINT "X"; J, X1$(J); : PRINT USING "####.##"; VALX(J): NEXT J: PRINT
200 PRINT
201 PRDT(N) = B / C(2, N + 2)
202 PRINT "CONSTRAINT", "LIMIT": PRINT
204 FOR I = 1 TO N: PRINT CON$(I), PRDT(I): PRINT : NEXT I
205 PRINT SPC(20); : FOR J = VP TO M: PRINT X1$(J); SPC(6); : NEXT J: PRINT
210 PRINT : FOR I = 1 TO N: PRINT CON$(I), : FOR J = VP TO M: OM(I, J) = C(I, J)
215 PRINT USING "#######.###"; C(I, J) * 100; : NEXT J: PRINT : NEXT I
230 FOR I = 1 TO N: VALY(I) = VALX(I): NEXT I
240 FOR J = 1 TO M: X(J) = J: NEXT J
250 NN = NN + 1: PRINT : PRINT "TRIAL  - "; NN
260 FOR J = 1 TO M: SUMP = 0: FOR I = 1 TO N: P = VALY(I) * C(I, J): SUMP = SUMP + P: NEXT I
270 RVLX(J) = VALX(J) - SUMP
280 NEXT J
290 ZMAX = 0: FOR J = 1 TO M: IF (RVLX(J) - ZMAX) >= 0 THEN 310
300 ZMAX = RVLX(J): K2 = J
310 NEXT J
320 IF ZMAX >= 0 THEN 620
330 FOR I = 1 TO N: IF PRDT(I) >= 0 THEN 350
340 PRINT "PRDT", I, PRDT(I): STOP
350 IF C(I, K2) > 0 THEN 370
360 AMT(I) = -1: GOTO 380
370 AMT(I) = PRDT(I) / C(I, K2)
380 NEXT I
390 I = 1
400 IF AMT(I) >= 0 THEN 430
410 I = I + 1: IF (I - N) <= 0 THEN 430
420 PRINT "AMT"; I; AMT(I): STOP
430 ZMIN = AMT(I): K1 = I
440 I = I + 1
450 IF (I - N) > 0 THEN 480
460 IF AMT(I) < 0 THEN 440
470 IF ZMIN - AMT(I) > 0 THEN 430 ELSE 440
```

```
480 Y(K1) = X(K2)
490 Y1$(K1) = X1$(K2)
500 VALY(K1) = VALX(K2)
510 FOR I = 1 TO N: PRDT(I) = PRDT(I) - ZMIN * C(I, K2): NEXT I
520 PRDT(K1) = ZMIN
530 FOR J = 1 TO M: FOR I = 1 TO N:
540 D(I, J) = C(I, J) - C(K1, J) * (C(I, K2) / C(K1, K2)): NEXT I: NEXT J
550 FOR J = 1 TO M: D(K1, J) = C(K1, J) / C(K1, K2): NEXT J
560 FOR J = 1 TO M: FOR I = 1 TO N: C(I, J) = D(I, J): NEXT I: NEXT J
570 IF A$ = "Y" THEN 580 ELSE 250
580 FOR I = 1 TO N: PRINT Y(I), PRDT(I): NEXT I
590 PRINT
600 GOTO 250
610 PRINT
615 D$ = DATE$: PRINT D$
620 PRINT " YOGHURT    : PER CENT COMPOSITION": PRINT
630 PRINT "LEVEL OF MILK FAT REPLACEMENT : "; A; "%"
640 PRINT "VAR.NO.", "INGREDIENT", "QUANTITY (g/100g)"
650 FOR I = 1 TO N
670 K = Y(I): ING(K) = Y(I): ING$(K) = Y1$(I): Q(K) = PRDT(I)
690 NEXT I: K = 1: FOR I = VP TO M: QK(K) = Q(I)
700 PRINT ING(I), ING$(I), : PRINT USING "####.###"; Q(I): K = K + 1: NEXT I
710 FOR I = 1 TO N: FOR J = VP TO M
730 RES(I) = RES(I) + OM(I, J) * Q(J)
737 NEXT J: NEXT I: PRINT : PRINT
739 FOR I = 1 TO N - 3: PRINT CON$(I), : PRINT USING "####.##"; RES(I): PRINT : NEXT I
740 ZVAL = 0: FOR I = 1 TO N: ZVAL = ZVAL + PRDT(I) * VALY(I): NEXT I
760 COST = ZVAL / 100
770 PRINT "COST = Rs."; : PRINT USING "####.###"; COST; : PRINT "  per kg"
780 DATA 08,13,09
790 DATA 1,0,0,0,0,0,0,0, 1,1,1,1,1
800 DATA 0,1,0,0,0,0,0,0, 0.005,0.30,0,0.73,0.005
810 DATA 0,0,1,0,0,0,0,0, 0.980,0.12,0,0.07,0.085
820 DATA 0,0,0,1,0,0,0,0, 0,0,1,0,0
840 DATA 0,0,0,0,1,0,0,0, 0.015,0.58,0,0.20,0.910
845 DATA 0,0,0,0,0,1,0,0, 0,0,0,1,0
846 DATA 0,0,0,0,0,0,1,0, 0,0,0,0,1
847 DATA 0,1,0,0,0,0,0,0, 0,1,0,0,0
850 DATA 1000000,1,1,1,1,1,1,1,110,20,16,60,8
860 DATA 100,03,14,06,77,15,85,20
870 DATA D1,D2,D3,D4,D5,D6,D7,D8,SMP,C.CR,SUGAR,M.CR,S.MILK
880 DATA QUANTITY =,FAT =,SNF =,SUGAR =,MOISTURE =,MCREAM,S.MILK,CCR
890 END
```

Appendix III

SCORE CARD

Yoghurt Evaluation

Date :

Taster :

Code No :

a. **Appearance and colour**

Defects.........................

b. **Body and texture**

Defects.......................

c. **Flavours**

Defects.........................

Over all Scores

Judge the three characteristics on 1 - 5 scale

5 Excellent

4 Very good

3 Good

2 Fair

1 Poor

The overall score is obtained by multiplying the flavour score by 2 and than adding the score to the rest. An excellent yoghurt gives an overall score of 20.

Appearance and colour: Extraneous matter, lack of uniformity, unnatural colour, surface discoloration, wheying- off, fat separation, gasiness.

Body & texture : Too thin, Gelatinous, chalky, lumpy or granular, slimy

Flavour : Excess acid, excess sugar, excess stabilizer, excess milk powder, yeasty, unclean

Signature

VISCOSITY TEST REPORT

DATE:

BY:

FOR:

TEST INFORMATION:

SAMPLE	MODEL	SPINDLE	R.P.M.	DIAL READING	FACTOR	VISCOSITY CPS.	SHEAR RATE	TEMP °C	TIME	NOTES

CONCLUSIONS: