“COMPOSITIONAL AND PHYSICO - CHEMICAL ATTRIBUTES OF YOGHURT PREPARED BY USING CAPRINE MILKS”

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BY

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CERTIFICATE

This is to certify that the thesis entitle "***COMPOSITIONAL AND PHYSICO-CHEMICAL ATTRIBUTES OF YOGHURT PREPARED BY USING CAPRINE MILKS"*** submitted by **Mr. MANMATHA RAJA, S.R.,** I.D. No **MDK 1201** in partial fulfillment of the requirements for the award of **MASTER OF TECHNOLOGY (Dairy Science)** in **DAIRY CHEMISTRY** of the Karnataka Veterinary, Animal And Fisheries Sciences University, Bidar is a record of bonafide research work carried out by him during the period of his study in this University under my guidance and supervision and the thesis has not previously formed the basis for the award of any degree, diploma, association ship, fellowship or other similar titles.

Bangalore

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DEDICATED TO

MY BELOVED

BROTHER

Late Sri S.R. Bharatesh

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LIST OF ABBREVIATIONS

%	-	Percent
ºC	-	Degree centigrade
Cfu/g	-	colony forming unit per gram
CD	-	critical difference
SNF	-	Solid not fat
G	-	Grams
Kg	-	Kilo grams
Mg	-	Miligrams
Hr	-	Hours
LDPE	-	Low Density Polyethylene
PE	-	Polyethylene
Min	-	Minutes
TVC	-	Total Viable counts
LA	-	Lactic acid
Hz	-	Hertz
FFA	-	Free fatty acid
TS	-	Total solids
CMY	-	cow milk yoghurt
IGMY	-	Indigenous goat milk yoghurt
EGMY	-	Exotic goat milk yoghurt
HCT	-	Heat coagulation time
RCT	-	Rennet coagulation time
%O.A	-	Percentage Oleic acid

Introduction

1. INTRODUCTION

Dairy goat and dairy sheep farming are a vital part of the national economy in many countries, especially in the Mediterranean and Middle-East region and European countries. Goat is one of the main contributors of dairy and meat products for rural people more than any other mammalian farm animal, particularly in developing country like India. Presently, India posses 126 million goats which contribute 14.5% of the world (FAO, 2009). The zoological nomenclature of goat is *Caprus hircus*. The annual milk production from goats in India is about 2 million tonnes contributing 3.5% to the total milk produced in the country. Goat is truly known as the poor man's cow.

Caprine milk is wanted or even needed by people of all income and age groups. One of the prominent aspects of demand of goat milk is its home consumption. This demand is increasing because of the growing populations of people as well as due to increasing levels of per capita income and the connoisseur interest in goat milk products especially in cheeses and yoghurts in many developed and developing countries. In addition to that, another important aspect of demand for goat milk derives from the affliction of persons with cow milk allergies and other gastro-intestinal ailments. Despite the much larger volume available of cow milk, it's much cheaper production and lower market price, the production and marketing of goat milk and its products is therefore, an essential niche in the total dairy industry sector.

Caprine milk is considered as a nutritional and therapeutic food. The unique and beneficial characteristics of caprine milk superior to bovine milk includes better digestibility, greater buffering capacity, better immunological characteristics, antimicrobial characteristics, higher absorption of iron and copper. The consumption of goat milk is known to have beneficial for patients suffering from variety of malabsorption, childhood epilepsy, gall stones, cystic fibrosis, coronary heart diseases and cow milk allergies etc.

Caprine milk differs from cow milk in composition with respect to fat, protein, lactose, mineral and vitamin profile. Further, the exact composition varies according to many factors like breeds, individual animal, lactation, health condition, environmental condition etc. Thus great deals of variation in composition of indigenous and exotic goat milk have been reported.

The difference between the bovine and caprine milk is in the composition and structure of the milk constituents contributing to the variations in physico-chemical, biochemical, nutritional and technological attributes of these milks and as well as flavor, consistency, texture of the dairy products obtained from these milks. The casein micelles in caprine milk differ markedly than those in bovine milk. The caprine milk shows a specific variation in protein fractions particularly with respect to $\boldsymbol{\alpha}$-s1 and $\boldsymbol{\beta}$-caseins. Whey proteins as well as non protein nitrogenous compounds of caprine milk possess higher biological value than bovine milk. Caprine milk exhibit great deal of variation in mineral composition and as well as vitamin profile. It has more calcium, phosphorus, potassium, magnesium, chlorides and less sodium and sulphur contents than cow milk and supplies adequate amounts of vitamin-A and niacin, excesses of thiamine, riboflavin and pantothenate.

Fermented goat milk products are traditionally produced in the Mediterranean peninsula, Middle East, southern Russia and in the Indian subcontinent. Lactic acid bacteria are often used as probiotic starter culture and health effects from these have been reported repeatedly. The viable lactic acid bacteria along with some of probiotics in fermented milk products have been associated with reduced lactose intolerance, a well balanced intestinal microflora, anti microbial activity, stimulation of the immune system and anti-tumor, hypo-cholesteremic and anti-oxidative properties in humans. One of the disadvantages with goat milk is the almost nonexistent content of Folic acid. In a fermented product the above problem could be solved by using folate producing bacteria during fermentation.

The use of caprine and bovine milk in cheese making is well known, but the production of fermented caprine milk via probiotics has not yet been developed, although many studies have highlighted the requirements for production of that kind of healthy food. During fermentation caprine milk loses its characteristic ‘goaty’ taste, which is unacceptable to many consumers. Moreover, the nutritive value of caprine milk increases during fermentation. The rise in the number of goat farms in Croatia has created the need to find other products that can be produced using caprine milk. According to the present situation in Croatia, there is no real possibility of producing fermented caprine milk for the global market, but many studies of fermented caprine milk have been performed.

Studies on the comparison of indigenous and exotic caprine milk with respect to it’s composition, physico – chemical, nutritional and technological attributes under Indian context are very scarce and limited. The generation of data with respect to the above aspect is very much important in promoting caprine milk and it's dairy products which are very much nutritionally superior than bovine milk and it's products. Keeping this in view, a study was carried out to elecit the information on composition and physico-chemical characteristics of indigenous and exotic caprine milk and to utilize these milks in the preparation of fermented milks like yoghurts, with the following objectives.

1. To study the compositional and physico-chemical characteristics of indigenous and exotic goat milk.
2. To optimize the process involved in the preparation of yoghurt from these milks.
3. To study the physico-chemical and sensory attributes of yoghurt.
4. To study the storage stability of yoghurt prepared by using goat's milk.

Review of Literature

2. REVIEW OF LITERATURE

The importance of goats as providers of essential food in meat and dairy products has been well recognised around the world. This importance is also reflected in the largest goat animal number increase during the last 20 years which led to largest goat milk production compared to other mammalian farm animals (FAO, 2001).

The demand for goat milk is increasing because of the growing populations of people, increasing levels of disposable incomes and the connoisseur interest in goat milk products especially cheeses and yoghurt in many developed and developing countries. The demand is also growing because of a wider awareness of problems with traditional medical treatments to such afflictions, especially in developed countries.

Basic composition of the goat milk is very similar to bovine milk however exact composition varies with many factors viz breed, individual, diet and feeding, lactation period, health statues etc (Park *et al* 2007). A high level of variability in biochemical composition, physico-chemical characteristics and bacteriological quality properties of Caprine milks have been reported (Morgan *et al*., 2003) and hence gains significance in nutritional and technological parameters of goat milk dairy products.

The special value of Caprine milk in nutrition, scientific and commercial interest in caprine milk and milk products increased over the past two decades (Martin-Diana *et al*. 2003; Boyazoglu *et al*. 2005a; Biss 2007). Hence it deserves in depth discussion and documentation, as it is widely accepted in practice and in anecdotal publications, but sparsely treated with biomedical research. Yet such research is essential for the future of the dairy goat industry, in developing as well as in developed countries.

2.1 Definition of milk

Milk is the "Normal mammary secretion derived from complete milking of healthy milch animals with or without addition there of or extraction there from. It shall be free from colostrum". As per FSSAI standards for goat milk the fat content ranges from 3.0-3.5% and S.N.F content of 8.5-9.0% respectively.

2.2 Gross Compositions of Goats milk

The average composition of goat milk does differ from the composition of cow milk and human milk in the contents of total solids, protein, fat, and lactose, ash and moisture content as shown in the table below.

Average composition (%) of Milks by Webb and Johnson (1965).

Species	Moisture	Fat	Protein	Lactose	Ash	Solids not fat	Total solids
Goat milk	87.00	4.25	3.52	4.27	0.86	8.75	13.00
Cow milk	87.20	3.70	3.50	4.90	0.70	9.10	12.80
Human milk	87.43	3.75	1.63	6.98	0.21	8.82	12.75

2.2.1 Total solids content

Goat milk has comparatively less amount of total solids 12.9±1.01% followed by cow milk 13.5 ± 1.22% and the highest was found in the buffalo milk 15.8 ±1.53%. The total solids in the Exotic Caprine breeds like Saanen, Camosciata, Ionica, Garganica, Maltese which has 12.02.%, 11.95%, 12.65%, 13.8% and 13.85% total solids contents in their milks which includes fat and non-fat materials. Goat milk collected from Greece Small and Medium enterprises had the highest percentage of total solids (ranging from 13.1 to 14.4%) and the amount of non-fat material is in the range of 7% to 10% (Webb *et al.*, 1974; Hassan, 2005).

The indigenous goat breeds like Barbari, Beetal, black Bengal and Jamunapari goat's milk contains 14.93%, 13.62%, 18.07% and 14.69% total solids in there milks respectively (Singh and Sengar, 1960).

2.2.2 Fat content

Fat content in milk samples were in the range of 6.99-8.41% in buffalo milk, 3.44-4.96% in cow milk, 3.16-4.73% in goat milk and 6.09-6.80% in sheep milk. The variation in fat content of milk is influenced by breeds, individuality of the animal, type of feed, health condition, nutritional status, stage of lactation, health of breeds, intervals of milking, age of animal (Strzalkowska *et al.*, 2009).

The exotic goat milks like Alpine goat's milk contains an average 3.33 % of fat, which agreed with the values reported by Zeng and Escobar (1996), but was lower than the values for Alpine goat's in Greece (3.44 %) reported by Voutsinias *et al*. (1990) and Alpine goat's in USA (3.73 -3.94%) reported by Zeng and Escobar (1996) but the values are lesser when compared to cow milk. Indigenous goats like Barbari, Beetal, black Bengal and Jamunapari goat's milk contains 5.69%, 4.74%, 7.93% and 5.59% milk fat (Singh, and Sengar., 1960).

2.2.3 Lactose content

The concentration of lactose in mature bovine, caprine and human milks is about 4.8%, 4.2% and 7.5% w/w, respectively. Lactose content increases slightly during the early stage of lactation but then decreases to about 70% of the maximum at the end of the lactation. The concentration of lactose in milks varies widely between species, breeds, disease condition and stage of lactation (Oftedal and Jennies, 1988).

The lactose concentrations of exotic Boer goat milk is 4.46-5.88% and the Rangeland goats is 4.86-6.04% respectively (Skinner, 1972). The indigenous were 4.31% for Barbari goat milks, 4.32% for Beetal goat's milk, 4.28% for Black Bengal goat's milk and 4.40% for Jamunapari goat milks (Singh and Sengar, 1960).

2.2.4 Protein content

The average protein content in goat milk (3.8%, w/w) which is lower when compared to sheep milk (4.6%, w/w) but higher when compared to cow milk (3.3%, w/w) (Grosclaude and Martin, 1997). Protein contents vary widely within species, and are influenced by breed, stage of lactation, feeding, climate, season, and udder health status (Souci *et al.*, 2000). Protein contents of the Boer goats of South Africa ranges from 2.93-6.71% and Rangeland goats of Australia ranges from 2.96 - 4.59% (Grosclaude and Martin, 1997). Indigenous goat's milk have protein percentage of 4.05% in Barbari goat milks, 3.74% in case of Beetal goat milks, 4.9% in black Bengal breed and 3.85% in Jamunapari goats milk.

Casein content in goat milk ranges from 16 to 26 g/l. The caseins (CN) in Caprine milk are about the same as in the milk of cows or sheep: $\boldsymbol{\alpha}_{s1}$-CN, $\boldsymbol{\alpha}_{s2}$-CN, $\boldsymbol{\beta}$ –CN and k-caseins. The percentage of the main casein fractions in Caprine and bovine milk are α_s-CN is 26 and 56; β-CN is 64 and 33; k-CN is 10 and 11 (Bozanic´ *et al*. 2002.b). Goat and sheep milk contains about 0.7–1.0% and 0.4-0.8% whey proteins respectively. Proteins in sheep milk account for approximately 95% of total nitrogen and5% is non-protein nitrogen. Goat milk has a higher level of non-protein nitrogen and less casein nitrogen than sheep and cow milk (Souci *et al*., 2000).

2.2.5 Ash content

Ash content in milk samples was in the range of 0.69-0.98% in buffalo milk, 0.40-0.80% in cow milk, 0.56-0.99% in goat milk and 0.78-0.98% in sheep milk. The goat milk has more of calcium, phosphorous, magnesium, potassium and chloride, while sodium and sulphur are lower in goat than in cow milk. Mineral contents of goat milk are also affected by diet, breed, individual animal, and stages of lactation (Park and Chukwu, 1989).

The indigenous goat milk has percentage of ash as 0.88% in Barbari goat milks, 0.82% in case of Beetal goats, 0.89% in black Bengal goats and 0.85% in Jamunapari goats milk (Singh and Sengar, 1960).

2.3 Physico -chemical properties of goat milks

2.3.1 Specific gravity

Specific gravity of milk samples was found in range of 1.027-1.031 Kg/m^{-3} for cow milk and 1.028 - 1.032 Kg/m^{-3} for goat milk. The specific gravity of cow and goat milk is almost similar and generally found in the range of 1.023 to 1.030 Kg/m^{-3}. The roughage has no effect on specific gravity of the values found by Chornobai (1998), who analyzed the milk from Saanen goats, obtained a value around1.031 kg.m-3. The specific gravity of milk depends upon the concentration of the individual components, the degree of hydration of proteins, physical state of fat and temperature system of the sample (Juarez and Ramos 1986; Park 1994a; Park *et al.* 2007).

2.3.2 Surface tension

The fat and proteins mainly contribute to the surface tension of milk (Sherbon, 1988) Surface tension of goat milk is 52.0 dynes/cm which is almost similar to bovine milk 42.3–52.1 dynes/cm. (Juarez and Ramos 1986; Park 1994a; Park *et al.* 2007).

2.3.3 Viscosity

The viscosity of goat or cow milk is reportedly much lower than sheep milk. The viscosity of Egyptian camel milk was estimated at 2.2 Cp (Hassan *et al*., 1987) and 2.35 Cp which is higher than for cows 1.7 Cp and goats 2.12 Cp, but less than for sheep 2.48 Cp, and similar to that of buffalo milk 2.2 Cp. The variation in the viscosity of different milks is related to the gross composition of respective milk samples particularly the concentration of proteins, fat and their state of distribution (Mukherjee, *et al* .1993).

2.3.4 Refractive index

The refractive index of milk is related to concentration and compositions of solutes in milk (Sherbon, 1988). Caprine milk has a 1.45 ± 0.39 refractive index than bovine milk 1.451 ± 0.35(Juarez and Ramos 1986; Park 1994a; Park *et al*. 2007).

2.3.5 Freezing point

The freezing point for goat milk ranges between -0.540 and -0.570°C, while the bovine milk usually is ranges in between -0.512 to -0.550℃. The milk of animals has freezing point much lower and amounted to -0.609°C, -0.596°C and -0.625°C for three subsequent lactation stages, respectively (Park *et al*. 2007). Such low values for the freezing point may be related to the fact that the concentration of individual milk components increased with the progress of lactation. The freezing point of the milk is governed by the concentrations of solutes in solution particularly lactose and milk salts (Sherbon, 1988).

2.3.6 Electrical conductivity

The Electrical conductivity of goat milk is to be found in the range of 0.0043 to 0.0139 ohm/cm^{1}, sheep milk is 0.0038 ohm/cm^{1} and for cow milk is 0.0040 - 0.0055 ohm/cm^{1} which is almost similar to cow milk. The principal ions responsible for the conductivity of milk are sodium, potassium and chloride ions since they are present in higher concentrations (Haenlein and Wendroff, 2006).

2.3.7. Rennet coagulation time (RCT)

Clotting by rennet is a complex phenomenon both primary and secondary phase of clotting depend on various factors concentration of rennet, temperature, homogenization, species, breed, fat content, fat globule size, composition of fat globule membrane, ionic calcium content etc (Srinivas, 1989).

The rennet coagulation time of the raw goat milk of Saanen, Camosciata and Ionica showed values in line with those found by other authors (Storry *et al.*, 1983), with the value for cow milk (17.4 min) slightly higher than that of the three breeds of goat cited (13.6, 12.9 and 11.7 min respectively) Garganica and Maltese, instead, ranged at a decidedly high level (34.7 and 42.3 min,) respectively.

The changes in RCT values obtained for cow milk, after each time of heating and as a function of the increase in temperature. The RCTs ranged from 18.8 (1 min, 70°C) to 60.7 (10 min, 95°C). When the values were examined as a function of the heating time from 0 to 10 min (columns), the decreases were always significant at each temperature, at 70°C (range 17.4± 21.0 min), at 80°C (range 17.4±35.2 min), and at 95°C (range 17.4 ± 60.7 min). These results are clearly consistent with the mechanism which gives that the clotting time for the cow milk (*Bruna Italiana*) was progressively longer as the intensity of heating increased (Montilla *et al.*, 1995).

The RCT values measured for the Ionica, Garganica and Maltese goat milks revealed the same trend when examined as a function of the increases in heating temperature (lines). The RCT values always decreased from 70 to 95°C. At the highest temperature (95°C) they were about 50, 60 and 70%, on average (Ionica, Garganica and Maltese, respectively), lower than the values obtained at 70°C. The examination of RCT values as a function of the heating times at each temperature (columns), allows the conclusion that Ionica RCT showed a highly significant decrease, with respect to raw milk, only for 1 min heating at 70°C and at the other temperatures.

2.3.8 Heat coagulation time (HCT)

Heat coagulation time (HCT) of milk measured during 1 min of heat coagulation time at 140℃ depends on the pH of milk of the specific species. Nevertheless, small ruminant milks are frequently not stable at their natural pH.

Concerning goat milk, heat stability of French and Portuguese goat milks was the highest at 125–133℃ (1 min) with pH 6.59–6.75, respectively. The low stability of Greek milk at 92-110℃ (1 min) is associated with lower pH values (6.51–6.61, respectively), due to the physico-chemical composition (especially protein concentration) and to microbiological characteristics (Morgan *et al.,* 2003).

Owing to its high content in minerals and caseins, sheep milk has a low natural pH compared to goat and cow milk. Maximum heat stability was in the pH range between 6.73 and 6.84 for sheep milk (Muir *et al.,* 1993) compared to the higher pH value for goat milk (6.9). Muir *et al*. (1993) followed heat stability for a whole lactation period of ewes and observed a decrease in both pH and heat stability (measured at 140℃) from March to September with HS of about 10 min at pH 6.5 and 1.0 min at pH 6.39 respectively. There is a negative correlation between heat stability and non-nitrogen protein fraction for ovine milk. Heat stability of milk is dependent upon the micellar stability of caseins which in turn influenced by several compositional factors like concentrations of divalent cations like calcium and magnesium; polyvalent anions like phosphates and citrates, Kappa caseins, $\boldsymbol{\beta}$-lacto globulin and $\boldsymbol{\alpha}$-lactalbumin, pH etc (Rose, 1961).

2.3.9 pH and acidity

pH of milk samples collected from different species was determined at the time of sampling. The values of pH value obtained 6.59-6.67 for cow milk, 6.48-6.64 in goat milk. When measuring the goat breeds milk pH from the Saanene of South Africa and Chamoisée breeds of Greece, throughout the lactation period, found variations between 6.5 and 6.8. Fresh milk acts as a complex buffer because of ionizable groups of proteins, phosphates, citrates and a number of minor constituents. Bacterial action introduces lactate and other organic anions as a additional buffer (Le Mens, 1991).

Titratable acidity is expressed as percentage of lactic acid. The values of titratable acidity of milk samples collected from cow and goat milk. The values of titratable acidity were in the range of 0.14-0.16% in cow milk and 0.14 - 0.18% in goat. The higher level of acidity is mainly contributed to presence of higher amounts of caseins, lactates, phosphates and citrates (Sawaya *et al*., 1984)

2.4 Nutritional and Health benefits of goat milk

Goat is one of the main contributors of dairy and meat products for rural people, more than any other mammalian farm animal, particularly in developing country. In addition to that, another important aspect of demand for goat milk derives from the affliction of persons with cow milk allergies and other gastro-intestinal ailments. Goat milk differs from cow or human milk in having better digestibility, alkalinity, buffering capacity and certain therapeutic values in medicine and human nutrition (Coni *et al*., 1999).

Goat milk with the genetic trait of low or no αs_1-casein, but instead with αs_2-casein, has less curd yield, longer rennet coagulation time, less heat stability, and weaker curd firmness, which also may explain the benefits in digestibility in the human digestive tract (Ambrosoli *et al*., 1988). Average amino acid composition of goat and cow milk shows higher levels of 6 of the 10 essential amino acids Threonine, Isoleucine, lysine, cystine, tyrosine, valine in goat milk (Posati and Orr, 1976). Goat milk improved the intestinal absorption of copper, which was attributed to the higher contents of cysteine (derived from cystine) in goat milk (83 mg/100 g) than in cow milk (28 mg/100 g) (Barrionuevo *et al*., 2002).

Capric, caprylic acids and medium chain triglycerides (MCT) have become established medical treatments for an array of clinical disorders, including malabsorption syndromes, chyluria, steatorrhea, hyperlipo-proteinemia, intestinal resection, premature infant feeding, non-thriftiness of children, infant malnutrition, epilepsy, cystic fibrosis, coronary by-pass, and gallstones, because of their unique metabolic ability to provide direct energy instead of being deposited in adipose tissues, and because of their actions of lowering serum cholesterol, inhibiting and limiting cholesterol deposition. Goat milk has higher content of monounsaturated (MUFA), polyunsaturated fatty acids (PUFA), and medium chain triglycerides (MCT) than cow milk, which all are proven to be beneficial for human health, especially for cardiovascular conditions (Alferez *et al.*, 2001).

Oligosaccharides content of goat milk is more than cow milk which acts as a prebiotic nature which acts as a feed supplement to the intestinal micro flora. The children on goat milk surpassed those on cow milk in weight gain, height, skeletal mineralization, and blood serum contents of Vitamin A, calcium, thiamine, riboflavin, niacin and haemoglobin. The feeding of goat milk instead of cow milk as part of the diet resulted in significantly higher digestibility and absorption of iron and copper, thus preventing anemia (Barrionuevo *et al*., 2002).

Goat milk supplies adequate amounts of vitamin-A and niacin, and excesses of thiamine, riboflavin and pantothenate for a human infant (Ford *et al.*, 1972). Compared to cow milk, goat milk has significant deficiencies in folic acid and Vitamin B_{12}, which causes "goat milk anemia" (Jenness, 1980).

2.5 History of yoghurt

Acidification of milk by fermentation is one of the oldest methods of preserving milk and conferring special organoleptic qualities to the product. Fermented products vary considerably in composition, flavor, and texture according to the nature of fermenting organisms, the type of the milk and the manufacturing process. Cultured milk products, which includes yoghurt, cheese, Lassi and shrikhand plays an important role in human diet, the low pH and extended shelf life make cultured milk products practically relevant to commercial production in subtropical countries. The sensory attributes are very important determinants for the acceptability of the fermented dairy products (Vedamuthu, 1991).

The term yoghurt is derived from the Turkish word called “Jughurt”. It is called by various names in different parts of the world. For instances in India it is known as Dahi or Dadhi or Dahee. In Egypt and Sudan it is known as Zabady. Origin of yoghurt could be traced to the Middle East and the evolution of this fermented product through the ages can be attributed to the culinary skills of the nomadic people living in that part of the world (Tamine and Robinson, 1985).

The process of yoghurt making is an ancient craft, which dates back to thousands of years, but it is assumed that prior to nineteenth century, the various stages involved in the production of yoghurt were little understood. The uniqueness of yoghurt is attributed to symbiotic fermentation (Vedamuthu, 1991). Use of fermented/cultured dairy products has been the essential part of our food consumption. Since ancient times, conservation of milk in to cultured dairy products by souring with appropriate microbial inoculation is a common practice in every house hold. Yoghurt a traditional product of the Middle East countries is relatively a new introduction to the Indian dietary system. (Thompkinson and Sahal,1995).

2.5.1 Definition of yoghurt

According to International Dairy Federation (IDF, 1969) Yoghurt may be defined on the basis of the source of milk viz. Cow, Goat, sheep and buffalo processing conditions, fermentation process using specific micro-organism and IDF suggest a minimum of 0.7% lactic acid content in the retail product. Yoghurt may be defined as the solid, custard like fermented milk product made from fortified high solids milk using a symbiotic mixture of *Streptococcus salvarius ssp thermophillus and Lactobacillus delbrueckii ssp. bulgaricus* as starters (Vedamuthu.1991).

Yoghurt can be defined as a cultured product obtained by using *Streptococcus thermophilus* and *Lactobacillus delbrueckii ssp. bulgaricus.* The product should contain 0.8% lactic acid, while Yeast and mold counts not exceeding 100 per gram and coliform count not more than 10 per gram. The product should be negative for phosphatase test.(IS 7035, 1973).

According to FAO/WHO (1976) "Yoghurt is a coagulated milk product obtained by lactic acid fermentation of milk through the action of *Streptococcus salvarius ssp thermophilus* and *Lactobacillus delbrueckii ssp. Bulgaricus* with or without addition of whole milk powder or skim milk powder or whey solids. The desirable microorganisms in the final product must be viable and abundant".

2.5.2 Composition of yoghurt

According to Food and Drug Administration (FDA, 1991) "Yoghurt is produced by culturing cream, milk, partially skimmed milk or milk either alone or in combination with lactic acid producing bacteria viz. *L. bulgaricus and S. thermophilus*". The regulations specify that yoghurt before addition of bulky flavors contains not less than 3.25% milk fat, 8.25% MSNF and titratable acidity of 0.9% Lactic acid (Vedamuthu, 1991).

The concentrations of milk solids in most of the commercial yoghurt made from whole milk ranges from 14 to 16%, while in yoghurt made from skimmed milk ranged between 9 to 10% (Kulakarni, 1990). An increase in total solids results in increase in the titratable acidity and reduction in the coagulation time. Levels of total solids in excess of 25% adversely affected the availability of moisture and there by hindered the starter activity (Tamine and Robinson, 1985) recommended total solids levels of 14 to 18% in yoghurt preparation.

2.5.3 Nutritional / Health benefits of yoghurt

Growth in the consumption of fermented dairy products particularly yoghurt has been due to the health image they possess and diversity in their availability (Patel and Schauen, 1997). The beneficial aspects of yoghurt consumption are attributed mainly to the biochemical changes brought about during the fermentation process. The advantage of yoghurt has been attributed either to its low lactose content or the lactase activity of *Lactobacillus bulgaricus and Streptococcus thermophilus*, which survives passage through the stomach and might contribute to lactose digestion in the small intestine (Malik *et al*., 1998). Since up to half of lactose is hydrolyzed during manufacture, a characteristic of yoghurt which finds favor with lactose intolerance, the protein is highly digested as most of the protein is in pre-digested form (Tamime and Deeth, 1980).

The constituents of milk are broken down in fermentation by lactic acid bacteria leading to increased efficiencies of utilization of protein, calcium, iron and phosphorus etc (Rameshwar, 1996). Lactic acid bacteria create an environment i.e intolerable to many bacteria including pathogens, by lowering the pH, decreasing the redox potential and producing antimicrobial compounds (Yaeshima, 1996). Yoghurt cultures are reported to synthesize vitamins, exhibit antagonism against undesirable flora, possess β-galactosidase activity and have the ability to survive in the gastro-intestinal tract (Sarkar and Misra, 2006).

2.5.3. Yoghurt Processing

Although there is no standard procedure for making a set or drinkable yoghurt, most processors agree on a general process. The main processing steps in the manufacture of these products include milk standardization (solids, casein and fat contents), heat treatment, homogenization, addition of starter culture and fermentation, cooling and storage (Lucey, 2004).

2.5.4. Standardization of milk

Standardization of milk with respect to fat and SNF is an important step not only for adherence to legal standards, but also for the overall effects on the flavour and texture attributes of the product, partially relating to the viscosity and mouthfeel. As per PFA (2008), yoghurt has been classified under five categories as yoghurt, partly skimmed yoghurt, skimmed yoghurt, sweetened / flavoured yoghurt and fruit yoghurt, with the following chemical composition.

Types of yoghurt classified as per PFA

Types of yoghurt	%Fat	%SNF
Yoghurt	≥3.0	≥8.5%
Partly skimmed yoghurt	0.5-2.9%	≥8.5%
Skimmed yoghurt	<0.5%	≥8.5%
Sweetened/flavored yoghurt	≥ 3.0%	≥8.5%
Fruit yoghurt	≥1.5%	≥8.5%

Generally, milk required for yoghurt manufacture should be standardized to a fixed composition in order to ensure a product of uniform quality. Importance of fat in relation to both consistency and flavour has been stressed (Chawala and Balachandran, 1993).

Seven different types of starch based fat substitutes were used for the production of set style yoghurt from reconstituted skimmed milk powder. The use of a higher concentration (5%) of starch based fat substitutes increased the firmness (Tamime *et al*., 1996). The fortification of MSNF content of milk allows the elevation of total solids to achieve a more viscous and firm consistency of yoghurt (Tamime and Robinson, 1999).

Fortification of solid matter can be achieved by using several materials including skim milk powder, milk protein concentrate and whey protein concentrate and four hydrocolloids viz k- carrageenan, xanthum gum, guar gum and pectin added at 0.01%. Firmness and the resistance of yoghurt gels against syneresis were reported to be improved as the protein content increased in case of whole fat and skimmed yoghurts (Soukoulis *et al*., 2007).

Fat level was found to exert a significant effect on flavour, body – texture and appearance of yoghurt samples. Increase in fat level to 6% resulted in the curd which was lumpy, greasy and tended to be ropy upon stirring (Chawala and Balachandran, 1993).

Brauss *et al*., (1999) observed that low fat yoghurt (0.2% fat) release volatiles more quickly and at higher intensity but with less persistence than whole fat yoghurt. The application of ultra filtered sweet buttermilk and sweet buttermilk powder in the manufacture of non-fat yoghurt (NFY) and low fat yoghurt (LFY). The titratable acidity and pH of LFY were higher than those of NFY. Nonfat yoghurt with tested ingredients was similar to the control w.r.t flavour, appearance, texture, aroma, smoothness, and sourness (Trachoo and Mistry, 1998).

2.5.5. Heat treatment

Milk heat treatment is considered to be a critical factor for texture formation and consistency of yoghurt (Lucey *et al.*, 1997). The application of heat is a crucial step in yoghurt production and affects both the safety and quality of the product with both temperature and time being critical factors. The effect of heat treatment can be broadly summarized as i) destruction of pathogens and other undesirable micro- organisms. ii) Production of factors stimulatory/inhibitory to the yoghurt starter's iii) changes in physicochemical properties of milk constituents which are relevant in yoghurt making (Early, 1998; Tamime and Robinson, 1999; Walstra *et al*., 1999).

Historically, yoghurt mixes were vat or batch pasteurized, for example at 85°C for 30 min, but now much of the milk is high- temperature short- time (HTST) processed at 85 - 98°C for times between 20s and 7 min.(Lucey, 2004).

Heating induces whey protein denaturation so that whey proteins can associate with casein micelles. Denaturation of whey proteins promotes interaction through disulfide linkages between ß-lactoglobulin (β-Lg) and k-casein at the micellar surface (Soukoulis *et al.*, 2007; Dalgleish, 1990).

The subsequent interaction of whey protein with casein micelles aids in the formation of firm gels with less tendency for syneresis. Also yoghurt prepared with unheated or inadequately heat – treated milk is characterized by poor texture, weak gel and firmness, and increased susceptibility against wheying off (Tamime and Robinson, 1999).

Depending upon the heating temperatures, such as those in high-temperature pasteurization, and the pH, various reactions on the side chains of these proteins may take place, preventing the peptide chain from reverting back to the original conformation. These denatured proteins are insoluble (Walstra *et al*., 1999).A variety of reactions involving the serum proteins may occur, but these are largely dependent upon the pH. For instance, application of heat at high temperatures (> 80°C) causes β-lactoglobulin to associate with k-casein on the outer layer of the casein micelle. As a result of these types of reactions, the volume of the protein increases, resulting in a slight increase in milk viscosity (Fox and Mc Sweeney, 1998).

2.5.6. Homogenization

The next step in yogurt processing also impacts the physical and chemical aspects of the milk. Natural milk fat globules do not interact with the casein gel matrix. Mixes containing fat are typically homogenized using high pressures of 10-17 MPa (1500-2500 psi) first stage and 3.4 MPa (500 psi) second stage at 55-71°C (Lucey, 2004)

Homogenization breaks the large fat globules into smaller ones, thereby creating a stable emulsion out of an oil - in – water mixture (Early, 1998). This action reduces the size of the fat globules, which may be from 1 to 18 µm in diameter (average size is 3-4 µm) to less than 2 µm there is a reduced tendency for cream layer formation and increased viscosity, especially with high fat contents (Tamime and Robinson, 1999; Lucey, 2004).

During homogenization, casein and some whey proteins get absorbed at the fat globule interface and this effectively increases the number of structure – building components (Walstra, 1998). As a result, homogenization serves several purposes, including preventing the separation of the cream layer, improving stability, altering the physical attributes etc. (Tamime and Robinson, 1999; Walstra *et al*., 1999).

The reduction in size of the fat globules and increase in the adsorption on the casein micelle leads to an increase in total volume, resulting in an increased viscosity and the formation of a softer gel (Spreer, 1998; Tamime and Robinson, 1999).

Higher homogenization pressures result in increased firmness and viscosity due to an increase in surface area caused by the formation of a larger number of smaller fat particles. Homogenization also helps to reduce whey separation and increases the whiteness of the product (Tamime and Robinson, 1999). The homogenization step can reduce the starch stabilizer functionality if the processing temperature and pressures are too high (depending upon the type of starch used) (Lucey, 2004)

Color is also affected with homogenized milk appearing whiter due to the scattering and reflectance of light by a larger number of fat globules (Fox and McSweeney, 1998; Tamime and Robinson, 1999). It has been found that the application of high pressure in the pre-treatment of cow milk intended for yoghurt improves the firmness of yoghurt curd and reduces its syneresis. The pressure above 200 MPa significantly inhibits the souring activity of yoghurt bacteria (Reps *et al*., 2008)

2.5.7. Starter cultures

In the typical fermentation of yoghurt, the lactic acid starter bacteria *Streptococcus thermophilus* (coccus) and *Lactobacillus bulgaricus* (rod) grow symbiotically; producing lactic acid and acetaldehyde, which is responsible for typical yoghurt flavor and texture (Wilkins *et al*., 1986; Vedamuthu, 1991). *Streptococcus thermophilus* and *Lactobacillus bulgaricus* are homofermentative thermophilic bacteria, which produce lactic acid by fermentation of the lactose in milk at higher temperatures. Optimum temperature for growth of *S.thermophilus* is from 40-45°C and 45-50°C for lactobacilli (Rasmussen, 1981).

L. bulgaricus usually seen as medium to long, slender rods sometimes bent or curved, in pairs and in chains. As a homo fermentative thermophile, it is known to be relatively tolerant to heat (Rybka and Kailasapathy, 1995). The other starter microorganism involved in yoghurt production, *S.thermophilus*, is spherically found in pairs or long chains, and is noted for the ability to withstand higher temperatures (up to 40-45°C), contributing to the classification of homofermentative thermophile (Rasmussen, 1981; Tinson *et al*., 1982).

Acetaldehyde is recognized as a major flavour component in yoghurt, and the evaluation of its flavour, is based mainly on acetaldehyde production by the starter culture. The flavor compounds produced by the starter bacteria were mainly synthesized during fermentation and the first 24 h of storage (Ekinci and Gurel, 2008).

The addition of propioni bacteria to yoghurt did not have any negative effect on the counts of *S.thermophilus* and *L.bulgaricus* in yoghurt (Ekinci and Gurel, 2008).The therapeutic value and flavor characteristics had improved by using *Lactobacillus acidophilu*s and *Lactococcus lactis ssp. lactis biovar*. *diacetylactis* when added separately, along with yoghurt cultures such as *S. thermophilus* and *L. bulgaricus* in the preparation of yoghurt (Jayan and Khan, 1994).

2.5.8. Incubation

During the manufacture of yoghurt, the heat treated milk is cooled to the incubation temperature of the starter cultures (*S. thermophilus* and *L. bulgaricus*); the milk is fermented at 40-45°C, which is the optimum growth condition for the mixed culture. The determination of incubation time is an essential technical parameter in industrial yoghurt production (Soukoulis *et al.*, 2007). In industry, generally two methods of incubation are followed for yoghurt preparation.

Short incubation method: Yoghurt is incubated at higher temperature i.e. 40-45°C for a period of as short as 2 ½ hours. Culture is added at higher concentration i.e. ≥3%

Long incubation method: For this method incubation conditions are 30°C for around 16-18 hours (overnight) or until the desired acidity is reached.

The effect of temperature of incubation (38°C vs. 43°C) on the physico – chemical and sensory qualities of set and stirred yoghurt was investigated and reported that there was no significant effect of temperatures of incubation and style of yoghurt for the characteristics titratable acidity, pH and viscosity. But with respect to sensory qualities, the effect of temperature of incubation was significant only for the characteristic texture; viscosity, acidity, flavor and degree of liking were not affected, although there was a higher score for yoghurts made at 38°C (Cho- Ah-Ying *et al.*, 1990).

The effect of heat treatment during yoghurt manufacture affects the acidification rate and incubation time. Thus, the reduction of incubation time is due to whey protein denaturation. The greater the whey protein denaturation induced, the shorter the incubation period achieved. The addition of 2% skim milk powder, whey protein or milk protein concentrate significantly influenced the incubation time of yoghurt (Soukoulis *et al.*, 2007).

The incubation time of yoghurts was considerably increased when the ratio of whey protein to casein was increased, suggesting that the protein components of yoghurt milk bases are important factors determining the incubation duration. Whey powder traditionally contains a high amount of whey protein, increasing the ratio of whey proteins to caseins (Puvanenthiran *et al*., 2002).

2.5.9. Cooling

In yoghurt manufacture cooling of the gel, once sufficient acidity has been developed, is considered to be an important factor in controlling the texture of the product (Lucey, 2004). At the appropriate acidity 0.9%LA or 4.7pH cooling of the fermented milk begins. Some acid development occurs during the cooling stage (depending on the cooling rate) so a higher pH value is selected to initiate the cooling or an undesirably low pH (e.g. < 4.2) will result. If the set gels cooling is achieved by transferring the container directly to a cold store or it can first blast chilled either within the fermentation chamber or using cooling tunnels (Zoon, 2003).

Cooling can be carried out in single stage or several stages, fruit and other preparations may be added after the product was partially cooled (e.g. 22°C), filtered to break up lumps and then filled. The stirred product is now blast chilled and stored at refrigeration temperatures to slow down physical, chemical and microbiological degradation. Cooling results in an increased firmness and viscosity due to an increase in the size of casein particles (Lucey, 2004).

2.5.10. Storage

Changes in the physical, chemical and microbiological structure of yoghurt determine the storage and shelf life of the product. Alteration of these properties causes colour, aroma, and texture deterioration of yoghurt, which are considered to be important quality criteria by consumers (Sofu and Ekinic, 2007).

A study by Yadav *et al*., (1994) on the sensory attributes and biochemical changes of yoghurt made with soy milk and buffalo milk blends with additives viz: alginate, carboxy methylcellulose, or potassium sorbate during 15-days at 7°C, reported to influence biochemical and microbiological aspects, and demonstrated a positive relationship with sensory characteristics.

2.5.11. Factors affecting setting of yoghurt

Factors influencing yoghurt texture and syneresis include total solids content, composition of milk including protein, salts, homogenization, type of culture, acidity resulting from growth of bacterial cultures and heat pre-treatment of milk (Biliaderis *et al*., 1992).

Increase in the denaturation of whey proteins primarily β-lacto globulin leads to a reduction in fermentation period (Shaker *et al*., 2000). Puvanenthiran *et al*., (2002) investigated the effect of substituting SMP with WPC added in different ratios and concluded that the increase of the whey to casein ratio was associated with the increase in fermentation time, pH of gelation and firmness.

The buffalo milk yoghurts were prepared with the fortification of various proportion of either apple fruit pulp or honey, by using mixed starter culture containing 1:1 ratio of *Streptococcus thermophilus* and *Lactobacillus bulgaricus*. The setting time of yoghurt reduced with increase in the concentration of the fortification. The higher setting time was required for the control sample (480 min) as compared with the other samples prepared with buffalo milk and fortified with honey or apple pulp separately at different concentrations (Ghadge *et al*., 2008).

When a modified starch at 1% w/w was added to yoghurt milk and the mixture fermented at 43°C, the viscosity of the stirred yoghurt increased, but the yoghurt developed a grainy texture. Lowering the fermentation temperature from 43°C to 35°C increased the fermentation time, decreased graininess and whey drainage, but decreased the viscosity of stirred yoghurt with added starch (Williams *et al*., 2003).

2.6 Physico-chemical properties of goat milk yoghurts

2.6.1 pH and Acidity

The pH of the goat’s milk used in probiotic yoghurt production was 6.64 ± 0.01. The initial pH of milk 6.64 ± 0.01 was reduced to 4.38 ± 0.01 during yoghurt production in approximately 3 ½ h, in line with the growth of the starter culture and the probiotic bacteria during incubation (Martin-Diana *et al.*, 2003).

The lactic acid levels of the strained yoghurt were determined to be between 1.36 and 1.38 g 100 g−1. Lactic acid, found mainly in the serum phase, is an essential compound affecting the characteristic aroma and flavour (sharp and acidic) of yoghurt. Atamer *et al.* (1993) reported that the amounts of serum separated as a result of draining were equivalent to 50.38–58.02% of the weight of the yoghurt used as a raw material in the manufacture of strained yoghurt. The variations in the pH and acidities may be attributed to the differing buffering capacities and as well as lactic fermentation by the metabolic activities of cultures. Further the buffering capacity is governed by the concentrations of proteins phosphates and citrates present in milk (Tamime and Robinson, 2007). Thus, the level of lactic acid in strained and control yoghurt was determined to be 0.82– 0.90 g 100 g−1 and 0.66 – 0.78 g 100 g−1, respectively (Atamer *et al.*, 1993).

2.6.2 Syneresis

Syneresis is the separation of the liquid phase from the gel. It may be spontaneous or may occur only when the gel is mechanically disrupted.

Syneresis, an undesirable property in yoghurt products, is the effect of liquid separating from the yoghurt curds (Wu *et al.*, 2001). Syneresis was found to be significantly lower 22.33% in plain yoghurt than in the stirred fruit yoghurts 32% regardless of the added fruit juice levels, probably due to its higher total solids, protein, fat, and ash content. High fat content in yoghurt has been associated with lower syneresis values in previous experiments (Isanga & Zhang, 2009). The coagulum observed in the goat milk yoghurt observed to be low α-s1 and β-lacto globulin resulting in higher whey separation indicating higher syneresis in goat milk (Sanjeev Kumar *et al* 2012).

2.6.3 Curd tension of yoghurt

The hardness of the curd is measured in terms of the depth of penetration as mm/5sec using a cone Penetrometer. The curd tension increases with the increase of MSNF content in yoghurt. The increase in the depth of softness of the curd is due to decrease in casein content in the yoghurt. Further decrease in penetration depth with the increase in MSNF content may be due to higher protein content especially casein content of the yoghurt mix (Chawla and Balachandran, 1994).

Penetrometer values of control samples were found to be higher (lower consistency) 175 mm/5 seconds than those of samples with transglutamase. Transglutamase treated samples had higher gel firmness. Similarly Lorenzen (2000) also found that there was a strong, positive relationship between the treatment of transglutamase and gel strength. The lower curd tension and weaker curd firmness may be attributed to lower contents of low α-s1 casein and smaller casein micelles (Sanjeev kumar *et al.*, 2012) and this is of significance in the digestibility of milk proteins in the human intestines and therefore beneficial in the case of infant and in general human nutrition.

2.6.4 Free fatty acid contents

The total amount of free fatty acids in Ewe milk, Goat milk and cow milk yoghurts were not significantly different from each other, which includes 52 µg/gm for

Ewe milk yoghurt, 49 μg/gm for Goat milk yoghurt and 49 μg/gm for cow milk yoghurt. In general, ethanoic acid and short, medium and long-chain FFAs as% of total FFAs represented approximately 12–16%, 17–24% and 76–82% in all the yoghurts, respectively for goat's milk. (Kondyli and Katsiari, 2002).

The development of FFA is mainly attributed to the lipolysis of fat by the culture organisms affecting significantly aroma and flavor of dairy products. The individual short chain fatty acids are responsible for the pronounced aroma and flavor of the goat milk products (Senel *et al* 2011).

2.6.5 Soluble nitrogen contents

The tyrosine value is considered to be the amount of total amino acids liberated as tyrosine equivalent as a result of the proteolytic activity of the starter culture. The threshold values for tyrosine in set type yoghurt have been determined to be 0.10 mg g−1 (Asperger, 1977), and 0.144 mg g−1 (Atamer *et al.*, 1993).

The higher soluble nitrogen content may be attributed to the higher non protein nitrogen content in goat milk yoghurts and as well as the higher proteolytic activity of starter cultures (Senel *et al* 2011). In addition, Atamer *et al.* (1993) reported that a higher tyrosine value (0.200 mg g−1) could be tolerated without exhibiting pronounced flavor impairment in strained yoghurt.

2.7 Storage studies of goat milk yoghurt

2.7.1 Effect of refrigeration storage on the physico - chemical characteristics of goat milks yoghurt

2.7.1.1 pH and total acidity

The pH and total acidity of both goat milk yoghurts and cow milk yoghurts were 5.71 and 5.60 and 0.74 and 0.68%, respectively. After 5 days of cold storage a significant increase in acidity and a decrease in pH for both yoghurt types were observed. The magnitude of increase in acidity is high in goat yoghurt. After 15 days of storage goat milk yoghurt had a higher acidity (2.58%) and a lower pH (2.67) compared to cow milk yoghurt.

A faster acidification and lower pH values in goat milk yoghurt was reported by Bozanic *et al* 1998. Different behaviour could be explained by the enhancement of the microbial growth, acidity progress and peptidase activity of lactic acid bacteria in goat's milk. Moreover, the activity and growth rate of the starter cultures are strain dependent. Hence, the acidification rate of lactic acid bacteria varied with the type of milk (Vargas *et al*., 2008).

2.7.1.2 Free fatty acid content

A sharp decrease was observed in the levels of individual FFAs in the strained yoghurt of about 177.62 (mg kg−1) on the 15th day of storage. The decrease in the level of FFA may be associated with catabolism of FFA by microorganisms. It is well-known that catabolism is a very important biochemical process in the formation of the characteristic aroma and flavor of some cheeses (especially blue-mold cheese). Some molds (such as Penicillium roqueforti) are responsible for the β-oxidation of FFA to produce methyl ketones, and for the subsequent reduction to secondary alcohols (Scott, 1981; Fox *et al*., 2000). After 15th day, the levels of FFAs remained almost unchanged or increased slightly. In the literature, there are only a few studies on the changes in the level of FFA in yoghurt and other dairy products during the storage or ripening period.

The level of individual FFAs in raw milks (cow's, goat's and sheep's) and yoghurts made from these milks. As a result, the increases and decreases in the FFA levels of yoghurts as compared to raw milks were inconsistent. These changes could be attributed to the difference between the behaviours of *S. thermophilus* and *L. delbrueckii ssp. bulgaricus* in cow, sheep and goat milk. (Tamime and Robinson, 2007) observed that FFA levels of 165.82 (mg kg−1) in yoghurt increased (significantly or moderately) over a period of 20 days in cold storage.

2.7.1.3 Soluble nitrogen content

The tyrosine value of the strained yoghurt varied from 0.22 to 0.24 mg per 5 gms during the storage. A small increase was observed in the tyrosine value on the 15th day of storage (Saldamlı and Temiz, 1998). On subsequent days, there was no appreciable change in the tyrosine value of the samples. This result could be related to the reduced metabolic activity of the starter culture as a result of the increased total solid content of the strained yoghurt. Hence similar trend was observed in cases of both the acidity and the tyrosine values in the strained yoghurt.

2.7.2 Effect of refrigeration storage on the microbiological quality of goat milk yoghurt

Refrigeration storage changes in total viable count of goat and cow milk yoghurt during storage. The results obtained revealed that goat and cow milk yoghurt contained total number of 1.3×10^5 and 2.6×10^5 cfu/g viable cells of bacteria, respectively. Initial bacterial count increased significantly during storage of both yoghurt types. Bacterial count reached its maximum increment at the 10th day and there after significantly declined to 1.25×10^6 and 1.9×10^6 cfu/g for goat and cow milk yoghurt respectively. The increment of the acidity of the growth media with the storage time may retard the bacterial growth. These results are in agreement with the findings of (Masud,. *et al*, 1991). Lactobacillus count in goat yoghurt (1.45×10^6 cfug^{-1}) was observed to be higher than that of cow yoghurt (1.7×10^5 cfug^{-1}). Throughout the storage period, the numbers of *Lactobacillus spp.* in cow yoghurt surpassed that of goat yoghurt. Fresh goat milk yoghurt had lower number (1.4×10^6 cfug^{-1}) of *Streptococcus spp.* than that of cow milk yogurt (1.6×10^6 cfug^{-1}). *Streptococcus spp.* load in both types of yoghurt significantly ($P \leq 0.05$) increased as the storage time prolonged, reaching its maximum at the 5th day, and then declined.

Tamime and Robinson (1999) reported that yoghurt should contain 10^7 viable cells of lactic acid bacteria per millilitre. On the other hand, yeasts and molds steadily increased with increase in storage time with maximum value of 8.0×10^7 for cow yoghurt and 6.6×10^7 cfug^{-1} for goat yoghurt at the 15th day. An increase in acidity and/or reduction in potential oxygen during fermentation process may provide suitable conditions for growth of yeasts and molds.

Coliforms and *Escherichia coli* viable cells were detected in both goat and cow yoghurt. In cow yoghurt they significantly increased during the first 5 days of storage and thereafter completely disappeared. In goat yoghurt coliforms increased but *Escherichia coli* decreased after 5 days of storage and thereafter both the organisms disappeared. The presence of coliforms gives clues to unsanitary conditions of processing. However, it was reported that coliforms, if present, in yoghurt could survive a maximum of 3 days (Dardashti *et al.*, 2001). Moreover, *Escherichia coli* was observed to survive the low pH of domestic yogurt developed during cold storage and could tolerate lower acidity up to 6 days (Morgan *et al* 1993; El-Kosi *et al*., 2000; Quinto *et al.*, 2000).

Materials and Methods

3. MATERIALS AND METHODS

The materials and the methods used for the compositional and physico – chemical analysis of milk of cow, pooled indigenous and pooled exotic goat breeds and procedure for preparation of yoghurt by utilizing these milks and methods employed for its analysis are described in this chapter.

3.1 Materials

3.1.1 Glassware

All the glassware used were soaked in a mixture of chromic acid and Sulphuric acid solutions, repeatedly washed with water, rinsed with distilled water and dried in hot air oven before use.

3.1.2 Chemicals and reagents

Only 'Analytical Grade' (AR) chemicals listed below were used for analytical work.

90% Gerber's Sulphuric acid, Amyl alcohol, Fehling solution-A & B, 0.5% standard lactose solution, 0.5% Methylene blue indicator, 50% sulphuric acid, Copper sulphate and potassium sulphate (1:2 ratio), 2% boric acid solution, Mixed indicator i.e. Methylene blue and methyl red (1:2), 0.02 N Hydrochloric acid, 0.1 N Sodium hydroxide, Phenolphthalein indicator, Buffer solutions of pH-4, pH-7 & pH-9, Standard potassium solutions of 0.1 M, 0.01M, 0.001M concentration, Diethyl ether, Petroleum ether, Ammonia, Paraffin oil, Cooling bath fluid, Calibration solution- A, Calibration solution- B.

3.1.3 Instruments/ equipments used

1. Homogenizer (Rannie Copenhagen)
2. Cone penetrometer (AIMC associated Instrumental manufacturers).
3. Oil bath (Spin co. Company).
4. Autoclave (Kumar).
5. pH meter (Chemi Line Company)
6. Muffle furnace (Elec. Ltd).
7. Abbe's – Refractrometer (Mayora scientific company).
8. Gerber centrifuge (JALCO motor company).
9. Conductivity meter (Chemi Line Company).
10. Cryoscope (Funke .N.Gerber laboratory technique).
11. Incubator (Tempco Industrial Corporation)

3.1.3 Other Accessories

Water bath, weighing balance, ash crucibles, glass beads, refrigerator, hot plate, automatic tilt measures, refrigerators, petri plates.

3.2 Ingredients

3.2.1 Milk

Fresh cow milk containing Fat and SNF of 3.5% and 8.5% was procured from the Karnataka Veterinary, Animal and Fisheries Science University's dairy farm, Hebbal, Bangalore. Exotic and indigenous goat milk was procured from Sinchana goat and sheep farm, Marenahalli village, Bangalore Rural (Dist).

3.2.2 Skim milk powder

Nestle spray dried skim milk powder was used to standardize the milk for the preparation of yoghurt.

3.2.3 Rennet solution

Pure rennet extract powder was procured from Christian Hansen PVT LTD. Rennet of 0.1 gm was dissolved in 100ml of distilled water to prepare rennet solution.

3.2.4 Starter culture

The mixed starter culture consisting of *Streptococcus thermophilus* and *Lactobacillus bulgaricus* in the ratio of 1:1 were procured from the Dept. of Dairy Microbiology, KVAFSU, Bangalore and used for the production of yoghurt. The culture propagation was done in sterilized skim milk at incubation condition of 42°C for 4-6 ½ hrs in an incubator. Sub culturing of yoghurt culture were carried out once in a week and maintained in a refrigerator.

3.2.5 Packaging cups

The packaging cups made up with 100 ml capacity with lids, purchased from local market were used. These were cleaned with teepol and sanitized by dipping in to 50 ppm chlorine solution and immersed in hot water at 80° C for 10 min, and cooled to room temperature before use.

3.2.6 Media used for microbiological study

The media used for microbiological study was MRS agar for enumeration of *Lactobacillus bulgaricus* and Yeast Glucose Agar (YGA) for enumeration of total bacterial count. VRBA and MEA were used for the enumeration of coliforms and yeast and mold count in yoghurt samples.

Composition of Manitol Salt Agar (YGA) (IDF, 2003)

Ingredients	Quantity
Peptone	10.0 g
Malt extract	10.0 g
Sodium chloride	5.0 g
D-glucose	5.0 g
Yeast extract	3.0 g
Agar	15.0 g
Distilled water	1000 ml
pH	7.0

Composition of Violet Red Bile Agar (VRBA) (IDF, 2003)

Ingredients	Quantity
Peptone	7.0g
Yeast Extract	3.0g
Bile salts	1.5g
Sodium chloride	5.0g
Lactose	10.0g
Neutral red (1% solution)	3ml
Crystal violet (0.05% solution)	4ml
Agar-Agar	15.09g
Distilled water	1000ml
pH	7.4

Composition of Malt Extract Agar (MEA) (IDF, 2003)

Ingredients	**Quantity**
Malt Extract	30.0g
Mycological peptone	5.0g
Agar	15.0g
Distilled water	1000ml
Ph	5.4

Composition of physiological saline (IDF, 2003)

Sodium chloride	8.5 gm
Distilled water	1000ml

Preparation: sodium chloride was dissolved in distilled water and transferred to sterile dilution bottles (99ml) and to sterile saline tubes (9ml) and sterilized by autoclaving at 121°C/15 min (IDF, 2003).

3.3 Methods

3.3.1 Compositional analysis of goat milk

3.3.1.1 Fat

Fat content of cow and goat milk were determined by Gerber method as per IS: SP18 (Part XI) 1981.

3.3.1.2 Protein

Protein content of cow and goat milk was determined by micro kjeldhal method as per ISI: SP18 part XI (1981).

3.3.1.3 Total ash

Total ash content of cow and goat milk were estimated by gravimetric method as per ISI: SP18 part XI (1981).

3.3.1.4 Lactose

Lactose content in content of cow and goat milk was estimated by Lane Eynon method as per ISI: SP18 part XI (1981).

3.3.1.5 Milk Solids Not Fat (MSNF)

MSNF content in content of cow and goat milk was estimated by using BIS Lactometer by using the following

Formula

SNF (%) = 0.25 CLR+0.2 F +0.35

Where,

CLR-Corrected Lactometer Reading

F-Fat (content in per cent)

3.3.1.6 Total Solids (TS)

Total solids of cow milk and goat milk were determined by gravimetric method as per ISI: SP 18 (Part XI) 1981.

3.3.1.7 Moisture

Moisture content of cow milk and goat milk were determined by gravimetric method as per ISI: SP 18 (Part XI) 1981.

3.3.2 Physico-chemical analysis of Goats milk

3.3.2.1 pH

pH of the milk sample were measured using a digital pH meter (Chemi line Pvt. Ltd.) at 25°C. About 20 ml of representative milk samples were used for pH determination.

3.3.2.2 Acidity

Acidity of the milk samples were measured as per method described in ISI: SP 18 (Part XI) 1981.

3.3.2.3 Specific gravity

Specific gravity of milk samples were estimated at 20°C by using a Standard specific gravity bottle of 25ml capacity by taking distilled water as a standard liquid.

3.3.2.4 Viscosity

Viscosity of milk samples were measured by using capillary viscometer. The measurement was made at 25℃ by recording the time required for same volume of water and milk to flow through the viscometer. The viscosity was calculated by using the formula.

$$\text{Viscosity of milk} = t_1/t_2 \times (c-a)/\ (b-a)$$

Where,

T1 = Average time of flow of milk

T2 = Average time of flow of water

A = empty weight of pycnometer (g)

B = empty weight of pycnometer (g) + water (g)

C= empty weight of pycnometer (g) + milk (g)

(a-b) = mass of distilled water having volume ‘V’ of the pycnometer (g)

(c-a) = mass of liquid having volume ‘V’ of the pycnometer (g)

3.3.2.5 Surface tension

Surface tension of milk samples were determined as per the method followed by the Mukherjee, *et al*. (1993)

3.3.2.6 Refractive index

Refractive index of milk samples was determined as per the ISI: SP18 part XI (1981).

3.3.2.7 Freezing point

Freezing point of milk samples were measured as per method described in ISI: SP 18 (Part XI) 1981.

3.3.2.8 Electrical conductivity

The electrical conductivity of milk samples were measured using direct reading conductivity meter (Elico, India).

3.3.2.9 Rennet coagulation time

Rennet coagulation time of milk samples were estimated by the subjective method of Hostettler and Stein free fatty acids, (1954).

Procedure

Milk sample of 10ml was taken into screw cap test tubes and kept for five minutes in a thermostatically controlled water bath at 30℃ to achieve the renneting temperature. 0.1ml of rennet solution was added to each test tube and the contents were mixed by inverting the tubes. This operation was carried on from the time of addition of rennet until the appearance of the first visible clot. This period was noted with a stop watch. Duplicate determinations were carried out for all the samples.

3.3.2.10 Heat coagulation time

Heat coagulation time of milk samples were estimated by the subjective method adopted by Davis and White (1966) at 135℃.

Skim milk sample of 4ml was placed in a corning tube with a capacity of 15×125 mm stopper tightly with a silicon rubber cork and clamped crosswise in a test tube stand, 5-6 tubes were accommodated at a time. The test tube stand was connected to a shaking motor while being held horizontally and immersed to a depth of four centimeters in a bath of liquid paraffin. The movement of stand caused by the shaking motors, made the sample tube to rock in a vertical plane about its center across an angle of 30℃ making the milk sample flow gently from one end of the tube to the other end. The tubes were illuminated from above by a lamp and viewed at it’s centre through magnifying lens. As soon as particles or clots were seen throughout the milk, the time was recorded as the “coagulation time”, in other words, this is the heat stability of the milk.

3.3.3 Experimental procedure for preparation of yoghurt

The procedure followed by Vargas (2006) for preparation of goat milk yoghurt was adopted with suitable modifications. Fresh whole milk was standardized to 3.5% milk fat and 9.0% MSNF using Skim milk powder. Then the mixture (60-65^{0}C) was homogenized at 2000 psi at first stage and 500 psi second stage and heat treated to 90^{0}C for 10 min followed by cooling to 42^{0}C. Starter culture consisting of *Streptococcus ssp thermophilus* and *Lactobacillus delbrueckii ssp bulgaricus* in the ratio of 1:1 was inoculated at the rate of 2.0 percent and incubated at 42±1^{0}C for $3^1/_2$ to 4 hours followed by packing and storage at 4°C.

3.3.3.1 Optimization of yoghurt prepared by using goat's milk

Yoghurt samples were prepared by using the goat milk in the following ratios of 1.5%, 2.0% and 2.5% (v/v) of cultures and the control yoghurt was prepared by using cow milk. The yoghurt was manufactured as described by Varga (2006). The resultant yoghurt was subjected for various physico-chemical analysis and served to a panel of judges along with the control to judge the sensory characteristics and overall acceptability. Based on sensory evaluation the best combination was selected and used for further studies.

3.3.3.2 Standardization of milk

The goat milk was adjusted to get 3.5% fat and 8.5% S.N.F. by using skim milk powder and butter.

3.3.3.3 Flow diagram for the preparation of control yoghurt

Whole milk

↓

Standardization (3.5% fat and 9.0% MSNF)

↓

Pre-heating (60 – 65^0C)

↓

Homogenization (Two stage, 2000 psi and 500 psi)

↓

Heat treatment (90^0C / 10 min)

↓

Cooling to 40^0C

↓

Addition of yoghurt cultures (2% level)

(*S. thermophilus and L. bulgaricus (1:1)*)

↓

Incubation (42±1^0C for $3^1/_2$ to 4 h)

↓

Storage (4±1^0C)

(Source: Vargas, 2006)

3.3.3.4 Flow Diagram for preparation of yoghurt by using goat's milk

Fresh goat milk

↓

Standardization (3.5% fat and 8.5% SNF by using SMP and butter)

↓

Heat to 50-60°C

↓

Homogenization (60-65°C) at 2500 psi –I stage, 500 psi-II stage

↓

Heat Treatment of Milk (90°C /10 min)

↓

Cooling to 42°C

↓

Inoculation with yoghurt culture (*ST* and *LB* at 0.75:0.75 ratio)

↓

Packaging in polystyrene cups

↓

Incubation at 42°C /4-5 h → Storage at 5°C

The control was also prepared from cow milk with a culture of 1.5%.

3.3.4 Physico-chemical analysis of goat milk yoghurt

3.3.4.1 Sensory evaluation

Yoghurt samples were given to a panel of four judges for sensory evaluation. Each judge was supplied with standard score card of a total of 9 point hedonic scale (Annexure-1) for firmness, whey separation, body and texture, flavour, color and appearance.

3.3.4.2 pH

pH of the goat milk yoghurt samples were measured using a digital pH meter (Chemi line Pvt. Ltd.) at 25°C. About 20 ml of representative samples were used for pH determination**.**

3.3.4.3 Titratable Acidity

Titratable Acidity of yoghurt samples were determined as per ISI: SP18 part XI (1981).

3.3.4.4 Curd tension

The penetration value was measured by using stainless steel cone penetrometer and expressed as mm/5sec. Higher the penetration value lower the hardness or curd tension of the product. The stored product at 5°C was tampered to a temperature of 5±2°C prior to firmness measurement. A cone and test rod (probe) weighing 32g was allowed to penetrate the sample for a fixed time of 5 seconds. The reading was taken at three spots of each sample and the average value was taken as millimeter of penetration.

3.3.4.5 Syneresis

Yoghurt samples of 35g were centrifuged at 1100 rpm for 10min at 5±2°C. The clear supernatant was poured off, weighed and recorded as syneresis (%) as per the procedure described by Gaston *et al.* (2007).

3.3.4.6 Soluble nitrogen

Nitrogen content of goat milk yoghurt samples were determined by Micro-Kjeldal method and Protein content was computed by multiplication of nitrogen with 6.38 as per ISI: SP 18(Part XI) 1981.

3.3.4.7 Free fatty acids

The free fatty acid content in the goat milk yoghurt samples were estimated as per the method of IS: SP: 18 (Part X1) -1981.

3.3.5 Storage stability of yoghurt

The yoghurt samples prepared by using goat milk showing maximum sensory score when subjected for the evaluation of storage stability**.**

The prepared yoghurt samples were stored at refrigeration temperature 4℃ in 100ml polyethylene cups. Yoghurt samples stored at refrigeration temperature were drawn on every two days for chemical parameters like soluble nitrogen, free fatty acids, pH, titratable acidity, coliforms, yeast and molds counts of yoghurt samples were determined to know the safety of the product using VRBA and MEA medias respectively, while viability of total ST and LB was analysed using yeast glucose agar and lactobacillus by using sterile MRS agar.

3.3.5.1 Viability of *Streptococcus thermophilus* and *Lactobacillus bulgaricus*

The viable count of the yoghurt samples were determined by serially diluting the samples and pour plating using yeast glucose agar and using sterile MRS agar for Lactobacillus bulgaricus of the yoghurt samples. The plates were incubated at 37°C for 24-48hours colonies were counted and expressed as cfu/gm (Harrigan, 1998).

3.3.5.2 Soluble nitrogen

The soluble nitrogen was determined by micro kjeldhal method by following the procedure of ISI: SP18 part XI (1981).

3.3.5.3 Titratable acidity

Titratable acidity of yoghurt samples were determined as per ISI: SP18 part XI (1981).

3.3.5.4 pH

pH of the goat milk yoghurt sample were measured using a digital pH meter. (Chemi line Pvt. Ltd.) at 25°C. About 20 ml of representative samples were used for pH determination**.**

3.3.5.5 Free fatty acid

The free fatty acid content of goat milk yoghurt samples were estimated as per the method of IS: SP: 18 (Part X1) 1981.

3.3.6 Statistical analysis

The data were analyzed using one way ANOVA, two factors ANOVA depending on the experiment and the number of treatments. The results were analyzed statistically for test of significance by using two and three factorial ANOVA.

Results

4. RESULTS

Goat milk differs from cow or human milk in composition, physico - chemical, functional, nutritional and therapeutic characteristics. The compositional differences are of significance in technological properties of caprine milk and milk products. The differences in physico-chemical properties are the consequences of the different structures of caprine and bovine constituents of milk and have appreciable significance in the preparation of dairy products like cheeses, fermented milks and heat desiccated dairy products. So with this back ground an attempt has been made in analyzing the composition and physico-chemical characteristics of goat's milk and also by converting it to the yoghurt with the following investigation

4.1 Gross composition of goat and cow milk

The indigenous goat milk, exotic goat milk and cow milk samples were analyzed for compositions like fat, proteins, lactose, ash, total solids, moisture contents. The average values obtained for indigenous goat milks were 4.0%, 3.7%, 4.2%, 0.82%, 12.72%, 87.28%, exotic goat milk were 3.82%, 3.52%, 4.0%, 0.79%, 12.13%, 87.87% and 3.6%, 3.3%, 4.5%, 0.6%, 12.00%, 87.00% for cow milk samples respectively. The goat milk has recorded higher composition compared to cow milk sample respectively. Classical ANOVA was applied for analyzing the data obtained (number of replications from each trail). It is evident from results (Table1) that there is a significant difference in value for the constituents like fat, protein, lactose, ash, total solids contents for indigenous goat milk, exotic goat milk and cow milk samples.

Table 1: Gross compositions of goat and cow milk

Constituents (%) / Species	Fat	Proteins	Lactose	Ash	Total solids	Moisture
Indigenous goat	4.00	3.70	4.20	0.82	12.72	87.28
Exotic goat	3.82	3.52	4.00	0.79	12.13	87.87
Cow	3.60	3.30	4.50	0.60	12.00	87.00
Result	⋆	⋆	⋆	⋆	⋆	⋆
CD≤0.05	0.15	0.18	0.16	0.10	0.48	0.86

Average of three trials

⋆ Statistically significant

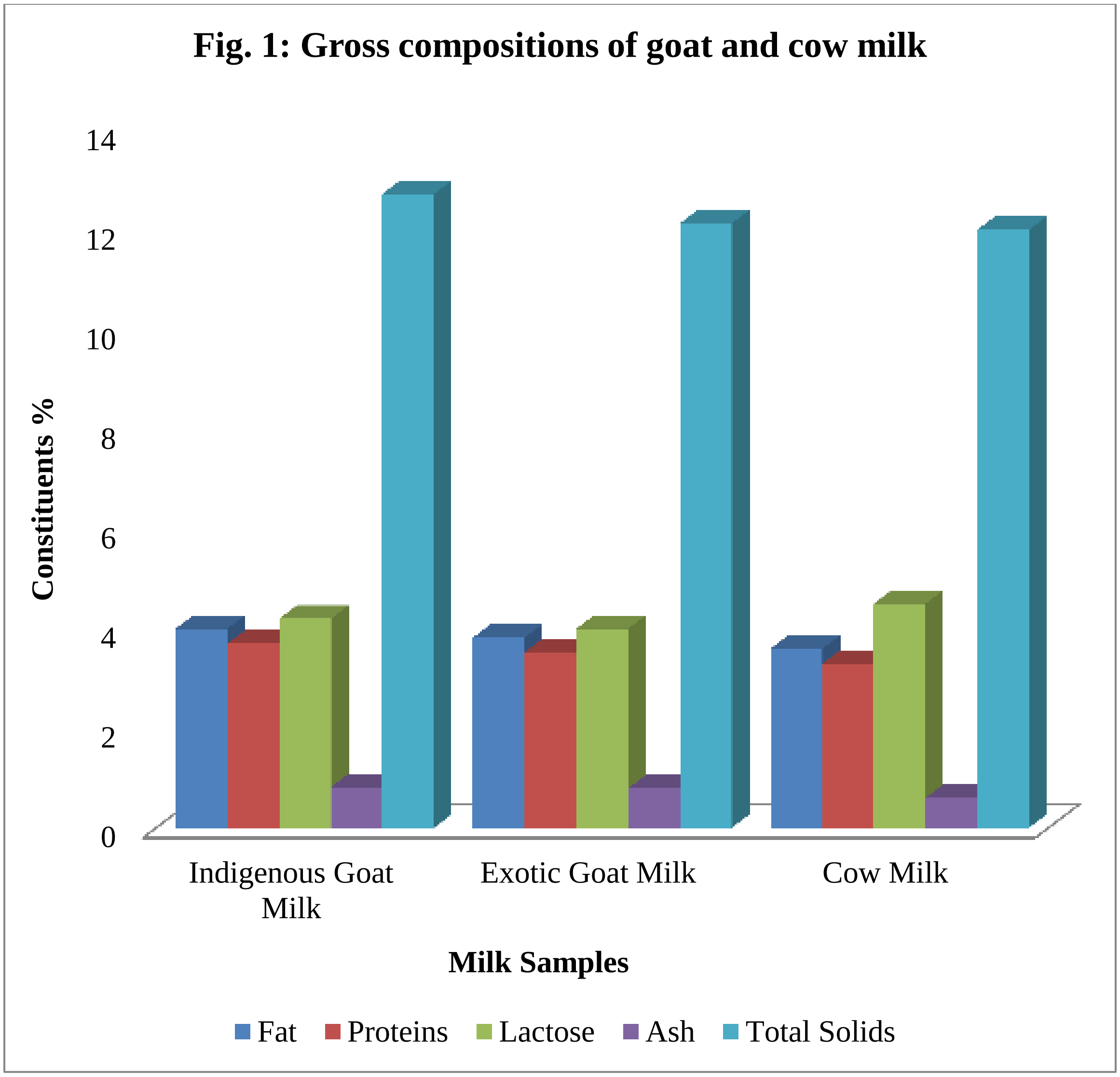


Fig. 1: Gross compositions of goat and cow milk
Constituents %
14
12
10
8
6
4
2
0
Indigenous Goat Milk
Exotic Goat Milk
Cow Milk
Milk Samples
Fat
Proteins
Lactose
Ash
Total Solids

4.2 Comparative physico - chemical properties of cow and goat milk

4.2.1 Specific gravity, viscosity and surface tension of goat and cow milk

The average values of 1.032, 1.028 and 1.026 were recorded at 27℃ for specific gravity of indigenous goat, exotic goat and cow milk samples respectively (Table 2a). Goat milk exhibited higher specific gravity compared to cow milk. Exotic goat milk has exhibited a lower specific gravity compared to indigenous goat milk.

The average values of 2.3, 2.1 and 1.5Cp were recorded at 25℃ for indigenous goat, exotic goat and cow milk samples respectively. The viscosity of goat milk was found to be higher compared to that of cow's milk. The exotic goat milk has recorded lower viscosity compared to indigenous goat milk.

The average of 56, 51 and 45Dynes/cm at 25℃ were obtained for indigenous goat, exotic goat and cow milk samples respectively. It was evident that surface tension value of goat milks was found to be higher compared to cow's milk. The surface tension of exotic goat was found to be lower than that of indigenous goat milk.

It is evident from Table 2a that the observed differences between the parameters like specific gravity, viscosity and surface tension values of goat and cow milk samples were found to be statistically significant.

Table (2a): Specific gravity, viscosity and surface tension of goat and cow milk

Parameters / Species	Specific gravity @27℃	Viscosity @25℃ (Cp)	Surface tension @25℃ (Dynes/cm)
Indigenous goat milk	1.032	2.3	56
Exotic goat milk	1.028	2.1	51
Cow milk	1.026	1.5	45
Results	⋆	⋆	⋆
CD≤0.05	0.0023	0.31	6.78

Average of three trials

⋆ Statistically significant

4.2.2 Electrical conductivity, refractive index and freezing points of goat and cow milk

The average values of 0.0041, 0.0034 and 0.0044 mho's were recorded at 20℃ for electrical conductivity of indigenous goat milk, exotic goat milk and cow milk samples respectively. Exotic goat milk has recorded least electrical conductivity followed by indigenous goat milk and cow milk samples.

The average values of 1.546, 1.542 and 1.538 at 40℃ were obtained for indigenous goat, exotic goat and cow milk samples respectively. Indigenous goat milk recorded higher refractive index followed by exotic goat milk and least for cow milk samples.

The average values of -0.575, -0.572 and -0.564℃ were obtained for indigenous goat, exotic goat and cow milk samples respectively. Goat milk exhibited higher freezing point compared to cow milk.

It is evident from Table 2b that the observed differences between the parameters like freezing point, electrical conductivity and refractive index of goat and cow milk samples were found to be statistically significant.

4.2.3 pH and acidity of goat and cow milk

The average values of 6.6, 6.8, 6.75 pH and 0.16, 0.14, 0.13 per cent lactic acid were obtained for indigenous goat milk, exotic goat milk and cow milk samples respectively (Table 2c). The exotic goat milks have recorded higher pH and lower acidity compared to cow milk.

Table (2b): Electrical conductivity, refractive index and freezing points of goat and cow milk

Parameters / Species	Electrical conductivity (mhos) @20℃	Refractive index @ 40℃	Freezing point (-℃)
Indigenous goat milk	0.0041	1.546	- 0.575
Exotic goat milk	0.0034	1.542	- 0.572
Cow milk	0.0044	1.538	- 0.564
Result	⋆	⋆	⋆
CD≤0.05	0.0079	0.0167	0.0161

Average of three trials

⋆ Statistically significant

Table (2c) pH and acidity of goat and cow milk

Parameters / Milk samples	pH @25℃	Acidity (%LA)
Indigenous goat milk	6.6	0.16
Exotic goat milk	6.8	0.14
Cow milk	6.75	0.13
Results	⋆	⋆
CD≤0.05	0.099	0.0154

Average of three trials

⋆ statistically significant

It is evident from Table 2c that the observed differences between the parameters like pH and acidity of goat and cow milk samples were found to be statistically significant.

4.2.4 Heat coagulation time (HCT) and rennet coagulation time (RCT) of goat and cow milk

The average HCT values of 3 Min, 1.30 Min and 25 min were obtained for indigenous goat milk, exotic goat milk, cow milk respectively at 130℃. Exotic goat milk has exhibited least HCT followed by indigenous goat milk and cow milk has exhibited highest HCT.

The average values of 44, 55 and 33 mins of RCT at 30℃ were obtained for indigenous goat milk, exotic goat milk and cow milk samples respectively. The exotic goat milk exhibited longer RCT followed by indigenous goat milk and least was observed for cow milk samples.

It is evident from Table 2d that the observed differences between the parameters like heat coagulation time and rennet coagulation of goat and cow milk samples were found to be statistically significant.

Table (2d): Heat coagulation time (HCT) and rennet coagulation time (RCT) of goat and cow milk

Parameters / **Milk samples**	**@ HCT (Min)**	***RCT (Min)**
Indigenous goat milk	3	44.00
Exotic goat milk	1.30	55.00
Cow milk	25	33.00
Results	⋆	⋆
CD≤0.05	0.063	5.84

Average of three trials

@ HCT - measured at 130℃

* RCT - incubated at 30℃

⋆ statistically significant

4.3 Optimization of inoculums level in the preparation of goat milk yoghurt

4.3.1 Influence of inoculums level on sensory attributes of indigenous goat milk yoghurt

The sensory scores for the indigenous goat milk yoghurts with culture levels of 1.5%, 2.0%, 2.5% is compared with cow milk yoghurt with culture levels of 1.5% (Table 3). The sensory scores for sensory attributes for yoghurts like flavor ranged from 9.0 – 7.0, sourness ranged from 0.5 – 1.0, appearance ranged from 5.0-4.0 and for body and texture was between 4.0 and 5.0, overall acceptability ranged from 21.50 – 19.0 with increase in culture levels. The sensory scores for indigenous goat milk yoghurt with 1.5% culture had higher overall acceptability which was comparable with cow milk yoghurt and each cultured yoghurts will differ from each other. The sensory scores for indigenous goat milk yoghurt with 2.0%, 2.5% compared with cow milk yoghurt 1.5% level showed significant difference with each other.

The least sensory scores for flavor attributes were obtained for indigenous goat milk yoghurt with 2.5% inoculum. The same sensory scores were obtained for indigenous goat milk yoghurt prepared with 1.5% and 2.0% inoculums against sensory scores of 9.0 obtained for control cow milk yoghurt with 1.5% inoculum.

The least sensory score for sourness was secured for indigenous goat milk yoghurt with 2.5% inoculums indicating inferior product while control cow milk yoghurt had secured maximum sensory score of 9.0 followed by a score of 8.0 for indigenous goat milk yoghurt with 1.5% inoculums. The increase in inoculums level resulted in decrease in scores indicating the higher acidity of the product**.**

Table 3: Influence of inoculums level on sensory attributes of indigenous goat milk yoghurt

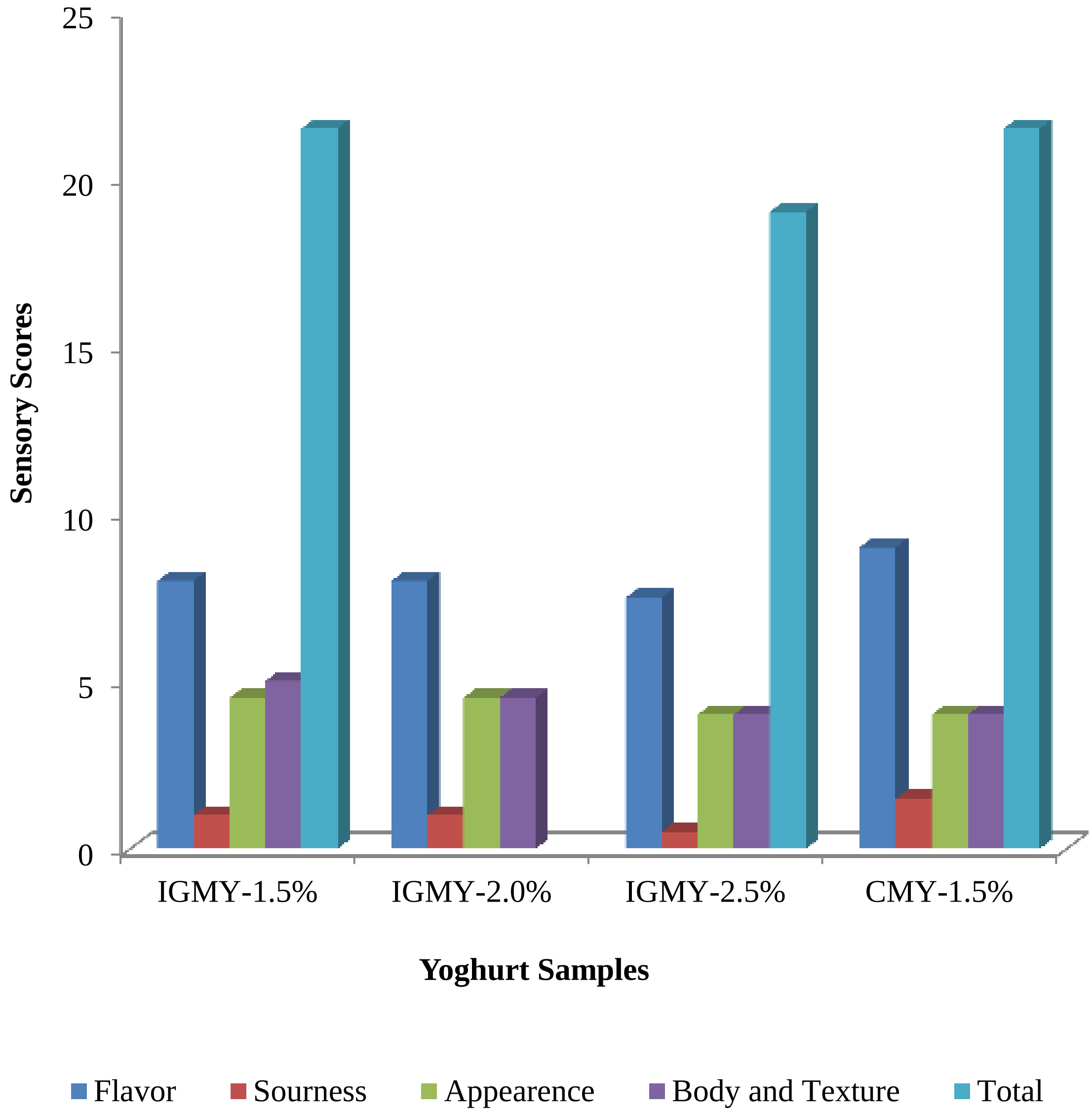
Attributes / Inoculum level	Flavor (10)	Sourness (2)	Appearance (5)	Body & Texture (5)	Overall acceptability (25)
1.5%	8.0	1.0	4.5	5.0	21.50
2.0%	8.0	1.0	4.5	4.5	21.00
2.5%	7.5	0.5	4.0	4.0	19.00
Control	9.0	1.5	4.0	4.0	21.50
CD≤0.05	1.34	0.57	0.24	0.68	2.70

Average of three trials

⋆Incubation: 42°C/6hrs

Control= cow milk yoghurt with 1.5% culture level

Fig. 2: Influence of inoculums level on sensory attributes of indigenous goat milk yoghurt



The optimum sensory score of 4.5 for appearance was obtained for indigenous goat milk yoghurt with 1.5% inoculums while scores indicate that increase in inoculums did not improve appearance of yoghurt sample.

The yoghurt prepared with 1.5% inoculum had secured higher sensory score for body and texture compared to control sample while increase in inoculums level did not improve the body and texture. The overall acceptability score of 21.5 was secured indicating product was comparable to control.

The sensory scores for indigenous goat milk yoghurt with 1.5% was higher which is also comparable with cow milk yoghurt of 1.5% culture level which was found to be significant with each other.

The sensory scores for indigenous goat milk yoghurt with 2.0%, 2.5% and cow milk yoghurt of 1.5% was found to be no significant with each other.

4.3.2 Influence of inoculums level on chemical attributes of indigenous goat milk yoghurt

The indigenous goat milk was inoculated with cultures such as *Streptococcus thermophilus* and *Lactobacillus delbruckeii ssp bulgaricus* of 1.5%, 2.0% and 2.5% levels at 1:1 ratio for the preparation of yoghurt to find out the optimum level of inoculums required for the preparation of yoghurt. These yoghurt samples were analyzed for pH and acidity at the end of yoghurt setting. The pH values of 5.3, 4.8, 4.3 and acidity (% LA) of 0.72%, 1.05% and 1.33% respectively recorded for the indigenous goat milk yoghurt samples prepared with 1.5%, 2.0% and 2.5% inoculums. Control yoghurt sample with 1.5% culture level recorded a pH of 5.1 and 0.66%LA acidity. The pH was decreased and the acidity was increased with increased level of addition of inoculums. However, indigenous goat milk yoghurt with 1.5% inoculums level recorded comparable acidity and pH obtained for control yoghurt sample and hence it is considered as optimum level of cultures for best indigenous goat milk yoghurt.

It is evident from results that the pH and acidity of indigenous goat milk yoghurts prepared by using 2.0%, 2.5% and control yoghurt sample prepared by using 1.5% culture showed significant difference (Table 04), while the pH and acidity of indigenous goat milk yoghurts prepared using 1.5% culture level did not differ significantly.

4.3.3 Influence of inoculums level on sensory attributes of exotic goat milk yoghurt

The sensory scores obtained for the exotic goat milk yoghurts with inoculums of 1.5%, 2.0%, 2.5% inoculums were compared with control yoghurt with 1.5% inoculum (Table 5). The scores for flavor sensory attributes ranged from 9.0 – 7.0, sourness ranged from 1.5-1.0, appearance ranged from 5.0-4.0 and for body and texture ranged from 4.5-4.0 and overall acceptability ranged from 21.50 – 19.50 in exotic goat milk yoghurt. The overall acceptability scores for exotic goat milk yoghurt with 1.5% showed higher values which is comparable to control yoghurt of 1.5% inoculums.

The sensory scores for indigenous goat milk yoghurt prepared using 2.0%, 2.5% and cow milk yoghurt prepared using 1.5% was found to be significantly different from each other.

Table 4: Influence of inoculums level on physical attributes of indigenous goat milk yoghurt

Yoghurt samples	**Level of inoculums (%)**	**pH**	**Acidity (%LA)**
Indigenous goat milk yoghurt	1.5	5.3	0.72
	2.0	4.8	1.05
	2.5	4.3	1.33
Cow milk yoghurt	1.5	5.1	0.66
CD≤0.05	-	0.34	0.12

Average of three trials.

⋆Incubation: 42℃/6hrs

Table 5: Influence of inoculums level on sensory attributes of exotic goat milk yoghurt

Attributes / Inoculum level	Flavor (10)	Sourness (2)	Appearance (5)	Body & Texture (5)	Overall acceptability (25)
1.5%	7.5	1.0	5.0	4 .5	21.50
2.0%	7.0	1.5	5.0	4.5	19.50
2.5%	8.0	1.5	4.0	4.0	20.00
Control	9.0	1.5	4.0	4.0	21.50
CD≤0.05	1.29	0.48	0.48	0	1.39

Average of three trials

⋆Incubation: 42℃/6hrs

Control - Cow milk yoghurt with 1.5% culture

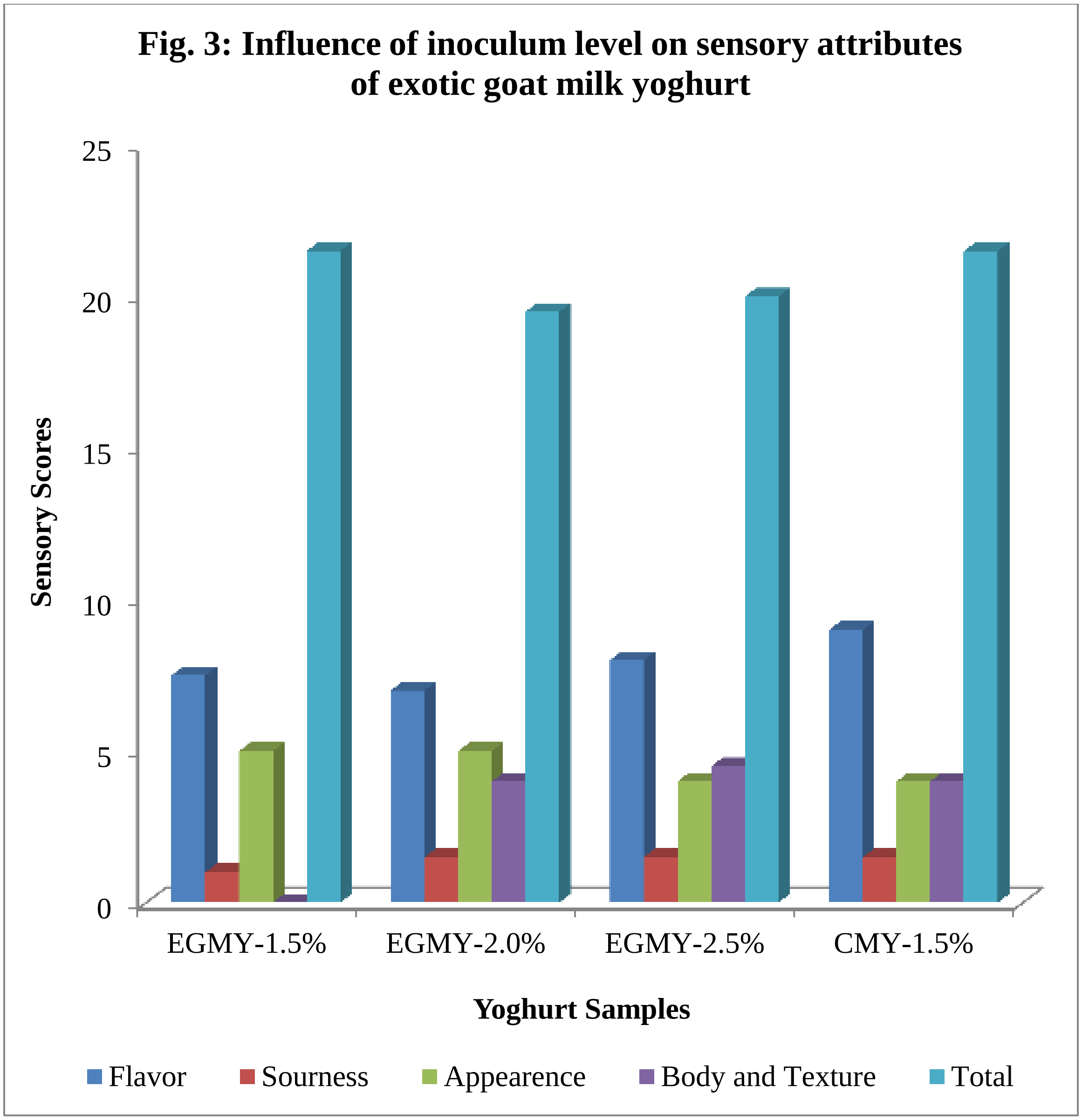


Fig. 3: Influence of inoculum level on sensory attributes of exotic goat milk yoghurt
25
20
15
10
5
0
Sensory Scores
EGMY-1.5%
EGMY-2.0%
EGMY-2.5%
CMY-1.5%
Yoghurt Samples
Flavor
Sourness
Appearence
Body and Texture
Total

The least sensory scores were obtained for flavor of exotic goat milk yoghurt at 1.5% level of cultures followed by yoghurts with 2.0% while higher score of 8.0 was obtained for product with 2.5% inoculum. The exotic goat milk yoghurt with 1.5% and 2.0% inoculums level had secured higher sensory score (5.0) for appearance compared to control yoghurt while higher inoculums resulted in decreased appearance. The body and texture of exotic goat milk yoghurt with 1.5% and 2.0% inoculums secured higher score and 2.5% inoculums addition resulted in decreased scores.

4.3.4 Effect of inoculums level on physical attributes of exotic goat milk yoghurt

The exotic goat milk was inoculated with yoghurt cultures *Streptococcus thermophillus* and *Lactobacillus delbruckeii ssp bulgaricus* at 1.5%, 2.0% and 2.5% inoculums. The yoghurt samples were analyzed for pH and acidity at the end of yoghurt setting to find out optimum level of inoculums. The pH values of 4.9, 4.6, 3.8 and acidity of 0.73%, 1.23% and 1.35% lactic acid respectively recorded for the exotic goat milk yoghurt samples prepared with 1.5%, 2.0% and 2.5%inoculums. Control yoghurt sample prepared using 1.5% culture level recorded a pH of 5.1 and 0.66%LA acidity. The pH decreased and the acidity increased with increased level of inoculums. However exotic goat milk yoghurt prepared using 1.5% inoculums recorded acidity and pH values comparable to control yoghurt sample prepared using 1.5% inoculums. Hence 1.5% inoculums was considered as optimum level for preparation of exotic goat milk yoghurt.

Classical ANOVA was applied for analyzing the data obtained (number of replications from each analysis). It is evident from results (Table 6) that there is a significant difference in for the pH values for culture 2.0%, 2.5 % and acidity of 1.5%, 2.0%.

Table 6: Effect of inoculums level on physical attributes of exotic goat milk yoghurt

Yoghurt sample	Level of culture (%)	pH	Acidity (%LA)
Exotic goat milk yoghurt	1.5	4.9	0.73
	2.0	4.6	1.23
	2.5	3.8	1.35
Cow milk yoghurt	1.5	5.1	0.66
CD≤0.05	-	0.18	0.07

Average of three trials.

⋆Incubation: 42℃/6hrs

4.4 Physico-chemical attributes of optimized goat milk yoghurts prepared with 1.5% inoculums level

4.4.1 pH and acidity of goat and cow milk yoghurt

The best optimized indigenous goat milk yoghurt, exotic goat milk yoghurt and cow milk yoghurt were analyzed for the physico –chemical parameters like pH and acidity. The average values obtained for the indigenous goat milk yoghurt was 5.3 pH and acidity of 0.72% LA, exotic goat milk yoghurt had pH of 4.8 and acidity of 0.78% LA while cow milk yoghurt had 5.1 pH and acidity of 0.66%LA respectively.

It is evident from results (Table 7) that exotic goat milk yoghurt had exhibited higher acidities at the end of curd setting compared to control cow milk yoghurt.

4.4.2 Curd tension and syneresis of goat and cow milk yoghurt

The optimized indigenous goat milk yoghurt, exotic goat milk yoghurt and cow milk yoghurt were analyzed for the rheological parameters like curd tension and syneresis. The average penetration values obtained was 345.65mm, 320.05 mm, 295.51mm and syneresis of 24%, 20%, 16% for indigenous goat milk yoghurt, exotic goat milk yoghurt and cow milk yoghurt respectively. The indigenous goat milk yoghurt has recorded a higher penetration value followed by exotic goat milk yoghurt and cow milk yoghurt indicating least curd tension for indigenous goat milk yoghurt and maximum for cow milk yoghurt. The maximum value of 24% syneresis was recorded for indigenous goat milk yoghurt followed by exotic goat milk yoghurt and cow milk yoghurt respectively.

Table 7: pH and acidity of goat and cow milk yoghurt

Parameters / Samples #	pH	Acidity (%LA)
Indigenous goat milk yoghurt	5.3	0.72
Exotic goat milk yoghurt	4.8	0.78
Cow milk yoghurt	5.1	0.66
CD≤0.05	0.29	0.06

Average of three trials.

⋆Incubation: 42℃/6hrs

Culture levels used: 1.5%

Classical ANOVA was applied for analyzing the data obtained (number of replications from each analysis). It is evident from results (Table 8) that there is a no significant differences in value for the physico- chemical parameters like curd tension, syneresis was analysed for optimized indigenous goat milk yoghurt and cow milk yoghurt. The values obtained for curd tension, syneresis has a significant difference for prepared exotic goat milk yoghurt and cow milk yoghurt.

4.4.3 Free fatty acids and soluble nitrogen contents of goat and cow milk yoghurt

The optimized indigenous goat milk yoghurt, exotic goat milk yoghurt and cow milk yoghurt was analyzed for the physico - chemical parameters like free fatty acids and soluble nitrogen content at the end of the curd setting time. The average values of free fatty acid content of 7.6, 8.0, 5.1% O.A and soluble nitrogen content of 0.14, 0.092, 0.10 % obtained for the indigenous goat milk yoghurt, exotic goat milk yoghurt and cow milk yoghurt samples respectively. The goat milk yoghurts had recorded higher FFA contents compared to cow milk yoghurt. The higher soluble nitrogen content was recorded for goat milk yoghurts compared to cow milk yoghurt.

Classical ANOVA was applied for analyzing the data obtained (number of replications from each analysis). It is evident from results (Table 9) that there is no significant difference in mean value for the physico - chemical parameters soluble nitrogen was analyzed for optimized indigenous goat milk yoghurt, exotic goat milk yoghurt and cow milk yoghurt. The values obtained for free fatty acids has significant difference for optimized indigenous goat milk yoghurt, exotic goat milk yoghurt and cow milk yoghurt.

Table 8: Curd tension and syneresis of goat and cow milk yoghurt

Parameters / Samples #	• Curd tension (mm/5 sec)	Syneresis (%)
Indigenous goat milk yoghurt	345.65	24
Exotic goat milk yoghurt	320.05	20
Cow milk yoghurt	295.51	16
CD≤0.05	5.2968	4.719

Average of three trials.

•Curd tension: expressed as penetration value

⋆Incubation: 42℃/6 hrs

Culture levels used: 1.5%

Table 9: Free fatty acids and soluble nitrogen contents of goat and cow milk yoghurt

Parameters / Samples #	Free fatty acids (%O.A)	Soluble nitrogen (%)
Indigenous goat milk yoghurt	7.6	0.14
Exotic goat milk yoghurt	8.0	0.09
Cow milk yoghurt	5.1	0.09
CD≤0.05	1.41	0.05

Average of three trials.

⋆Incubation: 42℃/6hrs

Culture levels used: 1.5%

4.5 Storage studies of goat and cow milk yoghurts

4.5.1 Development of acidity in goat and cow milk yoghurts during storage at 4±1 ℃

The rate of development of acidity in goat milk and cow milk yoghurts during storage at 4±1℃ was investigated. The acidity of indigenous goat milk, exotic goat milk and cow milk yoghurt increased from 0.72% to 1.38%LA, 0.78 to 1.42%LA and 0.61 to1.19%LA respectively at the end of 12^{th} day during storage at 4±1℃ (Table 10).

As per the trend analysis, the rate of development of acidities was found to be least in exotic goat milk yoghurt followed by indigenous goat milk yoghurt and found to be maximum in cow milk yoghurt.

4.5.2 Development of Free fatty acid and soluble nitrogen contents of goat and cow milk yoghurt during storage at 4±1℃

The rate of development of free fatty acids and soluble nitrogen content during storage at 4±1℃ for 12 days was investigated. The free fatty acid content of indigenous goat milk, exotic goat milk and cow milk yoghurt increased from 7.6 to 13.02 %OA, 7.0 to 12.30 %OA and 5.1 to 13.10 %OA respectively (Table 11). The soluble nitrogen content of 0.14-0.26, 0.09-0.23 and 0.99-0.28% were recorded for indigenous goat milk yoghurt, exotic goat milk yoghurt and cow milk yoghurt at the end of 12^{th} day during storage at 4±1℃ (Table 12).

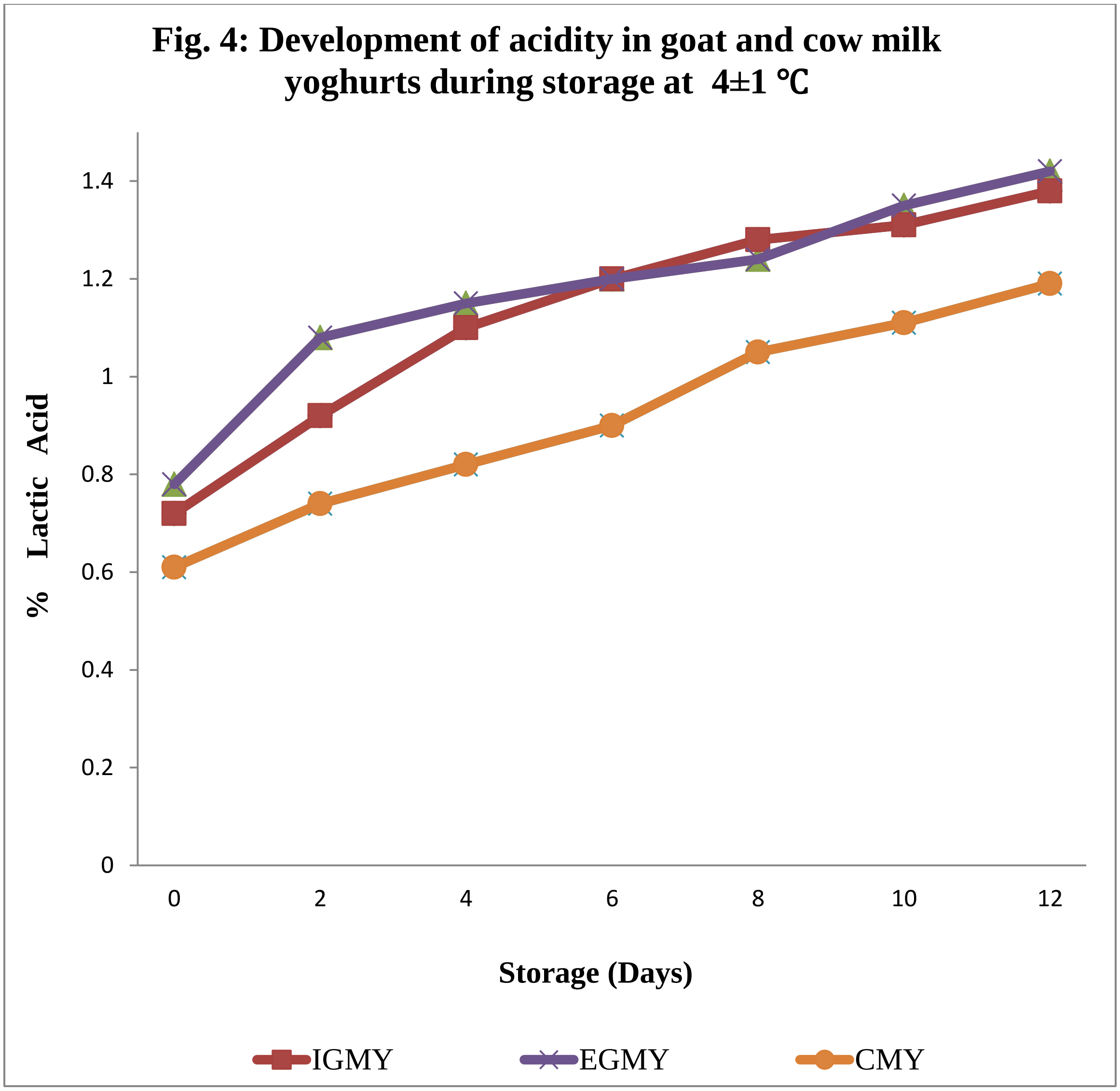
The trend analysis reveals that during the storage of yoghurt the higher FFA values recorded for exotic goat milk yoghurt followed by indigenous goat milk and cow milk yoghurt samples respectively. Cow milk yoghurt had higher soluble nitrogen content compared to goat milk yoghurt samples respectively at the end of storage at 4±1℃.

Table 10: Development of acidity in goat and cow milk yoghurt during storage at 4±1℃

Samples # / Storage (Days)	Indigenous goat milk yoghurt	Exotic goat milk yoghurt	Cow milk yoghurt
	Acidity (%LA)	**Acidity (%LA)**	**Acidity (%LA)**
0	0.72	0.78	0.61
2	0.90	1.08	0.74
4	1.10	1.15	0.82
6	1.20	1.20	0.90
8	1.28	1.24	1.05
10	1.31	1.35	1.11
12	1.38	1.42	1.19
Coefficient	0.959	0.942	0.995

Average of three trials

Culture levels used: 1.5%



IGMY = Indigenous Goat Milk Yoghurt

EGMY = Exotic Goat Milk Yoghurt

CMY = Cow Milk Yoghurt

Table 11: Development of free fatty acids• contents of goat and cow milk yoghurt during storage at 4±1℃

Samples # / Storage (Days)	Indigenous goat milk yoghurt	Exotic goat milk yoghurt	Cow milk yoghurt
0	7.60	7.00	5.10
2	8.01	8.10	8.40
4	10.53	9.50	10.20
6	10.76	10.75	11.30
8	11.52	11.42	11.50
10	12.50	11.90	12.30
12	13.02	12.30	13.10
Coefficient	0.971	0.56	0.21

Average of three trials

Culture level used: 1.5%

• Expressed as percentage oleic acid

Table 12: Influence of storage on soluble nitrogen• content of goat and cow milk yoghurts ★

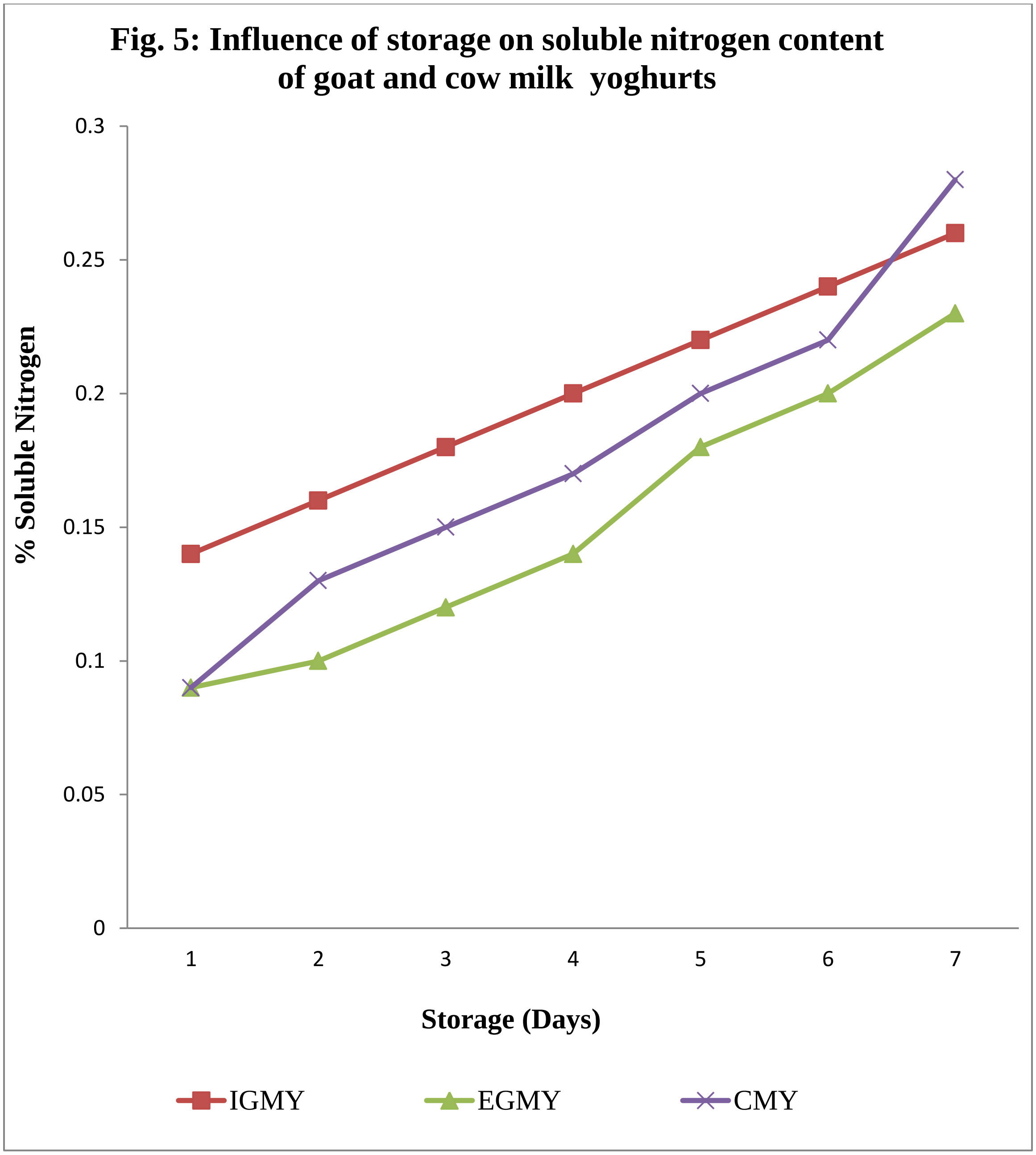
Storage (Days) \ Samples #	Indigenous goat milk yoghurt	Exotic goat milk yoghurt	Cow milk yoghurt
0	0.14	0.09	0.09
2	0.16	0.10	0.13
4	0.18	0.12	0.15
6	0.20	0.14	0.17
8	0.22	0.18	0.20
10	0.24	0.20	0.22
12	0.26	0.23	0.28
Coefficient	0.017	0.012	0.026

Average of three trials

★ Storage at temperature of 4±1 ℃

Culture levels used: 1.5%

• Soluble nitrogen: expressed as percentage



IGMY = Indigenous Goat Milk Yoghurt

EGMY = Exotic Goat Milk Yoghurt

CMY = Cow Milk Yoghurt

4.5.3 Microbial quality of goat and cow milks yoghurts during storage at 4±1℃

The Table 13 reveals that cow milk yoghurt stored at 4±1℃ showed decrease in viable count of yoghurt cultured on an average of 0.25log_{10}cfu/gm. The decrease in viable count of yoghurt was statistically significant on each day of storage. The viable count of yoghurt culture decreased on an average of 0.13log_{10}cfu/gm with statistically significant difference in yoghurt prepared using indigenous goat milk during storage at 4±1℃. The same trend was noticed in case of yoghurt prepared using exotic goat milk.

The yoghurt prepared by using cow milk, indigenous and exotic goat milk when subjected to coliform count showed a nil count throughout the storage period of 12 days at refrigeration temperature indicating safety of the product for consumption.

The yoghurts when subjected to yeast and mold enumeration did not show any colonies till the end of the storage period at refrigeration temperature. However molds growth was observed on the surface, indicating the spoilage of the product on 13^{th} day of storage.

Table 13 Microbial quality of goat and cow milk yoghurts during storage at 4±1℃

(A) Total viable count for goat and cow milk yoghurts #

Samples / Storage (Days)	Cow milk yoghurt (cfu/gm)	Indigenous goat milk yoghurt (cfu/gm)	Exotic goat milk yoghurt (cfu/gm)
0	8.00	8.06	8.00
4	7.20	7.54	7.48
8	6.10	7.00	6.90
12	5.00	6.50	6.38
Coefficient	-0.2525	-0.1335	-0.134
t- value	-19.43	-24.07	0.99

Average of three trials

⋆ storage at temperature 4±1 ℃

Culture levels used: 1.5%

(b) Coliform count for goat and cow milk yoghurts #

Samples / Storage (Days)	Cow milk yoghurt (cfu/gm)	Indigenous goat milk yoghurt (cfu/gm)	Exotic goat milk yoghurt (cfu/gm)
0	Nil	Nil	Nil
4	Nil	Nil	Nil
8	Nil	Nil	Nil
12	Nil	Nil	Nil
Coefficient	0	0	0
t- value	0	0	0

Average of three trials

⋆ storage at temperature 4±1 ℃

Culture levels used: 1.5%

(c) Yeast and molds count for goat and cow milk yoghurts #

Samples / Storage (Days)	Cow milk yoghurt (cfu/gm)	Indigenous goat milk yoghurt (cfu/gm)	Exotic goat milk yoghurt (cfu/gm)
0	Nil	Nil	Nil
4	Nil	Nil	Nil
8	Nil	Nil	Nil
12	Nil	Nil	Nil
Coefficient	0	0	0
t- value	1	1	1

Average of three trials

⋆ Storage at temperature 4±1 ℃

Culture levels used: 1.5%

Discussion

5. DISCUSSION

Modern nutrition is changing rapidly. Yoghurt has been firmly established globally as an important dairy product despite its obscure ethnic origin. New and innovative type of yoghurt and yoghurt products are being marketed resulting in a phenomenal increase in the per-capita consumption of this product. Yoghurt is being transformed into an exhilarating range of wholesome and natural food with a high nutritive value.

The investigation was undertaken to study the composition comparison between indigenous goat milks and exotic goat milks. Physico - chemical analysis of these milks and optimization of these milks with different yoghurt cultures was also done. Physico-chemical and rheological attributes analysis of prepared goat milk yoghurt and storage of these yoghurts at refrigeration temperature.

5.1 Gross Compositions of goat's milk

The gross chemical composition of pooled milk of indigenous goat breeds consisting Jamunapari, Beetal, Barbari and exotic goat breeds consisting breeds of Sannene, Boer and Damascus milks were determined and the data pertaining to fat, protein, lactose, ash, total solids and moisture contents are indicated in the Table 1.

5.1.1 Total solids content

The total solids content of goat milk was found to be higher than the total solids content of cow milk (Table 1). The cow milk has recorded 12% of total solids which was found to be the least compared to 12.72% and 12.13%TS observed for milk of indigenous and exotic goat breeds respectively. The value of total solids observed for milk from indigenous goat breeds was found to be lower than total solids values reported by the Singh and Sengar (1960). However total solids obtained for pooled milk samples were comparable to the total solids value reported by Hassan, 2005.

5.1.2 Fat content

The higher values of fat content were observed for indigenous goat milk followed by exotic goat milk and least contents in the cow milk in the current investigation. Singh and Sengar (1960) reported a higher value of fat content in indigenous goat milk and lower fat content for exotic goat milk. However Zeng and Escobar (1995 and 1996b) reported lower fat content in milk of Alphine goat breed compare to fat content of cow milks. The variation in fat content is observed in milk of indigenous and exotic goat milks are influenced by breeds, individuality of the animal, type of feed, health condition, nutritional status, stage of lactation, health of breeds, intervals of milking, age of animal (Strzalkowska *et al.*, 2009).

5.1.2 Lactose content

The lower lactose content was observed in indigenous and exotic goat milk compared to cow's milk (Table 1). However the pooled milks samples of indigenous goat breeds showed higher lactose content of 4.2% compared to 4.0% observed in samples of pooled exotic goat milk samples. Singh and Sengar, 1960 reported a similar lactose content of 4.31%, 4.32%, 4.28% and 4.40% for milks of Barbari, Beetal, Black bengal and Jamunapari goat breeds. The goat breeds has 4.46-5.88% and 4.86-6.04% of lactose contents in Boer goat and Rangeland goats as reported by Skinner (1972). However the results obtained for exotic goat milk has a similar values reported by Oftedal and Jennies, 1988; Doreau and Boulot, 1989 for the Boer goat's lactose content compared to cow milk lactose content.

5.1.3 Protein content

The indigenous and exotic goat milks had higher protein content compared to cow milk samples (Table 1). However higher protein content was observed in indigenous goat milk compared to that of exotic goat milk. Singh and Sengar (1960) reported 4.05%, 3.74%, 4.9% and 3.8% protein percentages in indigenous goat breeds of Barbari, Beetal, Black Bengal, Jamunapari goats respectively. However the percentage protein observed in pooled indigenous milk samples were within the ranges reported by Singh and Sengar, 1960. The protein content ranged between 2.93-6.71% and 2.96-4.59% in milk of exotic breeds of Boer goats of South Africa and Rangeland goats of Australia (Grosclaude and Martin, 1997).

5.1.4 Ash content

The higher values of ash content in goat milk were observed compared to cow milk samples (Table 1). The pooled milk samples of indigenous breeds recorded higher ash content compared to that of milk of exotic breeds. The observed values of ash content in the pooled milk samples of indigenous and exotic breeds were within the range of 0.56-0.99% in goat milk as reported by Park and Chukwu (1989). Similarly Singh and Sengar, 1960 reported percentage ash of 0.88%, 0.82%, 0.89% and 0.85% in milk of Barbari, Beetal, Black Bengal and Jamunapari goat breeds respectively.

5.2 Comparative physico - chemical properties of goat and cow milk

5.2.1 Specific gravity

The specific gravity was found to be higher for goat milk compared to that of cow milk samples (Table 2a). The higher values for the viscosity were obtained in the indigenous goat milks compared to exotic goat milk. The variation in the specific gravity of different milks was related to the gross composition of respective milks particularly fat and SNF (Mukherjee, *et al* .1993). The observed specific gravity of indigenous goat milk was found to be higher compared to that of exotic goat milk and this may be attributed to higher total solids content observed in indigenous goat milks.

5.2.2 Viscosity

The viscosity of goat milk was found to be higher than cow milk samples (Table 2a). However indigenous goat milk recorded higher viscosity compared to that of exotic goat milk. The variation in the viscosity of different milks is related to the gross composition of respective milk samples particularly the concentration of proteins, fat and their state of distribution (Mukherjee, *et al* .1993). The observed higher fat and protein contents of milk samples were responsible for the higher viscosity in goat milk particularly in indigenous goat milk.

5.2.3 Surface tension

The higher surface tensions were observed in indigenous goat milk and exotic goat milk compared to cow milk samples (Table 2a). The indigenous goat milk exhibited higher surface tension values compared to exotic goat milk. The fat and proteins have mainly contributed to the surface tension of milk (Sherbon, 1988). The higher observed surface tension in goat milk may be attributed to the higher fat and protein concentrations recorded in goat milks. Park (1994a) reported similar findings in cow and goat milk samples.

5.2.4 Electrical conductivity

The specific conductance of milk is mainly due to presence of ionic activity particularly sodium, chloride and potassium ions. However the normal conductivity in normal milk ranges between 0.0040-0.0045 ohms/cm and in caprine milk 0.0043-0.00139 ohms/cm (Park *et al* 2007). The observed electrical conductivity of indigenous goat and cow milk was found to be higher compared to the exotic goat milk. (Park *et al*., 2007) reported higher chloride and potassium contents in caprine milk compared to bovine milks.

5.2.5 Refractive index

The refractive index of milk is related to concentration and compositions of solutes in milk (Sherbon, 1988)**.** The observed refractive index values were found to be lower for milk of indigenous and exotic goat breeds compared to cow milks (Table 2b). Similar findings of refractive index were reported by Park *et al*. (2007) for caprine and cow milks.

5.2.6 Freezing point

The freezing point of the milk is governed by the concentrations of solutes in solution particularly lactose and milk salts (Sherbon, 1988). The goat milk exhibited lower freezing point than cow's milk in the present investigation. But however the freezing point of indigenous and exotic goat milk did not differ significantly. The variation in the solute composition may be attributed to the observed differences in freezing points of cow and goat milks.

5.2.7 Rennet coagulation time (R.C.T)

The rennet coagulation time obtained during present investigation was found to be higher for goat milk and lower RCT values were observed for cow milks indicating longer time to obtain the coagulation of Caprine milk compared to cow's milk (Table 2d). However the indigenous goat milk and exotic goat milk has a comparatively longer rennet coagulation time which may be attributed to the lower ratio of $\boldsymbol{\alpha}_{s1}$ to $\boldsymbol{\beta}$casein (Bozanic *et al* 2002b) and yielding weaker curd compared to bovine milk curd which has got direct influence on the digestibility of the gastro intestinal tract (Park *et al*., 2007)

5.2.8 Heat coagulation time (H.C.T)

The higher HCT values were recorded for the cow milk samples and it was found to be 25 min at 130℃ against the HCT values of 3 min and 90 seconds secured for indigenous and exotic goat milk respectively (Table 2d). Significant differences were found in the HCT of indigenous and cow milk samples. Heat stability of milk is dependent upon the micellar stability of caseins which in turn influenced by several compositional factors like concentrations of divalent cations like calcium and magnesium; polyvalent anions like phosphates and citrates, K- caseins, $\boldsymbol{\beta}$-lacto globulin and $\boldsymbol{\alpha}$-lactalbumin, pH etc (Rose, 1961). The observed heat stability may be attributed to the changes in the protein profile particularly lower k-caseins, $\boldsymbol{\beta}$ –lacto globulin and variation in the higher divalent cation activity observed in caprine milk compared to bovine milk (Park *et al* 2007).

5.2.9 pH and Acidity

Higher percentage of lactic acid was observed in indigenous goat milks compared to exotic goat milk and cow milk samples in the current study. The indigenous goat milks, exotic goat milk and cow milk were almost similar to the values obtained for the results reported by Sawaya *et al*., 1984. pH content is lower for indigenous compared to exotic goat and cow milk samples as shown Table (2c). The pH was almost similar compared to the values for Saanen breed of South Africa and Chamoisée breeds of Greece reported by Sawaya *et al*., 1984 for indigenous, exotic goat milks and cow milk samples. The higher level of acidity observed in indigenous, exotic goat milks when compared to cow milk samples is mainly attributed to higher buffering capacity contributed by the proteins as well as buffering milk salts particularly phosphates and citrates.

5.3 Optimization of inoculums level in preparation of goat milk yoghurt

The different culture levels of 1.5%, 2.0% and 2.5% containing *Streptococcus thermoplillus* and *Lactobacillus bulgaricus* (1:1) were used to find out the optimum level of culture in the preparation of indigenous and exotic goat milk yoghurts by analysing the sensory attributes, physical attributes like pH, acidity and observed results were discussed as listed below.

5.3.1 Influence of inoculums level on sensory attributes of indigenous goat milk yoghurt

The sensory scores obtained for color and appearance, flavor, body and texture whey separation and overall acceptability to find out the optimum level of cultures in the preparation of the yoghurt (Table 3) are presented below.

5.3.1.1 Flavor

The sensory scores secured for indigenous goat milk yoghurt were found to be lower compared to the sensory scores obtained for cow milk yoghurt. The least sensory scores were obtained for indigenous goat milk yoghurt at 2.5% level of cultures. The same sensory scores were obtained for indigenous goat milk yoghurt prepared with 1.5% and 2.0% culture level. The typical flavor of yoghurt is mainly attributed to acetaldehyde content in the yoghurts. The formation of acetaldehyde is governed by many factors. Species of the mammals is one of these factors which influence the acetaldehyde content in yoghurts. The lower sensory scores in goat milk may be attributed to the lower acetaldehyde content compared to cow's milk yoghurt (Tamime and Robinson, 2007). Besides level of short chain fatty acids may contribute to the characteristic flavor of goat milk yoghurt compared to cow milk yoghurt. However optimum sensory scores were obtained for goat milk yoghurt prepared at 1.5% culture levels.

5.3.1.2 Sourness

The sensory scores obtained were related to the combined effect of acidity contributed by lactic acid content as well as short chain fatty acids content in the yoghurt samples. In the present investigation the optimum sensory scores were obtained for product containing least sourness and thus least sensory scores were obtained for indigenous goat milk yoghurt prepared with 2.5% culture levels and optimum score was obtained for the yoghurt 1.5% culture level. However the sourness in all the samples was found to be higher compared to that of sensory scores secured. As the yoghurt culture concentration increased, the sourness will also increases with the ultimate decrease in the sensory scores for the yoghurts. The indigenous goat milk yoghurt sample with 1.5% culture level had secured optimum sensory score of 1.0 for sourness indicating higher sourness compared to that of cow milk yoghurt samples (Tamime and Robinson, 2007).

5.3.1.3 Appearance

The indigenous goat milk yoghurt with 1.5% and 2.0% yoghurt culture level had secured higher sensory score (4.5) compared to control yoghurt. However higher level of culture inoculation did not improve the appearance of the yoghurt hence the optimum appearance were obtained in indigenous yoghurt with 1.5% culture level.

5.3.1.4 Body and texture

The Body and texture of indigenous goat milk yoghurt with inoculated 1.5% yoghurt culture has secured maximum score indicating optimum body and texture. The sensory scores for body and texture decreased with increased culture level in the yoghurt samples. The indigenous goat milk yoghurt prepared with 1.5% and 2.0% exhibited superior body and texture compared to control sample.

5.3.1.5 Container and closure

The scores obtained for container and closure of all the experimental samples were found to be similar. Indicating it had no effect on their sensory characteristics.

5.3.1.6 Overall acceptability

The overall acceptability score obtained for indigenous goat milk yoghurt with 1.5% culture level was found to be optimum and the same was comparable with that of control yoghurt while rest of the yoghurt samples secured lower sensory scores indicating inferior yoghurt.

5.3.2 Influence of inoculums levels on physical attributes of indigenous goat milks yoghurt

5.3.2.1 pH and acidity

The pH of the yoghurt sample decreased with increase in level of yoghurt cultures. The indigenous goat milk yoghurt prepared with 1.5% culture level had recorded least decrease in pH which was comparable to the observed pH in control yoghurt. The drop in pH is mainly attributed to the increased hydrogen ion concentration as a result of lactic fermentation by the starter cultures. Hence the yoghurt sample prepared with 1.5% level cultures was found to be optimum with respect to sensory characteristics, pH and acidity and hence the same levels of cultures were maintained for further studies.

Similarly the acidity was increased significantly in the yoghurt samples with increase in the level of yoghurt cultures. The indigenous goat milk yoghurt prepared with

1.5% culture level recorded least acidity development of 0.72% LA which was closely comparable to observed acidity of 0.66% of control yoghurt. The higher levels of acidity were observed with increased level of cultures in the yoghurt samples which is mainly attributed to formation of lactic acid which in turn increase metabolic activity of starter cultures (Tamime and Robinson, 2007).

5.3.3 Influence of inoculums level on sensory attributes of exotic goat milk yoghurt

The effect of different culture levels on the sensory characteristics of the exotic goat milk yoghurt is shown in (Table 5).

5.3.3.1 Flavor

The sensory scores secured for exotic goat milk yoghurt were found to be lower compared to the sensory scores obtained for cow milk yoghurt. The sensory scores obtained for flavor of exotic goat milk yoghurt at 1.5% level of cultures were found to be optimum. The sensory scores obtained for exotic goat milk yoghurt prepared with 2.0% and 2.5% culture level was undesirable. The typical flavor of yoghurt is mainly attributed to acetaldehyde content in the yoghurts. The formation of acetaldehyde is governed by many factors like species of the mammals is one of these factors which influence the acetaldehyde content in yoghurts. The sensory scores in goat milk may be attributed to the acetaldehyde content compared to cow's milk yoghurt (Tamime and Robinson, 2007). Besides level of short chain fatty acids may contribute to the characteristic flavor of caprine milk yoghurt compared to cow milk yoghurt. However optimum sensory scores were obtained for goat milk yoghurt prepared at 1.5% culture levels.

5.3.3.2 Sourness

The sensory scores obtained related to the combined effect of acidity contributed by lactic acid content as well as short chain fatty acids content in the yoghurt samples. Present investigation of the optimum sensory scores were obtained for product containing least sourness and thus least sensory scores were obtained for exotic goat milk yoghurt prepared with 2.5% culture levels and optimum score was obtained for the yoghurt with 1.5% culture level. However the sourness in all the samples was found to be higher compared to that of sensory scores secured. As the yoghurt culture concentration increased the sourness also increases with the ultimate decrease in the sensory scores for the yoghurts. The exotic goat milk yoghurt sample with 1.5% culture level had secured a optimum sensory score of 1.0 for sourness indicating higher sourness compared to that of cow milk yoghurt samples (Tamime and Robinson, 2007).

5.3.3.3 Appearance

The exotic goat milk yoghurt with 1.5% and 2.0% yoghurt culture level had secured higher sensory score (5.0) when compared to control yoghurt. However higher level of culture inoculation did not improve the appearance of the yoghurt hence the optimum appearance were obtained in exotic goat milk yoghurt with 1.5% culture level.

5.3.3.4 Body and texture

The Body and texture of exotic goat milk yoghurt with inoculated 1.5% yoghurt culture secured maximum score indicating optimum body and texture. The sensory scores for body and texture decreased with increased culture level in the yoghurt samples. The exotic goat milk yoghurt prepared with 1.5% yoghurt culture exhibited superior body and texture compared to the control sample.

5.3.3.5 Container and closure

The scores obtained for container and closure of all the experimental samples were found to be similar. Indicating it had no effect on their sensory characteristics.

5.3.3.6 Overall acceptability

The overall acceptability score obtained for exotic goat milk yoghurt with 1.5% culture level was found to be optimum and the same was comparable with that of control yoghurt while rest of the yoghurt samples secured lower sensory scores indicating inferior yoghurt.

5.3.4 Influence of inoculums level on physical attributes of exotic goat milks yoghurt

5.3.4.1 pH and Acidity

The pH of the yoghurt sample decreased with increase level of yoghurt cultures. The exotic goat milk yoghurt prepared with 1.5% culture level had recorded least decrease in pH compared to the observed pH of control yoghurt. The drop in pH is mainly attributed to the increased hydrogen ion concentration as a result of lactic fermentation by the starter cultures. Hence the yoghurt sample prepared with 1.5% level cultures was found to be optimum with respect to sensory characteristics, pH and acidity and hence the same levels of cultures were maintained for further studies.

Similarly the acidity increased significantly in the yoghurt samples with increase in the level of yoghurt cultures. The exotic goat milk yoghurt prepared with 1.5% culture level recorded least acidity development of 0.73% lactic acid which was closely comparable to observed acidity of 0.66% of control yoghurt. The higher levels of acidity were observed with increased level of cultures in the yoghurt samples which is mainly attributed to formation of lactic acid due to increase in metabolic activity of starter cultures (Tamime and Robinson, 2007).

5.4 Physico-chemical attributes of optimized goat milk yoghurt prepared with 1.5% inoculums level

5.4.1 pH and acidity of goat and cow milk yoghurt

The average values of pH and acidity obtained for standardized indigenous goat milk yoghurt prepared with the optimum level of yoghurt cultures(1.5%) indicated that least change in pH and as well as acidity in case of indigenous goat milk yoghurt (Table 7) compared to that of exotic goat milk yoghurt. These recorded observations of pH and acidities were similar to the pH and acidities recorded in the control yoghurt sample. The variations in the pH and acidities may be attributed to the differing buffering capacities and as well as lactic fermentation by the metabolic activities of cultures. Further the buffering capacity is governed by the concentrations of proteins phosphates and citrates present in milk (Tamime and Robinson, 2007).

5.4.2 Curd tension and Syneresis of goat and cow milk yoghurt

The standardized indigenous goat milk yoghurt and exotic goat milk yoghurt prepared with optimum level (1.5%) were compared with the cow milk yoghurt to accesses the rheological parameters like curd tension and syneresis. It was observed that a maximum penetration value was recorded for indigenous goat milk yoghurt followed by exotic goat milk yoghurt and cow milk yoghurt respectively. The curd tension in the product is inversely related. Therefore indigenous goat milk yoghurt had least curd tension followed by exotic goat milk yoghurt and the cow milk yoghurt has maximum curd tension indicating the firmness of the coagulum in the cow milk yoghurt. Soft and weaker coagulum was obtained in the indigenous goat milk yoghurt compared to exotic goat milk yoghurt. The lower curd tension and weaker curd firmness may attributed to lower contents of low $\boldsymbol{\alpha}$-s1 casein and smaller casein micelles (Sanjeev kumar *et al*., 2012) and this is of significance in the digestibility of milk proteins in the human intestines and therefore beneficial in the case of infant and in general human nutrition.

The higher percentage of syneresis was observed in indigenous goat milk yoghurt followed by exotic goat milk yoghurt and least syneresis in cow milk yoghurt. The syneresis observed in milk is related to the firmness of the firm coagulum in the yoghurt samples. The curd coagulum essentially involves the interactions of caseins and whey proteins particularly in $\boldsymbol{\alpha}_{s1}$- casein and $\boldsymbol{\beta}$-lacto globulin during the slow lactic fermentations. Hence the coagulum observed in the goat milk yoghurt had low $\boldsymbol{\alpha}$-s1 and $\boldsymbol{\beta}$-lacto globulin resulting in higher whey separation indicating higher syneresis in goat milk when compared to cow milk yoghurt (Sanjeev kumar *et al* 2012).

5.4.3 Free fatty acids and soluble nitrogen contents of goat and cow milk yoghurt

The observed FFA content was found to be higher in indigenous goat milk yoghurt and exotic goat milk yoghurt compared to cow milk yoghurt (Table 9). The development of FFA is mainly attributed to the lipolysis of fat by the culture organisms affecting significantly aroma and flavor of dairy products. The individual short chain fatty acids are responsible for the pronounced aroma and flavor of the goat milk products (Senel *et al* 2011). However the cow milk yoghurt shows lower free fatty acids contents (Table 09). Kondyli and Katsiari, 2002 reported similar observations indicating higher FFA content in goat milk yoghurt compared to cow milk yoghurt.

The soluble nitrogen content of indigenous and exotic goat milk yoghurt was found to be higher than that of cow milk yoghurt (Table 9). Similar observations of higher soluble nitrogen contents were in goat milk yoghurt were reported (Atamer *et al.*, 1993). The higher soluble nitrogen content may be attributed to the higher non protein nitrogen content in goat milk yoghurts (Senel *et al* 2011).

5.5 Storage studies of goat and cow milk yoghurt

5.5.1 Development of acidity in goat and cow milk yoghurt stored at 4±1 ℃

The pH was decreased in all the yoghurt samples with increase in the storage period at refrigerated temperature (Table 10) indicating the decreasing shelf life of the products. All the yoghurt samples show spoilage at the end of the 12^{th} day during storage exhibiting yeast and mould growth. The rate of decrease in pH is marginally higher in indigenous and exotic goat milk yoghurt. However at the end of the 12^{th} day all the samples exhibited similar pH values indicating pH remains fairly constant.

Similarly the pH and acidity are inversely related, with decline in pH during storage there was corresponding increase in acidity. The rate of development of acidity was observed to be higher compared to cow's milk yoghurt. However the rate of development of acidity change did not differ much between indigenous goat milk yoghurt and exotic goat milk yoghurt samples.

5.5.2 Development of free fatty acids and soluble nitrogen content of goat and cow milk yoghurts stored at 4±1 ℃

The observed FFA content was found to be higher in cow milk yoghurt compared to goat milk yoghurt (Table 11) at the end of 12^{th} day storage at refrigeration condition. The development of FFA is mainly attributed to the lipolysis of fat by the culture organisms affecting significantly aroma and flavor of dairy products. However the cow milk yoghurt shows higher free fatty acids contents which was observed in indigenous goat milk yoghurt compared to exotic goat milk yoghurt (Table 11).

The soluble nitrogen content of cow milk yoghurt was found to be higher than that of goat milk yoghurt at the end of 12^{th} day storage at refrigeration temperature (Table 12). The higher proteolytic activity of starter cultures was observed in cow milk yoghurt compared to indigenous goat milk yoghurt and exotic milk yoghurt.

5.5.3 Microbial quality of goat and cow milk yoghurts stored at 4±1 ℃

The viability of the cultures declined in all the yoghurt samples during storage at the refrigeration temperature. The higher viability of yoghurt cultures in indigenous and exotic goat milk yoghurt were observed compared to that of cow milk yoghurt during storage at the refrigeration temperature (table 13). The similar observations of viability of yoghurt cultures in goat milk yoghurt samples were reported by Masud, *et al*, (1991) for strained yoghurt. The higher acidity of the yoghurt samples may be attributed to the decreased viability of the yoghurt cultures during the prolonged storage.

The yeast and molds growth was observed in all the yoghurt samples only after 12 days of storage at refrigeration temperature. The acidic condition of yoghurt samples might have favored the growth of coli forms was absent in all the samples.

Coliform were not detected in both goat and cow milk yoghurt during entire period of storage at refrigeration condition. The presence of coliforms indicates the unsanitary conditions during the period of preparation. The higher acidity in yoghurt samples might have created inhibitory effect on the growth and survival of coliforms during storage (Dardashti *et al* 2000, Qunstio *et al* 2000).

Summary

6. SUMMARY

The pooled milk samples of Jamunapari, Barbari, Beetal Indigenous goat breeds and Sannene, Boer, Damascus exotic goat breeds were procured from the goat farm which is located at Marenahalli village, Devanahalli (T) of Bangalore rural (Dist). These milks were analyzed for compositional characteristics viz fat, protein, lactose, ash, total solids and moisture content, physico - chemical characteristics such as pH, acidity, specific gravity, viscosity, surface tension, electrical conductivity, freezing point, rennet coagulation time and heat coagulation time. The pooled milks were utilized in the preparation of yoghurt with the inoculation of different levels of yoghurt cultures and their effect on physico - chemical, rheological, sensory characteristics and its storage stability were studied. The results are summarized as follows.

6.1 The average gross compositional values of fat, proteins, lactose, ash, total solids and moisture contents obtained for indigenous goat milks is 4.0%, 3.7%, 4.2%, 0.82%, 12.72%, 87.87%; for exotic goat milk is 3.82%, 3.52%, 4.0%, 0.79%, 12.13%, 87.28%; and 3.6%, 3.3%, 4.5%, 0.6%, 12.00%, 87.00% for cow milk samples respectively. Higher gross chemical compositions values for fat, proteins, lactose, ash, total solids and moisture contents were recorded by indigenous goat milk followed by exotic goat milk and cow milk samples respectively.

6.2 The average values of specific gravity, viscosity and surface tension obtained for indigenous goat milk were 1.032, 2.3Cp, 56 dynes/cm; for exotic goat milk were 1.028, 2.1Cp, 51 dynes/cm and for cow milk samples were 1.026, 1.5Cp, 45 dynes/cm respectively. The higher values of specific gravity, viscosity, surface tension were observed by indigenous goat milk compared to exotic goat milk and cow milk samples.

6.3 The average values of electrical conductivity, refractive index and freezing point obtained were 0.0034 $ohm^{-1}cm^{1}$, 1.546, -0.575℃; for indigenous goat milk were 0.0041 $ohm^{-1}cm^{1}$, 1.542, -0.572℃ for exotic goat milk and 0.0044 $ohm^{-1}cm^{1}$, 1.538, -0.564℃ for cow milk respectively. Higher values of electrical conductivity were observed in exotic goat milk samples. All the three milk samples exhibited comparable freezing point and refractive index values and did not differ significantly.

6.4 The average values of pH and acidity of 6.6 and 0.16%LA; 6.8 and 0.14%LA; 6.75, 0.13%LA were obtained for indigenous goat milk, exotic goat milk and cow milk samples respectively. Higher percentage of lactic acid was observed in indigenous goat milks compared to exotic goat milk and cow milk samples.

6.5 The average heat coagulation time (HCT) and rennet coagulation time (RCT) obtained were 3min and 44min; 90sec and 55min; 25min, and 33min for indigenous goat milk, exotic goat milk and cow milk samples respectively. The higher rennet coagulation time and lower heat coagulation time were observed for exotic goat milk compared to cow and indigenous goat milk.

6.6.1 The indigenous goat milk yoghurt prepared by inoculation with 1.5%, 2.0% and 2.5% levels yoghurt cultures(*Streptococcus thermophillus* and *Lactobacillus* *bulgaricus*) recorded a pH value of 5.3, 4.8, 4.3; acidity of 0.72%, 1.05%, 1.33% lactic acid respectively.

Cow milk yoghurt sample prepared with 1.5% culture level recorded a pH of 5.1 and 0.66%LA acidity. The acidity was increased while pH was decreased with increased level of cultures in yoghurt of indigenous goat milk yoghurt.

6.6.2 The sensory characteristics of indigenous goat milk yoghurt were influenced by the levels of cultures inoculated. The color and appearance, body and texture, flavor and overall acceptance scores were decreased with increase in the levels of cultures. The indigenous goat milk yoghurt obtained by inoculation with 1.5% yoghurt culture level recorded comparable scores to that of control yoghurt samples.

6.6.3 The exotic goat milk yoghurt prepared by inoculation with 1.5%, 2.0% and 2.5% levels of yoghurt cultures recorded a pH value of 4.9, 4.6, 3.8 and acidity of 0.73%, 1.23%, 1.35% Lactic acid respectively against 5.1 a pH and 0.66%LA recorded for control yoghurt.

The acidity of exotic goat milk yoghurt was increased while pH was decreased with increase in the level of cultures inoculated.

6.6.4 The sensory characteristics of exotic goat milk yoghurt were influenced by the level of yoghurt cultures inoculated. The sensory scores obtained for color and appearance, body and texture, flavor and overall acceptance were decreased with increase in the levels of cultures.

Exotic goat milk yoghurt with 1.5% yoghurt culture level secured comparable sensory scores to that of control yoghurt and hence considered to be the optimum level for further investigation.

6.7.1 The average values of pH and acidity is 5.3 and 0.72% LA; 4.8 and 0.78%LA; 5.1, 0.66%LA were obtained for optimized indigenous and exotic goat milk yoghurt and cow milk yoghurt respectively. The higher pH and lower acidity was observed in indigenous goat milk yoghurt compared to exotic goat milk yoghurt and cow milk yoghurts.

6.7.2 The average rheological values of curd tension and percentage syneresis obtained were 345.65 mm and 24; 320.05 mm and 20; 295.51mm and 16 for indigenous goat milk yoghurt, exotic goat milk yoghurt and cow milk yoghurts respectively. Optimized indigenous goat and exotic goat milk yoghurt prepared with 1.5% yoghurt culture levels had lower curd tension and higher syneresis compared to cow milk's yoghurt.

6.7.3 The average values of FFA (%O.A) 7.6, 8.0, 5.1 were observed for indigenous goat milk yoghurt, exotic goat milk yoghurt and cow milk yoghurts respectively indicating pronounced acidic pungent flavor in the goat milk yoghurts.

Similarly the average soluble nitrogen contents of 0.14%, 0.092% and 0.10% were obtained for optimized indigenous goat milk yoghurt, exotic goat milk yoghurt and cow milk yoghurt samples respectively indicating higher soluble nitrogen in indigenous goat milk yoghurt compared to exotic goat milk yoghurt and cow milk yoghurts.

6.8.1 The acidity of 1.38%, 1.42% and 1.19% were recorded at the end of 12 days refrigerated storage against the recorded acidities of 0.72%, 0.78% and 0.61% at zero day of refrigeration storage for indigenous goat milk yoghurt, exotic goat milk yoghurt and cow milk yoghurt respectively.

6.8.2 The free fatty acids (%O.A) 13.02, 12.30, 13.10% were recorded at the end of 12 days refrigeration storage against recorded free fatty acids 7.6, 8.0, 5.1 % at the end of zero day of refrigeration storage for indigenous goat milk yoghurt, exotic goat milk yoghurt and cow milk yoghurt respectively.

Similarly the soluble nitrogen during refrigeration storage at 12 days is 0.26%, 0.23%, 0.28% recorded against to the soluble nitrogen value 0.14%, 0.092%, 0.99% at the zero day of refrigeration storage for indigenous goat milk yoghurt, exotic goat milk yoghurt and cow milk yoghurt respectively.

6.8.3 The viability of yoghurt cultures was found to be 6.50 log_{10}cfu/gm, 6.38 log_{10}cfu/gm and 5.00 log_{10}cfu/gm at the end of 12 days at refrigerated storage conditions against the viability of 8.06 log_{10}cfu/gm, 8.00 log_{10}cfu/gm and 8.00 log_{10}cfu/gm at the zero day of refrigeration storage for indigenous goat milk yoghurt, exotic goat milk yoghurt and cow milk yoghurt respectively. The coliforms was absent in all the samples

The molds growth was observed in all the yoghurt samples after 12 days of storage at refrigeration temperature.

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Abstract

8. ABSTRACT

Caprine milk is superior to bovine milk. Because of it's unique and beneficial characteristics like greater buffering capacity, better digestibility, nutritional and therapeutic values. The milk composition varies with breed, species, age of animal, stage of lactation, feed, season etc. An attempt has been made in the present investigation to study the compositional and physico-chemical characteristics of indigenous and exotic goat milks. The compositional parameters viz total solids, fat, proteins, lactose and ash contents were analyzed. The indigenous goat milk had 12.72%, 4.0%, 3.7%, 4.2%, 0.82% against 12.13%, 3.82%,3.52%, 4.0%, 0.79% of exotic goat milk with respect to total solids, fat, proteins, lactose and ash content respectively. Indigenous goat milk recorded higher gross composition compared to exotic goat milks. The indigenous goat milk had specific gravity, viscosity, surface tension, electrical conductivity, freezing point and refractive index, pH and acidity values of 1.032, 2.3Cp, 56 Dynes/cm, was 0.0044 ohms/cm, 1.546, -0.575℃, 6.6 and 0.14%LA against 1.028, 2.1, 51,0.0043, 1.542, -0.572, 6.8 and 0.13%LA recorded for exotic goat milk respectively. The indigenous and exotic goat milk showed lesser HCT and longer RCT values compare to cow milk.

The indigenous and exotic goat milk yoghurts prepared with 1.5% yoghurt cultures recorded maximum sensory scores. The optimized indigenous and exotic goat milk yoghurts exhibited lower curd tension higher acidity, syneresis, %FFA and %soluble nitrogen content compared to cow milk. The viability of yoghurt cultures declined at a faster rate while acidity, FFA content and soluble nitrogen were increased in goat milk yoghurt compared to cow's milk yoghurt. The product had a good shelf life up to 12 days under refrigeration temperature of storage.

Annexure

9. ANNEXURE

SCORE CARD FOR SENSORY EVALUATION OF YOGHURTS

Name of the judge: Date:

Examine the sample for each of the attributes and award the score based on your preference for each attribute.

Max. Scores / Sample	Attributes						
	Flavor	**Sourness**	**Appearance**	**Body & Texture**	**Container & Closure**	**Total**	**Remarks / Comments**
	(10)	**(2)**	**(5)**	**(5)**	**(3)**	**(25)**	

Signature of the Judge