VARIATIONS IN QUALITY AND FERMENTATION PROPERTIES OF MILK FROM LOCAL GOATS

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Abstract

Milk samples collected biweekly during the 1997/1998 lactation from local goats kept at the Awassa College of Agriculture farm were used in this study. Microbial load, quality, gross composition, shelf life and fermentation properties of the milk were compared with that of cow milk stored under similar conditions. Significant variation was observed in gross composition, microbial quality, fermentation property and shelf life of local goat milk. Significant changes were observed in fat and protein contents as lactation advanced, while variation in lactose and ash was not significant. The shelf life of raw goat milk kept under ambient temperature was not significantly different from that of heat-treated milk during the first 12 hours of incubation. However, under cold storage the shelf life of raw milk was inferior compared with heat-treated milk. Acceptability of raw goat milk kept under cold storage was significantly reduced after 12 hours compared with heat-treated goat milk. The change of pH in goat milk differed from that of Holstein Fresian cow milk incubated under similar conditions. The viscosity and acceptability of fermented goat milk increased between 24 and 96 hr of incubation time whereas that of cow milk decreased under similar conditions. Sanitary handling of goat milk, maintenance of a clean production environment for sanitary handling of milk and heat treatment are essential prerequisites for extended shelf life, reduced microbial load and improved fermentation property of goat milk.

Introduction

Local goats are kept and managed to serve relatively resource poor households by providing essential nutrients (milk) and cash compared with large ruminants in southern and southeastern parts of Ethiopia (Fekadu, 1994). In the central rift valley of Ethiopia, goat milk is either consumed fresh or mixed with cow milk to be fermented for churning into butter or consumed as fermented milk. Under farmer management, estimated milk yield varies between 250 ml to 1000 ml per day per animal during a four-month period of lactation. Many diseases such as tuberculosis, brucellosis, diphtheria, scarlet fever, Q fever, and gastroenteritis are known to be transmitted via milk products (Vasavada, 1988). Little is known about the microbial load, fermentation property and composition of Borana goat milk produced in Ethiopia. Strict sanitary measures in production, handling, storage and processing of milk could minimize the potential threat of pathogenic bacteria. Knowing the inherent characteristics of milk from different sources is also essential in assessing product quality and shelf stability.

Lactic fermentation is a widely accepted method of preserving dairy products in warm climates. Fermentation properties of milk depend on the chemical composition, the type of fermenting organisms, pretreatment applied to milk and incubation conditions (Cooke et al., 1987). High microbial counts are associated with poor handling and sanitary conditions during preparation of traditional products from fermented cow milk in southern Ethiopia (Kassaye et al., 1991; Fekadu and Abrahamsen, 1997). Despite the role of goat milk in the family diet and livelihood of the relatively poorer households, little is known about the changes in microbial quality and fermentation properties of milk from local goats.

The current study reports on the changes due to various treatments on growth dynamics of microorganisms, fermentation properties and pH of local goat milk. Variations in gross composition of milk of the local Borana goat during lactation were also reported.

Materials and Methods

Sample collection

Sterile milk samples from ten lactating local breed does kept at the Awassa College of Agriculture goat farm were collected during 1997/98 to study changes in the flora, composition and fermentation properties under different conditions. The samples were taken during the first three days of lactation and every two weeks thereafter during the entire lactation period. Samples were brought to the Dairy Laboratory and kept under cold storage following standard procedures (Richardson, 1985). Composite milk samples were collected from ten Holstein Friesian cows kept at the Awassa College dairy farm and brought to the laboratory. Microbial analysis was done on bulk samples from the early, mid- and late lactation periods.

Sample preparation

Samples were divided into four lots of 300 ml in sterile glass jars and labeled M1, M2, M3, and M4. Two (M3 and M4) of the four samples were heat treated at 62°C for 30 minutes and cooled to 10°C. M3 was incubated under cold storage at 4° C, and M4 at room temperature, 21°C. The remaining two raw samples in glass jars (M1 and M2) were incubated at 21° and 4°C respectively. Microbial counts and sensory evaluations were made after 0, 24, 48, 72 and 96 hr. Holstein Friesian cow milk was obtained by milking ten cows directly into sterile bottles and treated in the same manner as goat milk.

Chemical analysis

Goat milk samples were evaluated for gross composition as follows. Total solids were determined by drying 5 gm of milk at 100°C for 3 hrs (AOAC, 1995). Fat was determined by the Gerber method (AOAC, 1995). Nonprotein nitrogen and crude protein contents were determined by Kjeldahl methods IDF Standard 20A (IDF, 1986). Lactose content was determined enzymatically using a test kit (Boehringer Mannheim GMBH Biochemia). Ash content was determined by igniting the dried samples at 500°C (AOAC, 1995). Titratable acidity was determined with NaOH and phenolphthalein and pH was analysed using a digital pH meter (Orion FA 210 with EL 9102 pH electrode, Orion Research Inc., Cambridge, MA).

Organoleptic evaluation

A test panel composed of five judges evaluated the appearance and flavor of fermented goat milk using a scale from 1 to 5, with 5 points as the best. The fermented milk samples were evaluated organoleptically to determine acceptability after 24, 48, 72 and 96 hr of incubation at 21°C.

Measurement of viscosity

For viscosity analysis of fermented milk samples, a SMR viscosimeter (Tip No. 5) was used after stirring of the coagulum (Holmen and Abrahamsen, 1977). The viscosity was measured after 24, 48, 72 and 96 hr of incubation at 21°C.

Whey separation

The volume of whey separated was measured after 24, 48, 72 and 96 hr of incubation at 21°C and evaluated as a proportion of the total volume of the fermented product.

Microbial counts

Total bacterial counts were made by plating dilutions of samples on plate count agar and incubating aerobically at 30°C for 48 hr. Lactic acid bacteria (LAB) were counted on MRS agar after 48 hr of anaerobic incubation at 30°C. Coliforms were enumerated on violet red bile agar after 24 hr of incubation at 30°C. Yeast and mold counts were made by plating appropriate dilutions on chloramphenicol bromophenol blue agar (yeast extract 5 g, glucose 20 g, chloramphenicol 0.1g, bromophenol blue 0.01 g, agar 15 g, distilled water 1000 ml) followed by 3 days incubation at 30°C. For determination of aerobic sporeformer, a 10 ml sample was poured into a sterile test tube and heated in a water bath at 80°C for 15 min. The heat-treated sample was cooled, plated on starch milk agar (reconstituted skim milk 1 ml., 10% starch solution 1 ml. and molten nutrient agar 100 ml.) and incubated at 30°C for 3 days. All counts were averages of duplicates.

Characterization of the microflora

Representative colonies (10%) from countable plates were picked randomly and pure cultures were prepared and inoculated into broth. Actively growing cultures were resuspended in Ringer's solution before inoculation of tests. Tests for cell morphology and grouping, presence or absence of endospores and motility were made following standard procedures (Richardson, 1985; Harrigan and McCance, 1976) using a phase contrast microscope. Gram reaction was determined following standard procedures. Catalase test was made using a 3% H_2O_2 solution; oxidase test was conducted by the Kovacs method; glucose metabolism was assessed by the O/F test (Hugh and Leifson, 1953); and API 20 was used to determine the species of the lactic acid bacteria isolates.

Statistical analysis

Data analysis was done by the Statgraphics program (Statistical Graphics Corporation, STSC Inc. Maryland, USA). Chemical composition data were analyzed by the ANOVA method, and significance of differences in average values were examined at P = 0.05 (Snedecor and Cochran 1974). Microbial counts were log transformed and statistically evaluated.

Results and Discussion

Changes in microbial counts of raw and pasteurized goat milk under 21°C incubation over 96 hr are given in Figures 1 and 2, respectively. In raw local goat milk, coliform counts significantly increased during the first 12 hrs at 21°C incubation. Total and LAB counts followed similar trends at the 21°C incubation, except that the initial higher growth rate had a longer duration. Total counts and LAB counts plateaued within 72 hr under 21°C incubation while a gradual increase in counts was observed under 4°C even after 72 hr. These findings indicate that cold storage is of little value, as it does not arrest the growth of certain microorganisms when initial contamination is rather high.

The micro flora of raw Borana goat milk produced on the Awassa College of Agriculture farm is given in Table 1. *Enterobacteriacae* were the dominant flora of raw goat milk followed by *Lactococcus* and *Bacillus* spp. Variation was very high for most of the micro flora of the raw goat milk.

Lactococcus spp. (46%) were the dominant flora of fermented raw goat milk incubated at 21°C, followed by Gram positive cocci (28%) and rods (13%), while the remaining were Gram negative cocci and rods (13%). *Lactobacillus* spp. including *L. brevis*, and *L. curvatus, L. plantarium* and *L. casei* and *Leuconostocs* spp. including *L. mesenteroides* and *L. lactis* were also isolated from fermented goat milk incubated at 21°C.

Changes in microbial counts of raw and pasteurized goat milk under 4°C incubation over 96 hr are given in Figures 3 and 4, respectively. Coliform counts showed a similar trend under both conditions, while growth of LAB significantly increased after 12 hr under 4°C incubation in pasteurized compared with raw milk. At 4°C proliferation of LAB was slow compared with the 21°C incubation. These values were still much higher than values reported by Mogessie and Fekadu (1994) for cow milk from a dairy farm. This difference may be due to the fact that other microorganisms such as non-lactic acid bacteria are also known to grow on MRS and are likely to proliferate well even under cold storage.

Variation in gross composition (%) and pH of Borana goat milk during the four months of lactation is given in Table 2. The fat content of local Borana goat milk showed wide variation during the middle and towards the last months of lactation. This is in agreement with earlier reports (Workneh, 1997; Hadjipanayiotou, 1995) on milk from the closely related Somali goat. The slight increase in the fat content in early lactation was followed by a significant increase towards mid- lactation, and a slight decline at the end of lactation. Protein composition showed a downward trend until mid-lactation and a significant increase towards the end of lactation. Saanen/Toggenburgs have mean values for fat, protein and lactose of 3.7, 2.9, and 4.4%, respectively (Sutton and Mowlem, 1991), which are very similar to concentrations for Friesian cows of 3.9, 3.2, and 4.6%, respectively. Conversely, Anglo-Nubian goat milk has a higher concentration of solids with

mean values of 3.7, 3.6, and 4.3%, for fat, protein and lactose, respectively (Sutton and Mowlem, 1991). Milk protein and fat concentrations for the local Borana goat were greater and very similar to values for local zebu cows (Fekadu, 1994). The variation in the ash content was not significantly different. Borana goat colostrum was observed to have slightly higher total protein content, but lower fat and lactose contents. The pH and ash contents of the colostrums remained similar to Borana goat milk from the later stages of lactation.

Comparison of the change in acidification of Holstein Friesian cow and Borana goat milk (Figure 5) showed that Borana goat milk ferments more slowly compared with Holstein Friesian cow milk, in agreement with an earlier report (Park, 1992). This could be due to the higher nonprotein N (0.29%) and crude protein content in Borana goat milk, which contributes to buffering capacity. This property is of importance in human nutrition, particularly in the treatment of gastric ulcers (Walker, 1965).

Extended optimal growth conditions due to the buffering capacity for microorganisms in Borana goat milk could also mean a better opportunity and longer growth period for pathogenic organisms. This requires special attention and dictates further study regarding how pathogenic organisms perform in Borana goat milk during the course of fermentation as microorganisms grew well for over 72 hr in goat milk. However, growth rate declined as the pH decreased to 4.2 within 48 hr under 21°C incubation. The decrease in pH for Borana goat milk was gradual and remained above 4.2 for more than 72 hr, which may affect performance for cheese making.

Whey separation was minimal at the early stage of fermentation of pasteurized Borana goat milk, but after 72 hr of incubation whey separation in raw Borana goat milk surpassed that of raw Holstein Friesian milk. Fermented raw Borana goat milk was less viscous than raw Holstein Friesian milk after 36 hr of fermentation. However, upon storage at 21° C for 72 hr the viscosity of raw Borana goat milk became greater than that of raw Holstein Friesian milk (Table 3). The viscosity of fermented raw Holstein Friesian milk decreased upon storage at 21°C. The flavor and appearance scores followed the same trend as viscosity. Fermented raw cow milk was preferred to fermented pasteurized cow milk, while fermented pasteurized Borana goat milk was preferred to fermented raw Borana goat milk. This is perhaps due to the fact that the pasteurization process might have destroyed some important microorganisms and enzymes potentially responsible for flavor development in cow milk during fermentation. These observations indicate that the use of a starter culture is essential following heat treatment of milk for better flavor properties and acceptability. After 72 hr of incubation at 21° C, fermented pasteurized goat milk was much preferred by the taste panel compared with fermented raw goat milk. This perhaps could be due to the fact that heat treatment removes some of the off flavors in goat milk. The Borana goat fermented milk gel does not appear to be at full development and strength until after 72 hr. This finding is in line with earlier reports (Vlahopoulou and Bell, 1993) indicating that caprine yogurt gels were weaker than the equivalent bovine yogurt. Heat treatment of Borana goat milk improved its fermentation properties and acceptability. The positive effect of cold storage is significant for heat-treated milk samples. At a later stage of incubation, the microbial count of pasteurized Borana goat milk kept at 21° C became higher than that of raw Borana goat milk incubated at 4°C. The decline in pH also followed the same trend (Figures 1 and 5) as the total plate count.

Local Borana goat milk showed wide variation in composition and fermentation properties over the lactation period. The effect of heat treatment was significant for microbial count and fermentation properties of goat milk. A clean production environment and heat treatment of milk could play an important role in the quality and shelf life of Borana goat milk. Further studies on the effect of processing on growth of pathogenic organisms in goat milk are needed. Pasteurization of goat milk resulted in improved fermentation properties and better organoleptic quality and shelf life, both under cold storage and at room temperature. Initial microbial load and sanitary production of milk influenced the effectiveness of pasteurization in reducing microbial load. Maintenance of a clean production environment is essential for production of better quality fermented Borana goat milk with an extended shelf life. Pasteurized goat milk incubated at 21°C was shown to have a shorter shelf life compared with raw goat milk kept under cold storage (4°C). Until recently, very little has been done to increase the productivity of goats in Ethiopia and it is obvious that with improved breeding and management practices there is potential for considerable progress. Due consideration of handling and processing problems is thus essential, along with measures for

improvement of productivity in extension programs.

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Table 1. Micro flora of raw Borana goat milk collected from Awassa College of Agriculture goat farm

Bacterial category	Percent of total count
Enterobacteriacae	20 – 30
Bacillus spp.	10 - 20
Staphylococcus spp.	12 - 36
Micrococcus spp.	5 - 13
Streptococcus spp.	1 - 3
Lactococcus spp.	1 - 40
Leuconostoc spp.	0.3 - 6
Lactobacillus spp.	5 - 18
Others	8 - 15

N = 10

Table 2. Variation in gross composition (%) and pH of Borana goat milk during four months of lactation

	n	Fat	Protein	Ash	Lactose	Total Solids	pH
Colostrum[1]	30	4.8±2.7[b]	6.0±1.5[a]	0.7±0.4	3.2±0.7[c]	14.5±2.3[b]	6.6±0.2
Initial stage[2]	20	6.2±2.2[b]	4.2±1.2[c]	0.9±0.1	4.4±0.5[b]	15.6±1.8[ab]	6.5±0.3
Mid-lactation[3]	30	7.8±2.5[a]	4.1±0.8[c]	0.8±0.0	4.3±1.0[b]	17.3±2.5[a]	6.4±0.1
End of lactation[4]	40	7.1±1.8 [ab]	4.5±0.4[b]	0.8±0.1	4.5±0.8[a]	16.7±3.2[ab]	6.4±0.2

[1] Milk obtained during the first three days of lactation
[2] Milk obtained from the 2nd to the 4th week of lactation
[3] Milk obtained from the 5th to the 9th week of lactation
[4] Milk obtained from the 10th to the 16th week of lactation
[a, b,c] Similar letters in the same column indicate the lack of significant differences
n Refers to the number of milk samples collected and analyzed from the experimental animals

Table 3. Comparison of viscosity and acceptability of pasteurized Borana goat and Holstein Friesian fermented milk

Incubation	Borana goat milk			Holstein Friesian Milk		
	Viscosity[1]	Appearance[2]	Flavor[3]	Viscosity	Appearance	Flavor
Time						
24 hr	58±3[d]	4.0±0.04[b]	3.5±0.02[b]	76±2[b]	4.2±0.03[a]	4.5±0.03[a]
48 hr	74±4[c]	4.1±0.05[b]	3.9±0.03[a]	88±4[a]	4.4±0.02[a]	4.2±0.01[a]
72 hr	86±5[b]	4.4±0.03[a]	4.1±0.05[a]	74±3[c]	3.8±0.05[b]	3.8±0.02[b]
96 hr	88±3[a]	4.5±0.01[a]	4.0±0.04[a]	69±3[d]	3.2±0.03[b]	3.6±0.03[b]

[1] Measured using SMR viscosimeter, given as time in seconds, higher values indicate greater viscosity. [2,3] Mean scores as evaluated by test panel using a scale from one to five, with five points as the best. [abcd]Different letters in the same column indicate significant differences.

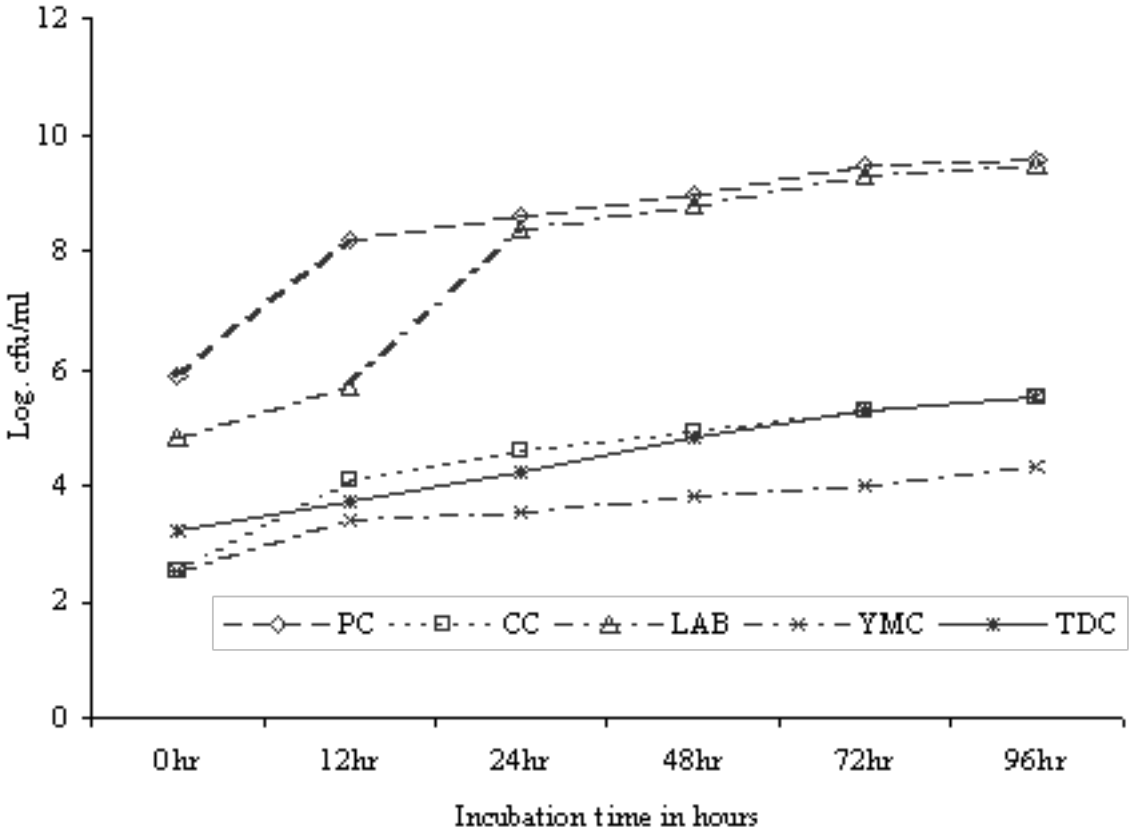

Figure1. Changes in microbial counts of raw goat milk incubated at 21C

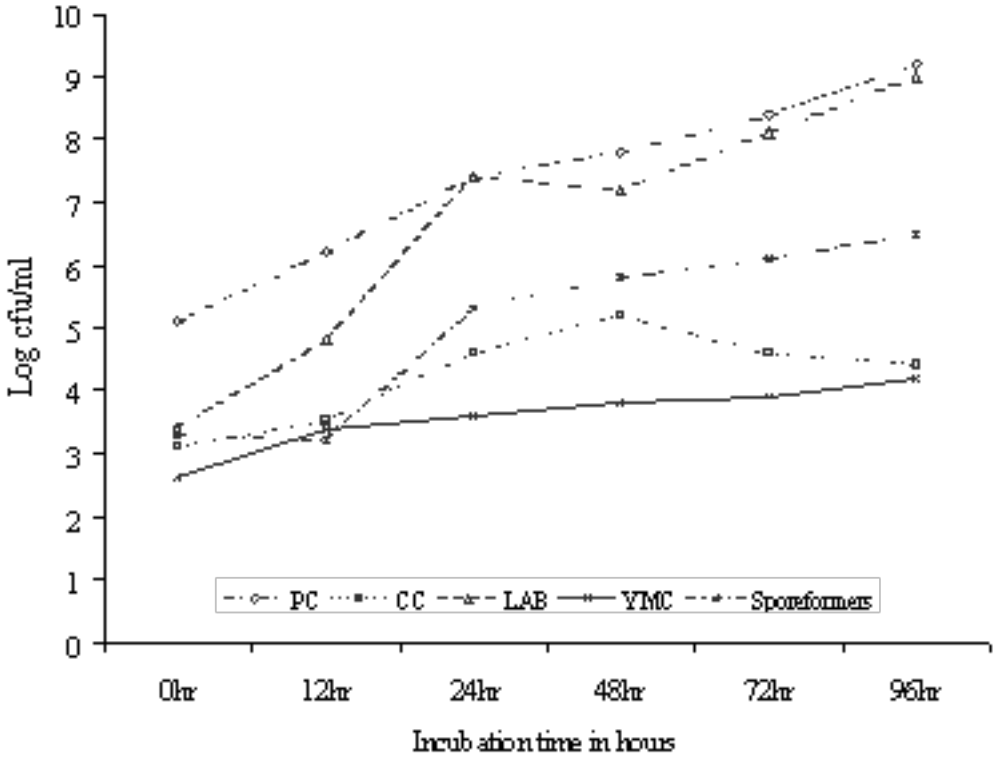

Figure 2. Changes in microbial counts of pasteurised local goat milk incubated at 21C

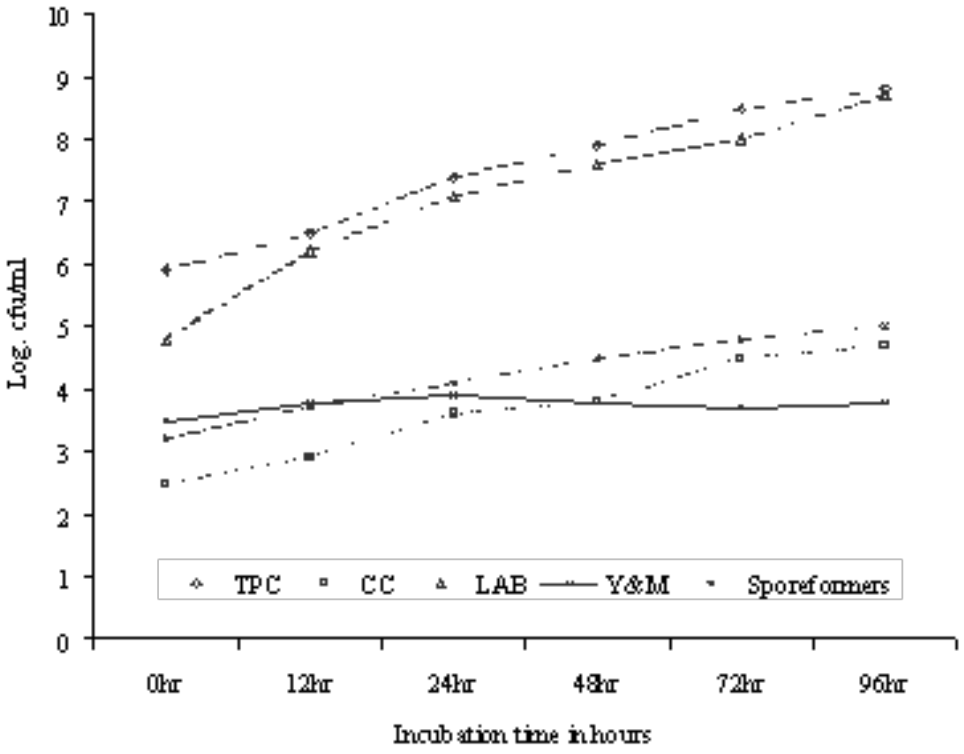

Fig. 3. Changes in microbial counts of raw goat's milk incubated at 4 C

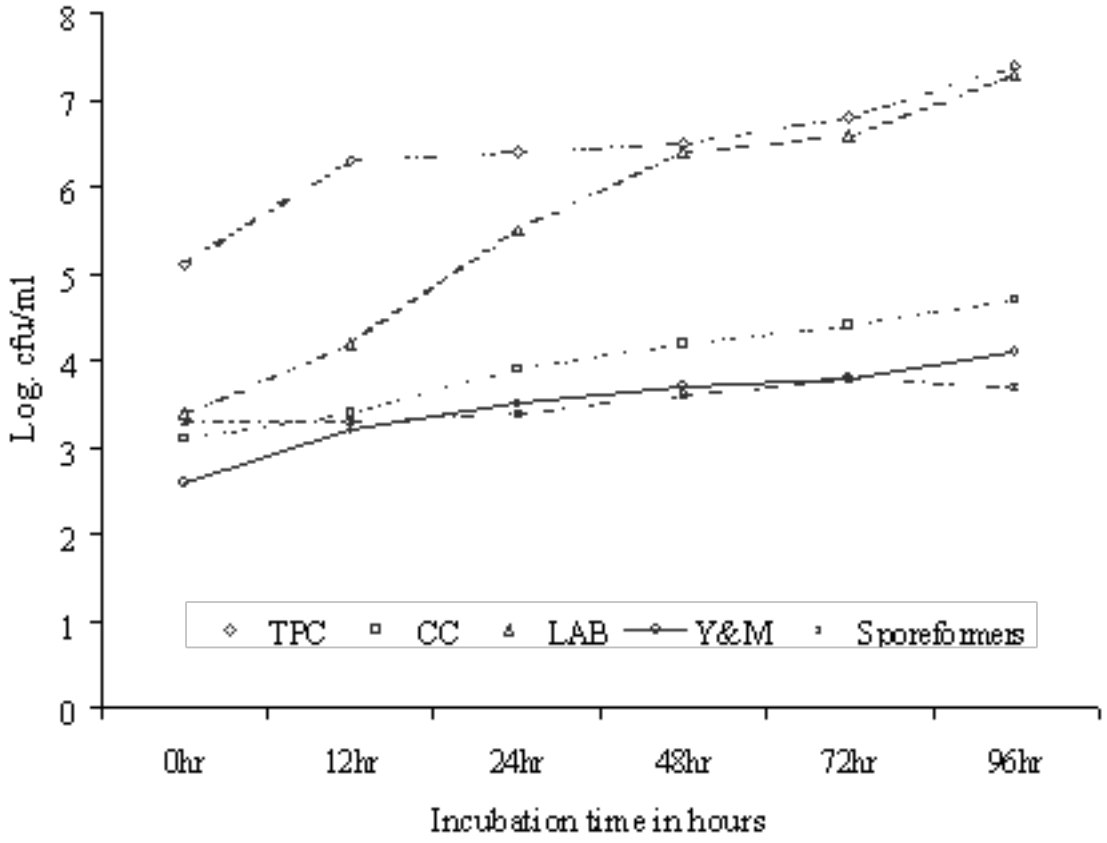

Figure. 4. Changes in microbial counts of pasteurised goat milk incubated at 4 C

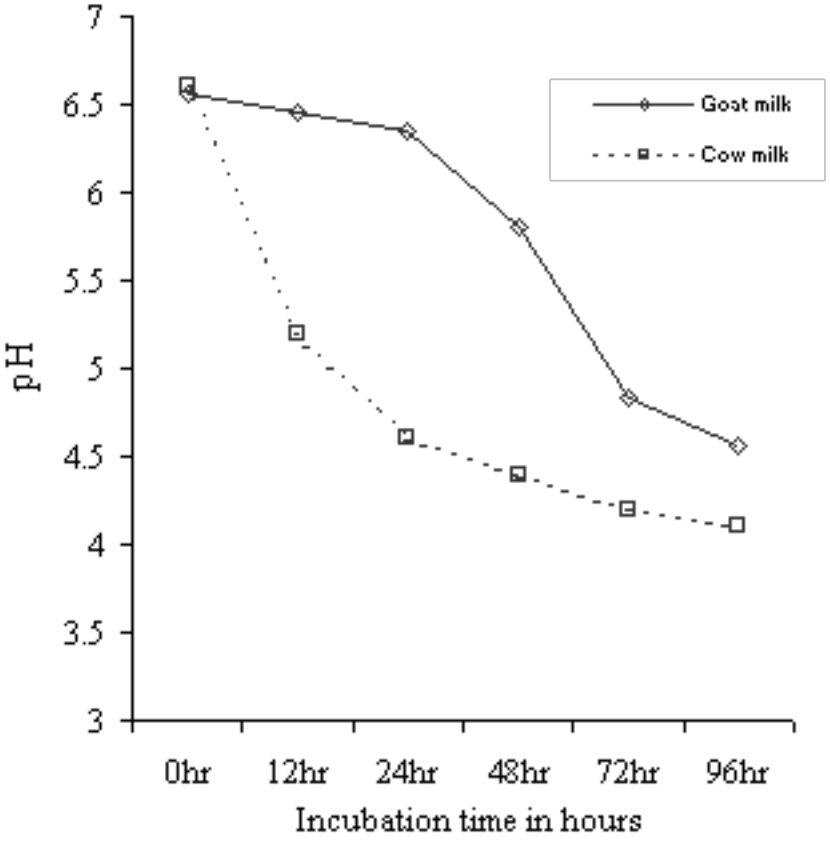

Figure 5. Changes in pH of local goat and cow milk incubated at 21C

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