

5. DISCUSSION

The results of the microbiological, chemical and physical quality analyses of the goat's milk and cow's milk used in these experiments showed that the latter had higher proportions of protein, fat, lactose and total solids in general, and also had better microbiological quality than the former. Statistically, the two milks differed significantly ($p < 0.05$) in all these components except protein content. Apart from this, the goat's milk and cow's milk had no significant difference in pH and titratable acidity.

The main cause of the difference found between the two milks may be the fact that they were produced by two different mammal species (Rosenthal, 1991). Apart from this, the variation could also be due to the fact the milk animals were from two different farms, University of Pretoria experimental farm and Medunsa goat farm, where each species was given a different treatment in terms of milking times and techniques, feeding practices, shelter provided and exposure to different geographical conditions (Lacroix *et al.*, 1993; Ozimek & Kennelly, 1993).

A marked difference in composition of the Feta cheese obtained by the different treatments was noted as early as directly after cheese manufacturing (renneting stage). One difference was in the time taken by the cheese curd to attain the required firmness before cutting. Pure cow's milk (treatment 1) and 65% cow's milk plus 35% goat's milk (treatment 2), attained the desired firmness within roughly one hour, while the curd of 35% cow's milk plus 65% goat's milk (treatment 3) and that of 100% goat's milk (treatment 4) required an extra 30 to 45 minutes (1.5 to 1.75 h after renneting) to achieve the desired firmness. A similar observation was also made by Eleye, Banaon, Ramet & Hardy (1995) on comparing the coagulability of goat's milk and cow's milk.

When pouring the curds into the Feta cheese moulds, problems were experienced with treatments 3 and 4 as their curds were very fragile and slipped through the holes of the moulds and between the bottom of the moulds and the draining mats. According to Adnoy & Abrahamsen (1995), poor rennetability of goat's milk is a common problem in cheesemaking. To a certain extent, the problem is believed to be related to geographical area and season. Adnoy & Abrahamsen (1995) found that poor rennetability was an inherent character and was also associated with low fat content.

According to Fox (1987a), casein content determines the time required for the curd to acquire certain consistency and strength. To clot casein micelles effectively using rennet, the κ -casein component must be split in the region of the Phe₁₀₅-Met₁₀₆ bond. However, there may be genetic variation in the amino acids between fractions 97 and 129 of the protein. Although the variants may be by only a few amino acids substitution, these differences cause significant changes in renneting and cheesemaking properties (Fox, 1987a). This implies that cow's milk probably contained a higher proportion of κ -casein variants which were susceptible to chymosin attack at the Phe-Met bond than goat's milk.

Analysis of the Feta cheeses revealed that the treatments differed significantly ($p < 0.05$) in terms of fat content, total solids content, log total plate count (TPC), texture, pH, protein content and free fatty acids (FFA) content. Other quality aspects, namely soluble protein, NaCl content and sensory evaluation scores did not differ significantly ($p > 0.05$) between treatments. During ripening, pH, log TPC, soluble protein content, FFA content, NaCl content and texture changed significantly ($p < 0.05$).

The mean salt content of the cheeses ranged between 3.93% and 4.01%, and did not differ significantly ($p > 0.05$) between treatments but it increased significantly during ripening. The magnitude of change was much greater between day 2 and

day 7 than between day 7 and day 21. According to Fox (1987a), the fact that the rate of salt absorption decreased with time may mean that there was a decrease in the NaCl concentration on the surface of the curd.

Since the brine was drained off and the surface of the cheese was blotted dry before sampling, it is likely that more concentrated brine was removed during the early stages of ripening than during later stages and this might have affected the results negatively. Moreover, the salt content may not be regarded very reliable since dry salting was used. According to Fox (1987a), a high error in dry salting is caused by the fact that not all of the salt weighed fall exactly on the surface of the curd and not all of that which fell on the curd is absorbed. Apart from that, the salt uptake is also affected by factors like the dimensions of the cheese, temperature, acidity and curd composition. The high error is verified by the standard deviation which was as high as 1.12.

The trend of fat content of the Feta cheeses indicated that fat content decreased systematically from treatment 1 to 4 and seemed to decrease with decrease in cow's milk proportion in the Feta cheese milk. The reason for this could be the fact that the cow's milk had significantly higher fat content than the goat's milk, and milk fat is one of the major components of cheese (van Boekel, 1993; Varnam & Sutherland, 1994).

Although Scott's (1986) theory stipulated that goat's milk lipids are easy to incorporate into the cheese as they occur in small fat globules and cow's milk usually result in high fat losses, this might not have had significant impact on the final fat content of the cheeses. The expected high fat losses in treatment 1 and 2 cheese might have been offset by the presence of the high amount of fat originating from cow's milk.

The total fat content of the four Feta cheese treatments did not change significantly ($p > 0.05$) during ripening. This may be due to the fact that moisture loss was minimal and the migration of lipolysis products from the curd might have been negligible as it depends on the dimensions of the cheese and level of saturation of the brine into which the products have to dissolve. The lipolysis products, namely long chain free fatty acids, are insoluble in water, hence they remain intact in the cheese curd (Morrison & Boyd, 1987). Although Fox (1987b) stated that a slight increase in fat content may occur due to the continuous losses of soluble degradation products of the solids-non-fat, the increase was negligible.

The mean FFA content of the cheeses differed significantly ($p < 0.05$), where treatment 4 had the highest values, treatment 1 had the lowest and those for treatment 2 and 3 almost overlapped. The trend did not indicate an increase in FFA content with increase in total fat content, but followed the reverse pattern. This may be due to the fact that goat's milk is usually richer in FFA and genetically more susceptible to lipolysis than cow's milk (Fox, 1983). Moreover, the Feta cheeses with high FFA content also had comparatively high microbial load, and hence higher chances of production of lipases. To attain the desired amount of FFA content in pure cow's milk Feta cheese, a commercial lipase is often added in the formulation to increase the degree of lipolysis (Scott, 1986).

Despite the fact that the difference in salt content was not significant between treatment 2 and 3, the higher lipolysis which was expected in the latter due to the presence of higher proportion of goat's milk, might have been slightly retarded by high salt content in this Feta cheese. Miadenov (1973), according to Fox (1987a) reported that fat breakdown increased with decrease in salt content in cheese.

Although the figures did not coincide exactly because of the difference in ripening conditions and age of the cheese, the increase in FFA content correlated with the results obtained by Litopoulou-Tzanataki, Tzanetakis & Vafopoulou-Mastrojiannaki

(1993) and Pappas, Kondyli, Voutsinnas & Mallatou (1996) on Feta cheese. According to the former authors, the amount of FFA ranged between 1.04 acid degree values (ADV) and 1.85 ADV between day 5 and day 20 whilst in the present study, the amounts ranged between 0.65 ADV and 1.62 ADV between day 2 and day 21.

Although the protein content of the goat's milk and the cow's milk did not differ significantly ($p > 0.05$), the four cheeses differed significantly ($p < 0.05$) in protein content. Generally, the values increased systematically from treatment 1 to 4. The research values ranged between 13.90% and 15.28%, and were lower than the literature value of 16.7% quoted by Robinson (1995). However, Robinson (1995) did not state the quality of milk used and age of the cheese.

The fact that the total protein content increased from treatments 1 to 4 may not necessarily imply that the percentage of proteins incorporated into the curd was higher in the cheeses with higher proportions of goat's (treatments 3 and 4) than in the treatment 1 and 2 cheeses. It could be that the amounts of proteins recovered in the latter were offset by its higher proportion of fat content. According to van Boekel (1993), cheese is a product in which the protein and fat of milk constitute the major fraction of the total solids, hence the higher the percentage of one component the lower the percentage of the other.

The total protein content of all the Feta cheeses did not change significantly during ripening and this corresponds with the fact that there was no significant moisture loss. This could be due to the fact that migration of the soluble proteins into the brine was accompanied by loss of water, and hence the net impact was that the total protein and moisture of the cheeses remained the same (Fox, 1987b). However, Renner & El-Salam (1977) stated that up to 15% of the total protein of ripe Feta cheese may be found in the brine, but this depends on the ripening conditions and age of the cheese.

The mean soluble protein content of the Feta cheeses did not vary significantly between the treatments, although they increased as the proportion of goat's milk increased. The soluble protein content seemed to be directly proportional to the mean total protein content in the respective cheeses. This trend may be attributed to the difference in the log TPC, since the soluble protein content values were slightly higher in cheeses with higher microbial load. According to Tsotsanis (1996), the degree of proteolysis of goat's milk and ewe's milk cheese through rennet action is often greater than that of cow's milk cheese during ripening. Despite the trend acknowledged, there is a possibility that the results have been affected by the fact that some of the soluble proteins had dissolved in the brine which was drained off at the beginning of sampling (Renner & El-Salam, 1993).

The mean soluble protein content of the cheeses increased significantly ($p < 0.05$) during ripening. According to Varnam & Sutherland (1994), proteolysis is a major biochemical reaction in the ripening of cheese due to the presence of proteolytic enzymes derived from rennet and both starter and non-starter microorganisms. The processes may take a few weeks or years depending on the desired quality attributes and ripening conditions, hence its products accumulate with ripening time.

The results of the amount of soluble proteins are difficult to compare with the results of the work done by other authors because of the difference in the methods used. The methods used by several authors (for example Efthymiou & Mattick, 1964; Mallatou *et al.*, 1994; Tzanetakis *et al.*, 1995;) is that of "soluble nitrogen in 12% trichloroacetic acid (TCA-N) as opposed to water soluble nitrogen (WSN) which was used in this research. Kandarakis *et al.* (1995) used both methods, but expressed the amount of soluble proteins as a percentage of total nitrogen and not as a fraction of the whole cheese. For these reasons, values obtained through the latter are lower than the values expressed as percentage of total nitrogen.

Generally, the total solid (TS) content of all the Feta cheeses did not change significantly ($p > 0.05$) during ripening, but the values differed significantly ($p < 0.05$) between the treatments. This correlates with the fact that there was no significant change in fat content and protein content of the Feta cheeses during ripening, as these components constitute the major percentage of TS (Van Boekel, 1993).

The results also indicated that the magnitude of difference in TS content between treatments 1, 3 and 4 was slightly smaller than that between treatment 2 and the other three. Although the mean salt content of the cheeses did not differ significantly, treatment 2 had the lowest salt content which might be responsible for the low TS content in this cheese (Fox, 1987a). However, TS content of treatment 2 cheese might have been most adversely affected by the dry salting method error as this cheese had the highest standard deviation in salt content results.

The mean TS content values were 41.50 %, 39.96%, 41.31% and 41.37% for treatments 1, 2, 3 and 4 respectively. Generally, the TS content correlated with the results of Pappas *et al.* (1996) who found that the moisture level of Feta cheese on day 0 to day 30 ranged between 57% and 63%.

The mean pH of all the Feta cheeses changed significantly ($p < 0.05$) during ripening and the values varied significantly ($p < 0.05$) between cheeses from the different treatments. During the early stages of ripening, the pH of the cheeses was close to 4.70 and dropped to about 4.60 at the end of ripening. A decrease in pH was also reported by Kandarakis *et al.* (1995), who found that pH values changed from 4.78 to 4.43 from day 1 to day 30. The main causes of the difference in pH values found in the present study and those by Kandarakis *et al.* (1995), could be the fact that Kandarakis *et al.* (1995) used ewe's milk, a different

starter culture, different ripening conditions and the age of the cheese also differed.

Compared to the pH of the milks (6.70 and 6.73) the pH of the Feta cheeses was significantly lower. This is attributed to the changes which began during cheesemaking when starter culture was added. The starter and the non-starter lactic acid micro-organisms biodegrade lactose in milk and produce lactic acid, which is responsible for the drop in pH (Bohinski, 1987). In general the main difference between pH values of the Feta cheeses was that cheese from treatment 4 had significantly lower values than that from the other three treatments. This may be attributed to the fact that treatment 4 Feta cheese accumulated more FFA and more amino acids during ripening, and also had higher microbial load than the other cheeses and ultimately its magnitude of change in pH was larger.

The mean log total plate count (TPC) in the cheese from all the treatments changed significantly ($p < 0.05$) with time, and there was a significant ($p < 0.05$) difference between various treatments. The trend for the log TPC showed a significant increase in numbers from day 2 to day 7, but after day 7 the numbers generally leveled-off. This showed that at early stages of ripening, conditions were suitable for the growth of micro-organisms. Later, conditions like high salt content, diminished lactose content and low pH slowed down growth of the micro-organisms (Fox, 1987a).

The log TPC trend verified Scott's (1986) theory that the early stages of the cheesemaking process is concerned with a phase of maximum growth of the bacteria, and that during cheese ripening the retardation phase and death phase become important and their enzymes and other substances are released into the curd. Since the milk was pasteurised, the largest fraction of the micro-organisms must have originated from the starter culture. The rapid growth seen at the beginning of ripening may also be due to the fact that commercial lactic acid

cultures are stimulated by low levels of NaCl but are inhibited by $>2.5\%$ (Fox, 1987a).

The difference in mean log TPC between different cheeses seems to be directly related to the original counts of the cheese milk. Since the goat's milk had a significantly higher microbial load than the cow's milk, the cheeses with higher proportions of goat's milk had higher microbial counts.

According to Tzanetakis & Litopoulou-Tzanetaki (1992) low pH (5.19 to 4.56) and salt content below 5.9% favour the growth of lactobacilli, which dominates over other genera throughout ripening. However, since the types of microorganisms which were present in the Feta cheeses were not identified in this research, it is not easy to say whether Tzanetakis & Litopoulou-Tzanetaki's (1992) findings applied in the present study. Apart from this, the starter cultures used in the two researches were not the same.

The results of the texture of the Feta cheeses did not show any specific trend during ripening and between the cheeses made from different proportions of goat's milk and cow's milk mixture. The values fluctuated significantly ($p < 0.05$) and ranged between 0.85 N and 1.66 N and the standard deviation was as high as 0.90. According to Fox (1987a), the reproducibility which one may expect when making replicate analysis of one sample, with penetrometer methods used in this study, is limited and the variation may go as high as 30%.

Another cause of fluctuations in the results might be the fact that the replicate samples used for analysis were taken randomly from different parts of the cheeses (some from the surface and others from the center). This might have increased the error since cheese is known to be softer in the center where ripening changes are believed to be more rapid than on the surface (Fox, 1987a; Varnam & Sutherland, 1994).

The lactose content of the Feta cheeses was found to be almost negligible from the second day after renneting of the cheese milk. This supports Cogan's (1995) statement that "generally lactose is undetectable in cheese 24 h after manufacture". This could be caused by the fact that a very high proportion of lactose is lost in the whey during the initial stages of cheesemaking, and the addition of the starter culture resulted in the biodegradation of almost all the residual lactose during the period of about 48 h before the lactose content was first determined (Cogan, 1995).

The sensory evaluation scores of the Feta cheeses which was obtained after ripening the cheeses for a period of three weeks, indicated that there was no significant ($p > 0.05$) difference in acceptability between Feta cheeses made from different proportions of the cow's milk and the goat's milk mixture. The overall score for all the Feta cheeses was "like slightly". Despite the fact that the Feta cheeses differed significantly in some of the chemical and physical quality aspects, there was no specific cheese which was more preferred than others.