Journal of Food Science and Engineering 6 (2016) 215-226
doi: 10.17265/2159-5828/2016.04.004

Effect of Fortifying Camel Milk with Sheep Milk on the Processing Properties, Chemical Composition and Acceptability of Cheeses

Abdl Whap M. A. Derar and Ibtisam E. M. El Zubeir

Department of Dairy Production, Faculty of Animal Production, University of Khartoum, Khartoum, P. O. Pox 321, Sudan

Abstract: This study investigates the properties of cheeses made from camel milk, sheep milk and their mixtures. Cheeses were made using Camifloc enzyme as a coagulant after addition of calcium chloride. Camel's milk was mixed with sheep's milk at the levels of 25%, 50% and 75%. Then, the cheeses were stored for 21 days in the whey at room temperature (37-40 °C). The study revealed that fortifying camel's milk with sheep's milk improved the processing properties of camel milk for cheese making. The addition of 50% sheep's milk to camel's milk reduced the coagulation time to about 46.15%. The addition of 25%, 50% and 75% sheep's milk to camel's milk revealed yield of 13.76%, 21.33% and 26.2%, respectively. However, the cheese made from pure camel's milk and sheep's milk revealed yield of 10.66% and 23.53%, respectively. There were significant ($P < 0.001$) differences in total solids, protein, fat, ash, acidity and overall acceptability among the cheeses made from different types of milk. The cheeses made from camel's milk after addition of 75% and 50% sheep's milk were the most acceptable compared to other cheeses. Hence sheep's milk could be added to camel's milk for improvement of cheese properties.

Key words: Camels, sheep, milk, cheese processing, composition, sensory characteristics, Camifloc enzyme.

1. Introduction

Reports on the manufacture of camel cheese are rare and often contradictory [1]. This might be due to difficulties in making camel cheese that include longer coagulation time and weak coagulum [2]. The rennet coagulation of camel milk is two to four times slower than for cow's milk treated under the same conditions [3]. The limited ability of camel milk to be coagulated by enzymes is probably largely due to the composition of casein micelles, moreover the kappa casein, representing the micellar fraction which reacts with the clotting enzymes, has different electro-potential from cow's milk, which cause lower electrophoretic mobility [4]. Nevertheless, soft unripened cheese can be made from camel milk, and the difficulties in making camel cheese most probably arise from the technique which is being used [5]. Various types of soft cheeses from camel were tried [1, 5-8]. Some authors [3, 5, 7] reported that the addition of calcium chloride and rennet to camel milk caused a clotting reaction and the formation of a soft light coagulum.

Despite all the possible physico-chemical adjustments, and the type and concentration of coagulant used, the yield of cheese from camel milk cannot be expected to reach that obtained from other species milk [7, 8]. The low content in kappa-casein and its ratio to total proteins in addition to the lack of β-lactoglobulins are the main factors that limit cheese making performances from camel milk [9]. Further build of the coagulum is slow and weak [3, 7, 10]. The gel texture is characterized by low elasticity and high fragility. Moreover, the fragility of the curd is increased where acid fermentation occurs [11, 12]. Higher yield of cheese from camel milk was obtained when using starter culture [1, 13-15] or calcium chloride [5, 7, 8]. The sensory features of camel milk cheese are light, soft coagulum with a moist paste [8].

Corresponding author: Ibtisam E. M. El Zubeir, Prof., research fileds: milk production, qualit control of milk and dairy products, milk hygieney and safety, dairy processing.

The camel cheese was highly satisfactory, with the smooth texture, sharp taste and intense acid flavor [2].

Sheep population in Sudan was estimated as 52.079 million heads [16]. This numbers ranks Sudan among the 5 countries in owing sheep. However camel's and sheep's dairy products are not so common, but they can play an important role in human nutrition in many arid and semi-arid countries [17]. Because sheep milk is mainly used for the manufacture of cheese [18], the present study was carried out to assess the processing properties and sensory evaluation of fresh soft cheese made from camel, sheep and their mixtures milk during the storage of the cheeses.

2. Material and Methods

2.1 Source of Milk, Camifloc and Salt

The present study was conducted during the period of June to September 2009. Fresh camel's milk was obtained from Camel Research Center (12.5 liter), University of Khartoum, while fresh sheep's milk (12.5 liter) was obtained from a private farm in Khartoum North, Khartoum State. Camifloc powder (calcium phosphate and vegetable rennet) is a product from Bio Serae Laboratories, Bram, France, which was recommended by FAO [19] obtained from the Department of Animal Production, Ministry of Animal Resources. Calcium chloride is a product of Merck (Denmark). The salt (commercial grade) was obtained from the local market.

2.2 Cheese Processing

Three batches of five types of milk: camel's milk, sheep's milk and mixtures of camel's and sheep's milk (25%, 50% and 75%) were used. The milk samples, after milking, were kept in the refrigerator (4 °C) for 15-18 hours brought to room temperature (37 °C) before use. Five treatments of cheeses were made from the five types of milk under the same conditions using Camifloc enzyme, calcium chloride and sodium chloride. The cheeses were made using the available cheese making equipment at the laboratory of the Department of Dairy Production, Faculty of Animal Production, University of Khartoum. The milks were first filtered using clean white cheese cloth, and then the milks were heated to 62 °C for 15 minutes and then cooled for 5 minutes in an ice water. The pH values of the milks were measured using a pH-meter, and then the cheeses were made as described previously [7, 8]. One sachet was diluted into half glass of drinking water and added to 5 liter of milk samples at 30-32 °C and no starter culture used. Calcium chloride was added at the rate of 0.03% (w/v) according to El Zubeir and Jabreel [7]. After coagulation, the curds were cut into one inch cube shape and left for one hour. The curds were placed into clean cheese cloths that were hung over a long hanging metal cheese disk and left to drain over night (room temperature of about 30-35 °C) to allow the drainage of whey that received into clean pots. In the next day, the cheeses were cut into one squire inch pieces. The cheese whey's were salted using commercial salt NaCl (2% w/v) and poured into glass packaging that used for preservation of the cheeses that kept for three weeks at room temperature (37-40 °C).

2.3 Evaluation of Milk, Cheese and Whey

Coagulation time, cheese yield, chemical composition and sensory characteristics were estimated for all types of milks, whey and cheeses at the laboratory of Department of Dairy Production, Faculty of Animal Production—University of Khartoum.

2.4 Cheeses Yield

Cheeses yield were calculated as the weight of cheese divided by weight of milk expressed as a percentage.

2.5 Analysis of Milk, Cheese and Whey

The fat content of milk, cheese and whey were determined by Gerber's method and the protein

content was determined by the Kjeldahl method [20]. The total solids and the ash content and the titratable acidity were determined according to the method of AOAC [20].

2.6 Sensory Evaluation

Ten panelists, untrained however they are familiar with cheeses, were asked to judge on the quality of cheeses using sensory evaluation sheet. The sensory attributes that were initially established by Zubeir and Jabreel [7], using 4 scales, were used as follows: The sensory evaluation sheet stated the score for appearance as acceptable, slightly acceptable, moderately unacceptable and not acceptable. The flavor scores were extremely intense, moderately intense, slightly acceptable and bland. However the scores for taste of the cheeses were stated as absent, slightly acidic, acidic and excessive acidic. The texture scores of the cheeses were smooth, slightly smooth, harsh and pasty. The saltiness of the cheeses was evaluated as moderately salted, salted, over salted and absent of salt. However the overall acceptability of camel and sheep cheeses were reported as acceptable, slightly acceptable, moderately acceptable and not acceptable.

2.7 Statistical Analysis

Data were analyzed by SPSS (Statistical Package for Social Science) program (Version 10.5) using Completely Randomized Design (CRD). The analysis was carried out by ANOVA test and Dunkan multiple ranges test to indicate the differences between means. Also Chi-squire test was used to analyze sheet of panel tests.

3. Results

3.1 Chemical Composition of Milk and Cheese Whey Produced from Camel, Sheep and Their Mixtures Milk

Chemical composition of sheep milk revealed higher values for total solids, protein, fat and solids not fat compared to that of camel milk and their mixtures with sheep milk, while significantly ($P < 0.05$) higher ash value was obtained for camel milk compared to sheep's milk. The means of pH of camel's milk was lower compared to that of sheep's milk (Table 1).

The total solids, protein, fat and ash of whey cheeses were significantly ($P < 0.05$) higher for pure camel milk compared to that obtained after addition of sheep milk (Table 3).

3.2 Cheese Yield

The yield of cheese made from camel's milk (10.67% ± 4.02%) recorded the lowest value (533.33 ± 246.64 grams). Higher yield of cheese from camel milk was obtained after addition of different percentages of sheep milk. The addition of 25%, 50% and 75% sheep's milk to that of camel's revealed higher yield compared to the of sheep milk (23.53% ± 5.49%) as shown in Table 2.

Table 1 Chemical content of camels, sheep and their mixture milks.

Parameters	Type of milk					LS
	Camel's milk	Camel's milk: sheep's milk (75%: 25%)	Camel's milk: sheep's milk (50%: 50%)	Camel's milk: sheep's milk (25%: 75%)	Sheep's milk	
	Means ± SD	Means ± SD	Means ± SD	Means ± SD	Means ± SD	
Total solids (%)	11.39 ± 0.42^{c}	13.26 ± 0.48^{b}	13.61 ± 0.40^{b}	14.58 ± 0.4^{a}	16.42 ± 0.29^{a}	***
Protein (%)	3.05 ± 1.88^{c}	3.31 ± 0.28^{c}	3.58 ± 0.27^{b}	3.78 ± 0.27^{b}	4.64 ± 0.99^{a}	***
Fat (%)	2.66 ± 0.49^{c}	2.98 ± 0.57^{c}	3.65 ± 0.54^{b}	4.02 ± 0.59^{a}	4.66 ± 0.47^{a}	***
Ash (%)	0.99 ± 0.22^{a}	0.68 ± 0.56^{b}	0.49 ± 7.41^{c}	0.73 ± 6.69^{a}	0.65 ± 5.73^{b}	***
S.N.F (%)	7.60 ± 0.68^{c}	8.02 ± 0.95^{c}	9.17 ± 0.52^{b}	9.41 ± 0.31^{b}	11.57 ± 2.43^{a}	***
Density (%)	1.027 ± 2.50^{c}	1.029 ± 2.35^{c}	1.033 ± 1.82^{b}	1.033 ± 1^{b}	1.0417 ± 1.44^{a}	***
pH	6.30 ± 0.30^{c}	6.31 ± 0.23^{c}	6.44 ± 0.18^{b}	6.56 ± 0.13^{ab}	6.59 ± 0.17^{a}	***

[a, b, c]: Values in the same row bearing different superscript letters are significantly different ($P < 0.05$).

L.S = Significant level *** = Significant ($p < 0.001$) SD = Standard deviation.

Table 2 Yield and coagulation time of cheese made from camels, sheep and their mixtures milk

Type of cheese	Cheese properties (Means ± SD)	
	Yield (%)	Coagulation time (minutes)
Camel's milk cheese	10.67 ± 4.02	260.51 ± 7.07
Camel's milk: sheep's milk (75%: 25%)	13.76 ± 1.67	161.66 ± 6.23
Camel's milk: sheep's milk (50%: 50%)	21.33 ± 4.49	140.44 ± 10.27
Camel's milk: sheep's milk (25%: 75%)	26.2 ± 5.37	85.5 ± 7.07
Sheep's milk cheese	23.53 ± 5.49	74.25 ± 14.14

SD = Standard deviation.

Table 3 Chemical content of whey separated from cheeses made from camels, sheep and their mixtures milk

Parameters	Type of whey					LS
	Camel's milk	Camel's milk: sheep's milk (75%: %25)	Camel's milk: sheep's milk (50%: 50%)	Camel's milk: sheep's Milk (25%: 75%)	Sheep's milk	
	Means ± SD	Means ± SD	Means± SD	Means± SD	Means ± SD	
Total solids (%)	5.11 ± 1.99^{a}	4.49 ± 1.65^{b}	3.68 ± 0.75^{c}	4.66 ± 1.71^{c}	4.92 ± 1.72^{b}	***
Protein (%)	2.52 ± 0.88^{a}	2.48 ± 1.58^{b}	1.36 ± 1.90^{c}	2.13 ± 1.93^{ab}	1.53 ± 1.66^{c}	***
Fat (%)	2.27 ± 1.57^{a}	1.86 ± 1.23^{b}	0.64 ± 0.63^{c}	1.16 ± 1.49^{b}	0.36 ± 0.13^{d}	***
Ash (%)	0.59 ± 0.75^{a}	0.58 ± 0.88^{ab}	0.33 ± 0.77^{c}	0.53 ± 1.28^{bc}	0.57 ± 1.66^{b}	***

$^{a, b, c}$: Values in the same row bearing different superscript letters are significantly different ($P < 0.05$).

L.S = Significant level *** = Significant ($P < 0.001$) SD = Standard deviation.

Table 4 Effect of type of milk on the chemical composition of cheeses made from camels, sheep and their mixtures milk.

Parameters	Types of cheeses					LS
	Camel's milk	Camel's milk: sheep's milk (75%: 25%)	Camel's milk: sheep's milk (50%: 50%)	Camel's milk: sheep's milk (25%: 75%)	Sheep's milk	
	Means ± SD	Means ± SD	Means ± SD	Means ± SD	Means ± SD	
Total solids (%)	44.47 ± 5.07^{c}	46.13 ± 7.57^{b}	48.40 ± 2.79^{a}	47.20 ± 11.58^{c}	47.83 ± 3.84^{b}	***
Protein (%)	16.41 ± 3.60^{c}	17.99 ± 2.66^{b}	21.85 ± 3.87^{a}	21.41 ± 3.98^{a}	21.78 ± 5.16^{a}	***
Fat (%)	16.56 ± 2.95^{e}	18.10 ± 3.78^{c}	21.28 ± 2.28^{b}	22.21 ± 2.23^{a}	23.08 ± 3.06^{a}	***
Ash (%)	1.64 ± 0.38^{b}	1.61 ± 0.79^{b}	1.42 ± 0.53^{c}	1.73 ± 0.70^{a}	1.62 ± 0.84^{b}	***

$^{a, b, c}$: Values in the same row bearing different superscript letters are significantly different ($P < 0.05$).

L.S = Significant level *** = Significant ($P < 0.001$) SD = Standard deviation.

3.3 Coagulation Time

The average coagulation time (minutes) of cheese made from camel's milk was 260.51 ± 7.07 minutes. The addition of different levels of sheep's milk to camel milk reduced the coagulation time (Table 2). Moreover the cheese made from pure sheep milk took the shortest time (74.25 ± 14.14 minutes) to coagulate (Table 2).

3.4 Chemical Composition of Cheese Produced from Camels, Sheep and Their Mixtures Milk

There were significant ($P < 0.001$) differences in compositional content between cheeses made from different types of milk as shown in Table 4.

3.5 Titratable Acidity

The acidity of whey of camel's cheese revealed

lower value (0.33% ± 0.86%) compared to that made from sheep (0.47% ± 0.89%), while the mixture of camel and sheep milks revealed intermediate values as was shown in Fig. 1. Moreover there were significant ($P < 0.001$) differences in titratable acidity between the cheeses made from the different types of milk as shown in Fig. 1.

3.6 Sensory Evaluation

The cheeses appearance as reported by the panelist indicated that there were significant ($P < 0.001$) differences between appearance in the different types of cheeses and during storage period (Figs. 2 and 3). Similarly there were significant ($P < 0.001$) differences in flavor between the types of cheeses produced from camel's milk: sheep's milk (25%: 75%) and cheese produced from sheep's milk received the highest flavor score compared to cheese made from camel's milk and cheese made from camel's milk: sheep's milk (75%: 25%) as shown in Figs. 2 and 3. Also significant ($P < 0.001$) differences were found for the taste of the cheeses made with different types of milk. The most acceptable taste was that of camel's milk: sheep's milk (50%: 50%) cheese followed by camel's milk: sheep's milk (75%: 25%) cheese and camel's milk: sheep's milk (25%: 75%) cheese compared to the cheese made from sheep's milk and camel's milk, respectively (Figs. 2 and 3). The data shown in Figs. 2 and 3 showed significant ($P < 0.001$) differences in the texture of the cheeses made from the different types of milk during storage period. Cheese made from camel milk had a pasty texture according to the panelists. However the addition of 50% and 75% of the sheep's milk improved cheese texture. The data showed significant ($P < 0.001$) differences in saltiness scores for the cheeses made from the different types of milk during storage period (Figs. 2 and 3). The overall acceptability revealed significant ($P < 0.001$) differences among cheeses made from the different types of milk during storage period (Figs. 2 and 3). Moreover the cheeses made from camel's milk after addition of 75% and 50% sheep's milk were the most acceptable compared to those of 100%, 25% and 0% sheep's milk.

4. Discussion

The data obtained for the chemical composition of camel's milk and sheep's milk (Table 1) supported the previous reports [17, 21]. The present study has shown that the Camifloc enzyme was useful in processing camel cheese, which supported El Zubeir and Jabreel [7] who reported that there was a possibility of making cheese from camel milk using Camifloc enzyme and that if calcium chloride is added, a higher yield can be obtained.

The cheese yield obtained using camel milk in the present study was reported as 10.67% (Table 2) which is similar to the finding that obtained 10.5%-11.5% [7]. The cheese yield obtained using sheep's milk was reported as 23.53%, which agreed with Wendorff [22] who reported that sheep milk have a cheese yield of 16%-22%. The addition of sheep's milk to camel's milk at 25% and 50% increased cheese yield to 13.76% and 21.33%, respectively. Both yields were very comparable to those found previously [23]. The lower yield obtained from pure camel milk compared to that fortified with sheep milk (Table 2) was also in accord to the previous findings [7, 17]. The lower yield might be due to the higher total solids of the whey as more than 50% were found in the cheese whey (Table 3). The recovery of dry matter in cheese produced from camel milk is limited to about 30% [2]. However the higher yield of cheese done after addition of sheep milk to that of camel might be due to the fact that the fat globules in sheep milk are nearly totally incorporated into the casein network during the clotting process. The interactions of the fat globule and protein influence the structure of the curd and the cheese yield [24, 25].

Whey obtained from camel's milk cheese contained higher content of fat, total solids and ash (Table 3). The composition of camel whey is characterized by

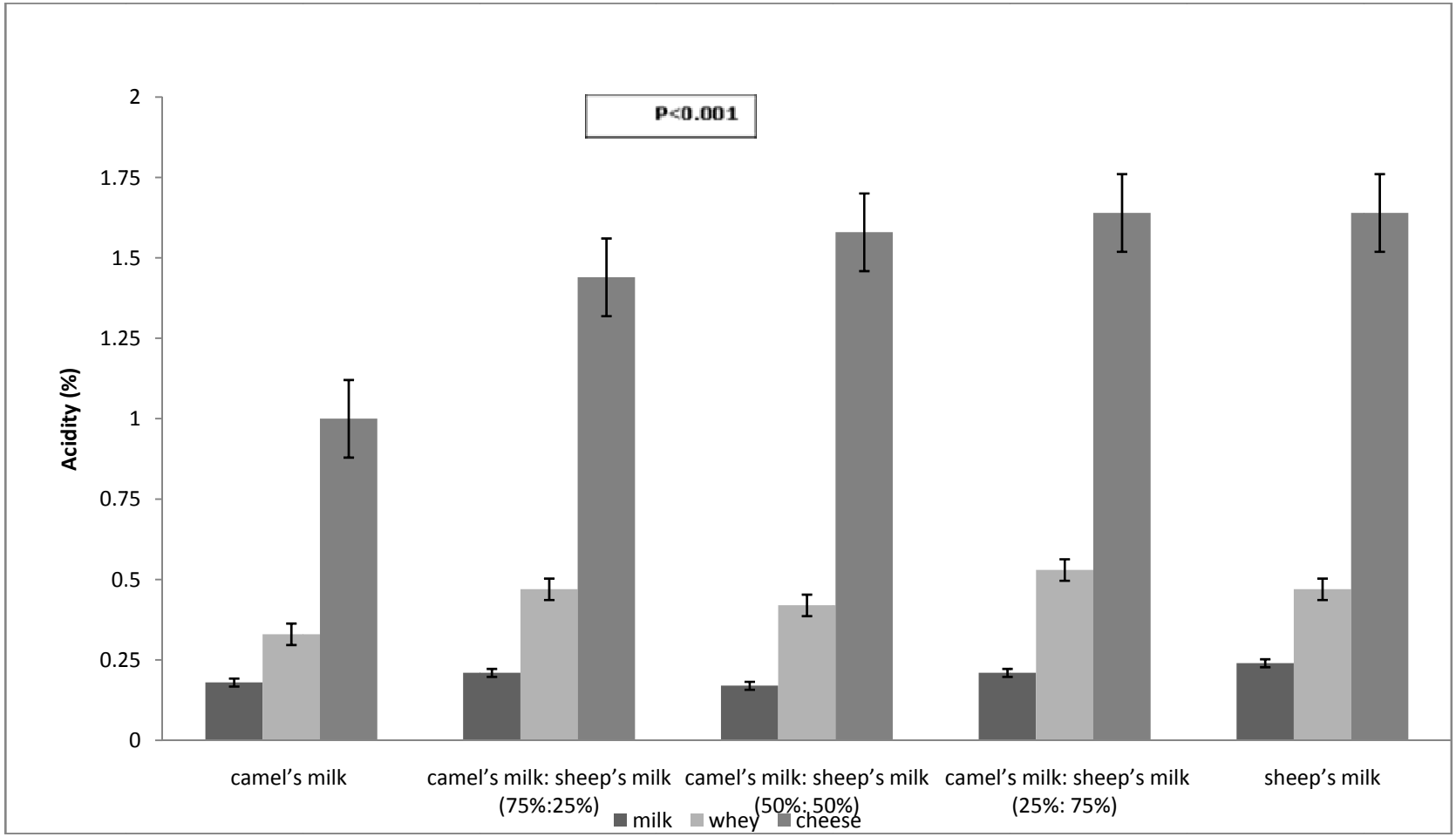

Fig. 1 The acidity of cheeses and whey made from camels, sheep and their mixture milks.

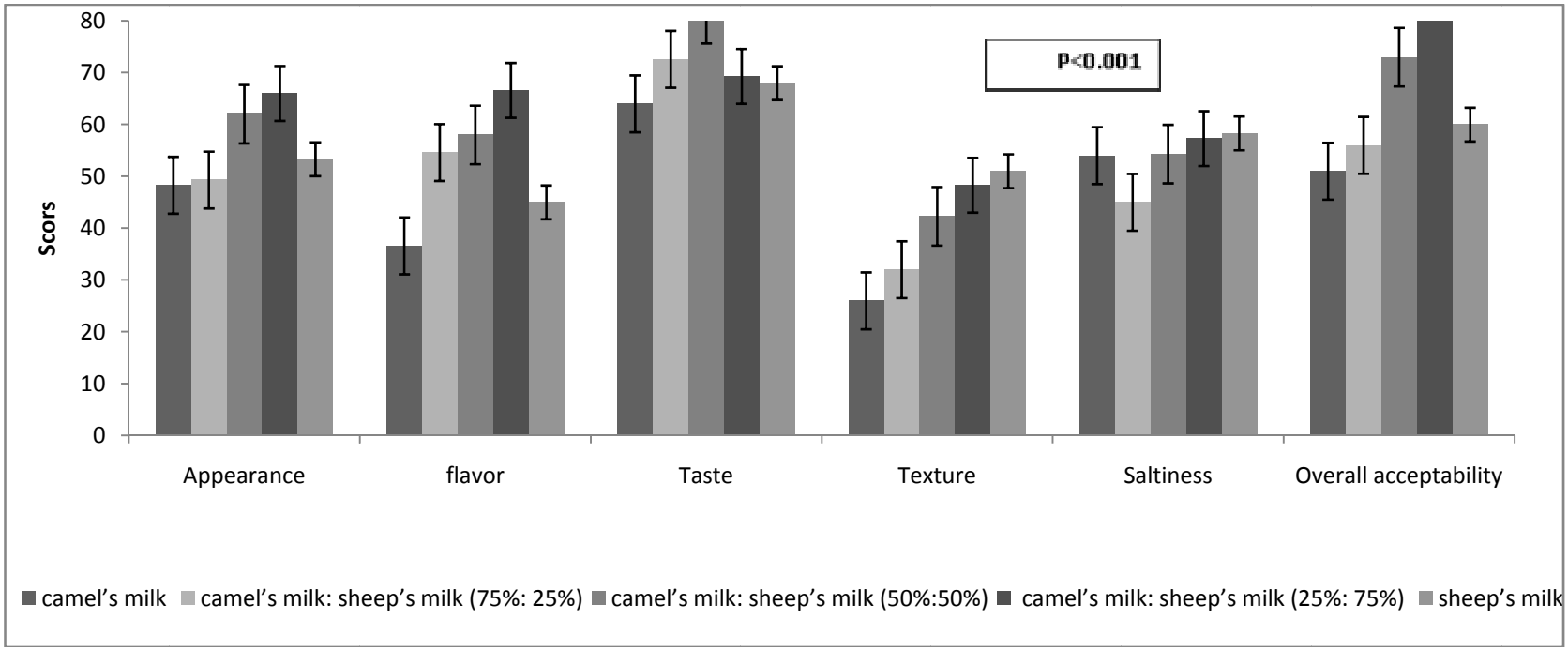

Fig. 2 Effect of type of cheese on acceptability of cheeses made from camels, sheep and their mixtures milk.

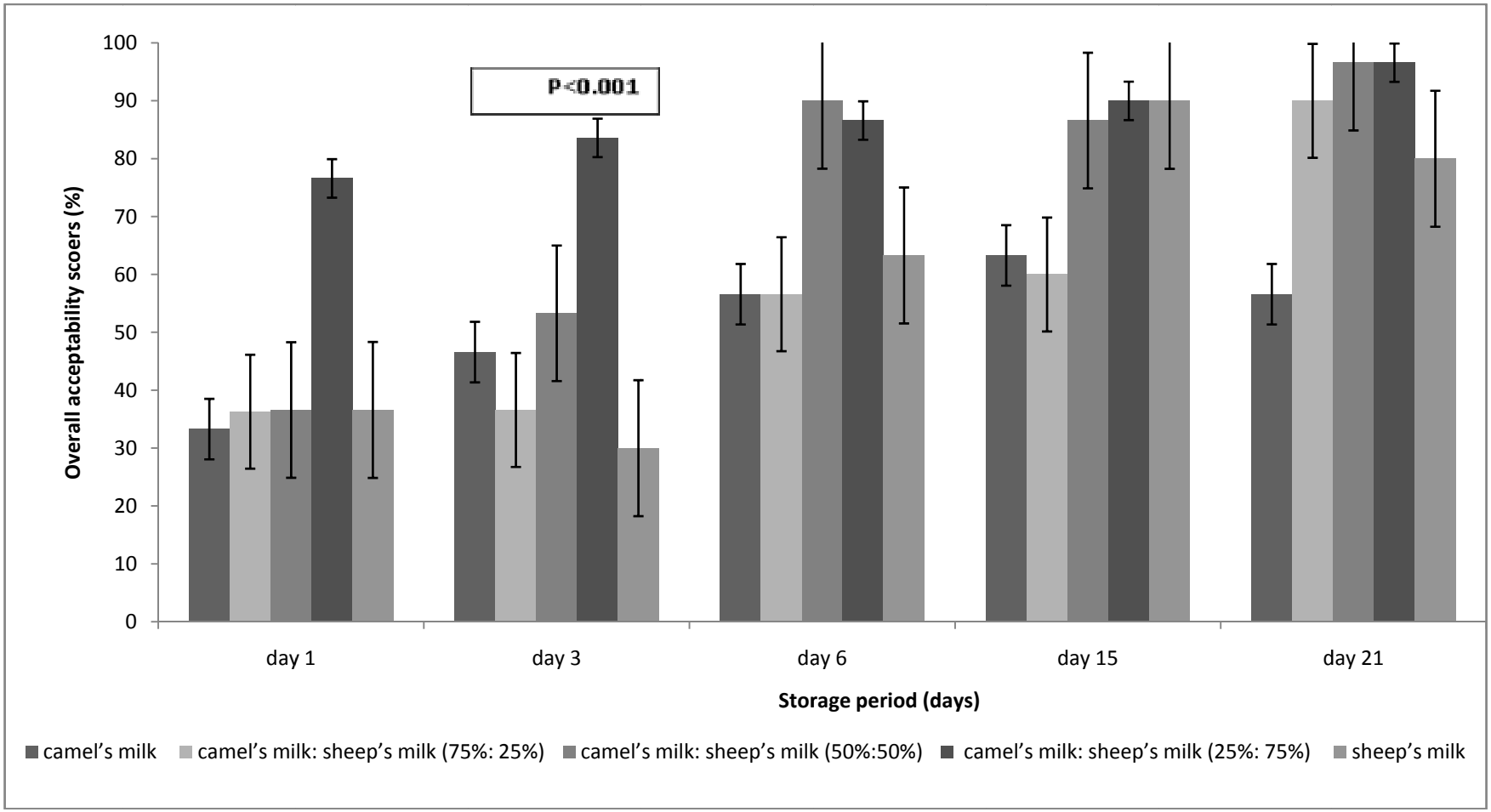

Fig. 3 Effect of the storage period on overall acceptability of cheeses made from camels, sheep and their mixtures milk.

higher total solids than cow's milk, and the recovery of dry matter increases to about 50% for cow's milk and 68% for sheep's milk under similar manufacturing conditions [2]. This could be also explained by the whiter color of the whey [2, 7].

The higher fat content in some of the cheeses' whey might be due to the smaller size of fat globules and the fragility of the casein micelle network [2]. Whey obtained from cheese made from camel's milk: sheep's milk (50%: 50%) contained the lowest content of protein, total solids and ash compared to other types (Table 3). This showed an increase in the content of the solids being held in the clot. Sheep whey generally has 10%-15% more solids than cow and goat whey [26].

The present study has shown the relationship between increased yields and reduced coagulation time (Table 2). The addition of 50% sheep's milk to that of camel's reduced the coagulation time to about 46.15%. The fortifying camel milk with sheep's milk at levels of 10% reduced the coagulation time by about 30% [2]. Moreover the fortifying camel milk with sheep's milk at levels of 10 to 50 percent has a beneficial effect on coagulation and draining [12]. The limited ability of camel milk to be coagulated by enzymes is probably due to the composition of casein micelles as the kappa casein, representing the micellar fraction which reacts with the clotting enzymes, has different electro-potential from cow's milk, which causes lower electrophoretic mobility [4]. The low content of kappa-casein and its ratio to total proteins and the lack of ß-lactoglobulins are the main factors that limit cheese making performances from camel milk [9]. On the other hand, the addition of calcium chloride prior to rennet resulted in a reduction in clotting time and improvement in cheese properties [1, 7].

Table 4 showed the effect of various mixing of camel and sheep milk on the chemical composition of the cheeses. The total solids of camel milk cheese present in this study (44.47% ± 5.07%) was in agreement with that reported by Khan et al. [14] who found 44.36% ± 3.433% when preparing cheese from camel milk by using starter culture. The few rare cheeses made from camel milk seem to have the characteristics of perishable fresh cheese with high moisture content [2]. The highest percentage of protein was reported for the camel's milk: sheep's milk (50%: 50%) cheese (21.85% ± 3.87%) and the lowest was the camel's milk cheese (16.41% ± 3.60%). This was in agreement with that reported by Ahmed and El Zubeir [8] who found 16.12% ± 0.71%. However it was found as 21.30% ± 0.638% and 17.67 ± 1.528% when preparing cheese from camel milk using starter culture and acidification, respectively [14]. The protein contents in cheese made from mixture milks were higher than the protein content in camel milk cheese. Sheep's milk mixed with camel's milk at a 50%: 50% ratio raised the protein content of cheese. On the other hands, camel milk is considered a useful component of the diet for individuals that show allergic reactions to the protein fraction of cow, ewe or goat milk, as camel milk does not contain ß-lactoglobulin and the content of alpha-casein is much lower than in milk of other herbivores mentioned [27, 28]. Significant differences were reported in the fat content among the five types of cheeses (Table 4). The fat content of camel milk cheese obtained in this study was 16.56% ± 2.95%. It was 16.34% ± 0.19% when preparing cheese from camel milk using different salt levels [8], and 16.50% ±1.3% when preparing cheese from camel milk using acidification [14]. The addition of 25% and 50% sheep's milk to camel's revealed fat content of 18.10% ± 3.78% and 21.28% ± 2.28%, respectively. The ash content of camel milk cheese found in this study was 1.64 ± 0.38%, this comparable with 1.74 ± 0.09% when preparing cheese from camel milk by using different salt levels [8]. Similarly 1.53% ± 0.577% and 2.99% ± 1.181% were found when preparing cheese from camel milk using starter culture and acidification, respectively [14]. The ash content of

soft unripened cheese made from camel milk was 2.15% ± 0.14% [5].

Data given in Fig. 1 showed that the titratable acidity of the milk, whey and cheese revealed significant ($P < 0.001$) differences between different types of milk. The highest values of the acidity were obtained for sheep and the lowest values were obtained for camel. Similar increases in the acidity of camel cheese were reported before [7, 8]. This could be probably due to growth of lactic acid bacteria in the cheese. The acidity development is accelerated after adding 10% sheep's milk, which reduces the buffering capacity of the mix compared with camel milk alone [2]. The lower levels of camel milk acidity might be due to presence of the antimicrobial agents in the camel milk [29].

The result of the sensory evaluation revealed that appearance, texture, flavor, taste and the overall acceptability of cheeses made during the present study were affected by different types of cheeses and storage period (Figs. 2 and 3). Cheeses appearance was affected by different types of cheeses and storage period, where the appearance of cheese was acceptable in all cheeses. The flavor of cheese was more intense for cheese made from mixtures camel's milk: sheep's milk (25%: 75%) and sheep's milk cheese than the other types. This was in consistent with the report that sheep milk cheese has a strong aroma, with a strong flavor and a good after taste [30]. It was found that cheese from pure ewe's milk received higher scores for body, texture, flavor and total organoleptic quality than cheese from other milks [31].

The taste of cheese was acid in cheese made from camel's milk: sheep's milk (50%: 50%). This was the most acceptable taste compared to the other types; the cause of this might be due to the cheese made from ewe's milk seems to be less susceptible to bitterness [32]. Ewes' milk cheeses have a strong quality and authenticity image and their traditional character plays a positive role on the consumers market [33]. On the other hand, the smooth texture and sharp taste of the camel milk curd were well liked by panelists. It was concluded that cheese made from camel milk could be accepted by consumers in Sudan, provided that suitable salt concentration (1.0%) was added [8]. The somewhat chalky structure is probably a result of the reduced fat content of the cheese because of high fat losses in the whey and the weak water-binding capacity of camel milk curd (Tables 3 and 4). The sensory profile of soft camel cheese is very similar to that of low-fat soft cheese made from cow's milk [10].

The texture of cheese was pasty in the cheese made from camel's milk and camel's milk: sheep's milk (75%: 25%), the general sensory features of camel milk cheese are light, soft coagulum with a moist paste [7]. The texture of cheese was slightly harsh in sheep's milk cheese and camel's milk: sheep's milk (25%: 75%), slightly smooth in camel's milk: sheep's milk (50%: 50%) cheese (Figs. 2 and 3). El Zubeir and Jabreel [7] reported that some panelists, when asked to judge on the quality of camel cheese noticed a harsh or rough body texture. Similar observations were reported previously attributed this to the reduced fat content of the cheese, because of high fat losses in the whey and the weak binding capacity of camel milk curd [2]. The data in Table 3 and 4 also confirmed this assumption.

It is clear that the addition of sheep's milk by 50% lead to improve the texture in cheese made from camel's and sheep's milk. These results confirmed the report that curd firmness, measured by empirical and instrumental methods, was doubled after adding only 10% sheep's milk to camel milk [2].

All cheeses were reported as salty, which might be due to the addition of calcium chloride [2, 8]. Moreover it was recommended that when the Camifloc was used for making cheese from camel milk with addition of calcium chloride the rate of salting should be reduced, and further drainage and storage of the cheese should be done [7].

The cheese made from camel's milk: sheep's milk

(25%: 75%) and camel's milk: sheep's milk (50%: 50%) was the most acceptable followed by sheep's milk cheese, camel's milk: sheep's milk (75%: 25%) cheese and camel's milk cheese. It was reported before that the camel cheese was highly satisfactory, with the smooth texture, sharp taste and intense acid flavor. These supported previous work [7, 8, 11, 12, 23]. From the results, it was clear that in general; the panelists gave lower sensory scores for cheese made from 75% camel's milk: 25% sheep's milk and camel's milk cheese compared to highest scores for 25% camel's milk: 75% sheep's milk cheese and 50% camel's milk: 50% sheep's milk cheese.

5. Conclusion

The present study concluded that fortifying sheep's milk with camel's milk improved the processing properties of camel milk for cheese making. The mixing process made significant differences in the types of blended milk in all properties (improves clotting time, curd firmness and reduce curd draining with comparable yield and shelf life). The sheep's milk can be added to camel milk at rates of 50% and 75%. This may be a solution for proper utilization and preservation of both camel and sheep milk. However further research should be conducted to study the effect of mixing sheep's milk with camel milk on the mechanism of camel milk coagulation.

References

[1] Mehaia, M. A. 1993. "Fresh Soft Cheese (Domiati Type) from Camel Milk: Composition, Yield and Sensory Evaluation." *Journal of Dairy Science* 76: 2845-55.

[2] Ramet, J. P. 2001. "The Technology of Making Cheese from Camel Milk *(Camelus Dromedarius).*" In: FAO Animal Production and Health Paper. No. 113, Rome, Italy: Food and Agriculture Organization of the United Nations, 74.

[3] Farah, Z., and Bachmann, M. R. 1987. "Rennet Coagulation Properties of Camel Milk." *Milchwissenschaft* 42: 689-92.

[4] Farah, Z. 1993. "Composition and Characteristic of Camel'S Milk: A Review." *Journal of Dairy Research* 60: 603-26.

[5] Inayat, S., Arain, M. A., Khaskheli, M., and Malik, A. H. 2003. "Study of the Effect of Processing on the Chemical Quality of Soft Unripened Cheese Made from Camel Milk." *Pakistan Journal of Nutrition* 2: 102-5.

[6] Mehaia, M. A. 2006. "Manufacture of Fresh Soft White Cheese (Domiati Type) from Dromedary Camels Milk Using Ultra Filtration Process." *Journal of Food Technology* 4: 206-12.

[7] El Zubeir, I. E. M., and Jabreel, S. O. 2008. "Fresh Cheese from Camel Milk Coagulated with Camifloc." *International Journal of Dairy Technology* 61: 90-5.

[8] Ahmed, N. A. A., and El Zubeir, I. E. M. 2011. "Effect of Salt Level on Some Physical and Chemical Properties and Acceptability of Camel Milk Cheese." *Journal of Camelid Science* 4: 40-8.

[9] Zhang, H., Yao, J., Zhao, D., Liu, H., Li, J., and Guo, M. 2005. "Changes in Chemical Composition of Alxa Bactrian Camel Milk during Lactation." *Journal of Dairy Science* 88: 340-10.

[10] Ramet, J. P. 1994. "Les aspects scientifiques et technologiques particuliers de la fabrication des fromages au lait de dromadaire Comm. Coll. Dromadaires et chameaux: animaux laitiers." Nouakchott, Mauritania.

[11] Ramet, J. P. 1987. "Production de fromages à partir de lait de chamelle en Tunisie." Mission Report. Rome, FAO, 33.

[12] Ramet, J. P. 1994b. "Production de fromages à partir de lait de dromadaire en Mauritanie." Mission report. Rome, FAO, 60.

[13] Gassem, M. A., and Abu-Tarboush, H. M. 2000. "Lactic Acid Production by *Lactobacillus Delbrueckii ssp. Bulgaricus* in Camel's and Cow's Wheys." *Milchwissenschaft* 55: 374-8.

[14] Khan, H., Ather, I. H., and Aslam, M. 2004. "Evaluation of Cheese Prepared by Processing Camel Milk." *Pakistan Journal of Zoology* 36: 323-6.

[15] Benkerroum, N. 2010. "Antimicrobial Peptides Generated from Milk Proteins: A Survey and Prospects for Application in the Food Industry. A Review." *International Journal of Dairy Technology* 63: 320-38.

[16] FAO/STAT. 2011. Food and Agriculture Organization of the United Nations, Geneva, Switzerland. http://faostat.fao.org/site/604/default.aspx#ancor.

[17] El Zubeir, I. E. M., Basher, M. A. E., Alameen, M. H., Mohammed, M. A. S., and Shuiep, E. S. 2012. "The Processing Properties, Chemical Characteristics and Acceptability of Yoghurt Made from Non Bovine Milks." *Livestock Research for Rural Development* 24 (3). Available at http://www.lrrd.org/lrrd24/3/zube24050.htm.

[18] Pellegrini, O., Remeuf, F., Rivemale, M., and Barillet, F. 1997. "Renneting Properties of Milk from Individual Ewes: Influence of Genetic and Non-Genetic Variables,

and Relationship with Physicochemical Characteristics." *Journal of Dairy Research* 64: 355-66.

[19] FAO. 2001. Prod STAT. "Livestock Primary and Processed." http://faostat.fao.org/site/569/DesktopDefault.aspx?PageID=569.

[20] AOAC. 1990. "Dairy Products." Chapter 15. In: Official methods of Analysis. Association of Official Analytical Chemists, 15th ed., Washington DC. USA, 220-56.

[21] Shuiep, E. S., El Zubeir, I. E. M., El Owni, O. A. O., and Musa, H. H. 2008. "Influence of Season and Management on Composition of Raw Camel (*Camelus dromedarius*) Milk in Khartoum State, Sudan." *Tropical and Subtropical Agroecosystems* 8: 101-6.

[22] Wendorff, B. 2002. "Milk Composition and Cheese Yield." In *Proc. of 8th Great Lakes Dairy Sheep Symp*., Ithaca, NY, Nov. 7-9, Univ. of Wisconsin: Madison, 104-17.

[23] Ramet, J. P. 1990. "Processing of Dairy Products from Camel Milk in Saudia Arabia." Mission report. Rome, FAO.

[24] Cho, Y. H., Lucey, J. A., and Singh, H. 1999. "Rheological Properties of Acid Milk Gels as Affected by the Nature of the Fat Globule Surface Material and Heat Treatment of Milk." *International Dairy Journal* 9: 537-45.

[25] Lopez, C., and Dufur, E. 2001. "The Composition of the Milk Fat Globule Surface Alters the Structural Characteristics of the Coagulum." *Journal of Colloid and Interface Science* 233: 241-9.

[26] Casper, J. L., Wendorff, W. L., and Thomas, D. L. 1998. "Seasonal Changes in Protein Composition of Whey from Commercial Manufacture of Caprine and Ovine Specialty Cheeses." *Journal of Dairy Science* 81: 3117-22.

[27] Restani, P., Gaiaschi, A., Plebani, A., Beretta, B., Cavagni, G., Fiocchi, A., Poiesi, C., Velonam, T., Ugazio, A. G., and Galli, C. L. 1999. "Cross-Reactivity between Milk Proteins from Different Animal Species." *Clin. Exp. Allergy* 29: 997-1004.

[28] Shuiep, E. S., El Zubeir, I. E. M., Giambra, I. J., and Erhardt, G. 2013. "Biochemical and Molecular Characterization of Polymorphisms of α_{s1}-casein in Sudanese Camel (*Camelus dromedarius*) Milk." *International Dairy Journal 2*8: 88-93.

[29] Wernery, U., Johnson, B., and Abrahm, A. 2005. "The Effect of Short-Term Heat Treatment on Vitamin C Concentrations in Camel Milk." *Milchwissenschaft* 60: 266-7.

[30] Gonza´les-Vinas, M. A., Poveda, J., Ruiz, A. G., and Cabezas, L 2001. "Changes in Chemical, Sensory and Rheological Characteristics of Manchego Cheeses during Ripening." *Journal of Sensory Stud.* 16: 361-71.

[31] Mallatou, E. 1994. "Manufacture of Feta Cheese from Sheep Milk, Goat Milk and Different Mixtures." *International Dairy Journal* 4: 641-4.

[32] Pelissier, J. P., and Manchon, P. 1976. "Comparative study of the Bitter Taste of Enzymic Hydrolysates from Cow, Ewe and Goat Caseins." *Journal of Food Science* 41: 231-3.

[33] Freitas, C. A., and Malcata, F. X. 2002. "Microbiology and Biochemistry of Cheeses with appe'lation d'origine proteg'e and Manufactured in the Iberian Peninsula from Ovine and Caprine Milks." *Journal of Dairy Science* 83: 584-602.