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Manufacture of Fresh Soft White Cheese (Domiati-Type) from Dromedary Camels' Milk Using Ultrafiltration Process

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Abstract: Manufacturing procedures and composition of fresh soft white cheese manufactured from camels' milk using ultrafiltration (UF) and conventional processes were compared. Cheese yield, recovery of protein, fat and total solids and sensory properties of the cheese were also evaluated. UF process resulted in 88.5, 84.5, 88.4 and 85.9% reduction in added salt, calcium chloride, starter culture and rennet and 80% processing time reduction. UF cheese was higher in pH and moisture contents and lower in the protein and fat contents. Increment rates achieved by UF process were 45% in cheese yield, 40% in protein recovery, 42% in fat recovery and 40% in total solids recovery. Mean sensory evaluation scores for UF cheese were significantly higher ($p<0.05$) than those recorded for conventional cheese. The UF process has the potential for developing a camels' milk cheese with high yield and good acceptability.

Key words: Ultrafiltration, camel milk, cheese, domiati cheese

INTRODUCTION

In 1992, the total population of camels in the world was estimated to be about 18.8 million, with about 73% in Africa and 27% in Asia[1]. There are two different species of camels belonging to the genus *Camelus,* namely, the dromedary camel (*Camelus dromedarius*; one-humped) and bactrian camel (*Camelus bactrianus*; two-humped). The dromedary camel is a unique producer of food in the arid and semi-arid zones of the world. It is the only animal that can exist for several weeks without water and remaining to provide its offspring and humans with milk[2].

Although camel milk has been consumed as fresh milk in traditional pastoral system for several centuries, the processing of camel milk into dairy products is not developed and camel milk products are not common. However, reports exist on manufacturing camel milk products, such as pasteurized milk[3] cheese[4-9] butter [10,11] ice cream[12] and fermented camel milk[13,14].

Domiati cheese is considered to be the most popular soft white cheese in Egypt and in other Middle Eastern countries. Domiati cheese is made mainly from buffaloes' milk, cows' milk, or a mixture of both, but it is also made from sheep or goat milk[15,16].

During the past thirty years, the use of ultrafiltration (UF) technique to concentrate milk for cheesemaking has attracted considerable[17-24]. The precheese technology known as the Maubois, Mocquot and Vassal (MMV) process[25,26] is used in many dairies in the world to produce different cheese varieties[27,28,18,19,24].

Although several reports have characterized the manufacture of Domiati cheese, from cows' milk, using MMV process[29-35] and from ultrafiltered goats' milk[36], no report was found in the literature on manufacture of fresh soft cheese (Domiati-type) from dromedary camels' milk using ultrafiltration process.

The objectives of this study were to evaluate chemical composition, yield, recovery of protein, fat and total solids and sensory characteristics of soft white cheese (Domiati-type) manufactured from camels' milk by conventional and UF processes.

MATERIALS AND METHODS

Materials: Fresh whole dromedary camels' milk was obtained from Qassim University Farm, Buriedah, Saudi Arabia. The milk was immediately cooled to 5±1°C, transported to the laboratory and maintained cold until use. Rennet powder, calcium chloride (food quality grade), a yogurt starter (B-6) (a mixed strain of *Streptococcus thermophilus* and *Lactobacillus delbrueckii sp. Bulgaricus*) was obtained from Chr. Hansen's Laboratories A/S (Copenhagen, Denmark). Table salt (sodium chloride) was obtained from a local market.

Ultrafiltration process: Sixteen kilograms of raw whole camels' milk were pasteurized at 65°C for 30 min. The pasteurized milk was cooled to 50°C before ultrafiltration (UF). UF process was conducted as described by[37].

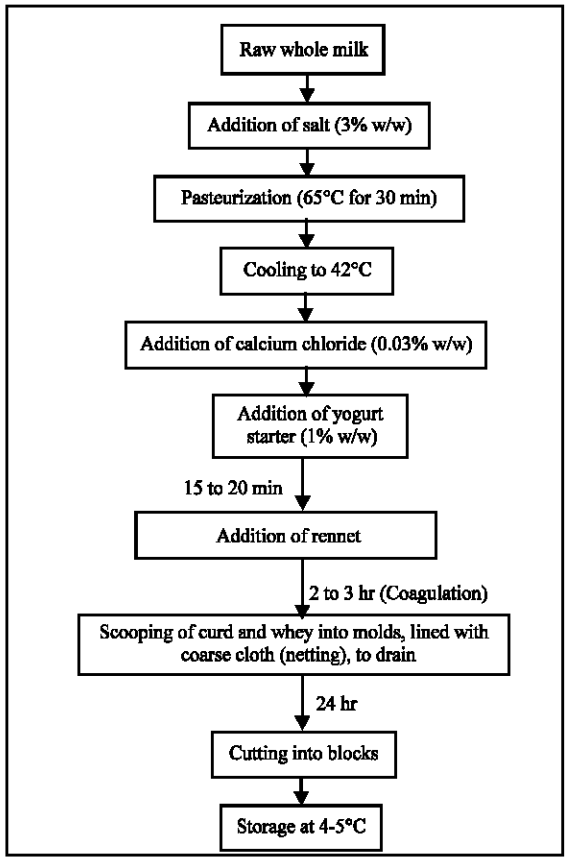

Fig. 1: Manufacturing procedure for fresh soft white cheese (Domiati-type) made from camels' milk using conventional process

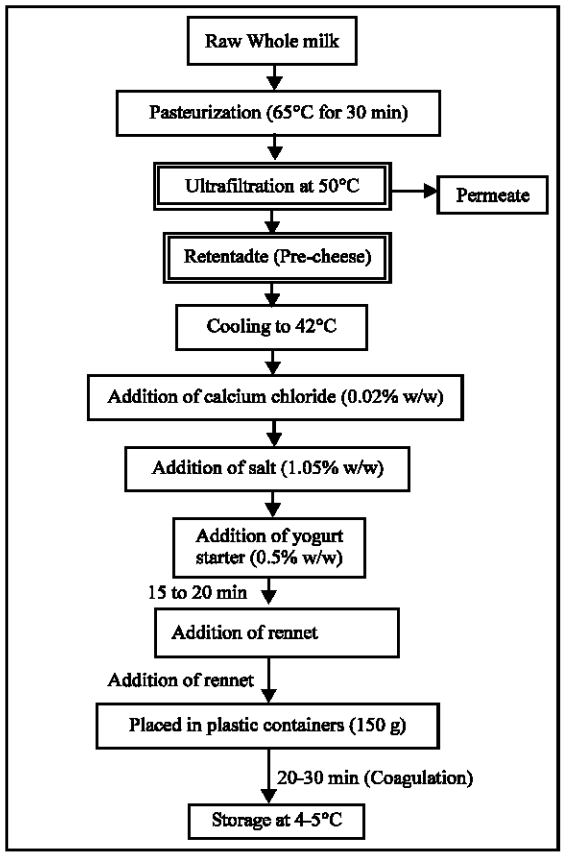

Fig. 2: Manufacturing procedure for fresh soft white cheese (Domiati-type) made from camels' milk using ultrafiltration process

Cheese manufacturing: Three cheesemaking trials were conducted at our dairy technology laboratory. Two methods, conventional and Ultrafiltration (UF) processes were used to manufacture fresh soft cheese (Domiati-type) from camels' milk. In the conventional process, 16 kg of whole camels' milk were used for producing cheese as shown in Fig. 1. In the UF process, milk retentate obtained from UF process was used for producing UF cheese as shown in Fig. 2. Cheese samples were taken for analyses after one day.

Chemical analyses: Whole milk and cheese samples were analyzed for moisture and fat as described by[38]. Nitrogen was determined by the micro-Kjeldahl method and salt (sodium chloride) by m odified Volhard test according to[39]. A nitrogen conversion factor of 6.38 was used to calculate protein content. Ash was determined by using a muffle furnace at 550°C[40]. Lactose was calculated by difference. Titratable acidity was determined by titrating 10 g of sample with 0.1 N NaOH to a pink endpoint using phenolphthalein indicator and pH was measured with an Orion pH meter (Orion Research Inc., Cambridge, MA). All analyses of milk and cheese samples were performed in duplicate. All reagents were of analytical grade.

Cheese yields and component recovery: Actual cheese yields were calculated as a weight of cheese divided by weight of milk expressed as kg 100 kg^{-1}. However, adjusted cheese yields were calculated according to Lau and colleagues equation[23]:

$$\text{Adjusted yield} = \text{Actul yield} X \frac{[100 - (\text{actul\% water} + \text{actul\% salt})]}{[100 - (\text{desired\% water} + \text{desired\% salt})]}$$

Cheese yield efficiency was calculated by dividing the actual cheese yield by percent total of fat, protein or total solids in milk. Component (protein, fat and total solids) recovery was calculated as the weight of the component in the cheese divided by the original weight of the component in the milk expressed as kg 100 kg^{-1}.

Sensory evaluation: Sensory evaluation of cheeses was performed after one day of storage at 5±1°C. A panel of

12 University faculty and staff members who were familiar with soft cheese (Domiati-Type) evaluated the cheeses. Sensory attributes of appearance, texture, flavour and overall acceptability was considered by the panelists. A nine-point hedonic scale[41] was utilized in this study (9 = like extremely; 5 = neither like nor dislike and 1 = dislike extremely). Panelists were also asked to list defects, if any were detected. The cheeses were randomly coded with three-digit numbers. Cheeses manufactured on the same day were evaluated together. Each attribute was separately scaled and analyzed. Sensory attributes were analyzed for significance along with the other measurements as described in the Statistical Analysis section.

Statistical analysis: Data from the cheesemaking trials were statistically analyzed using analysis of variance of the SAS package[42]. Standard Error (SE) of the means was derived from the error mean square term of the ANOVA. If the F test for the treatments within each trial was significant ($p<0.05$), a protected Least Significant Difference test (LSD) was used to compare treatment means.

RESULTS AND DISCUSSION

Cheese manufacturing: Cheese was difficult to make from camels' milk under natural conditions, this may be due to the differences in availability of ê-casein[43], but success was achieved when pH of milk was decreased or calcium chloride was added[6,7,44-50] or when 50 to 70 times the normal amount of rennet was used[51,45]. Our previous reports[6,7] on cheesemaking from camels' milk, using conventional method, indicated that a good fresh soft cheese could be produced with yogurt or lactic fermentation starter culture.

Figure 1 and 2 shows the manufacturing procedures for fresh soft cheese (Domiati-type) from camels' milk using conventional and ultrafiltration (UF) processes. Processing parameters and composition of milk used for camels' milk cheese are summarized in and Tables 1 and 2. The UF process showed reduction rates of 88.5, 84.5, 88.4, 85.9 and 80% in salt, calcium chloride, starter culture, rennet added and in processing time, respectively[22]. Reported that the amount of rennet needed for Domiati cheese made from ultrafiltered cows' milk to a concentration factor of 4 (34% dry matter) could be reduced by 90%[26]. Reported that UF process saves 80% of the quantity of rennet usually needed for the preparation of a given weight of cheese[36]. Reported that Domiati cheese made from goats' milk using UF process showed 83-85, 83.3, 75, 82.5 and 75% reduction in total process time, salt, starter culture, rennet and calcium chloride used, respectively. However, production of Domiati cheese by UF process also eliminates the disposal problem associated with the highly salted whey of the conventional process.

Chemical composition of cheese: Chemical composition of the Domiati-type cheese made from camels' milk is shown in Table 3. Cheese made from camels' milk using the conventional or the UF process was similar in moisture, fat, protein, salt and ash contents but significantly different in acidity and pH. Cheese made with the UF process had higher moisture content and lower fat and protein contents than did cheese produced by the conventional process. The pH and acidity of UF cheese were significantly ($p>0.05$) higher than those of cheese produced by conventional process. This difference appears to be due to the high buffering capacity occurred in cheeses made with the UF process[52-55]. In general the chemical composition of fresh soft cheeses, made from camels' milk, by the UF process, were within the normal composition range for fresh soft Domiati cheese made from cows' milk[15,29-32,35] or goat's milk[36].

Cheese yields: Yield and recovery of protein, fat and milk total solids of cheeses made from camels' milk are shown in Table 4, clearly indicating that UF cheese yields are higher than those produced by conventional process. For comparison of cheese yield between different vats, adjusted cheese yield at 60% moisture was calculated. Given the original amount of milk and the amount of retentate from the UF process and considering that there was practically no whey loss from packaged cheese, the adjusted cheese yield of UF cheeses was 20.2% whereas the adjusted cheese yields of conventional cheeses was 13.9%. An increase of 45% in adjusted cheese yields was achieved by UF process, because increased recovery of proteins, fat and milk total solids. However, incorporation of whey proteins raises cheese yield, due to the higher moisture level in UF cheeses resulting from the greater water holding capacity of whey proteins[56]. The average actual cheese yield obtained from camels' milk (14.9%), using conventional, was in agreement with that reported by[6], 14.8%. This low yield of conventional cheese may have been caused by the lower moisture content in the cheese and by lower recovery of protein, fat and solids of cheeses[6] and[5] observed that more than 50% of the camels' milk total solids, during cheese making using conventional method, were retained in the whey, which was white.

El-Itofi[33] reported that the yield of Domiati cheese produced from ultrafiltered cows' milk could be increased

Table 1: Manufacturing parameters for fresh soft white cheese (Domiati-type) made from camels' milk

Process	Conventional	Ultrafiltration	% Reduction
Raw milk (Kg)	16	16	-
Retentate (Kg)	-	3.7	36.9
Salt used (g)	480 (3 % w/w)	55.5 (1.5 %w/w)	88.5
Starter used (g)	160 (1 %w/w)	18.5(0.5 %w/w)	88.4
Rennet used (g)	3.2	0.45	85.9
Calcium chloride (g)	4.8 (0.03 %)	0.74 (0.0 2%)	84.5
Total process time (hr)	30	6	80

Table 2: Chemical composition (mean±SD)[1] of whole camels' milk used for manufacture of fresh soft white cheese (Domiati-type)

	g 100g^{-1}					
pH	TA[2]	Moisture	Fat	Protein[3]	Lactose	Ash
6.62±0.04	0.15±0.02	87.98±0.15	3.6±0.2	3.20±0.14	4.41±0.08	0.81±0.03

[1]Means of duplicate analyses on each of three trials. [2]TA = titratable acidity. [3]Protein: total nitrogen x 6.38

Table. 3: Chemical composition of fresh soft white cheese (Domiati-type) made from camels' milk[1]

Sample[2]	pH	TA[3]	Moisture	Fat	Protein	Salt	Ash
				g 100g^{-1}			
CC	5.78^{b}	0.49^{b}	61.96^{b}	16.91^{a}	14.81^{a}	2.11^{a}	3.22^{a}
UFC	6.31^{a}	0.59^{a}	64.15^{a}	15.50^{b}	13.35^{b}	1.50^{b}	3.21^{a}

[1] Means of duplicate analyses on each of three trials. Means with same letter in the same column are not significantly different ($p<0.05$). [2]CC: conventional cheese; UFC: ultrafiltration cheese. [3]TA = titratable acidity

Table 4: Mean[1] yields and recovery of fat, protein and total solids of fresh soft cheese (Domiati-type) made from camels' milk

			Recovery (%)		
Cheese sample[2]	Actual yield	Adjusted Yield[3]	Fat	Protein	Total solids
CC	14.9^{b}	13.9^{b}	70.0^{b}	69.0^{b}	47.2^{b}
UFC	23.2^{a}	20.2^{a}	100.0^{a}	97.0^{a}	66.2^{a}

[1]Means of duplicate analyses on each of three trials. Means with same letter in the same column are not significantly different ($p<0.05$). [2]See Table 3. [3]Cheese corrected to 60% moisture

Table 5: Mean[1] yields efficiencies of fresh soft white cheese (Domiati-type) made from camels' milk

Cheese sample[2]	Cheese[3]		
	Fat	Protein	Total solids
CC	3.86^{b}	4.34^{b}	1.16^{b}
UFC	5.61^{a}	6.31^{a}	1.68^{a}

[1]Means of duplicate analyses on each of three trials. Means with same letter in the same column are not significantly different ($p<0.05$). [2]See Table 3. [3]Cheese corrected to 60% moisture

by about 31%[22]. Reported that the yield of UF Domiati cheese was increased by about 20% and the UF cheese had normal properties compared with the traditional product[36]. Reported that the yield of Domiati cheese produced from ultrafiltered goats' milk was increased by about 21%. However, greater cheese yields are accompanied by higher milk solids recovery. However, the average actual cheese yield obtained from camels' milk (23.2%), using UF process, was in agreement with that reported from cow milk, 20.6 to 24.6%, but was lower than that reported from buffalo's milk, 32.9 to 35.3%[16] and[34]. Cheese yield efficiencies (Table 5) expressed as kilogram of cheese (60% moisture) obtained per kilogram fat, protein, or total solids were significantly ($p<0.05$) higher for UF cheeses, confirming the advantage of UF process. Similar results reported by[36] for UF fresh Domiati cheese made from goat's milk.

Components recovery: Cheese recovery values for fat, protein and total solids are shown also in Table 4. An increase of 41.6-42.9% in fat recovery, 40% in protein recovery and 40.2% in total solids recovery was achieved by UF-process. The recovery of fat, protein, total solids was significantly ($p<0.05$) higher for UF cheeses. This was consistent with the reported findings on cows', camels' and goats' milk concentrated with UF membrane[36,55,57-60].

Sensory evaluation: Table 6 shows the mean taste panel scores for the Domiati-type cheeses made from camels' milk using conventional and UF processes. These data show that appearance, texture, flavour and overall acceptability of cheeses were affected by the manufacturing process. The mean scores for appearance, texture, flavour and overall acceptability of cheeses made using UF process, were significantly higher ($p<0.05$) than mean scores for the cheeses made using the conventional process, indicating that cheeses made by UF process were the more acceptable cheeses. No differences ($p<0.05$) were found in appearance, texture, flavour and overall acceptability between cheeses made with the two starter cultures using UF or conventional process.

[61] reported that UF Domiati cheese made from cows' milk had a uniform and closed texture, good

Table 6: Mean[1] taste panel scores for fresh soft white cheese (Domiati-type) made from camels' milk[2]

Cheese sample[3]	Appearance	Texture	Flavour	Overall acceptability
CC	6.50[b]	6.41[b]	5.91[b]	5.84[b]
UFC	8.21[a]	8.15[a]	7.50[a]	8.09[a]

[1] Means of duplicate analyses on each of three trials. Means with same letter in the same column are not significantly different ($p<0.05$). [2]Nine-point scale (9 = like extremely, 5 = neither like nor dislike and 1 = dislike extremely). [3]Table 3

appearance and better sensory properties than the cheese made by conventional process[29,61] and[35] reported that a good quality Domiati cheese was produced from cows' milk using UF process compared with that made by conventional process. Similar observations were reported by[36] for UF Domiati cheese made from goats' milk.

CONCLUSION

From the foregoing results it can be concluded that fresh Domiati cheese with good yield and acceptability can be made from camels' milk concentrated by ultrafiltration technique. Composition of UF cheeses obtained in this study compared favorably with UF Domiati cheese composition reported from cows' or goats' milk. The cheeses made by UF process was higher in pH and moisture contents, whereas the protein and fat contents were lower in cheese manufactured by the conventional process. UF cheese was higher in yield and recovery of protein and fat. The mean scores for appearance, texture, flavour and overall acceptability of the cheese manufactured by UF process were significantly higher ($p<0.05$) than those recorded by the cheese manufactured by the conventional method. The UF process has the potential for developing a camels' milk cheese with high yield and good acceptability.

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