Fresh Soft White Cheese (Domiati-Type) from Camel Milk: Composition, Yield, and Sensory Evaluation

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ABSTRACT

Manufacturing procedures and composition of fresh soft white cheeses (Domiati-type) from camel milk were characterized. Different percentages of fat and salt and two lactic starter cultures (yogurt and lactic fermentation) were used.

Yields and recovery of protein, fat, and milk total solids of cheeses were calculated. The yield was highest with cheeses made from camel milk (3% salt and 1.5% fat) and from yogurt or lactic ferment culture, whereas the yield was lowest with whole milk (3.9% fat and 0% salt). However, the average fresh cheese yield (12.29 ± 1.63%) obtained from camel milk was lower than that for cow and buffalo milks. In general, the greater soft cheese yields are accompanied by higher recovery of solids. However, more than 50% of the milk total solids were retained in the whey, which was white.

Sensory evaluation by a taste panel was conducted to determine acceptability of cheeses. The cheeses made from milk (1.5% fat and 3% salt) with lactic starter cultures were the most acceptable, whereas the least acceptable cheeses were those made from whole milk (3.9% fat) and 0 or 1% salt.

The methods investigated for soft white cheese have potential for the development of cheese with good acceptability from camel milk. However, more research is needed to improve the quality and the yield of this type of cheese.
(**Key words**: camel milk, Domiati cheese, soft white cheese)

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INTRODUCTION

For centuries in Saudi Arabia, the camel (*Camelus dromedarius*) has helped Bedouins to sustain their desert lives by providing milk and meat. The camel still plays an important role in the human diet in many hot and arid countries. In Saudi Arabia, the population of camels is estimated to be .6 million (9); most of their milk is consumed fresh. However, most Bedouin families pool the surplus camel milk with goat milk and convert it to a dry fermented product, oggtt (5, 38). Recently, pasteurized camel milk has been introduced to the local Saudi Arabian market on a very limited scale.

Domiati cheese is considered to be the most popular soft white cheese in Egypt and in other Middle Eastern countries. Domiati cheese is usually made from buffalo milk, cow milk, or a mixture but is also made from sheep or goat milk (1, 21). This soft white cheese has been made from pasteurized milks containing 1 to 6% fat and by addition of 2 to 15% salt. Domiati cheese also has been made with or without the addition of starter cultures to cheese milk (1, 12, 14, 22, 23). To avoid the use of excessive salt and to retain the typical flavor and body characteristics of Domiati cheese, various heat treatments (50 to 95°C for 15 to 30 min) of the milk and the addition of lactic cultures to the milk prior to manufacture have been studied (1, 12, 30). Single- or mixed-strain cultures of streptococci and lactobacilli in different combinations have been used by several investigators (1). Generally, starter cultures govern the flavor, body, and texture of the cheese, and help suppress the growth of pathogenic and spoilage bacteria. However, fresh Domiati cheese without starter cultures is still produced by some local cheese makers.

Although camel milk has been consumed for centuries, camel milk products are not common. Recently, however, the manufacture of camel milk products, such as ice cream (4), butter (17), and fermented camel milk (18), has been reported. Reports of possible methods for making cheese from camel milk are rare and often contradictory. Some authors (15, 26, 27, 32, 33, 40, 42) reported that the addition of calcium chloride and rennet to camel milk caused a clotting reaction and the formation of a soft light coagulum, but others (19) stated that camel milk alone cannot be coagulated with rennet. However, Rao et al. (34) and Yagil (41) reported that cheese can be successfully produced from camel milk, but only after it is mixed with the milk of other species (goats, sheep, or buffalo). However, a recent study (29) in Somalia on hard cheese manufacture from camel milk showed that hard cheese could be made from camel milk if whey culture is included.

The objectives of this work were 1) to define and to characterize the manufacturing procedures for the production of fresh soft white cheese from camel milk, 2) to determine composition and yield for cheese manufactured by different procedures, and 3) to evaluate sensory characteristics of cheese produced from camel milk by various methods.

MATERIALS AND METHODS

Materials

Fresh whole camel milk from Najdi camels, Majaheem (*Camelus dromedarius*), was obtained from a private farm near Riyadh in central Saudi Arabia. Milk was immediately cooled to 5 ± 1°C, transported to the pilot plant, and maintained cold until use. Camel skim milk was obtained by separation of raw camel milk at 45 ± 1°C, using an Electrem 1 Separator (Electro Eremeuse Constructeur, Paris, France). Rennet powder, calcium chloride, yogurt B-6 starter (a mixed strain of *Streptococcus salivarius* ssp. *thermophilus* and *Lactobacillus delbrueckii* ssp. *bulgaricus*), and lactic fermentation CH-normal 01 starter (a mixed strain of *Lactococcus lactis* ssp. *cremoris*, *Lactococcus lactis* ssp. *lactis*, and *Lactococcus lactis* ssp. *diacetylactis*) were obtained from Chr. Hansen's Lab. A/S (Copenhagen, Denmark). Salt was obtained from a local market.

Cheese Manufacturing

Three methods were used to manufacture soft white cheese from camel milk (Figure 1). One method utilized 15 L of whole milk containing 0, 1, 2, or 3% salt or milk containing 3% salt with different percentages of fat (0, 1, 2, or 3%) and rennet. The second method utilized 15 L of milk containing 3% salt, 0 or 1.5% fat, yogurt starter culture, and rennet. In the third method, lactic fermentation starter culture was used instead of yogurt starter culture. Rennet (.004%, wt/wt) was added to coagulate each milk sample within 2 to 3 h. The coagulum of each milk was ladled and left to drain for 20 to 24 h. The resultant cheeses from each trial (Table 1) were weighed, cut into blocks, packed in plastic bags, and stored at refrigerated temperature (5 ± 1°C) for 1 d until analysis.

Experimental Design and Statistical Analysis

Cheese making was divided into four trials (Table 1); each trial was designed as a randomized complete block design (37).

Data from the cheese-making trials were statistically analyzed using analysis of variance of the SAS package (36). Standard error 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 ($P < .05$), a protected least significant difference test was used to compare treatment means.

In trial 1, whole camel milk and four different percentages of salt were used to manufacture soft white cheese using the procedure shown in Figure 1. On a single day, four vats (treatments) of cheese were made simultaneously from one batch of whole milk that was split into four portions.

In trial 2, milks with 3% salt and four different percentages of fat were used to manufacture soft white cheese. Cheese was manufactured as for trial 1. For trials 1 and 2, simultaneous manufacture of four vats of cheese was replicated on 3 different d.

In trial 3, skim milk with 3% salt and two different lactic cultures (1%, wt/wt) were used to manufacture soft white cheese using the procedure shown in Figure 1. On a single day, three vats (treatments) of soft white cheese were made simultaneously from one batch of camel skim milk that was split into three portions.

In trial 4, cheese was manufactured as for trial 3, but a standardized milk (1.5% fat) instead of skim milk was used. For trials 3 and 4, simultaneous manufacture of three vats of cheese was replicated on 3 different d.

All cheese-making methods and analyses were completed for one trial before the next trial was started. All cheese making was performed at the Department of Food Science by one experienced cheese maker.

Chemical Analysis

Milk, whey, and cheese samples were analyzed for moisture, fat, salt, and total nitrogen, as described by Ling (25). Ash was determined

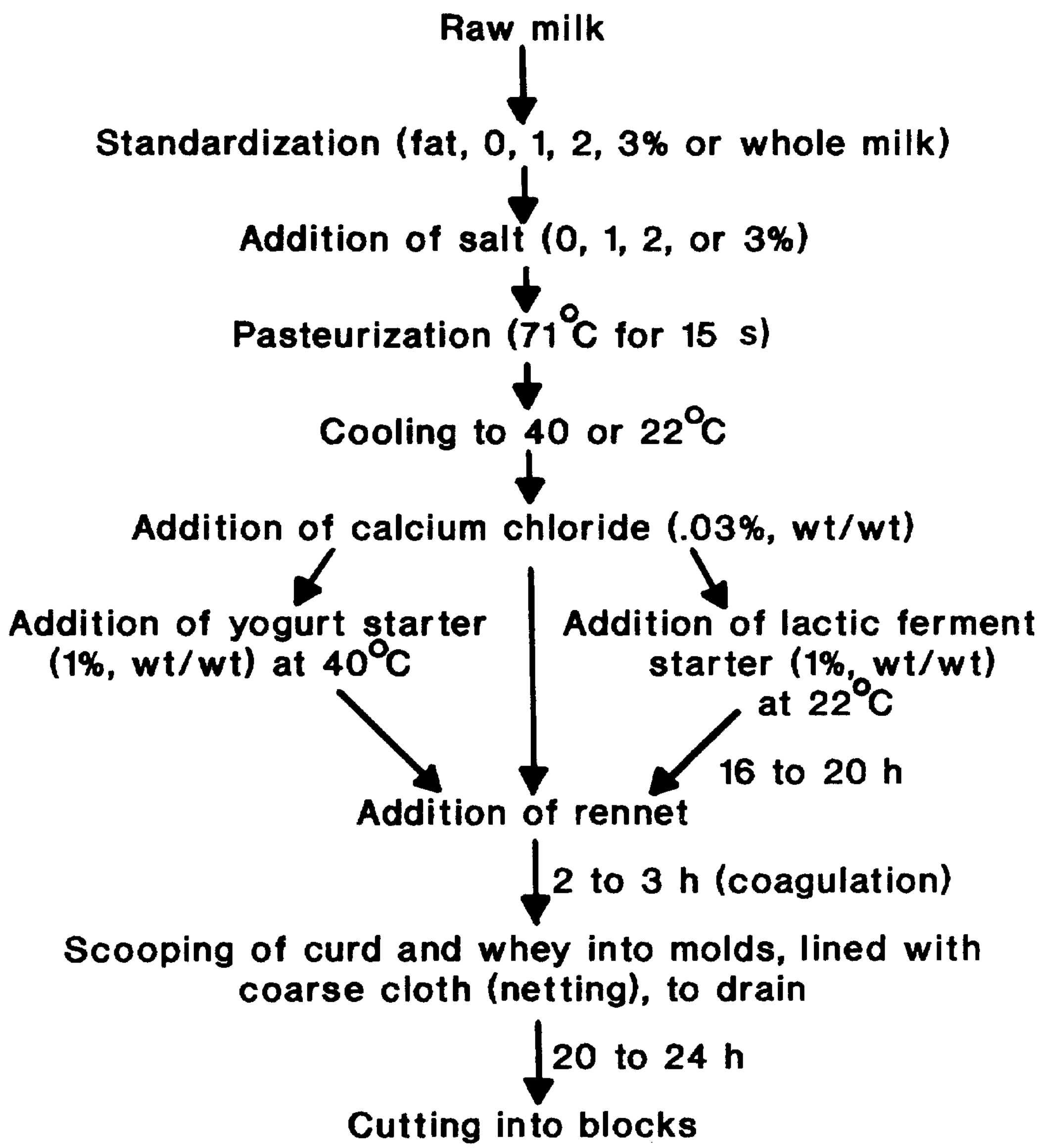

Figure 1. Manufacturing procedures for fresh soft white cheese from camel milk using different percentages of salt and fat, with or without yogurt or lactic fermentation starter culture.

by use of a muffle furnace at 550°C (8). Lactose was calculated by difference. Titratable acidity was determined by titration of 10 g of sample with .1*N* NaOH to a pink endpoint using phenolphthalein indicator (8), and pH was measured with an Orion pH meter (Orion Research Inc., Cambridge, MA). All analyses of milk, whey, and cheese samples were performed in duplicate.

Cheese Yields and Component Recovery

Cheese yields were calculated as a weight of cheese divided by weight of milk expressed as a percentage. Recovery of components (protein, fat, and milk total solids) was calculated as the weight of the component in the cheese divided by the original weight of the component in the milk expressed as a percentage.

Sensory Evaluation

Sensory evaluation of cheeses was performed after 1 d of storage at 5 ± 1°C. The cheeses were evaluated by a panel of 15 University faculty, staff members, and students who were familiar with soft white cheese (Domiati-type). Sensory attributes of appearance, texture, flavor, and overall acceptability were considered by the panelists. A nine-point hedonic scale (39) was utilized in this study (9 = like extremely, 5 = neither like nor dislike, and 1 = dislike extremely). Panelists were also asked to list any defects. 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 Experimental Design and Statistical Analysis section.

RESULTS AND DISCUSSION

Cheese Manufacturing

The manufacturing procedure, processing parameters, and composition of milk used for camel milk cheese are summarized in Figure 1 and Tables 1 and 2. Four trials were conducted to study the manufacture of fresh soft white cheese from camel milk (Table 1). Different percentages of salt and fat and two different lactic starter cultures were used. Lactic cul-

TABLE 1. Description of treatments used to manufacture cheese from camel milk.

Trial and treatment[1]	Milk	Salt	Fat	Starter
		(%)		
1				
3.9F-0S	Whole milk	0	3.90	None
3.9F-1S	Whole milk	1	3.90	None
3.9F-2S	Whole milk	2	3.90	None
3.9F-3S	Whole milk	3	3.90	None
2				
.3F-3S	Milk	3	.3	None
1F-3S	Milk	3	1	None
2F-3S	Milk	3	2	None
3F-3S	Milk	3	3	None
3				
.15F-3S	Skim milk	3	.15	None
.15F-3S-Y	Skim milk	3	.15	Y
.15F-3S-LF	Skim milk	3	.15	LF
4				
1.5F-3S	Standardized milk	3	1.5	None
1.5F-3S-Y	Standardized milk	3	1.5	Y
1.5F-3S-LF	Standardized milk	3	1.5	LF

[1]F = Percentage of fat; S = percentage of salt in milk; Y = yogurt starter culture; LF = lactic fermentation starter culture.

TABLE 2. Manufacturing parameters for soft white cheese from camel milk.[1]

	Trial 1	Trial 2	Trial 3		Trial 4	
			Y[2]	LF[3]	Y	LF
Initial pH of milk	6.55	6.60	6.70	6.70	6.70	6.70
Titratable acidity, %	.14	.14	.14	.14	.14	.14
Fat, %	3.90	.3–3.0	.15	.15	1.50	1.50
Salt, %	0–3	3.00	3.00	3.00	3.00	3.00
pH at rennet addition	6.54	6.56	6.25	5.00	6.30	5.10
Titratable acidity, %	.14	.14	.26	.78	.24	.84
pH at scooping curd	6.55	6.54	6.05	4.50	5.90	4.60
Titratable acidity, %	.14	.14	.29	1.15	.26	1.10
Total manufacturing time, h	28–30	28–30	28–30	48–50	28–30	48–50

[1]Means of duplicate analyses on each of three vats.

[2]Y = Yogurt starter culture.

[3]LF = Lactic fermentation starter culture.

tures (mixed-strain cultures) are primarily responsible for the production of lactic acid, which improves curd firmness and suppresses the growth of undesirable bacteria in the curd, and the flavor compounds that contribute to the aroma of fresh cheese (10). Our preliminary results (M. A. Mehaia, 1989, unpublished data) on cheese making from camel milk indicated that a good fresh soft white cheese could be produced with yogurt starter (thermophilic starter) or with lactic fermentation starter (mesophilic starter) using the procedures shown in Figure 1. As expected, the rate of acid development was different in trials 3 and 4 because of the addition of lactic cultures (Table 2). On average, the titratable acidities at scooping curd were .26 to .29 and 1.10 to 1.15% for yogurt and lactic fermentation starter, respectively. The amount of rennet added was calculated to coagulate each milk within 2 to 3 h. Fresh Domiati cheese differs from other fresh soft white cheese varieties because the milk is highly salted before renneting.

Calcium chloride (30 g/100 kg of milk) was added prior to rennet addition to reduce clotting time and to improve the renneting properties. Cheese was difficult to make from camel milk under natural conditions, but success was achieved when pH of milk was decreased or calcium chloride was added (15, 26, 27, 32, 33) or when 50 to 70 times the normal amount of rennet was used (24, 32, 40). Farah and Ruegg (16) reported that, because of differences in availability of κ-casein, camel milk has more large casein micelles than does cow milk, which may relate to the poor rennetability of camel milk.

The milk to which only rennet was added formed a light and fragile curd, whereas the curd obtained after addition of yogurt or lactic fermentation starter culture was firmer. However, whey drainage was white and was expelled slowly from curd because of losses of curd and fat in cheese whey and because fat globules in camel milk appear to be very small (41, 42). A similar observation was reported by Mohamed et al. (29) in hard cheese manufacture from camel milk. Cheese-making experiments with low renneting milk show that soft curd gives whey with high fat content because fat in Domiati cheese is lost through whey during draining (14, 31).

Milk, Cheese, and Whey Composition

Mean composition of milk used to manufacture cheese samples is shown in Table 3. The percentage of total solids in milk used to manufacture cheese samples in trial 1 was significantly higher than in milk used for other trials. This difference reflects the lower fat content of milk used to manufacture samples in other trials. No significant difference occurred in the protein content of the milk used for trials 1 and 2 or for trials 3 and 4. The percentage of protein in milk used for trials 3 and 4 was significantly higher than in milk

TABLE 3. Composition[1] of the camel milk used to manufacture cheese samples.

Trial	Milk	pH	TA[2]	TS[3]	Fat	Protein[4]	Lactose	Ash
			(%)					
1	Whole milk	6.61[a]	.14[a]	11.94[a]	3.90[a]	2.54[b]	4.71[b]	.79[a]
2	Milk	6.60[a]	.14[a]	8.78[d]	.30[c]	2.47[b]	5.19[a]	.82[a]
3	Skim milk	6.65[a]	.14[a]	9.65[c]	.15[d]	3.51[a]	5.18[a]	.81[a]
4	Standardized milk	6.66[a]	.14[a]	11.05[b]	1.50[b]	3.52[a]	5.21[a]	.82[a]
SE		.01	0	.03	.02	.03	.05	.02

[a,b,c,d]Means in the same column with no common superscripts are significantly different ($P < .05$).

[1]Means of duplicate analyses on each of three vats.

[2]TA = Titratable acidity.

[3]TS = Total solids.

[4]Total nitrogen times 6.38.

used for trials 1 and 2; this difference appears to be related to the variations of camel milk composition (2, 26, 27, 28), which are mainly affected by the feeding and drought conditions (42, 43). The pH, titratable acidity, and ash of the milks used in all trials were not significantly different.

Table 4 shows mean composition of fresh soft white cheeses made from camel milk. Cheese made from whole milk and with differ-

TABLE 4. Composition[1] of fresh soft white cheeses made from camel milk.

Trial and treatment[2]	pH	Titratable acidity	Moisture	Fat	Protein[3]	Ash	Salt
		(%, wet basis)					
1							
3.9F-0S	6.57[a]	.14[a]	54.5[a]	26.2[a]	13.65[a]	1.85[d]	.10[d]
3.9F-1S	6.53[a]	.14[a]	53.6[a]	26.1[a]	13.90[a]	2.30[c]	.78[c]
3.9F-2S	6.54[a]	.15[a]	53.5[a]	26.2[a]	13.93[a]	3.10[b]	1.36[b]
3.9F-3S	6.55[a]	.14[a]	54.1[a]	26.2[a]	13.73[a]	3.70[a]	1.80[a]
SE	.01	.01	.45	.08	.09	.01	.02
2							
.3F-3S	6.56[a]	.13[a]	68.7[a]	2.5[d]	19.10[a]	4.50[a]	1.75[a]
1F-3S	6.57[a]	.14[a]	65.4[b]	7.1[c]	16.41[b]	4.10[b]	1.74[ab]
2F-3S	6.54[a]	.14[a]	63.4[bc]	11.5[b]	14.90[c]	3.90[bc]	1.73[b]
3F-3S	6.59[a]	.14[a]	62.5[c]	16.1[a]	13.51[d]	3.60[c]	1.71[c]
SE	.01	0	.59	.04	.19	.11	.01
3							
.15F-3S	6.60[a]	.14[c]	70.6[a]	1.0[a]	20.41[a]	4.10[a]	2.20[a]
.15F-3S-Y	6.05[b]	.30[b]	68.2[a]	1.0[a]	20.61[a]	4.30[a]	2.20[a]
.15F-3S-LF	4.40[c]	1.20[a]	68.0[a]	1.0[a]	20.10[a]	4.20[a]	2.30[a]
SE	.01	.02	.97	.03	.39	.13	.04
4							
1.5F-3S	6.60[a]	.14[c]	64.8[a]	9.0[b]	16.72[a]	4.30[a]	2.20[a]
1.5F-3S-Y	5.90[b]	.29[b]	64.5[b]	9.2[a]	16.91[a]	4.10[a]	2.30[a]
1.5F-3S-LF	4.60[c]	1.12[a]	65.0[a]	9.1[ab]	16.81[a]	4.20[a]	2.30[a]
SE	.03	.01	.50	.03	.12	.11	.04

[a,b,c,d]Means in the same column within a trial with no common superscripts differ significantly ($P < .05$).

[1]Means of duplicate analyses on each of three vats.

[2]F = Percentage of fat in milk; S = percentage of salt in milk; Y = yogurt starter culture; LF = lactic fermentation starter culture.

[3]Total nitrogen times 6.38.

ent percentages of salt (trial 1) were similar in titratable acidity, moisture, fat, and protein contents but significantly different in ash and salt contents. These cheeses had lower moisture and higher fat content than those made in the other three trials. Cheeses made from milk with 3% salt and different percentages of fat (trial 2) were similar in titratable acidity, ash, and salt contents but significantly different in fat and protein contents, reflecting the difference in milk composition. The titratable acidities (.13 to .15%) of cheese made in trials 1 and 2 are in agreement with those reported (1, 21, 23, 30) for fresh Domiati cheese made without the addition of starter culture. In trial 3 or 4, no significant differences ($P > .05$) occurred in moisture, fat, protein, ash, and salt contents between cheeses made with or without the addition of starter cultures. However, cheeses from trial 3 had higher moisture contents than did cheeses from trial 4. This difference appears to be due to the difference in fat and protein contents of cheeses and is in agreement with previous reports on the low moisture content of skim milk cheeses made from cow milk. However, Ibrahim et al. (22) reported that moisture of fresh Domiati cheese, made from cow milk, was decreased by 1.6 to 2% for every 1% of fat increase in cheese milk. The percentage of titratable acidity (within trial 3 or 4) was significantly higher, and the pH was significantly lower, in cheeses made with yogurt or lactic fermentation culture than in other cheese samples. In general, the composition of all cheeses, over all trials, was within the normal composition range for fresh soft white Domiati cheese (1).

Total solids and ash content of salt wheys produced from cheese making in trial 1 (Table 5) were significantly different ($P < .05$) because of different percentages of salt used for cheese making. However, fat contents of salt wheys produced from camel milk cheeses in trial 1 were significantly higher than those

TABLE 5. Composition[1] of the salt whey produced from cheese making with camel milk.

Trial and treatment[2]	pH	Titratable acidity	Total solids	Fat	Protein[3]	Ash	Salt
		(%)					
1							
3.9F-0S	6.51[a]	.15[a]	8.15[d]	1.39[a]	1.29[a]	.72[d]	.05[d]
3.9F-1S	6.52[a]	.14[a]	8.90[c]	1.36[a]	1.24[a]	1.62[c]	1.02[c]
3.9F-2S	6.51[a]	.15[a]	9.75[b]	1.17[a]	1.15[b]	2.58[b]	2.07[b]
3.9F-3S	6.53[a]	.14[a]	10.81[a]	1.15[a]	1.14[b]	3.66[a]	3.14[a]
SE	.01	0	.01	.09	.02	.04	.03
2							
.3F-3S	6.55[a]	.14[a]	8.41[a]	.04[d]	.34[c]	3.72[a]	3.15[c]
1F-3S	6.56[a]	.14[a]	7.77[b]	.20[c]	.52[b]	3.69[bc]	3.16[bc]
2F-3S	6.54[a]	.13[a]	7.65[c]	.61[b]	.53[b]	3.75[a]	3.18[ab]
3F-3S	6.57[a]	.14[a]	7.61[c]	.89[a]	.57[a]	3.66[c]	3.20[a]
SE	.01	.01	.03	.01	.01	.01	.01
3							
.15F-3S	6.58[a]	.14[c]	9.41[a]	.04[a]	1.39[a]	3.52[ab]	3.10[a]
.15F-3S-Y	6.01[b]	.31[b]	8.32[b]	.03[a]	.82[b]	3.66[a]	3.12[a]
.15F-3S-LF	4.41[c]	1.18[a]	8.30[b]	.03[a]	.92[b]	3.64[a]	3.11[a]
SE	.03	.01	.04	0	.03	.01	.01
1.5F-3S	6.65[a]	.14[c]	9.51[a]	.39[a]	1.56[a]	3.54[a]	3.12[a]
1.5F-3S-Y	5.87[b]	.32[b]	8.81[b]	.17[b]	1.21[b]	3.57[a]	3.12[a]
1.5F-3S-LF	4.56[c]	1.15[a]	8.85[b]	.18[b]	1.21[b]	3.49[b]	3.11[a]
SE	.01	.01	.02	.01	.01	.01	.01

[a,b,c,d]Means in the same column within a trial with no common superscripts differ significantly ($P < .05$).

[1]Means of duplicate analyses on each of three vats.

[2]F = Percentage of fat in milk; S = percentage of salt in milk; Y = yogurt starter culture; LF = lactic fermentation starter culture.

[3]Total nitrogen times 6.38.

produced in the other trials (Table 5), reflecting the differences in milk and cheese composition. However, the data indicate that more than 50% of the milk total solids were retained in the whey, which was white.

Cheese Yields and Component Recovery

Cheese yield is one of the most economically important aspects of cheese manufacturing. Abou-Donia (1) reported that factors such as milk composition, addition of salt, pasteurization of milk, milk concentration, and addition of starter affect the yield of Domiati cheese. Yield and recovery of protein, fat, and milk total solids of cheeses made from camel milk are shown in Table 6, which indicates that cheese yield is proportional to the percentage of fat in the cheese milk (trial 2). Davis (11) reported that the fat content of cheese milk controls its yield. Also, Hamdy and El-Koussy (20), Ibrahim et al. (22), and El-Neshawy et al. (13) found that the yield of Domiati cheese was higher when the fat content of milk was increased. Yields were highest ($P < .05$), 14.7 and 14.8%, for cheeses made with yogurt and lactic fermentation starter cultures, respectively, because of increased recovery of proteins and fat. Asker et al. (7) observed that the yield of fresh Domiati cheese was increased by direct acidification of milk before renneting, which indicates that curd firmness plays an important role in determination of fat recovery because acidification normally improves curd firmness. The yield was lowest ($P < .05$), 10.10%, with whole milk and 0% salt (Table 6). This low yield may have been caused by the lower moisture content in the cheese and by less recovery of protein, fat, and solids of cheeses. However, the average fresh cheese yield (12.29 ± 1.63%) obtained from camel milk was lower than that reported from cow

TABLE 6. Mean[1] yields and recovery of protein, fat, and milk total solids of fresh soft white cheeses made from camel milk.

Trial and treatment[2]	Yield	Recovery		
		Protein	Fat	Solids
	(%)			
1				
3.9F-0S	10.1[c]	54[b]	68[b]	38[b]
3.9F-1S	10.3[b]	56[b]	69[b]	39[b]
3.9F-2S	10.9[a]	60[a]	73[a]	41[a]
3.9F-3S	11.1[a]	60[a]	74[c]	41[a]
SE	.05	1.0	.96	.37
2				
.3F-3S	10.8[d]	86[a]	90[a]	36[d]
1F-3S	11.6[c]	80[b]	77[b]	39[c]
2F-3S	12.8[b]	80[b]	74[c]	41[b]
3F-3S	13.9[a]	80[b]	75[c]	42[a]
SE	.06	.37	.32	.17
3				
.15F-3S	11.1[b]	65[c]	74[b]	31[b]
.15F-3S-Y	13.6[a]	80[a]	90[a]	42[a]
.15-3S-LF	13.5[a]	78[b]	90[a]	42[a]
SE	.03	.33	.19	.30
4				
1.5F-3S	12.9[b]	61[b]	77[b]	39[b]
1.5F-3S-Y	14.7[a]	71[a]	90[a]	44[a]
1.5F-3S-LF	14.8[a]	71[a]	90[a]	44[a]
SE	.05	.19	.18	.19

[a,b,c,d]Means in the same column within a trial with no common superscripts differ significantly ($P < .05$).

[1]Means of duplicate analyses on each of three vats.

[2]F = Percentage of fat in milk; S = percentage of salt in milk; Y = yogurt starter culture; LF = lactic fermentation starter culture.

milk, 20.6 to 24.6% (6, 21), or from buffalo milk, 32.9 to 35.3% (7, 21).

Cheese recovery values for protein, fat, and milk total solids are shown in Table 6. Fat recovery (68 to 90%) was higher than protein recovery (54 to 86%), whereas total solids recovery (31 to 44%) was very low. This difference may be because the camel milk has less casein nitrogen (61 to 71% of the total nitrogen) and more noncasein nitrogen (29 to 39% of total nitrogen) than cow milk does (2, 28). Mohamed et al. (29) reported that hard cheese yield from camel milk was about 5%, and about one-half of the fat in the raw milk was lost with the whey. However, greater cheese yields (treatments 2 and 3 of trials 3 and 4) were accompanied by higher milk solids recovery (42 to 44%).

Sensory Evaluation

Mean sensory evaluation scores for cheese made from camel milk are listed in Table 7. These data show that appearance, texture, flavor, and overall acceptability of cheeses were affected by fat and salt contents of the cheese milk and by the addition of yogurt or lactic fermentation starter culture to cheese milk. The cheese made from the milk with lower fat content (.3 and 1%) scored lower for appearance and texture than that from milk with ≥ 1.5% fat, whereas the cheese made from milk with higher fat content, without lactic culture, scored lower for flavor and overall acceptability than that from milk with ≤ 1.5% fat, with or without lactic cultures.

The mean scores for flavor and overall acceptability of cheeses made with yogurt or lactic fermentation starter culture (treatments 2 and 3 of trials 3 and 4) were significantly higher ($P < .05$) than mean scores for other cheeses, indicating that cheeses made with cultures were the most acceptable. The least acceptable cheeses were those made from whole

TABLE 7. Mean[1] taste panel scores for fresh soft white cheeses made from camel milk.[2]

Trial and treatment[3]	Appearance	Texture	Flavor	Overall acceptability
1				
3.9F-0S	6.81[b]	7.21[b]	3.00[c]	4.10[b]
3.9F-1S	6.75[b]	7.11[c]	3.91[b]	4.75[b]
3.9F-2S	6.61[c]	7.40[a]	5.83[a]	6.14[a]
3.9F-3S	7.30[a]	7.31[a]	6.11[a]	6.39[a]
SE	.02	.03	.25	.19
2				
.3F-3S	5.86[b]	4.95[c]	5.01[b]	5.26[a]
1F-3S	6.03[b]	6.60[b]	5.90[a]	6.23[a]
2F-3S	7.61[a]	7.71[a]	5.85[a]	6.41[a]
3F-3S	7.71[a]	7.61[a]	5.10[b]	5.20[b]
SE	.11	.08	.08	.08
3				
.15F-3S	6.10[b]	5.10[b]	5.50[b]	5.50[b]
.15F-3S-Y	7.40[a]	7.50[a]	7.80[a]	7.50[a]
.15F-3S-LF	7.50[a]	7.60[a]	7.90[a]	7.70[a]
SE	.05	.07	.04	.07
4				
1.5F-3S	7.50[b]	6.80[b]	5.50[b]	6.50[b]
1.5F-3S-Y	7.80[a]	7.50[a]	7.90[a]	7.60[a]
1.5F-3S-LF	7.70[a]	7.60[a]	8.10[a]	7.80[a]
SE	.03	.06	.08	.07

[a,b,c]Means in the same column within a trial with no common superscripts are significantly different ($P < .05$).

[1]Means of duplicate analyses on each of three vats.

[2]Nine-point scale (9 = like extremely, 5 = neither like nor dislike, and 1 = dislike extremely).

[3]F = Percentage of fat in milk; S = percentage of salt in milk; Y = yogurt starter culture; LF = lactic fermentation starter culture.

milk and 0 or 1% salt (treatments 1 and 2 of trial 1). This difference may be because the melting point of camel milk fat (41 ± .9°C) was significantly higher than that of cow milk fat (32.6 ± 1.5°C) (3, 35), causing the greasy and unacceptable mouthfeel noted by the panelists.

CONCLUSIONS

Manufacture of fresh soft white cheese (Domiati-type) from camel milk appears to be feasible. Composition of cheeses obtained from this study compared favorably with Domiati cheese composition reported from cow or buffalo milks (1). The average cheese yield (12.29 ± 1.63%) obtained from camel milks was lower than that reported for cow or buffalo milks (6, 7, 21). Fresh soft white cheeses made from camel milk with yogurt or lactic fermentation starter culture were the most acceptable. The least acceptable cheeses were those made from whole milk (3.9% fat) and 0 or 1% salt.

Based on these results, the composition of the best cheeses, as selected by the panelists, is given in Table 8. The following treatment combinations resulted in soft camel milk cheese with good flavor, texture, and overall acceptability: 1.5% fat and 3% salt in milk with yogurt or lactic fermentation starter culture.

However, cheeses made from camel milk without use of starter cultures had high moisture and very high pH, which could cause serious health problems by growth of pathogens. Moreover, the resulting cheeses had lower sensory quality and lower yield than cheeses made with starter cultures. Thus, our data indicate that cheese making without use of starter cultures should be strongly discouraged.

However, more research is needed to study the mechanism of enzymatic coagulation of camel milk, to improve the quality and the yield of camel milk cheeses, and to utilize the nutritious whey that is produced from cheese making with camel milk.

TABLE 8. Mean[1] composition of the best fresh soft white cheese made from camel milk with yogurt or lactic fermentation starter culture.

	Starter culture	
Variable	Yogurt	Lactic fermentation
pH	5.90	4.60
Titratable acidity, %	.29	1.12
Moisture, %	64.50	65.00
Fat, %	9.20	9.10
Protein, %	16.91	16.81
Ash, %	4.10	4.20
Salt, %	2.30	2.30

[1]Means of duplicate analyses on each of three vats.

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