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Impact of camel breeding system on the composition and cheese-making ability of the produced milk

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Abstract

During these last years, the commercialization of camel milk was developed in Algeria, especially by the intensification of dromedary husbandry and the introduction of forage and concentrated food. For this purpose, the present work aims to identify the influence of camel feeding on the composition of milk, particularly on the technology of its transformation into cheese. Camel milk was taken from two breeding systems, the extensive and the semi-intensive. The results showed that pH and protein content were significantly higher for milk from the semi-intensive farming were 6.54 ± 0.12 and 33.11± 0.85 g/l, respectively. Higher cheese yield was obtained for cheese samples made from a semi-intensive system 24.85 ± 0.22 %. Sensory analysis indicated significant differences in terms of appearance and elasticity ($p < 0.05$). These observations suggested that camel feeding seems to be partly responsible for certain characteristics of milk. The obtained results could confirm that livestock intensification of dairy camels could develop the commercialization of camel milk while transforming a part of it into derived products such as cheese.

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Introduction

The dromedary (*Camelus dromedarius*) is an important component of the desert ecosystem since it has exceptional tolerance to hostile conditions of arid regions. This animal can get the high food value from scarce resources of Saharian rangelands to proteins of high nutritional value: meat and milk. Dromedary milk is of very particular interest to calves and nomads. The native consumer gives it many health claims, some of which have been highlighted by scientific works (Mal *et al.,* 2001; Agarwal *et al.,* 2003 & 2005; Shabo *et al.,* 2005; Saltanat *et al.,* 2009; Korashy *et al.,* 2012).

Due to its therapeutic virtues, this milk has experienced strong demand in recent years. However, its availability is hampered by the problem of the distancing rangelands, the lack of basic infrastructure for collecting milk and the low milk potential in the natural environment. In fact, productions in the natural environment, cited in the literature (El-Badawi, 1996; Raziq *et al.,* 2008), are generally less than 10 kg, depending on the breed, feeding, lactation stage and milking frequency. In Tunisia, Moslah (1998) reported an average milk production of 1.62 L per day (between 1.22 and 2.02 L per day) during 7 months of lactation for camels reared on rangelands. In order to satisfy this high demand, special intensive camel milk dairy farms have been set up around the world to increase productivity and to facilitate the acquisition of this product, the first of them was created in Dubai in 2006 (Juhasz and Nagy, 2012). In Algeria, some breeders have tended, in recent years, to supplant the traditional (extensive) breeding system, based on the exclusive consumption of diversified plants from Saharan rangelands, by the semi-intensive (semi-stable) system based mainly on concentrate consumption and occasionally on range plants. Several studies showed that there had been an improvement in camel productivity with the intensification of herding. Nagy *et al.* (2013) found an average daily production of a camel in intensive breeding of 6 ± 0.12 kg. Indeed, the milk yield varies according to the animal's feeding, the stage of lactation, the management of the breeding, the animal's age and race (Faraz *et al.,* 2020). The production increase is an advantage to give the possibility of transforming a part of it to some derivative products. Indeed, camel milk-derived products are very rare, although their diversity is a means of developing the dairy sector of this animal, particularly in their origin countries (Faye, 2018). Although Algeria has been considered among the regions of camel breeding for a long time, the milk yield is low in traditional extensive breeding, and the quantity produced is limited to calves and self-consumption. The quantity produced is generally consumed in a raw or fermented state. There is no transformation of this product in Algeria. Indeed, trials to transform camel milk collected from natural rangeland to cheese are still at the laboratory level (Boudjenah-Haroun *et al.,* 2012). Nowadays, camel milk is becoming more accessible than before, and its production is quite important due to the emergence of milk outlets close to consumers and the intensification of dairy camel breeding with the availability of forages and concentrated food. This work aims to establish a qualitative comparative study on dromedary milk raised in two different breeding systems in the Southern-East of Algeria (Ouargla) and to evaluate their influence on the peculiarities and cheese-making ability of the camel milk produced. For this purpose, we have chosen to make a fresh cheese (Takamarit type) from camel milk. In fact, takemarit is a traditional cheese very well-known and appreciated in southern Algeria, usually made of (from) raw goat's or cow's milk.

Material and methods

Milk origin

Samples of fresh milk were collected from camels of the Sahrawi population in Ouargla region, south-eastern Algeria. Ten (10) samples were obtained from camels kept in extensive breeding (M-ext); their feeding is based only on natural desert grazing plants such as *Anabasis articulata* (Baguel), *Traganum nudatum* (Damrane), *Ephedra alata* (Alanda), *Retama raetam* (Rtem), *Limoniastrum guyonianum* (Zeiîta), *Stipagrostis pungens* (Drinn), *Calligonum azel* (L'azale), *Corulaca monacantha* (Hadd). Ten

(10) others were obtained from the camels led in semi-intensive breeding (M-s.int). These camels are allowed to graze in the morning in the natural pastures near the stable from 20 to 30 km and in the evening, on their return to the stable, they receive fodder and concentrated feed such as wheat straw alfalfa, barley and wheat bran (2 kg/camel/day). In both types of breeding, the breeders practice only one milking per day in the morning. The watering of the herds in semi-intensive breeding is daily. On the other hand, in extensive breeding system, the herds are watered every 7 to 10 days.

Traditional cheese making « Takemarit »

The cheese-making process was done by enzymatic coagulation. The coagulating agent is chymosin Chy - Max ® M 2500 Powder NB (Chr. Hansen, Horsholm, Denmark) at 2500 IMCU (International Milk Coagulation Units). An enzymatic preparation diluted to a fifth (1/5) was obtained and used at a rate of 25 µL / 500 mL of milk. The steps of takamarit making from camel milk are the same as those made of cow's or goat's milk. First, raw milk undergoes thermalization at 63 °C for 15 s as reported by (Cuq, 2007) to destroy pathogenic bacteria without modifying its technological characteristics. These cheese-making steps are summarized in Fig. 1.

The milk is distributed in 500 mL beakers. As soon as the two phases of the milk (whey and curd) have been separated, the mixture is poured onto a filter cloth to facilitate drainage. The experimental setup is put at 10 °C overnight. All the dripping whey is collected. The milk and curd weights are noted to be used in calculating the yield as follow (Equation 1):

$$Yield\ (\%) = Weight\ of\ curd\ /Weight\ of\ milk \times 100\ (Equation\ 1)$$

Two types of cheese have been obtained; the one made by milk from extensive farming was coded (CM-ext) and the other made from milk from semi-intensive farming is coded (CM-s.int).

The cheese obtained from each sample was weighed then packaged in sterile plastic boxes and stored at 4 °C for further uses.

Physicochemical and biochemical analysis

For each sample of both milk and cheese, physicochemical and biochemical measurements were carried out. pH, density, and titratable acidity of milk were carried out according to the AOAC standard methods (AOAC, 2016). Dry matter content was determined by drying 5 mL of milk or 5 g of cheese in an air oven at 105 °C (IDF 21B, 1987).

Ash content was determined by mass loss after incinerating 5 mL of milk or 5 g of cheese in a furnace at 550 °C for 6 h (NF V04-208 1989). Fat content was determined by acid-butyrometric method (Gerber method) (Ling, 1963). The total nitrogen content (TN) of milk and cheese, noncasein nitrogen (NCN) and nonprotein nitrogen (NPN) fractions were determined by the Kjeldahl method (ISO 8968-1:2001). Lactose content in milk was carried out using lactoscane (Ultrasonic milk analyzer, SL 30, India).

Texture Profile Analysis (TPA)

In the present study, texture profile analysis (TPA) was performed to determine the physical characteristics of both curds (CM-ext and CM-s.int). Before starting these tests, the curds were stored at room temperature (25 °C) for 1 hour. This instrumental texture analysis was performed using a "TP plus LLOYD instruments, England" texturometer. Each sample was axially compressed to 50% of its initial height (30 mm) in two cycles and at a speed of 60 mm/min by a cylindrical probe of 25 mm in diameter (Xinhuai and Xiaoting, 2009). Texture profile parameters such as hardness, cohesion, elasticity, and adhesion were calculated from a curve using Texture Technologies Corp software, connected directly to the instrument.

Sensorial analysis

The produced cheese samples' acceptability was assessed by a jury of 60 panelists, made up of students, laboratory technicians and teachers familiar with cheeses and knowledgeable about organoleptic qualities. The attributes of sensory evaluation: appearance, texture, smell, taste, and overall appreciation were considered by the panelists. Each panelist received two cheese samples and a tasting sheet. The cheese samples were tempered to room temperature and cut into 10 g pieces and placed in white plates, and each sample was coded with a three-digit number. The tasting sheet contains hedonic scales from 1 to 9 points, corresponding to each sensory attribute ranging from 1 (very low) to 9 (very high).

Statistical analysis

Results were presented as the mean and standard deviation of three replicates of each parameter. Data processing of all milk and cheese samples measurements was carried out by one-way statistical analysis of variance (ANOVA). All statistical analyses were performed using SPSS (Statistical Package for Social Sciences, v 26) software. *P*-values less than 0.05 were considered statistically significant.

Results

Physicochemical and biochemical composition of the collected milk

The results of physicochemical and biochemical parameters of collected milk from both rearing systems, extensive (M-ext) and semi-intensive (M-s.int), are given in Table 1.

Table 1. Physicochemical and biochemical characteristics of collected camel milk from both extensive (M-ext) and semi-intensive (M-s.int) breeding systems.

Parameter	M-ext	M-s.int	*p*-value*
pH	6.40 ± 0.09	6.54* ± 0.12	0.019
Titrable acidity (°D)	16.25 ± 0.64	16.86 ± 0.97	0.135
Density	1.028 ± 0.00	1.028 ± 0.00	0.311
DM (g/L)	106.72 ± 1.15	108.10 ± 0.86	0.815
Fat (g/L)	32.84 ± 0.84	29.94 ± 0.65	0.144
Total protein (g/L)	28.70 ± 0.07	33.11* ± 0.85	0.035
Lactose (g/L)	37.28 ± 0.57	35.56 ± 0.82	0.326
ash (g/L)	7.66 ± 0.44	7.24 ± 0.76	0.579
Caseinic protein (g/L)	19.26 ± 0.78	23.48* ± 0.07	0.020
Whey protein (g/L)	9.43 ± 0.41	9.63 ± 0.43	0.761

*: $p < 0.05$; the difference is significant.

DM: Dry matter; M-ext: Milk obtained from camel kept in extensive farming;

M-s.int: Milk obtained from camel kept in semi-intensive farming.

The obtained results showed a significant difference ($p < 0.05$) between samples only for pH values. pH was higher in the M-s.int than in the M-ext (6.54 *vs.* 6.40, respectively). No significant difference was recorded for titratable acidity, density, DM, and ash contents in the two types of milk ($p \geq 0.05$). Total proteins and casein proteins contents were significantly ($p < 0.05$) higher for M-s.int (33.11, 23.48 and 5.99 g/L, respectively) compared with those obtained for M-ext (28.70, 19.26 and 5.25 g/L, respectively).

Fat and lactose contents were not significantly different in the milk from the two systems ($p \geq 0.05$).

Chemical composition of fresh cheese "Takemarit"

The results relating to the chemical composition of the fresh cheeses (takamarit type) made from camel milk from both systems are presented in Table 2. The obtained results showed a significant difference only in pH and cheese yield values between both samples ($p < 0.05$). Indeed, pH of CM-s.int was significantly higher ($p < 0.05$) than that of CM-ext (6.14 *vs.* 5.95 respectively). This could be related to the initial milk pH used for the cheese manufacture. The results also showed that the yield of cheese made from semi-intensive farming (CM-s.int) was significantly higher (24.85%) than that made from the extensive system (CM-ext) (17.91%) ($p < 0.05$). This result confirms that the high milk protein content, mainly that of caseins, could increase the cheese yield of semi-intensive compared to milk from the extensive system. Statistically, total protein content was not different between both pieces of cheese from the two systems with higher content for the semi-intensive system. This difference seemed to lie on whey proteins levels in the expulsed whey. No significant difference could be reported for fat and ash percentages of cheeses as well as their moisture ($p \geq 0.05$).

Texture profile analysis

The texture parameters of curds obtained after the coagulation of both milk types are presented parameters in Table 3. Although statistically, the difference was not significant between both pieces of cheese ($p \geq 0.05$), a slight difference in the values of their textural profile parameters was noticed.

The hardness of CM-ext was slightly higher (1.85) compared to that of CM-s.int (1.14). This parameter is affected by pH and moisture content. Hardness was also affected by cheese yield; CM-ext drained better statistically than CM-s.int with yield values of 17.91 and 24.85%, respectively (Table 2). Cohesion and elasticity of CM-s.int were superior to those of CM-ext. This difference could be attributed to the low-fat content in the semi-intensive system of milk and cheese (Tables 1 and 2). In terms of stickiness, a higher value was obtained for CM-ext than that of CM-s.int, which had a higher pH value.

Table 2. Composition of cheese made of camel milk conducted according to extensive (CM-ext) and semi-intensive (CM-s.int) farming systems.

Parameter	CM-ext	CM-s.int	*p*-value*
pH	5.95 ± 0.17	6.14* ± 0.04	0.020
Yield (%)	17.91 ± 0.85	24.85* ± 0.22	0.040
DM (%)	28.77 ± 0.08	27.52 ± 0.19	0.716
Moisture (%)	71.23 ± 0.08	72.84 ± 0.18	0.717
Fat/DM (%)	42.27 ± 0.24	38.55 ± 0.65	0.139
Protein/DM (%)	46.33 ± 0.81	49.62 ± 0.74	0.215
Ash /DM (%)	4.84 ± 0.69	4.83 ± 0.54	0.993

*: $p < 0.05$; the difference is significant; **CM-ext**: Cheese by Milk obtained from camel kept in extensive farming; CM-s.int: Cheese by Milk obtained from camel kept in semi-intensive farming.

Sensorial characteristics

The results of sensorial profiles (color, appearance, texture, smell, taste, and overall appreciation) of both pieces of cheese are presented in Table 4. A significant difference was noted for the appearance of the two pieces of cheese ($p < 0.05$). The CM-s.int was preferred by the panelists for its appearance similar to traditional cheese (takamarit) made of cow's milk, which is soft and slightly moist. Texture properties indicated that CM-s.int exhibited higher elasticity compared to that of CM-ext. Moreover, both pieces of cheese were characterized by a lactic odor with a slight intensity. Likewise, no significant difference was recorded for taste characteristics ($p \geq 0.05$). Both pieces of cheese were classified as cheeses with very light acidity and salinity. As for taste persistence, no significant difference was recorded between both pieces of cheese ($p \geq 0.05$). According to the panelists, there was a slight fat persistence in the mouth for a few seconds, especially for the CM-ext.

Discussion

Milk

The values recorded for the physicochemical and biochemical composition of the studied milk samples were within the range of those reported by many authors who have worked on camel milk collected from two farming systems in different regions of the world (Shuiep *et al.*, 2014; Benmohamed *et al.*, 2018; Ayadi *et al.*, 2019). pH of M-s.int was significantly higher than that of M-ext ($p < 0.05$). These variations were probably due to the type of feeding since pH as well as the taste of the milk depending on the type of forage as well as water availability (Gorban and Izzeldin, 1997). These variations may be mainly related to the hygienic quality of the milk samples, which was not controlled in our study. Indeed, a high pH indicates a better hygienic quality of the milk, which is the case for the M-s.int sample with a pH value of 6.54 *vs.* 6.40 for M.ext. Furthermore, water deprivation caused pH decrease, which could reach a value of 6.3 after 7 days of dehydration (Kouniba, 2002). However, the high protein content of M-s.int was consistent with the results reported by (Parraguez *et al.,* 2003); these authors concluded that the availability of high-quality foods explained the variations in protein content of milk between different production systems. Yagil and Etzion (1980) also reported that protein content reached values between 4.6 and 5.7% in a hydrated regime or between 2.5 and 3.3% in a poorly hydrated regime. For cheese making process, raw material's physicochemical and biochemical characteristics are the most important parameters on processing ability. Milk protein content, mainly caseins, largely determined the cheese yield (Pellegrini *et al.,* 1997), as well as its pH, which affected both the clotting time and the gel firmness. Indeed, the lower the pH, the faster the clotting, the faster the gel firms and the greater its firmness was (Ramet and Weber, 1980).

Table 3. Texture profile of Takemarit, cheese made of camel's milk, carried out according to two breeding systems (extensive and semi-intensive).

Parameter	CM-ext	CM-s.int	*p*-value*
Hardness (N)	1.85 ± 0.35	1.14 ± 0.33	0.241
Cohesion	0.26 ± 0.11	0.39 ± 0.24	0.261
Elasticity (mm)	7.84 ± 0.84	10.87 ± 1.60	0.385
Adhesiveness (N)	0.49 ± 0.38	0.19 ± 0.15	0.098

*: $p < 0.05$; the difference is significant.

Cheese "Takemarit" made of camel milk

The cheese yield recorded in this study for both pieces of cheese were higher than the one obtained in similar research works reported on camel milk cheese obtained with the use of Chy-Max, i.e., Hailu *et al.* (2014) in Ethiopia (11.4%); Konuspayeva *et al.* (2017) in Saudi Arabia (7.4%); Mbye *et al.* (2019) in the United Arab Emirates (12.3%) and Felfoul *et al.* (2021) in Tunisia (13.16%). These variations may be related to the fact that in our study, the cheese obtained did not undergo any pressing, indicating that the draining was not complete.

Table 4. Sensorial evaluation of Takemarit, fresh cheese, made of camel milk collected from extensive and semi-intensive farming systems.

Parameter	CM-ext	CM-s.int	*p*-value
Color	2.33 ± 0.84	3.20 ± 0.32	0.109
Appearance	4.13 ± 1.73	5.67* ± 0.29	0.000
Firmness	4.27 ± 0.15	4.80 ± 0.97	0.377
Elasticity	3.00 ± 0.20	4.67* ± 0.50	0.022
Adhesiveness	4.20 ± 0.93	4.13 ± 0.67	0.919
Odour	2.00 ± 0.00	1.67 ± 0.82	0.238
Acidity	1.73 ± 0.96	1.80 ± 0.01	0.827
Salinity	2.27 ± 0.58	2.93 ± 0.98	0.173
Aftertaste	4.53 ± 0.17	3.53 ± 0.33	0.114
General appreciation	4.20 ± 0.74	4.60 ± 0.35	0.395

*: $p < 0.05$; the difference is significant.

The type and concentration of the coagulating enzyme used to have a clear impact on coagulation and cheese yield (Benkerroum *et al.,* 2011; Boudjenah-Haroun *et al.,* 2012; Shahein *et al.,* 2014; Hailu *et al.,* 2016; Soltani *et al.,* 2016; Mohammed *et al.,* 2019). The yield of CM-s.int is higher than for CM-ext; this result confirmed that higher milk protein content, mainly caseins, could increase the cheese yield of the semi-intensive system compared to the extensive system. The dry matter content of both pieces of cheese was around 28%. It was close to that reported in the literature. Indeed, the dry matter content of camel milk cheese was limited to around 30%, while it increased to ~50% for cow's milk and 68% for sheep's milk under similar manufacturing conditions (Ramet, 2001). The dry matter content of the cheese sample was linked to that of milk fat (Konuspayeva *et al.,* 2017), of which the difference was not significant for both pieces of cheese. Fat is a very important factor affecting the textural and sensory cheese properties (Sundaram and Mehmet, 1957). Statistically, total protein content was not different between both pieces of cheese of the two systems with higher values for the semi-intensive system. In fact, protein content was strongly correlated with casein concentration in milk, which is one of the determining factors in the gel firmness as well as the cheese yield (Remeuf *et al.,* 1991).

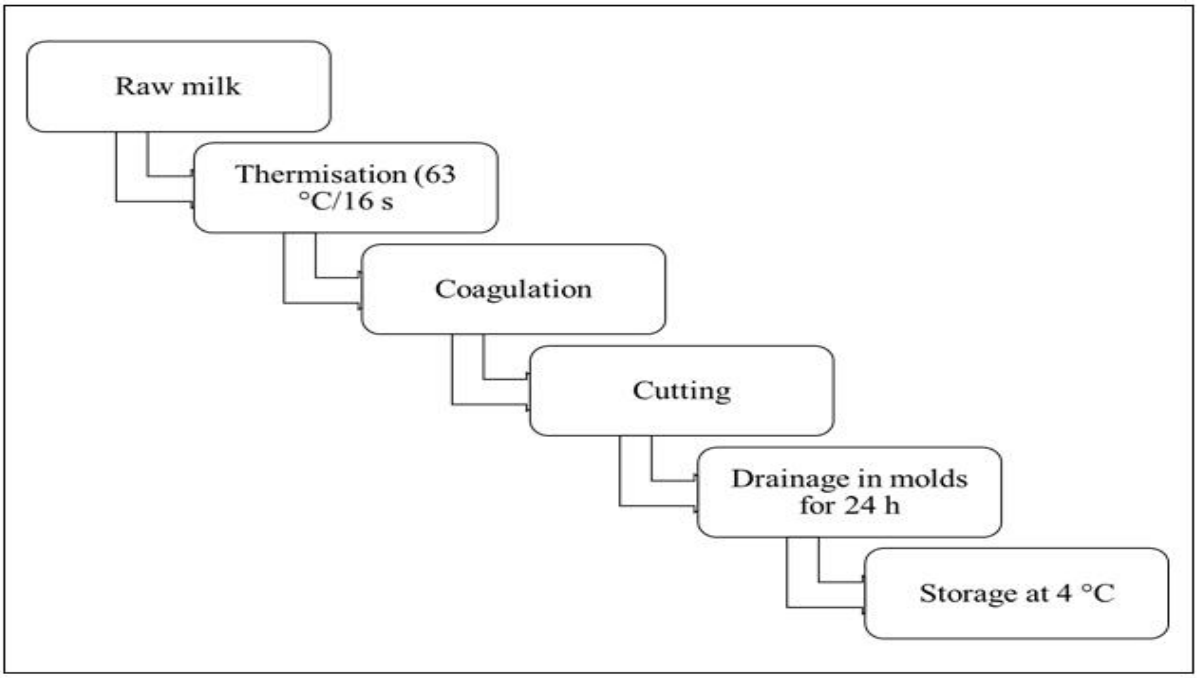

Fig. 1. Steps of traditional cheese "Takemarit" making from camel milk.

Physical and sensory characteristics of cheese

Cheese texture is a very important parameter that determines the cheese quality; it correlates directly with the cheese composition and pH (Chen *et al.,* 1979). The higher hardness recorded for CM-ext compared to CM-s.int was affected by pH and moisture. Indeed, a low pH value of milk at the enzyme addition resulted in a harder cheese (Jack and Paterson, 1992). According to Mbye *et al.* (2019), the hardness of cheese made from camel milk was lower than that made from cow's milk due to the low casein content in camel milk compared to cow's milk; it is only 60% of the total protein, compared to 80% in total cow's milk protein. Thus, the stickiness of CM-ext was higher than that of CM-s.int with a higher pH value. According to Watkinson *et al.* (2001), cheeses with higher pH values are less sticky. Moreover, cohesion and elasticity were higher for CM-s.int than those of CM-ext. This difference could be attributed to the low-fat content in milk and resulting cheese of semi-intensive system (Tables 1 and 2). Indeed, according to some authors, cheeses with a reduced fat content are more cohesive and elastic (Olson and Johnson, 1990; Bryant *et al.,* 1995).

Regarding sensory evaluation, the two camel milk pieces of cheese produced in our study CM-s.int and CM-ext show good acceptability of the tasting panel with overall appreciation scores of 4.20 and 4.60 for CM-ext and CM-s.int, respectively (Table IV). The results showed that camel milk has the potential for the development of cheeses with good acceptability. The two pieces of cheese were close to Takemarit cheese made from cow's milk, which is characterized by a soft, slightly acidic, medium intense smell and aroma with a weak aftertaste (Adamou *et al.,* 2012). According to El Zubeir and Jabreel (2008), the cheese made from camel milk is characterized by a light and soft coagulum with a moist paste.

Conclusion

Based on the obtained results, it can be concluded that the composition of camel milk collected from two breeding systems (extensive and semi-intensive) had comparable dry matter, fat, ash, and acidity contents. However, pH, total protein and casein contents were significantly higher for M-s.int compared to CM-s.int. Fresh cheeses (takamarit type) made from these two milk types had an overall acceptance for taste and texture. The camel milk cheese yield was higher for CM-s.int. The obtained data suggested that feeding and husbandry practices generally did not demonstrate an influence on the characteristics of camel milk. However, protein content, especially caseins, tended to increase for M-s.int. It can be concluded that improved husbandry practices and management-oriented towards milk production in the semi-intensive system positively influenced the quality of camel milk composition. In addition, the semi-intensive system provided urban dwellers with camel milk which is in great demand in the market. However, the amount of milk produced in the extensive system could not be commercialized. It can therefore be necessary to create a bridge between nomadic producers and urban consumers.

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