

# DESCRIPTIVE TYPOLOGY OF CAMEL MILK QUALITY IN TOUGGOURT, SOUTHERN ALGERIA

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## ABSTRACT

The objective of this work is to identify the diversity of camel milk quality in the arid region of Touggourt, and to classify the milk samples according to physicochemical parameters in order to have a real and correct vision of the quality of the milk produced in this region. A total of seventy-five samples of mixed milk were taken from various communes in Touggourt for physico-chemical analysis, including the following parameters: pH, lactose content, protein content, mineral content and fat content. The results of the analyses were processed to produce a typology close to the reality of the quality of camel milk produced in the study area. Milk quality parameters are highly variable but generally considered acceptable. The results show that the pH of Touggourt camel milk is equal to  $6.62 \pm 0.57$ . It is close to that found in Saudi Arabia and Tunisia. At the same time, the collected milk has an overall acceptable composition of basic nutrients (protein, fat and lactose). The fat content is equal to  $34.76 \pm 5.85$ . Camel milk also contains a protein level equal to  $33.21 \pm 2.54$  and  $47.28 \pm 3.94$  for lactose. It contains  $3.17 \pm 0.95$  of minerals. The typology of the analysed camel samples revealed 04 classes of milk. The main sources of variation were the fat and mineral content.

**Key words:** Algeria, camel milk, descriptive analysis, diversity, physico-chemical composition, Saharan regions

The emergence of awareness of the benefits of camel milk in Algeria is recent, hence the enthusiasm to promote this breeding. Indeed, in recent years, camel breeding has begun to develop and even move towards intensification, particularly for the production and marketing of milk (Bedda *et al*, 2019).

In terms of scientific research, camel milk has attracted increasing interest in recent years on various aspects such as production, nutritional composition, functional properties and optimisation of coagulation parameters (Bouras *et al*, 2022, AL Hadj and Al Kanhal, 2010). The study of the quality parameters of this milk across the different producing regions of Algeria is lacking. The objective in present study was therefore aimed to assess the quality of the milk produced in one of the camel milk producing areas, the Touggourt region in southern Algeria.

## Materials and Methods

The physicochemical characteristics of camel milk from the Touggourt region and its production conditions was studied.

## Survey

The survey was conducted among 25 breeders in the Touggourt region (Algeria) using an individual

questionnaire. The choice of the study region was based on the existence of a relatively large camel population, accessibility to the region in all seasons, security concerns, and the availability of breeders willing to collaborate with our study

The Touggourt region is a group of oases located in the south-east of Algeria, 160 km north-east of Ouargla, 225 km south of Biskra and approximately 600 km south-east of Algiers (Map 1). The sampling was carried out on the basis of information collected at the level of the Directorates of Agricultural Services (administrative unit) of the Daïra (Table 1).

Each breeder's camel milk was subjected to a physicochemical analysis during the spring season with 3 samples per breeder. Milk samples were taken from small herds at the farm to determine the quality of the milk immediately after the morning milking.

## Camel milk sampling

These milk samples came from herds of healthy Sahraoui camels. The animals ranged in age from 7 to 22 years. Lactation ranks ranged from 2 to 6. A total of 75 samples were analysed for 9 variables, representing 675 data points.

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### Physico-chemical analysis of milk

pH was measured using a pH meter (LinoLab pH 720). Dry matter, fat content, ash, total solids (T.S), solids non-fat (S.N.F), lactose and protein in milk samples were measured using a Lactoscan previously calibrated (Lactostar, Funke Gerber 3510).

### Statistic analysis

Milk quality characteristics were first described using descriptive statistics. Then, a one-way ANOVA was used to analyse the impact of breeding practices on the physicochemical composition of camel milk. A principal component analysis (ACP) followed by an ascending hierarchical classification was then carried out to establish a typology of the samples according to five quality variables (lactose, proteins, freezing point, minerals, fat). The analysis was carried out using SPSS version 23 software.

### Results and Discussion

#### Overall physico-chemical quality of camel milk (Table 2)

The pH is the first parameter that informs us about the freshness of the milk and plays an important role in determining its quality (El Hosseiny *et al*, 2018). The pH of the milk samples analysed was between 5.09 and 7.09 with an overall average of  $6.62 \pm 0.57$  which agrees with the values given by the FAO (1982) for camel milk, i.e. 6.5 - 6.7 (FAO, 1982) and the value given for the same Sahrawi breed by Bouras *et al* (2022) i.e. a pH of  $6.56 \pm 0.34$ .

Variations in the pH of camel milk can be explained by various environmental and physiological factors, including geographical location, climate, diet, water availability, breed, stage of lactation and age of the animal (Gorban and Izzeldin, 1997; Al-Haj and Al-Kanhal, 2010). The pH is therefore an essential indicator of milk quality and health status, particularly for the detection of mastitis (Sharma, 2006).

The naturally lower pH of camel milk compared to cow's milk is partly due to its high vitamin C

content (Saley, 1993). The slight variation in pH during the first 24 hours of storage can be explained by the strong buffering capacity of camel milk, as reported by Farah and Ruegg (1989), Ramet (1994) and Abu-Tarboush (1996), confirming its short-term stability (Kaskous, 2019). On the other hand, prolonged storage leads to gradual acidification due to the fermentation of lactose into lactic acid, resulting in pH values below 5, in agreement with Sodini *et al* (2002) and Fguiri *et al* (2017).

The pH values recorded in this study are also within the range of values reported by many authors who have worked on camel milk in the Ouargla region of Algeria (Siboukeur, 2008; Mahboub, 2010). These values were also close to those reported by some authors in other regions as cited by Mehaia (1994) in Saudi Arabia (pH =  $6.61 \pm 0.02$ ), Kamoun (1995) in Tunisia (pH =  $6.51 \pm 0.12$ ) and Elhosseiny *et al* (2018) in Egypt (6.61). Of the samples analysed, only 16% had a pH below 6 (between 5.09 and 5.59). On the other hand, the pH of camel milk depends on other factors, i.e. the nature of the fodder and the availability of water (Gorban and Izzeldin, 2001; Gorban and Izzeldin, 1997), the citrate and casein content and the health of the udder (Siboukeur, 2008).

The fat content of the milk analysed ranged from 24.2 to 46.9 g/l, with an overall average of  $34.76 \text{g/l} \pm 5.85$ . This average was in line with that found by Ellouze and Kamoun (1989); Gorban and Izzeldin (2001) (32 to 35 g/l) and was lower than that found by Kamal *et al* (2007) (37.8g/l), Sboui *et al* (2016) (37.5g/l) and also by Bouras *et al* (2022) ( $37.76 \pm 1.54$  g/l). It lies between the extreme values recorded for the Somali breed and reported by Karue (1994) (56 g/l) and those recorded by Mehaia *et al* (1995) for the Wadah breed (24.6 g/l). In fact, Konuspayeva *et al* (2009) noted a wide variation in the fat content of camel milk throughout the world. The study by Al-Haj *et al* (2022), reports an overall average fat content of 3.47%. However, its physicochemical composition shows marked

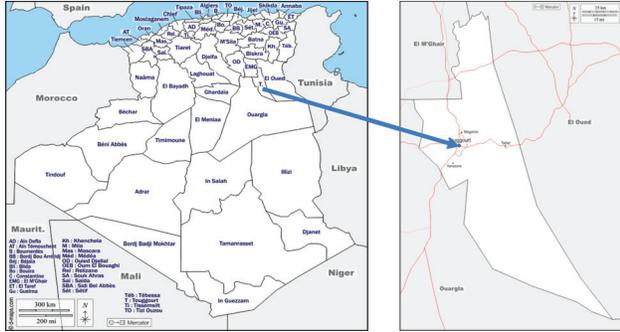
**Table 1.** Distribution of breeders surveyed by municipality.

The municipalities	Taibet	Touggourt	Tamacine	El mguarin	Total
Number of breeders surveyed	11	6	4	4	25

**Table 2.** Average physicochemical characteristics of milk collected from the farms studied.

	pH	MG	Lactose	Protéine	Minerals	Freezing point
Max	7.09	46.9	58.8	39.9	4.9	-0.43
Mean ± Standard deviation	6,62±0.57	34.76±5.85	47.28±3.94	33.20±2.54	3.17±0.95	-0.55±0.03
Min	5.09	24.2	35.3	25.9	1	-0.66

Max : maximum; Min :minimum



**Map 1.** Geographical location of the study area (Touggourt, Algeria). (<https://d-maps.com/>)

variability, attributable to various biological and environmental factors, including breed, season, geographical origin, diet and analytical methods, which explains the discrepancies observed between studies, particularly with regard to fat and lactose content. On the other hand, among the analysed milk samples, we found that only 20% of them have a fat content of less than 30 g/l. Abdalla *et al* (2015) explained that the low fat content of camel milk is a sign of poor nutrition in desert areas. Indeed, the composition of camel milk has been shown to vary widely in its constituents depending on physiological, genetic and environmental factors (Musaad *et al*, 2013).

In fact, morning milking gives milk that is relatively low in fat compared to evening milking (Kamoun, 1994). This is due to the fact that the milk at the beginning of milking is a little wet and low in fat that has a more or less significant molecular weight, so it remains behind. This study is based on the analysis of mixed milk from morning milking. Previous studies indicate that the time of milking influences the composition of camel milk, with evening milking associated with higher levels of fat, acidity and certain minerals (Cl, P), while protein and lactose remain broadly stable. These results, in agreement with Nagy *et al* (2017) and Ayadi *et al* (2009), confirm that milk from morning milking is relatively lower in fat content.

The average total protein content of the analysed camel milk is equal to  $33.20 \text{ g/l} \pm 2.54$ . This concentration is comparable to those mentioned by Siboukeur (2008) ( $35.68 \pm 5.64 \text{ g/l}$ ) and by Kamoun (1994) ( $34.3 \pm 4.4 \text{ g/l}$ ). However, it is higher than those reported by Mehaia *et al* (1995) which was  $29.1 \text{ g/l}$  and by Gnan *et al* in Libya (1994) ( $21.5 \text{ g/l}$ ) or Bouras *et al* (2022) in Algeria ( $28.6 \pm 0.4 \text{ g/l}$ ) and on the other hand it is lower than that recorded by Mohamed *et al* (1989) in Somalia ( $46 \text{ g/l}$ ). The nitrogenous substance in milk is found mainly in

**Table 3.** Results of the ANOVA analysis of one factor between and within milk classes.

				Sum of squares	ddl	Mean of squares	F	Signification
MG	Inter-group	(Combined)		2472,20	24	103,00	80,89	,00
		Linear term	Contrast	,32	1	,32	,25	,61
			Difference	2471,87	23	107,47	84,39	,00
	Intra-group			63,67	50	1,27		
	Total			2535,87	74			
TP	Inter-group	(Combined)		372,15	24	15,50	7,20	,00
		Linear term	Contrast	35,02	1	35,02	16,28	,00
			Difference	337,12	23	14,65	6,81	,00
	Intra-group			107,54	50	2,15		
	Total			479,69	74			
lac	Inter-group	(Combined)		927,43	24	38,64	8,61	,00
		Linear term	Contrast	131,72	1	131,72	29,34	,00
			Difference	795,71	23	34,59	7,70	,00
	Intra-group			224,41	50	4,48		
	Total			1151,85	74			
Min	Inter-group	(Combined)		18,96	24	,79	,80	,71
		Linear term	Contrast	6,83	1	6,83	6,94	,01
			Difference	12,12	23	,52	,53	,94
	Intra-group			49,23	50	,98		
	Total			68,19	74			

MG: fat content; TP: protein content; lac: lactose; Fpp: freezing point; Min: minerals; ddl: degree of freedom

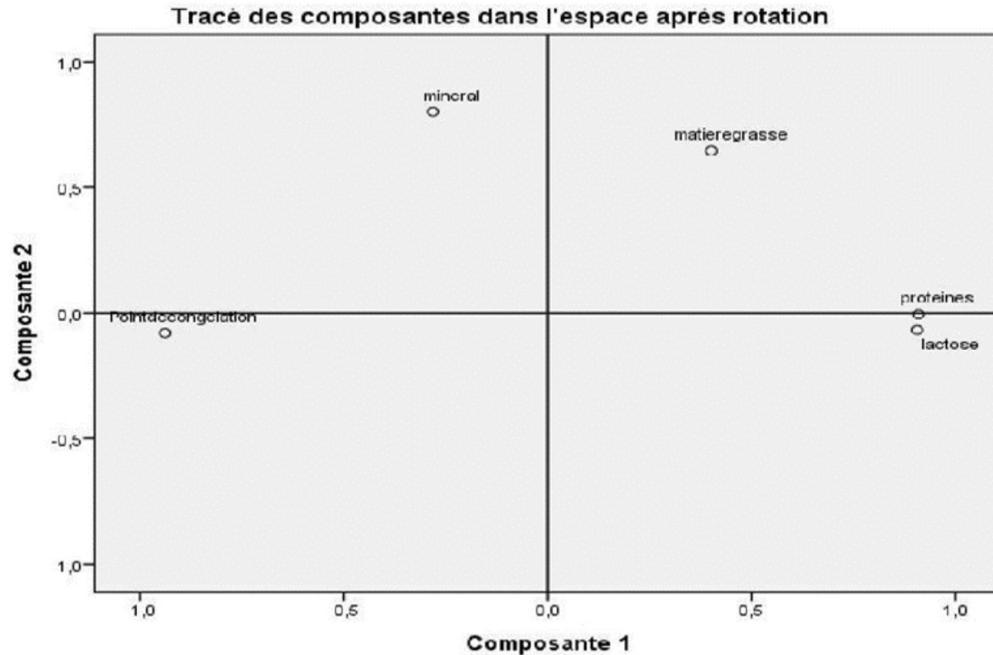


Fig 1. Distribution of milk quality variables on axes F1 and F2 of the ACP.

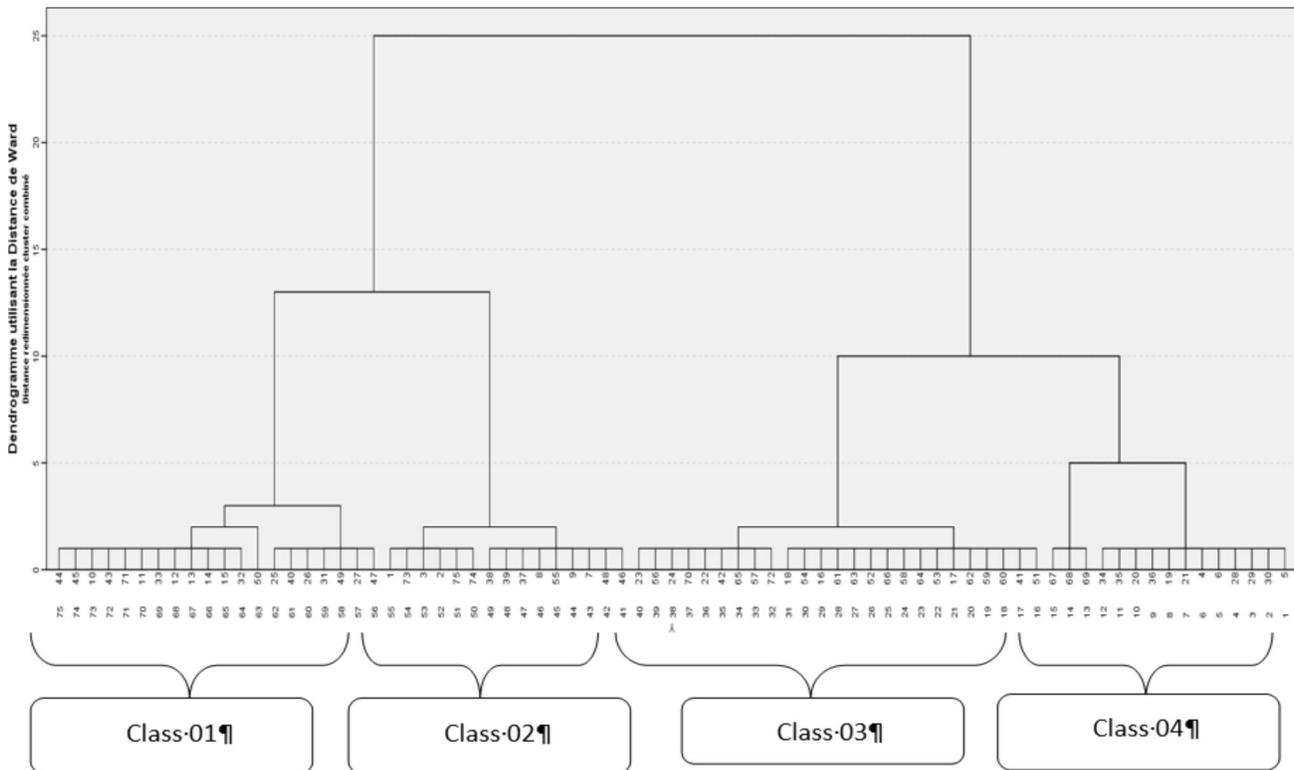


Fig 2. Dendrogram of the automatic classification of milk samples.

the form of protein nitrogen (90% of total nitrogen). Camel milk contains more free amino acids and other non-protein nitrogen compounds (NPN) than bovine milk (Atarhouch *et al*, 1997). Protein content varies depending on the stage of lactation. The first two months of lactation are characterised by a decrease

in protein and fat levels in camel milk.. According to Musaad *et al* (2013), the protein content of camel milk varies significantly depending on the stage of lactation and the season. It tends to increase at the end of lactation, while seasonal variations are also observed, reflecting the influence of physiological and

environmental conditions on the protein composition of camel milk.

The average lactose content of the camel milk samples analysed was 47.28g/l  $\pm$ 3.94. The lactose concentration of camel milk is close to the values reported by several authors: Mehaia *et al* (1995), Gorban and Izzeldine (1997), Gnan and Sheriha (1986) in Libya (56 g/l), Desal *et al* (1982) (42 g/l) and Sboui *et al* (2016) (42.78g/l). The lactose content of milk is one of the most stable parameters, except in the case of extreme dietary change. Its concentration remains unchanged regardless of the season (Haddadin and al, 2008) or the animal's state of hydration, whether hydrated or dehydrated (Yagil and Etzion, 1980). According to Musaad *et al* (2013), the lactose content of camel milk shows limited variability compared to other major constituents. It is only slightly influenced by the stage of lactation and physiological variations, remaining generally stable throughout lactation. The seasonal fluctuations observed are modest and mainly reflect the animal's metabolic adaptation to environmental conditions, confirming that lactose is one of the most consistent components of camel milk.

The total amount of minerals is generally expressed as total ash. The total value of minerals is around 1 g/l and 4.9 g/l. These results are low compared to those reported by Sboui *et al* (2009) with 7.5 g/l and those reported by Siboukeur (2008) with 7.28 g/l. Our results differ from those of Konuspayeva *et al* (2009), who report an average ash content in camel milk of 0.79  $\pm$  0.09 g/100 ml. However, these authors highlight significant variations among populations in East Africa, which corresponds to the region covered by our study. In contrast, studies conducted in Asia generally show higher concentrations for most milk constituents, with the exception of ash, probably due to the predominance of Bactrian camels in this region.

The mineral content of camel milk decreases in case of water deprivation (Yagil, 1985). It also varies according to the stage of lactation (Farah, 1993). The minerals present in camel milk are key compounds that explain its beneficial effects on human health. However, data on the influence of camel nutrition on the mineral content of their milk remain limited (Konuspayeva *et al*, 2022). These observations suggest that the mineral composition of camel milk is the result of multiple interdependent factors, requiring an integrative approach to elucidate its determinants.

### Comparative analysis of milk composition

The comparison of camel milk samples in the study region led us to carry out a one-factor analysis of variance (Table 3). The results of the analysis of variance showed that at the 5% threshold, there are significant variations between the milk samples and which are mainly due to fat content (MF), protein content (TP), lactose content (lac). These marked differences between samples also confirm the direct consequences of breeding practices, mainly feeding. The variations observed between samples are mainly attributable to farming practices, particularly feeding practices, although individual factors such as stage of lactation may also influence the results. Overall, feeding appears to be the major determinant of camel milk quality, as indicated by the descriptive analysis of the analytical data obtained.

In fact, milk from farmers offering a ration rich in concentrates and alfalfa (20% of the farms studied) was characterised by a high protein content. On the other hand, samples of milk from farmers who graze on different pastures and do not supplement their rations (12% of farms) show low protein levels.

Although the study took place in spring, a period of good feed availability, some samples (particularly from Taibet and central Touggourt) showed low fat levels, likely because the majority of the camels were primiparous. It is well known that camel milk is lower in fat and protein after the first births, with a peak between the third and fifth lactations. Furthermore, 20% of the samples had a high fat content (40 to 45.5 g/l), which is explained by a quality diet and camels in 3rd lactation.

### Typology of raw milk samples collected

The first two factorial axes of the PCA on the milk composition data account for 76.83% of the total variability (Table 5 and Fig 1). Axis 1 explains 55.41% of the total variation and is considered to represent the protein level and lactose content while axis 2 represents 21.41% of the total variation and is related to the variables fat level and mineral content.

**Table 4.** Eigenvalues of the factorial axes of the PCA.

Component	Initial eigen values		
	Total	% of variance	Cumulative %
1	2,771	55,41	55,41
2	1,071	21,41	76,83

### Hierarchical Ascending Classification

The analysis was followed by a Hierarchical Ascending Classification (HAC) on the PCA results.

**Table 5.** Characteristics of the different classes of milk identified.

	Class01 (n=20)	Class 02 (n=15)	Class03 (n=25)	Class04 (n=15)
MG (g/L)	32.68±2.56	27.14±1.69	35.62±1.98	43.72±2.61
Lactose (g/l)	42.27±2.64	49.53±2.12	48.50±1.27	49.67±3.92
MP (g/L)	32.95±2.02	34.21±1.44	33.88±1.477	34.9±2.36
Minerals (g/l)	3.57±0.98	2.88±0.86	2.93±0.853	3.35±1.05
FPP(°C)	-0.51±0.03	-0.56±0.02	-0.55±0.01	-0.58±1.54

MG: fat content, Lactose: Lactose content, MP: Protein content, FPP: freezing point, Results are expressed as mean ± standard deviation.

Four classes of milk can be identified (Fig 2). The general characteristics of the four identified groups are in the following (Table 6).

- **Class 1 “milk class with the highest mineral content, average protein, lactose and fat content” (n=20).** They are characterised by an average protein content (32.95g/L), lactose (42.27g/l) and fat (32.68g/L). The highest mineral content 3.57g/l, is associated with the lowest freezing point (-0.51°C). The freezing point value observed in our samples is similar to that reported by Konuspayeva *et al* (2023), who obtained  $-0.523 \pm 0.064$  °C from 736 samples analysed using the Express method (Milkoscan FT1).

- **Class 2 “milks with the lowest fat and mineral contents, associated with high protein and lactose contents” (n=15).** Its main characteristics are the lowest fat (27.14) and mineral (2.88g/l) contents, high protein (34.21g/l) and lactose (49.53g/l) contents. The milk samples in this class are characterised by a medium freezing point (-0.56°C).

- **Class 3 “milks with high protein, fat and lactose contents associated with a low mineral content” (n=25).** These milk samples are distinguished by high contents of useful materials: protein (33.88 g/l), fat 35.62 g/L and lactose 48.50 g/l, associated with a low mineral content (2.93 g/l).

-**Class 4 “milks with the highest protein, fat and lactose content and with a high mineral content.”(n=15).** The milk samples in this class are characterised by the highest protein and lactose contents, respectively 34.95g/L, 49.67g/L and 43.72g/L, associated with a high mineral content (3.35g/L).

Multidimensional statistical analyses made it possible to characterise the milk samples according to the main variables reflecting milk quality: the content of useful matter. Although the differences in Figs within the different classes are rather small due to the fact that the information collected only tendentiously reflects the situation (without monitoring of farms, it

remains difficult to make quantifications according to breeders), we can therefore make the following observations through the definition of the classes:

- The distribution of camel milk samples in the different classes confirms the irregularity of the quality of camel milk produced in the study region.

- The four classes resulting from the class analysis are distinguished essentially by the content of useful matter, essentially that of fat and mineral matter.

- a class of milk deserves particular attention: class 4, on the other hand, has the most favorable characteristics (satisfactory butterfat protein content and mineral content).

- The typology of milk samples made it possible to draw up a descriptive diagram of the diversity of variations that milk can undergo in a breeding environment based on variations in the content of useful materials which also confirms the direct consequences of breeding practices on the quality of milk.

## Conclusion

Through this study, we attempted to make a contribution to a better understanding and characterisation of camel milk produced in southern Algeria, in the case of the Touggourt region of the Sahraoui breed, the most abundant. The results of the physicochemical analyses indicate that camel milk has satisfactory characteristics overall. The typology of the milk samples made it possible to define four milk classes reflecting the variations that camel milk can undergo in a breeding environment based on variations in useful matter content. The distribution of milk samples in the different classes confirms the irregularity of the quality of the milk produced by the different camel herders in the study area. Only one milk class deserves special attention: class 4 having the most favorable characteristics and the highest in relation to the satisfactory fat, protein and mineral content.

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