## FACTORS INFLUENCING THE PHYSICOCHEMICAL AND MINERAL COMPOSITION OF CAMEL MILK IN EASTERN ALGERIA

## Meroua Kraimia<sup>\*1, 2</sup>, Abdelkader Adamou<sup>1</sup>, Saliha Boudjenah-Haroun<sup>3</sup> and Mohammed Hocine Benaissa<sup>4</sup>

<sup>1</sup>Laboratory of Saharan Bioresources, Preservation and Valorisation Kasdi Merbah University, Faculty of Nature and Life Sciences - Ouargla, 30,000 Algeria

<sup>2</sup>Department of Veterinary Sciences, Faculty of Nature and Life, University of Eloued, 39,000, Algeria

<sup>3</sup>Research Laboratory on Phoeniciculture Kasdi Merbah University, Faculty of Nature and Life Sciences - Ouargla, 30,000 Algeria

<sup>4</sup>Scientific and Technical Research Centre for Arid Areas (CRSTRA), Nezla, Touggourt, Algeria

#### ABSTRACT

This study was conducted to evaluate the impact of lactation stage, season, number of births and the milking of the day on the chemical composition of camel milk in the Tebessa region (East Algeria). A total of 44 milk samples obtained from 10 healthy Saharawi camels were collected over the course of one year, divided into four seasons. The sampling occurred at various stages of lactation (the beginning, middle and end) and at parity numbers ranging from 1 to 8. The results of this study showed that fat, lactose, Zn and I were significantly (P<0.05) affected by the stage of lactation where the highest levels were recorded at the beginning of lactation and then gradually decreased until the end of lactation. Moreover, the majority of milk's physicochemical and mineral parameters were significantly influenced by the season where winter and autumn showed the highest mean values, whereas summer exhibited the lowest rates. Our research revealed a difference in the composition of morning and evening milk, particularly in terms of acidity D°, Fat g/l, Ca g/l, CL g/l and P g/l where the evening milk recorded the highest levels. On the other hand, no parity number impact on milk composition was detected. Our findings suggest that the stage of lactation during the season and the milking of the day have an impact on the composition of camel milk. These results could be taken into consideration when studying the improvement of the nutritional and technological aspects of milk.

Key words: Camel milk, dromedary camel, lactation stage, mineral composition, season

The dromedary camel is known to be able to live and produce in harsh conditions, enabling them to produce milk of high nutritional quality for longer durations compared to other species (Wernery, 2006; Patel et al, 2016). In Algeria, camel is a multipurpose animal used in protein production such as milk and meat and in transportation and tourism (Adamou and Boudjenah, 2012; Harek et al, 2022). Rural inhabitants living in the arid and semi-arid regions primarily depend on camel milk to fill the protein deficiency of animal sources (Faye et al, 2014). On the other hand, camel milk differs from milk of other dairy species by its nutritionally and medicinally important composition (Konuspayeva et al, 2007; Sboui et al, 2009). Indeed; since the literature has touted its curative and preventive therapeutic virtues (Sboui et al, 2016; Agrawal et al, 2005), there has been a surge in the interest of consumers from other non-desert regions for the purchase of camel milk. During the last decade, the situation started changing in the south of Algeria and many peri-urban camel dairy farms were established

(Senoussi *et al*, 2023). The physicochemical properties of camel milk were reported to be influenced by many factors (Yoganandi *et al*, 2014a; Yoganandi *et al*, 2014b). Several studies have been carried out on the milk of dromedaries from Algeria, in particular on its physicochemical and biochemical composition (Siboukeur and Siboukeur, 2012), antimicrobial activity and the potentialities of its production (Adamou and Boudjenah, 2012). However, to our knowledge, studies on camel milk characteristics and factors influencing its composition in Algeria are very scarce. This study aims to evaluate the variations of the physicochemical composition and mineral milk of Saharawi camel in a steppe region according to the stage of lactation, season, number of parities on its composition.

## Materials and Methods

#### Animals and Sampling

Our study focused on ten Sahrawi camels, all in excellent health and raised in an extensive manner.

SEND REPRINT REQUEST TO M KRAIMIA email: marouakraimia@gmail.com

These camels were at various stages of lactation (early, mid and late) and had between 1 and 8 births. Ranging in age from 4 to 15 years, these animals were part of a herd residing in the Ferkan commune within the Tebessa province, located in a steppe area of Algeria.

Forty samples were taken over the course of a year spread over four seasons (10 samples/season) were taken during the morning milking each season before leaving the herd, while in addition to the ten samples taken in the morning in the fall, we added four samples from the evening milking. The milk was immediately labeled, stored at 4°C and promptly transported to the laboratory. Further, information on the adopted livestock management and treated females was collected through a questionnaire.

## Physicochemical, biochemical and mineral analysis

The milk quality analysis involved 18 parameters for each sample, resulting in a total of 792 data points over 44 samples. The pH values were detected using a pH meter (FE20, Mettler Toledo Technology Co., LTD, Shanghai, China). The titratable acidity was measured according to the Algerian Institute of Standardisation (IANOR) (NA 687-2011) by titrating the samples with 0.1 mol/L NaOH. Ash content was determined by incineration of the sample placed in the muffle furnace at 550 °C for 6 h (AOAC, 2000). Total dry extract (TDE) was determined by drying the sample in the oven at  $103 \pm$ 2°C for 24 hours and weighing the residue according to the method AOAC 926.08 (Association of Official Analytical Chemists, 1995). The milk fat content in all the milk samples were determined according to Gerber method (ISO 11870/ IDF 152:2009). The milk protein content of all the milk sample was determined using Kjeldahl method of nitrogen estimation as described in BIS Handbook. Density at 20°C was determined using a thermo-lactodensometer. lactose contents of milk samples were determined by the infrared spectrometric method (ISO, 2013), using a Bentley 150 instrument (Shimadzu, Model: 1800, Tokyo, Japan). To analyse the contents of different minerals (Na, k, Ca, Mg, Zn, Cu, I, Fe CL, P) flame atomic absorption spectrometry (A. Analyst 700, Perkin Elmer, USA) was used.

## Statistical studies

The obtained results were statistically processed by the computer program MINITAB (version 19.0). Comparisons between the two variants were performed by ANOVA one way followed by HSD

muneResults and Discussione areaHerd Characteristic

The owner concerned by the herd experience had inherited the profession from his grandparents, who were conventional breeders, raising diverse animals, including sheep, goats, horses, poultry and camels.

Tukey post Hoc test to estimate the significant

differences at a 5% probability threshold.

Feeding was based on the exploitation of natural rangelands that are characterised by their harshness and many constraints related to food, watering and climate. A supplement of concentrates for young animals was present, especially for those intended for slaughter. Moreover, watering was based on the installation of a well.

The size of the study herd consisted of 82 heads (2 males and 80 females) where 70% of it was composed of the Sahrawi breed and 30% of the Targui breed.

The use of milk from this herd remains within the family. The daily milk production was between 3 to 4 litres extract from 1 to 3 milkings per day, while lactation duration in general was between 8 months to a year, the dry-out period was 3 to 5 months and the average weaning age was 7 months for male and 12 months for female camels. Additionally, the gestation period was 12 months in each of the three farming systems. Calving intervals were about 25 months.

The process of reproduction followed natural breeding principles, which involved introducing camels, with limited interactions to females only during the breeding season.

# Biochemical, mineral and physicochemical analysis of milk

## Lactation stage effect

The obtained data regarding the effect of the lactation stage on the composition of camelina milk (Table 1) indicated the presence of a significant difference only for 4 parameters (fat, lactose, zinc and iodine). Importantly, milk fat was strongly influenced by the lactation stage where the highest rate in camels was recorded during the first three months of lactation (34.67±1.30g/l) compared to that obtained in the middle (27.40±5.69 g/l) and at the end (29.12±2.83 g/l). On the other hand, the lactose content was high in the first 6 months of lactation (42.5 g/l at the beginning) followed by a decrease

Physicochemical parameters		Lactation stage				
		Beginning	Middle	End	Р	
Physical analysis	pН	6.60 ±0.22	6.58±0.36	6.55±0.39	0.95	
	Acidity(D°)	35.47±4.01	37.12±3.98	36.225±3.74	0.66	
	Density	1.023±0.003	1.024±0.004	1.025±0.004	0.55	
Chemical analysis	Ash (%)	7.22±0.63	7.53±0.47	7.61±0.46	0.26	
	TDE (%)	11.81±1.68	11.64±0.22	12.23±0.98	0.51	
	Protein(g/l)	29.95±2.26	31.30±1.51	30.59±3.06	0.47	
	fat (g/l)	34.67± 1.30 <sup>a</sup>	$27.40 \pm 5.69^{b}$	29.12±2.83 <sup>b</sup>	0.001	
	Lactose(g/l)	42.49± 3.18 <sup>a</sup>	42.50± 2.81 <sup>a</sup>	38.35±4.07 <sup>b</sup>	0.02	
Mineral analysis	Na (g/l)	0.432±0.017	0.442±0.074	0.410±0.058	0.44	
	K (g/l)	2.63±0.19	2.35±0.23	2.37±0.13	0.94	
	Ca (g/l)	1.51±0.35	1.67±0.16	1.75±0.17	0.12	
	Mg (g/l)	0.073±0.0088	0.070±0.0041	0.074±0.0049	0.51	
	Zn (g/l)	$0.0048 \pm 0.0004^{a}$	0.0040±0.0006 <sup>b</sup>	0.0039±0.0005 <sup>b</sup>	0.005	
	Cu (g/l)	0.0013±0.0002	0.0014±0.0002	0.0012±0.0002	0.14	
	I (g/l)	0.145±0.023 <sup>a</sup>	0.137±0.019ab	0.117±0.009 <sup>b</sup>	0.02	
	Fe (g/l)	0.0021±0.00026	0.0019±0.00035	0.0018±0.00038	0.20	
	CL (g/l)	0.0013±0.00006	0.00126±0.00007	0.0013±0.0001	0.52	
	P (g/l)	0.715±0.123	0.65±0.102	0.69±0.086	0.36	

Table 1. Physical-chemical and mineral composition of raw milk according to lactation stage.

Different letters in the same line indicate a significant difference ( $P \le 0.05$ )

Lactation stage : beginning: birth-3 months/ middle: 3 months - 6 months/ 6 months until the end of lactation

at the end of lactation  $(38.35\pm4.07 \text{ g/l})$ . Moreover, a decrement was reported in zinc  $(0.0048\pm0.0004 \text{ at the beginning}, 0.0040\pm0.0006$  in the middle and  $0.0039\pm0.0005$  at the end) and iodine  $(0.145\pm0.023; 0.137\pm0.019; 0.117\pm0.009)$ , respectively.

In comparison with other studies; the lactation stage has a strong influence on the chemical composition of milk, particularly on the level of lactose, fat, protein, degreased dry extract, total dry extract, density and ash (Aljumaah *et al*, 2012; Musaad *et al*, 2013; Dowelmadina *et al*, 2014; Babiker and El-Zubeir, 2014; Nagy *et al*, 2017; Kadri *et al*, 2020). In contrast to the work of Guliye *et al* (2000) which indicated that the lactation stage did not affect camel milk composition.

The findings of our study are consistent with the research conducted by Zeleke (2007), Konuspayeva *et al* (2010), Aljumaah *et al* (2012) and Babiker and El-Zubeir s(2014). These studies reported that the levels of fat content, lactose, protein and total solids were higher during the first few months of lactation and then gradually decreased until the end of lactation; they interpreted it as due to the increase in the proportion of water in milk at the end of lactation. However, other studies reported higher fat content at the end of lactation (Kadri *et al*, 2020).

On the other hand; The decrement in lipid content likely reflects the typical malnutrition of desert habitat conditions (Abdalla *et al*, 2015); as well as the lack of nutritional supplementation (Dowelmadina *et al*, 2014).

If we consider lactose oxide content; it has been reported that it is the only element that remains almost unchanged during lactation (Farah *et al*, 2004; Haddadin *et al*, 2008). In contrast, studies conducted by Abdalla *et al* (2015) and Hadef *et al* (2018) revealed no significant variation in lactose content throughout the various stages of lactation. However, it can vary slightly depending on camel breeds in different parts of the world (Haj and Al Kanhal, 2010).

On the other hand; among the ten minerals investigated in this study, only zinc (Zn) and iodine (I) were affected by lactation displaying a significant difference and a gradual decrease throughout the lactation stages. In contrast, the levels of the remaining eight minerals (Na, k, Ca, Mg, Cu, Fe CL, P) remained stable from early to late lactation. In comparison with the work of Zhang *et al* (2005) and Aljumaah *et al* (2012); Na, K and Ca are significantly affected by the lactation stage, Na and K levels are relatively low at the beginning and then rise gradually throughout lactation.

The Ca content was found low during the first day of lactation, then it increased slightly until the 7th day and it gradually decreased until the 90th day, as well as the level of P. In addition; a large variation was noted in Cl content throughout the lactation period (Zhang *et al*, 2005). By contrast; Aljumaah *et al* (2012) reports that the highest Ca content is recorded in mid-lactation.

Variations in the main mineral contents of camel milk were attributed to racial differences, diet, lactation stage, drought conditions or analytical procedures (Farah, 1993; Mehaia *et al*, 1995), health status (Farah, 1996) and water consumption (Haddadin *et al*, 2008).

### Season effect

The data presented in Table 2 revealed that the physicochemical and mineral composition of camel milk were highly significant (p < 0.001) depending on the season. Indeed; The pH value was very low in winter (6.33±0.09) then it increased gradually to reach its maximum in summer at 6.88±0.30 then fell again to 6.65±0.29 in autumn.

Nevertheless, a large variation was observed regarding the acidity value, where the highest levels were recorded in autumn and summer  $(40.97\pm4.39D^{\circ})$  while the lowest was in spring  $(33.02\pm3.33D^{\circ})$ .

However, the density remained stable for three seasons at a value of 1.026 and then decreased slightly in winter to 1.020. On the contrary, the highest MS value was recorded in winter and spring at 12% compared to the other two seasons. Additionally, the protein content showed a remarkable variation with the season with the highest content recorded in winter (32.76±1.09g/ l) and the lowest in autumn and spring. Meanwhile, the low lactose content was marked only in summer at 38.25±3.94g/l.

Furthermore, Na concentration reached its peak in autumn at  $0.512 \pm 0.060$ g/l and its minimum in spring at  $0.392 \pm 0.043$ g/l. In contrast, Ca appears in low value across three seasons but showed a significant increase in spring ( $1.90\pm0.02$ g/l). Similarly, Mg had its highest value ( $0.0837\pm0.0055$ g/l), while exhibiting a decrease only in spring at  $0.0036\pm0.0005$ , contrasting with calcium. Also, a slight variation in the Cl rate was detected and correlated to the season changes.

On the other hand, the mineral content of K, Cu, Fe and P in addition to ash and fat, were not affected by the season.

The results of our study revealed that the mean values of the majority of the chemical and mineral components of milk (TDE, protein, lactose, Na, Mg and Zn) were elevated in winter and autumn while

Table 2. Biochemical and mineral physicochemical composition of raw milk according to season.

Physicochemical parameters		Season						
		Winter	Spring	Summer	Fall	Р		
Physical analysis	pН	6.33±0.09 <sup>c</sup>	6.51±0.14 <sup>bc</sup>	6.88±0.30 <sup>a</sup>	6.65±0.29 <sup>ab</sup>	0.0001		
	Acidity (D°)	36.27±1.30b <sup>c</sup>	33.02±3.33 <sup>c</sup>	39.52±2.59 <sup>ab</sup>	40.97±4.39 <sup>a</sup>	0.000 3		
	Density	1.020 ±0.0005 <sup>bc</sup>	1.026±0.0012 <sup>a</sup>	1.026±0.0042 <sup>a</sup>	1.020±0.0024 <sup>a</sup>	0.0003		
Chemical analysis	Ash (%)	7.55±0.40	7.38±0.23	7.42±0.84	7.6±0.76	0.84		
	TDE (%)	12.23±1.03 <sup>a</sup>	12.38± 0.79 <sup>a</sup>	11.07±1.00 <sup>ab</sup>	11.94±0.68 <sup>b</sup>	0.01		
	Protein (g/l)	32.76±1.09 <sup>a</sup>	28.8±1.91 <sup>b</sup>	30.27±1.54 <sup>ab</sup>	27.42±5.03 <sup>b</sup>	0.002		
	fat (g/l)	33.17±1.89	29.32±4.33	28.7±6.52	30.57±4.07	0.17		
	Lactose (g/l)	41.72± 2.75 <sup>ab</sup>	43.37±2.94 <sup>a</sup>	38.25±3.94 <sup>b</sup>	41.32±1.74 <sup>ab</sup>	0.007		
Mineral analysis	Na (g/l)	$0.455 \pm 0.078^{ab}$	0.392±0.043 <sup>b</sup>	0.447±0.038 <sup>ab</sup>	0.515±0.060 <sup>a</sup>	0.001		
	K (g/l)	2.26±0.15	2.44±0.19	2.38±0.13	2.28±0.21	0.43		
	Ca (g/l)	1.48±0.28 <sup>a</sup>	1.90±0.02 <sup>b</sup>	1.55±0.09 <sup>a</sup>	1.61±0.14 <sup>a</sup>	0.000 4		
	Mg (g/l)	0.0705±0.0037 <sup>b</sup>	0.0710±0.0041 <sup>b</sup>	0.0765±0.0081 <sup>b</sup>	$0.0837 \pm 0.0055^{a}$	0.0005		
	Zn (g/l)	0.0044±0.0004 <sup>a</sup>	0.0036±0.0005 <sup>b</sup>	$0.0046 \pm 0.0004^{a}$	0.005±0.0007 <sup>a</sup>	0.000 1		
	Cu (g/l)	0.0014±0.0002	0.0013±0.0002	0.0012±0.0002	0.0012±0.0002	0.22		
	I (g/l)	0.122±0.018 <sup>b</sup>	0.125±0.013 <sup>b</sup>	0.152±0.017 <sup>a</sup>	0.13±0.021 <sup>ab</sup>	0.004		
	Fe (g/l)	0.0017±0.0005	0.0020±0.0001	0.0020±0.0001	0.0021±0.0001	0.06		
	CL (g/l)	0.0012±0.00006 <sup>b</sup>	0.0013±0.00004 <sup>a</sup>	0.0012±0.00006 <sup>b</sup>	0.0013±0.00002 <sup>a</sup>	0.0003		
	P (g/l)	0.66±0.16	0.70±0.04	0.68±0.07	0.77±0.03	0.08		

Different letters in the same line indicate a significant difference ( $P \le 0.05$ ).

the lowest levels were recorded in summer. These results are consistent with those reported by Nagy *et al* (2017) for Fat, Protein, TDE and ash and by Musaad *et al* (2013) for fat, protein and lactose. This could be explained by the better availability of quality food and water during the wet months compared to the dry months.

In parallel, Haddadin *et al* (2008), Shuiep *et al* (2008) and Hamed *et al* (2017) recorded a minimum fat content in camel milk during the warm season. While, protein and lactose recorded their minimum levels in autumn, which is in contrast to the Fat rate which was at its peak in the summer period according to Bakheit *et al* (2008) diverging from the findings of our study where the fat rate remained stable throughout the year. All these variations could be explained by seasonal changes that affect food quality because total energy intake is directly related to fat content (Shuiep *et al*, 2008), as well as the state of hydration of camels during the summer (Yagil, 1982).

Our results are in concordance with those reported by Hamed *et al* (2017) suggesting that the ash content was not influenced by the season and close to that observed by Zhang *et al* (2005) on the Bactrian camel and by Musaad *et al* (2013) indicating that the

ash rate is relatively stable throughout the year, with a slight decrease in autumn.

In the same line, TDE, pH and Cl values were not affected by the season (P > 0.05) according to Bakheit *et al* (2008) and Hamed *et al* (2017), respectively.

On the other hand, the ash content, K, Cu, Fe and P were slightly varying throughout the year, with the exception of Ca which rose only during the spring.

In addition, regarding minerals Hamed *et al* (2017) demonstrated variations in the average amounts of K, Ca, Na and Mg, the first two being high during the rainy season, while the last two were during the dry season and these variations may be due to a dilution effect. Furthermore, Guler (2007) concluded that these changes were likely related to animal feeding behaviour and changes in pasture composition.

## Parity effect

Statistical analysis of the data mentioned in Table 3 we noted that the physicochemical and mineral composition of camels' milk was not significantly affected by parity (p < 0.05).

Physicochemical parameters		Number of parity				
		1 <sup>st</sup> lactation	2 <sup>nd</sup> to 6 <sup>th</sup> lactation	> 6 <sup>th</sup> lactation	Р	
Physical analysis	pН	6.28±0.06	6.28±0.15	6.26	0.98	
	Acidity(D°)	39.86±5.95	39.65±4.35	55.9	0.08	
	Density	1.02±0.005	1.11±0.10	1,029	0.33	
Chemical analysis	Ash (%)	7.41±0.47	7.13±0.70	7.11	0.83	
	TSM (%)	11.90±0.33	12.64±0.94	11.33	0.29	
	Protein(g/l)	31.45±0.80	30.85±1.24	30.1	0.89	
	fat (g/l)	35.43±2.21	31.92±1.48	30.2	0.07	
	Lactose(g/l)	43.46±1.42	43.82±5.03	45.7	0.88	
Mineral analysis	Na (g/l)	0.493±0.02	0.462±0.08	0.44	0.73	
	K (g/l)	2.28±0.18	2.19±0.09	2.40	0.39	
	Ca (g/l)	1.67±0.02	1.48±0.29	1.66	0.56	
	Mg (g/l)	0.070±0.001	0.071±0.04	0.079	0.14	
	Zn (g/l)	0.0045±0.0004	0.0040±0.0005	0.0042	0.71	
	Cu (g/l)	0.0015±0.0002	0.00013±0.00009	0.0013	0.33	
	I (g/l)	0.126±0.02	0.117±0.009	0.11	0.60	
	Fe (g/l)	0.0016±0.0003	0.0017±0.0005	0.0013	0.63	
	CL (g/l)	0.0012±0.00006	0.0012±0.00004	0.0012	0.98	
	P (g/l)	0.63±0.14	0.78±0.10	0.66	0.31	

Table 3. Physicochemical and mineral composition of raw milk according to parity number.

Different letters in the same line indicate a significant difference ( $P \le 0.05$ ) (One parity: 3 camels, 2-6 parities: 4 camels, more than 6 parities: 1 camels)

The findings of this study are consistent with those of Musaad *et al* (2013); Abdelgadir (2018) and Kadri *et al* (2020) who stated that parity had no effect on milk quality parameters. In contrast to the other studies, parity had a significant effect (P < 0.001) on all milk parameters analysed by Nagy *et al* (2017) according to which; the milk chemical composition of primiparous dromedaries was superior to that of multiparous.

Zeleke (2007) demonstrated that milk components are at their maximum values in the third lactation and the minimum values in the first and sixth lactation. Likewise, Aljumaah *et al* (2012) found that the highest mean values were recorded in the first lactation and then gradually decreased thereafter; however, the fat composition of milk as well as some minerals (Ca, Na) have not changed with parity.

The absence of significant differences between lactation ranks on all milk parameters may be attributed to the small number of experienced camels.

## Effect of day milking (morning and evening milking)

The effect of milking time on milk composition was evaluated using four dairy camels. Milk samples were collected from each lactating camel from morning and evening milking and taken for the determination of composition and physical characteristics of milk. Indeed, the data mentioned in Table 4 reported the presence of significant differences between the composition of milk collected in the morning and that collected in the evening. However, the acidity content, Fat, Cl and P were higher in evening milk than in morning milk, reaching 40.22±2.34D°, 36.12±2.38g/l, 0.0014±0.00001g/l, 0.83±0.01g/l, respectively, but exactly the opposite for the Ca content which decreases in the evening.

Our results concerning the effect of morning and evening milking on milk composition showed in general that the component content of milk is higher during evening milking in comparison to the morning. These results are consistent with the studies of Nagy et al (2017) indicating that the fat and TDM content was significantly important in afternoon milk (P < 0.001), on the other hand, lactose was more elevated in the morning and the protein content remained constant in both milkings times. These authors reported no increase in daily milk production when camels with high productivity were milked three times daily, in comparison to those milked twice a day. They propose that increasing the milking frequency might not enhance milk production for this particular species. This is contrary to what was shown by Faye in 2008, according to which three milkings can increase daily production to 28%.

In addition, Alshaikh and Salah (1994) and Ayadi *et al* (2009) reported that the rate of milk

Physicochemical parameters		Morning	Evening	Р
Physical analysis	pH	6.51±0.12	6.52±0.07	0.88
	Acidity D°	33.05±2.89 <sup>b</sup>	40.22±2.34 <sup>a</sup>	0.01
	Density	1.02±0.001	1.02±0.001	0.82
	Ash (%)	7.38±0.20	7.69±0.20	0.11
	TDE (%)	12.38±0.68	12.27±0.70	0.85
Chemical analysis	MP (g/l)	28.80±1.66	28.85±1.51	0.97
	fat (g/l)	29.32± 3.75 <sup>b</sup>	36.12±2.38 <sup>a</sup>	0.03
	Lactose (g/l)	43.55±2.34	43.57±2.18	0.98
	Na (g/l)	0.392±0.04	0.450±0.03	0.08
	K (g/l)	2.44±0.17	2.39±0.16	0.71
	Ca (g/l)	$1.90 \pm 0.018^{a}$	1.73±0.12 <sup>b</sup>	0.03
	Mg (g/l)	0.071±0.003	0.069±0.003	0.49
Chamical analysis	Zn (g/l)	0.003±0.0004	0.003±0.0003	0.63
Chemical analysis	Cu (g/l)	0.0013±0.0001	0.0013±0.0001	0.5
	I (g/l)	0.0125±0.011	0.125±0.011	1
	Fe (g/l)	0.0020±0.001	0.0022±0.003	0.46
	CL (g/l)	0.0013±0.00004	0.0014±0.00001	0.02
	P (g/l)	0.70±0.40 <sup>b</sup>	0.83±0.01 <sup>a</sup>	0.002

**Table 4.** comparison of the physicochemical, biochemical and mineral composition of morning and evening milk.

Different letters in the same line indicate a significant difference (P $\le$  0.05).

secretion decreased with increasing milking intervals as well as for the rate of organic constituents (lactose, SNF, fat and protein) and inorganic milk (sodium, potassium, calcium and magnesium).

However, several components of the milk treated in this study were not affected by morning and evening milking for pH, density, protein, lactose and most minerals except for the Ca level that rises in evening milking. These results are consistent with the results obtained by Ayadi *et al* (2009) who observed that protein, lactose, density and ash values remained constant for all milking intervals. While the K, Ca and Mg content of milk increased with the interval between milkings. It will be very interesting to do further studies in order to explore in depth the consequences of this difference.

#### Conclusion

In conclusion, the present study confirmed that the physicochemical and mineral composition of camel milk could be influenced by several factors such as lactation stage, season and day milking. Our data reported no impact of Number of births. Forward research on breed effect, husbandry practice, feeding conditions, geographic location and production system on more animals is essential for a more comprehensive evaluation of management factors. On this basis, we can improve Algerian camel breeding, relying on them as valuable contributors to milk production and their active participation in boosting the country's economy.

### **Conflicts of Interest**

The authors declare no conflict of interest.

#### References

- Abdalla EB, Ashmawy AEHA, Farouk MH, Salama OAER, Khalil FA and Seioudy AF. Milk production potential in Maghrebi she-camels. Small Ruminant Research. 2015; 123:129-135.
- Abdelgadir AMM. Measurements of Milk Flow and Udder Morphology and Their Impact on Milkability and Selecting of Dairy Camels (*Camelus dromedarius*) Under Intensive System. Sudan University of Science and Technology. 2018.
- Adamou A and Boudjenah S. Potentialités laitières chez la chamelle Sahraoui dans la région du Souf. Annals of Science and Technology. 2012; 4:7-7.
- Agrawal R, Sahani M, Tuteja F, Ghouri S, Sena D, Gupta R and Kochar D. Hypoglycemic activity of camel milk in chemically pancreatectomised rats-an experimental study. International Journal of Diabetes in Developing Countries. 2005; 25:75-79.
- Aljumaah RS, Almutairi FF, Ismail E, Alshaikh MA, Sami A and Ayadi M. Effects of production system, breed,

parity and stage of lactation on milk composition of dromedary camels in Saudi Arabia. Journal of Animal and Veterinary Advances. 2012; 11:141-147.

- Alshaikh MA and Salah MS. Effect of milking interval on secretion rate and composition of camel milk in late lactation. Journal of Dairy Research.1994; 61:451-456.
- AOAC, Official methods of analysis of AOAC International, 17<sup>th</sup> Ed., AOAC International, Gaithersburg, MD, USA, 2000.
- Ayadi M, Hammadi M, Khorchani T, Barmat A, Atigui M and Caja G. Effects of milking interval and cisternal udder evaluation in Tunisian Maghrebi dairy dromedaries (*Camelus dromedarius L.*). Journal of Dairy Science. 2009; 92(4):1452-1459.
- Babiker WI and El-Zubeir IE. Impact of husbandry, stages of lactation and parity number on milk yield and chemical composition of dromedary camel milk. Emirates Journal of Food and Agriculture. 2014; pp 333-341.
- Bakheit SA, Majid A. M and Nikhala, A. Camels (*Camelus dromedarius*) under pastoral systems in North Kordofan, Sudan: Seasonal and parity effects on milk composition. Journal of Camelid Science. 2008; 1, 32-36.
- Dowelmadina I, El-Zubeir I, Salim A and Arabi, O.. Influence of some factors on composition of dromedary camel milk in Sudan. Global Journal of Animal Scientific Research. 2014; 2:120-126.
- Farah K, Nyariki D, Ngugi R, Noor, I and Guliye A. The Somali and the camel: Ecology, management and economics. The Anthropologist. 2004; 6:45-55.
- Farah Z. Composition and characteristics of camel milk. Journal of Dairy Research. 1993; 60:603-626.
- Farah Z. Camel milk properties and products: Swiss Centre for Development Cooperation in Technology and Management. 1996.
- Faye B. Potentiel de productivité laitière des chameaux. ICAR TechnicalSeries Dans : Cardellion, R, Rosati, A. et Mosconi, C. (eds) État actuel des ressources génétiques, systèmes d'enregistrement et de production chez les camélidés africains, asiatiques et américains, No. 11, Actes du Séminaire ICAR/ FAO, Sousse, Tunisie, 30 mai 2004. ICAR, Rome, Italie. 2008; pp 93-104.
- Faye B, Jaouad M, Bhrawi K, Senoussi A, Bengoumi M., Elevage camelin en Afrique du Nord: 'etat des lieux et perspectives; Camel farming in North Africa: current state and prospects; Cría de cam'elidos en 'Africa del Norte: situaci'on actual y perspectivas. Revue D'élevage et de Médecine Vétérinaire Des Pays Tropicaux. 2014; 67:213–221.
- Güler, Z. Levels of 24 minerals in local goat milk, its strained yoghurt and salted yoghurt (tuzlu yoğurt). Small Ruminant Research, 2007; 71:130-137.
- Guliye, A, Yagil, R, & Deb, F. Milk composition of Bedouin camels under semi-nomadic production system. Journal of Camel Practice and Research. 2000; 7(2):209-212.
- Haddadin MS, Gammoh SI and Robinson RK. Seasonal variations in the chemical composition of camel milk in Jordan. Journal of Dairy Research. 2008; 75:8-12.
- Hadef L, Aggad H, Hamad B and Saied M. Study of yield and composition of camel milk in Algeria. Scientific

Study & Research. Chemistry & Chemical Engineering, Biotechnology, Food Industry. 2018; 19:1-11.

- Haj OA and Al Kanhal Hamad A. Compositional, technological and nutritional aspects of dromedary camel milk. International Dairy Journal. 2010; 20:811-821.
- Hamed H, El Feki A and Gargouri A. Influence of wet and dry season on milk composition of dromedary camels (*Camelus dromedarius*) from Tunisia. Iranian Journal of Applied Animal Science. 2017; 7:163-167.
- Harek D, Ikhlef H, Bouhadad R, Sahel H, Djellout N and Arbouche F. Gene-driving management practices in the dromedary husbandry systems under arid climatic conditions in Algeria. Pastoralism. 2022; 12(1):1-12.
- ISO. International Standard Organisation: Standard ISO 9622:2013 (IDF 141:2013), ISO Central Secretariat, Geneva Switzerland, 2013.
- Kadri S, Adamou A, Boudjenah-Haroun S and Baameur M. Effets du génotype, de la parité et du stade de lactation sur la composition du lait de dromadaire au Sud-Est Algérien. Livestock Research for Rural Development. 2020; 32(10).
- Kjeldahl J. Determination of protein nitrogen in food products. Encyc. Food Agric. 1983; 28:757-765.
- Konuspayeva G, Faye B, Loiseau G and Levieux D. Lactoferrin and immunoglobulin contents in camel's milk (*Camelus* bactrianus, *Campus dromedarius* and *Hybrids*) from Kazakhstan. Journal of Dairy Science. 2007; 90:38-46. https://doi.org/10.3168/jds.S0022-0302(07)72606-1.
- Konuspayeva G, Faye B, Loiseau G, Narmuratova M, Ivashchenko A, Meldebekova A and Davletov S. Physiological change in camel milk composition (*Camelus dromedarius*) 1. Effect of lactation stage. Tropical Animal Health and Production. 2010; 42(3): 495-499.
- Mehaia MA, Hablas MA, Abdel-Rahman KM and El-Mougy SA. Milk composition of majaheim, wadah and hamra camels in Saudi Arabia. Food Chemistry. 1995; 52: 115-122.
- Musaad AM, Faye B and Al-Mutairi SE. Seasonal and physiological variation of gross composition of camel milk in Saudi Arabia. Emirates Journal of Food and Agriculture, 2013; 618-624.
- Nagy P, Fábri ZN, Varga L, Reiczigel J and Juhász J. Effect of genetic and nongenetic factors on chemical composition of individual milk samples from dromedary camels (*Camelus dromedarius*) under intensive management. Journal of Dairy Science. 2017; 100:8680-8693.

- Patel AS, Patel SJ, Patel NR and Chaudhary GV. Importance of camel milk-An alternative dairy food. Journal of Livestock Science. 2016; 7(1):19-25.
- Sboui A, Djegham M, Belhadj O and Khorchani T. Le lait de chamelle: qualités nutritives et effet sur les variations de la glycémie. Options Méditerranéennes, A 2016; 115:487-492.
- Sboui A, Khorchani T, Djegham M and Belhadj O. Comparaison de la composition physicochimique du lait camelin et bovin du Sud tunisien; variation du pH et de l'acidité à différentes températures. Afrique Science: Revue Internationale Des Sciences Et Technologie. 2009; 5(2).
- Senoussi, A, Abazi, A, Bezziou, S and Brahimi, Z., March). The Camel in Algeria: Animal of the Past, Present and Future: What Is the Scope of Farming Systems?. In Biology and Life Sciences Forum. 2023; 22:1-3.
- Shuiep, E, El Zubeir, I, El Owni, O and Musa, H. Influence of season and management on composition of raw camel (*Camelus dromedarius*) milk in Khartoum state, Sudan. Tropical and Subtropical Agroecosystems. 2008; 8:101-106.
- Siboukeur A and Siboukeur O. Caractéristiques physicochimiques et biochimiques du lait de chamelle collecté localement en comparaison avec le lait bovin. Annals of Science and Technology. 2012; 4:6-6.
- Wernery U. Camel milk, the white gold of the desert. Journal of Camel Practice and Research. 2006: 13(1):15-26.
- Yagil R. Camels and camel milk (FAO animal production and health paper). FAO (Food and Agriculture Organisation of the United Nations). [Google Scholar] 1982.
- Yoganandi J, Mehta BM, Wadhwani KN, Darji VB and Aparnathi KD. Comparison of physico-chemical properties of camel milk with cow milk and buffalo milk. Journal of Camel Practice and Research. 2014a; 21(2):253-258.
- Yoganandi J, Mehta BM, Wadhwani KN, Darji VB and Aparnathi KD. Evaluation and comparison of camel milk with cow milk and buffalo milk for gross composition. Journal of Camel Practice and Research. 2014b; 21(2):259-265.
- Zeleke Z. Non-genetic factors affecting milk yield and milk composition of traditionally managed camels (*Camelus dromedarius*) in Eastern Ethiopia. Parity. 2007; 1, 97.
- Zhang H, Yao J, Zhao D, Li, H, Li J and Guo M. Changes in chemical composition of Alxa Bactrian camel milk during lactation. Journal of Dairy Science. 2005; 88:3402-3410.