Emirates Journal of Food and Agriculture. 2018. 30(4): 251-255
doi: 10.9755/ejfa.2018.v30.i4.1658
http://www.ejfa.me/

CAMEL MILK AND MILKING

Influence of feeding on some physicochemical and biochemical characteristics of camel milk (*Camelus dromadarius*)

Benmohamed Cherifa[1]*, Siboukeur Oumelkheir[2], Edoud Amar[1]

[1]Department of Biological Sciences, Faculty of Natural and Life Sciences,KASDI Merbah University, Ouargla, Laboratory for the Protection of Ecosystems in Arid and Semi-Arid Zones, Ouargla, Algeria 30000, [2]Department of Biological Sciences, Faculty of Natural and Life Sciences,KASDI Merbah University, Ouargla, Laboratory of Water and Environmental Engineering in Saharan Environment, Ouargla, Algeria 30000

ABSTRACT

Composition of camel milk changes according to the type of farming systems; (i) the traditional system based on the consumption of grassland natural plants and (ii) the "modern" system with feeding based on barley and alfalfa. Among components, we did not reveal any significant effect of farming system on either: pH, density, Dornic acidity, total dry extract, fat-free dry matter content, ash content, total protein content and fat content. However, a significant effect ($P < 0.05$) on the vitamin C content was observed. The concentration being higher in the milk from camels in extensive system than in semi-intensive system. Although the diameter of the fat globules was comparable in both cases, a better dispersion was registered in the milk from the camels in the extensive system. If no difference occurred on the global fatty acid profile (proportion of short/medium/long chain fatty acids), lauric acid ($C_{12:0}$) and two fatty acids with 2n + 1 carbon atoms ($C_{15:0}$ and $C_{17:0}$) were present only in the lipids of milk from camels exclusively fed with Saharan rangelands plants. These results suggested that feeding would have consequences on the characteristics inherent in camel milk and partly responsible for its properties.

Keywords: Breeding system; *Camelus dromedarius*; Fatty acid; Milk; Vitamin C

INTRODUCTION

As it is very rich food in terms of basic nutrients (proteins, lipids, carbohydrates, minerals, vitamins), camel milk is of interest for both young camel and human consumer. Especially, its relatively high amounts of vitamin C compared to other mammals' milk (Farah, 1993) should be mentioned. There is indeed an average of 3 to 10 times more vitamin C in camel milk than in cow's milk (Farah et al., 1992; Elkhidir, 2002; Konuspayeva et al., 2011). It therefore represents a source in this vitamin that is not biosynthesizable by humans and large animals (Farah et al., 1992; Latham, 2001; Konuspayeva, 2007). In recent decades, the Algerian consumers increased interest in camel milk because it perfectly meets the nutritional and expected "therapeutic" requirements. The dromedary can valorize the meager resources of the Saharan grassland into milk proteins. Structural and functional characteristics of camel milk attracted the attention of many researchers all around the world. Some authors have reported variability in the composition of camel milk, originating mainly from animals feeding (Khan and Iqbal, 2001; Sanz Sampelayoa et al., 2007; Konuspayeva et al., 2009; Musaad et al., 2013: Faye et al., 2013). At the same time, the traditional system based on natural grazing is declining, and tending to be progressively replaced by a more modern system based on intensive feeding of cultivated fodder in order to increase dairy production. The present paper is focused on one question: Does camel feeding influence some characteristics to which camel milk owes its properties, namely relatively high vitamin C content, small size of fat globules and quality of fatty acids ?

MATERIALS AND METHODS

Amongst the total number of examined samples of camel milk, some were collected from dromedary females

***Corresponding author:**
Benmohamed Cherifa, Department of Biological Sciences, Faculty of Natural and Life Sciences ,KASDI Merbah University, Ouargla, Laboratory for the Protection of Ecosystems in Arid and Semi-Arid Zones , Ouargla, Algeria 30000.
E-mail: cherifarebaibenmohamed@gmail.com

Received: 18 December 2017 ; **Accepted:** 21 March 2018

belonging to the "Sahraoui" population bred under an extensive system in the region of Ouargla (South-East of Algeria). Their grazing menu consist essentially of the following plant species: *Savignya longistyla (lgoulglan), Asphodelus fistulosus (tazia), Ephedra alata (alanda), Stipagrostis pungens (Drinn), Limoniastrum guyonianum (zeita)* and *Tamarix gallica (tarfa), Artemisia herba alba (Chih), Rhantherium adpressum (Arfage), Oudneya africana (Hanet ibel)* and *Zilla macroptera (Chebrok)*. Moreover, other samples taken from dromedary females belonging to the same population bred in semi-stabling (semi-intensive) system in the same region were collected. The animals' feed consisted of alfalfa, barley, wheat bran, and *Cornulaca aucheri* (hadd). Each milk sample represented a small mixture issued from four camels (Table 1). The number of samples depended on the availability of milk. Milk samples were transported to the laboratory in a cooler containing ice pack.

Determination of the physicochemical and biochemical parameters of camel milk

pH was measured at room temperature (20°C) (IDF115A: 1989). Titratable acidity was determined by the titrimetry expressed in Dornic Degree (°D) (IDF 81: 1981). Density was determined by a lactodensimeter at 20°C. Total dry extract was calculated by drying the sample in the oven at 105 ± 2°C for 3 hours (IDF 21B 1987). Fat-free dry matter content was quantified by drying (IDF 22B, 1987). Ash content determination was achieved by incinerating the milk dry matter at 525°C ± 25°C for 4 hours (AFNOR 1989 NF V 04-208). Total protein content was measured by the method of Lowry et al., (1951). The vitamin C content was calculated by titrimetry. Fat was determined by the acid-butyrometric method (AFNOR, 1990 NF-V-04-210) (Table 1). The determination of the fatty acid profiles of the samples was carried out by GC/MS (Gas chromatography-mass spectrometry) analyzed at INRAP (National Institute of Research and Physico-chemical analysis) Tunisia, using an Agilent 6890 gas chromatograph coupled to an Agilent 5975B mass selective detector with electron impact ionization (70 eV) and an Agilent Chemstation software (Agilent Technologies, Palo Alto, USA). Finally, the size of fat globules was determined after staining membrane lipids of the milk fat globules by the Sudan black to (1g/100 ml of ethanol at 70°) and visualization under optical microscope (x400). All the analyzes were done in triplicate.

Statistical analysis

To test the difference between the two camel farming systems, an analysis of variance (simple ANOVA) was applied, with milk component as explained variables. All statistical analyses were assessed using, the software R Core Team (2013, 3.3.0).

RESULTS AND DISCUSSION

Overall, regarding physicochemical and biochemical characteristics of milk samples, no significant differences ($p>0.05$) were recorded for milk pH, density, Dornic acidity, total dry extract content, fat-free dry matter content, ash, fat content and total protein content between the two types of farming systems (Table 2). However, a significant difference ($p\leq0.05$) was observed for vitamin C content with higher values in milk from extensive compared to the semi-intensive system (Table 3). The size of fat globules was similar in both systems. Even though, a more noticeable separation or dispersion of small size fat globules milk was revealed in extensive system samples (photos 1 and 2) (with lower distribution frequency in the extensive system samples). The fatty acid profiles (Table 4) were analogous between the two systems, essentially the absence of short chain saturated fatty acids (C_4 to C_{10}) and the presence of medium to long chain fatty acids. However, we note some differences, particularly the presence of lauric acid $C_{12:0}$ and fatty acids with 2n+1 carbon atoms, namely $C_{15:0}$ and $C_{17:0}$, in milk lipids of samples issued from camels exclusively fed with plants in the Saharan grasslands.

Camel milk pH values, as well as Dornic acidity, in the two breeding systems were within the range of values reported by many authors who have worked on camel milk in different regions of the world (Mehaia, 1994; Kamoun, 1995; Siboukeur, 2007; Konuspayeva, 2007; Sboui et al., 2009; Mint Meiloud et al., 2011). According to Gorban and Izzeldin (1997), these parameters may be affected

Table 1: Number of milk samples of small mix for each farming system

Parameter	Number of milk samples (n)/Extensive	Number of milk samples (n)/Semi- intensive
pH	14	13
Density	9	9
Dornic Acidity (D°)	13	13
Total dry extract (g /L)	15	11
Fat-free dry matter content (g /L)	10	10
Ashes (g /L)	15	10
Total proteins (g /L)	10	10
Vitamin C (mg /L)	9	9
fat (g /L)	12	10

by feeding and water availability, which does not appear to be the case in the present study. In fact, the acidity of milk is depending more on the quality of storage than on the feeding status of the animals. Thus, the conditions of collection and storage in our study were quite similar in both systems. The values of density in the two systems were comparable to those obtained by Farah, (1993); Kamoun, (1995); Konuspayeva, (2007); Siboukeur (2007), Sboui et al. (2009) and Mint Meiloud et al., (2011). This parameter, linked to the dry matter content of the milk is strongly dependent on the watering frequency (Siboukeur, 2007) rather than on the feeding system. The total dry matter content of the analysed samples was comparable to those found by several authors (El-Agamy, 1983; Abu-Lehia, 1987; Ellouze and Kamoun 1989; Kamoun, 1995; Karue, 1998; Konuspayeva, 2007; Siboukeur, 2007; Sboui et al., 2009). Ramet (1994) indicated that one of the main characteristics of camel milk was indeed its reduced dry matter content compared to that of other species. Only the lactation stage has been reported in the literature as a variation factor in the dry matter content (Bengoumi et al., 1994). Ash content fluctuated within the range of reported values by numerous authors worldwide (Wangoh et al., 1998; Attia et al., 2001; Siboukeur, 2007 and Sboui et al., 2009). It decreases in the case of water deprivation (Yagil, 1985) and varies according to the lactation stage (Farah, 1993; Musaad et al., 2013). All these references consolidated the absence of significant differences between milk samples from camels bred differently. Total protein content was about the range reported by the authors (Mohamed et al., 1989; Kamoun, 1995 and Sboui et al., 2009). It varies according to lactation stages (Abu-Lehia, 1987; El-Hatmi et al., 2007; Musaad et al., 2013) and under the dependence of genetic factors. This may explain the fact that we did not revealed significant differences in the present study. The fat content observed in this study was in the same interval cited by Mohamed et al. (1989); Kamoun (1995) and Sboui et al., (2009). This parameter may vary with the lactation stage and species (Musaad et al., 2013). At our knowledge, no work reported the effect of feeding system on the amount of fat in camel milk although a recent study was done to assess the effect of olive cake on fatty acid profile and fat content in camel milk (Faye et al., 2013).It is known that the fat of the forage grazed by the animal conditioned the quality of the milk fat and hence its fatty acids profile (Palmquist et al., 1993; Gorban and Izzeldin 2001; Sanz Sampelayoa et al., 2007). The size of fat globules in our milk samples was comparable to that reported by Attia et al. (2000). These fat globules were in the form of small droplets separated by a continuous dispersing phase in the aqueous phase of milk, but with a low frequency of distribution of the fat globules in the milk from extensive farming

Table 2: Physicochemical and biochemical characteristics

Parameter	Breeding systems		Test T: P value
	Extensif	Semi intensif	
pH	6.59±0,12	6.58±0,18	0.900
Density	1.0293±0.002	1.0296±0.001	0.776
Dornic Acidity (D°)	16.83±1.40	16.50±1.50	0.308
Total dry extract (g /l)	112.47±14.98	109.77±9.54	0.358
Fat-free dry matter content (g /l)	82.29±10.90	82.17±10.46	0.966
Ashes (g /l)	8.28±2.17	8.35±1.74	0.891
Total proteins (g /l)	40.47±6.13	39±5.30	0.336
Vitamin C (mg /l)	66.75±17.96	51.58±12.76	0.001
Fat (g /l)	31.94±5.09	29.78±4.72	0.218

Table 3: Appearance of the fat globules under a microscope with a magnification (x400)

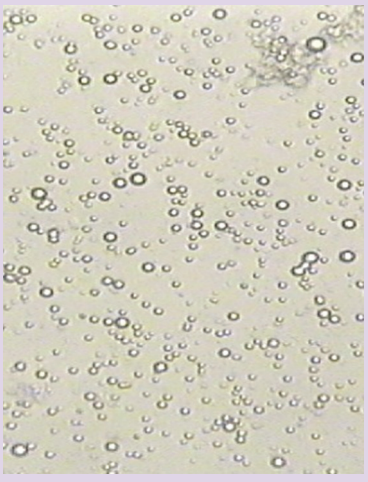
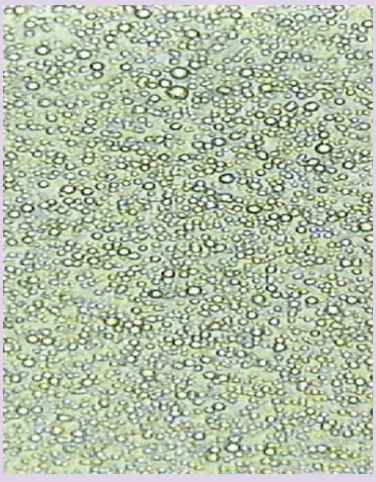
Breeding method	
Extensive	Semi-intensive
	

Table 4: Fatty acids profiles (in %)

Saturated fatty acids	Short Form	extensive	Semi-intensive
Butyric acid	C4:0	<0.01	<0.01
Caproic acid	C6:0	<0.01	<0.01
Caprylic acid	C8:0	<0.01	<0.01
Capric acid	C10:0	<0.01	<0.01
Lauric acid	C12:0	0.84	<0.01
Iso-lauric acid	iC12:0	<0.01	0.44
Myristic acid	C14:0	13.05	6.02
9-methyl Myristic acid	C14:0 9-m	1.68	1.71
Pentadecylic acid	C15:0	1.92	<0.01
Palmitic acid	C16:0	37.59	25.13
Methyl Palmitic acid	C16:0 m	1.93	1.50
Margaric acid	C17:0	1.7979	<0.01
Stearic acid	C18:0	<0.01	<0.01
Acides gras insaturés:			
Oleic acid	C18:1	35.60	37.73
Linoleic acid	C18:2	1.98	2.65
Total identified		96.42	75.20
Saturated fatty acids		61.01	46.29
Monounsaturated fatty acids		36.93	50.18
Polyunsaturated fatty acids		2.06	3.53

system. This property leads to a better stability of the fat emulsion in the camel milk. This state brings camel milk closer to human milk, allowing more efficient hydrolysis by cleavage enzymes in the intestinal tract (Karray et al., 2005) and makes fat digestion of this milk relatively easier. However, this organization raises a problem regarding butter processing ability. Compared to the milk obtained from extensive farming system, a relatively high frequency of distribution of fat globules noted with the milk from semi-intensive farming system would probably be due to the feed received by camels in semi-stabling. Regarding the fatty acid profile, the absence of short chain fatty acids (C4 to C10) was noted, which could be explained by a rapid metabolism in the tissues before their secretion in milk (Gorban and Izzeldin, 2001). Concerning the presence of medium-chain (C12-C14) and long-chain fatty acids, it is likely that their synthesis is carried out in the mammary glands (Karray et al., 2005) from exogenous inputs (grassland plants) (Palmquist et al., 1993; Gorban and Izzeldin, 2001; Sanz Sampelayoa et al., 2007), from pre-existent fatty acids elongation or from both. The presence of lauric acid (C12:0) in the milk from extensive system compared to the milk from semi-intensive one would have originated from plants grazed by camels. This experimental observation appeared to be valid for fatty acids 2n+1 carbon atoms (C15:0, C17:0) detected only in the samples collected in the extensive system.

The vitamin C content of the collected samples was higher than that reported by Farah et al. (1992) and Siboukeur (2007), respectively, 37.4 mg/l and 46 mg/l for the same breeding system, while Sawaya et al. (1984) and Mehaia (1994) outlined clearly lower proportions (respectively, 24 mg/l and 24.9 mg/l). Furthermore, Konuspayeva et al. (2007) reported a clearly higher value of 146 ± 93 mg/l for the same breeding system with quite higher value in Bactrian camel compared to dromedary camel (Faye et al., 2008). The transition from extensive to semi-intensive system negatively affected this particularity of the camel milk. Thus, despite the poor feeding, the camel under extensive system produced richer milk in vitamin C and some fatty acids. In other words, it seems that feeding under semi-intensive system attenuates the nutritional value of dromedary milk for the benefit of populations relatively deprived from significant intake of fresh fruits and vegetables.

CONCLUSION

Feeding system would not affect pH, density, Dornic acidity, total dry extract, fat-free dry matter content, ash content, total protein content and fat content of camel milk. However, natural grazing in desert contributed to a lower distribution frequency of fat globules in milk, although their size was comparable to milk collected in semi-intensive farm. Desert grazing was linked also to the presence of specific fatty acids and higher concentration of vitamin C in milk. Finally, the results suggested that feed would have negative consequences on some characteristics of camel milk, responsible for the expected dietetic property of camel milk properties.

REFERENCES

Abu-Lehia, I. A. 1987. Composition of camel milk. Milchwissenschaft Milk Sci. Int. 42(6): 368-371.

Attia, H., N. Kherouatou, N. Fakhfakh, T. Khorchani and N. Trigui. 2000. Lipids dromedary milk fat: Biochemical, microscopic and rheological characteristics. J. Food Lipids. 7: 95-112.

Attia, H., N. Kherouatou and A. Dhouib. 2001. Dromedary milk lactic acid fermentation: Microbiological and rheological characteristics. J. Ind. Microbiol. 26: 236-270.

Bengoumi, M., B. Faye and J. C. Tressol. 1994. In: Composition Minérale du Lait de Chamelle du sud Marocain. Actes du Colloque. Dromadaires et Chameaux Animaux Laitiers, Nouakchott, Mauritanie, pp. 24-26.

El-Agamy, EI. 1983. Studies on Camel's Milk. M.Sc Thesis, University of Alexandria, Egypt.

El-Hatmi, H., J. B. Gaillard, M. A. Yahyaoui and H. Attia. 2007. Characterization of whey proteins of camel (*Camelus dromedarius*) milk and colostrums. Small Rum. Res. 70: 267-271.

Elkhidir, H. E. 2002. Vitamin C Status in Sudanese Camels. Ph.D

Thesis, University of Utrecht, Pays-Bas.

Ellouze, S., and M. Kamoun. 1989. Evolution de la composition du lait de dromadaire En fonction du stade de lactation. Options Méditerranéennes. 6: 307-323.

Farah, Z., R. Rettenmaier and D. Atkins. 1992. Vitamin content of camel milk. Int. J. Vitamin Nutr. Res. 62: 30-33.

Farah, Z. 1993. Composition and characteristics of camel milk. J. Dairy Res. 60: 603-626.

Faye, B., G. Konuspayeva, S. Messad and G. Loiseau. 2008. Discriminant milk components of Bactrian camel (*Camelus bactrianus*), dromedary (*Camelus dromedarius*) and hybrids. Dairy Sci. Technol. 88: 607-617.

Faye, B., G. Konuspayeva, M. Narmuratova, A. Serikbaeva, A. M. Musaad and H. Mehri. 2013. Effect of crude olive cake supplementation on camel milk production and fatty acid composition. Dairy Sci. Technol. 93: 225-239.

Gorban, M. S. and O. M. Izzeldin. 1997. Mineral content of camel milk and colostrum. Dairy Sci. Technol. 64: 471-474.

Gorban, M. S. and O. M. Izzeldin. 2001. Fatty acids and lipids of camel milk and colostrum. Int. J. Food Sci. Nutr. 52: 283-287.

Kamoun, M. 1995. Le Lait de dromadaire: Production, aspects qualitatifs et aptitude à la transformation. Options Méditerranéennes. 13: 81-103.

Karray, N., C. Lopez, M. Ollivon and H. Attia. 2005. La matière grasse du lait de dromadaire: Composition, microstructure et polymorphisme. Ocl Oleagineux Corps Gras Lipides. 12: 439-446.

Karue, C. N. 1998. The dairy characteristics of the Kenyan camel. In: P. Bonnet (Ed.), Actes du Colloque, Dromadaires et Chameaux, Animaux Laitiers/Dromedaries and Camels, Milking Animals. CIRAD Publ, Nouakchott, Mauritania, pp. 55-60.

Khan, B. B. and A. Igbal. 2001. Production and composition of camel milk: A review. Agric. Sci. 38(3-4): 64-68.

Konuspayeva, G. 2007. Variabilité Physico-chimique et Biochimique du lait des Grands Camélidés (*Camelus bactrianus, Camelus dromedarius* et hybrides) au Kazakhstan. Ph.D. Thesis. Université Montpellier II, France.

Konuspayeva, G., B. Faye and G. Loiseau. 2009. The composition of camel milk: A meta-analysis of the literature data. J. Food Composit. Anal. 22: 95-101.

Konuspayeva, G., B. Faye and G. Loiseau. 2011. Variability of vitamin C content in camel milk from Kazakhstan. J. Camelid Sci. 4: 63-69.

Latham, M. C. 2001. La Nutrition Dans les Pays en Développement Collection. Alimentaire et Nutrition Éd, FAO, Rome.

Lowry, O. H., N. J. Rosebrough, A. L. Farr and R. J. Randall. 1951. Protein measurement with Folin phenol reagent. *J. Biochem*. 193: 265-275.

Mehaia, M. A. 1994. Vitamin C and riboflavin content in camel milk: Effects of heat. Food Chem. 50: 153-155.

Mint, M. G., I. N. O. Bouraya, A. Samb and A. Houmeida. 2011. Composition of Mauritanian camel milk: Result of first study. Int. J. Agric. Biol. 13: 145-147.

Mohamed, M. A., A. I. Mursal and M. Larsson-Raznikiewicz. 1989. Separation of camel milk casein fraction and its relation to the coagulation properties of fresh milk. Milchwissenschaft Milk Sci. Int. 44(5): 278-280.

Musaad, A., B. Faye and S. Al-Mutairi. 2013. Seasonal and physiological variation of gross composition of camel milk in Saudi Arabia. Emirates J. Food Agric. 25(8): 618-624.

Palmquist, D. L., A. D. Beaulieu and D. M. Barbano. 1993. Feed and animal factors influencing milk fat composition. J. Dairy *Sci*. 76: 1753-1771.

Ramet, J. P. 1994. Les Aspects Scientifiques et Technologiques Particuliers de la Fabrication de Fromage au Lait de Dromadaire. Actes du Colloque: Dromadaires et Chameaux Animaux Laitiers, Nouakchott, Mauritanie, pp. 24-26.

R Core Team. 2013. R: A Language and Environment for Statistical Computing. R Foundation for Statistical Computing, Vienna, Austria.

Sanz, S. M. R., Y. Chilliard, P. Schmidelyc and J. Bozaa. 2007. Influence of type of diet on the fat constituents of goat and sheep milk. Small Rum. Res. 68: 42-63.

Sawaya, W. N., J. K. Kalil, A. Al-Shalhat and H. Al-Mohamed. 1984. Chemical composition and nutritional quality of camel milk. J. Food Sci. 49: 744-747.

Sboui, A., T. Khorchani, M. Djegham and O. Belhadj. 2009. Comparaison de la composition physicochimique du lait camelin et bovin du sud tunisien: Variation du pH et de l'acidité à différentes températures. Afr. Sci. 5(2): 293-304.

Siboukeur, O. K. 2007. Etude du Lait Camelin Collecté Localement: Caractéristiques Physico-chimiques et Microbiologiques; Aptitudes à la Coagulation. Thèse de Doctorat en Sciences Agronomiques. Université INA El-Harrach Alger Algérie.

Wangoh, J., Z. Farah and Z. Puhan. 1998. Composition of milk from three camel (*Camelus dromedarius*) breeds in Kenya during lactation. Milchwissenschaft Milk Sci. Int. 53: 136-139.

Yagil, R. 1985. The Desert Camel; Comparative Physiological Adaptation. éd KARGER, pp. 109-120.