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FATTY ACIDS COMPOSITION OF DROMEDARY AND BACTRIAN CAMEL MILK IN KAZAKHSTAN

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ABSTRACT

The fatty acid composition is probably linked to one of the health effects attributed to camel milk. In the present paper, the fatty acid compositions of dromedary camel, bactrian camel and hybrids are analysed in Kazakhstan where all these species cohabit. The results confirm the higher quantity of unsaturated fatty acids compared to cow milk. Palmitic acid, stearic acid, oleic acid and miristic acid are the most important part of the camel milk fat. As our sampling method included 3 variation factors (species, season, regions) with not more than one sample per case, only general trends were observed. The milk samples collected in summer, on bactrian camel and in the Caspian region (Atyrau, Aralsk) tend to be richer in long-chain fatty acids. At reverse, the milk samples taken in winter, on hybrids or dromedary and from the southern part of Kazakhstan seem richer in short-chain fatty acids.

Keywords: Camel, fatty acid, Kazakhstan, milk composition, milk fat.

The genus *Camelus* includes two species: the one-humped camel (*C. dromedarius*) and the bactrian two-humped camel (*C. bactrianus*). In Kazakhstan, these two species cohabit in the same areas and even in the same farms (Konuspayeva and Faye, 2004). This particularity allows comparing the milk composition of those animals reared in similar environment. Elsewhere, crude camel milk and fermented product (named *shubat*) were always an important food of Kazakh peoples. Especially shubat is renowned and used for some medicinal purpose (Djangabylov *et al*, 2000; Konuspayeva *et al*, 2004). The fatty acid composition of milk is one of the aspects linked to the discussion on the health effect of milk and milk products (Wahle and Heys, 2002). However, the fatty acid composition of camel milk is not well documented (Farah, 1996), especially in bactrian camel (Zhang *et al*, 2005). No recent data are available in Kazakhstan. The present study aims to present results on fatty acid composition in dromedary and bactrian camel living in the same areas of Kazakhstan and to compare the results with some references concerning camels in other countries.

Materials and Methods

Animals and milk samples

In order to have a high variability in fatty acid composition, the healthy animals were randomly selected in 4 different regions of Kazakhstan during 4 different seasons where the whole 31 of milk samples were collected. The samples came from 4 farms : Daulet-Beket (Almaty region, n = 10), Sary-Arka (close to Shimkent in South-Kazakhstan region, n = 11), Aralkoum (close to Aralsk in Kzylorda region, n = 4) and Tendik (Atyrau region, n = 6). The maximum distance between those farms was more than 2000 km.

The number of milk samples was balanced between winter (n = 8), spring (n = 7), summer (n = 8) and autumn (n = 8). The 31 milk samples included 11 bactrian camels, 10 dromedaries, 3 hybrids, and finally 3 mixed crude milks (bactrian and dromedary) and 4 fermented milks (got from mixed milk also).

Milk was collected at milking time at the end of milking. It was stored in ice-box up to the laboratory then frozen at -20°C up to the analysis.

Lipid analysis

Milk fat extraction

The milk fat was extracted from milk in liquid form by hexane. After formation of two phases, the water phase was poured into another flask and the same quality of a hexane was added. This procedure was repeated 3 times and the 3 organic phases were collected Further, the hexane was removed by distillation with a rotavapor at 30°C. The mass of fat

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Table 1. Mean, Standard-deviation, Minimum and Maximum of each fatty acid (in %) in camel milk and shubat (n = 31).

Fatty acids	Ñ4	Ñ6	Ñ8	Ñ10	Ñ12	Ñ14	Ñ16	Ñ16:1	Ñ18	Ñ18:1/9	Ñ18:1/7	Ñ18:2/6	Ñ18:3	Ñ20	Res.
Mean	0.16	0.08	0.10	11,24	1.05	12.78	24.55	7.16	18.84	14.86	4,64	2.35	0.87	1.34	8.72
SD	0.29	0.09	0.10	18.08	0.52	5.94	11.74	3.56	8.83	11.26	4.97	1.33	0,14	0.00	11.60
Min	0.00	0.00	0.00	0.57	0.00	0.00	0.00	0.00	6.73	0.00	0.00	0.00	0.77	1.34	0.05
Max	0.95	0.28	0.31	89.13	2,310	28.62	42,041	17.55	38.35	36,930	26.50	5.64	0.97	1.34	31.15

obtained was about 1 gram. This fat was used for further analyses.

GC analysis for fatty acid composition

One gram of fat was dissolved in 5 ml hexane. Seventy-five µl of the solution was placed under a nitrogen pump to remove hexane. Then a mixture of hexane and isopropanol (3/2, V/V) was added. One ml of a mixture of isopropanol (1 ml) with 36N sulfuric acid (200 ml) was added to the mixture. Then the mixture was placed into a oil bath at 100°C for 1 hour. Then, 1ml distilled water was added and incubated for 10 min in an ice bath. It resulted in a formation of an organic and a water phases. The organic phase was diluted by 2 ml hexane and used for further work. 0.5 µl of the solution was analysed by gas-chromatography.

Fatty acid was analysed by GC (Carlo Erba *8000 Top*) with a split injector (ratio 1/30), flame-ionisation detector and a fused silica capillary column SUPELCOWAX- 10 (30 m, 0.32 mm, id, 25 mm film thickness, Supelco, Bellafonte, USA). The column temperature was kept at 190°C for 4 min, then raised to 210°C at 4°C/min and held at 210°C for 15 min. The injector and detector temperatures were 250°C. Helium was used as carrier gas at flow rate of 2 ml/min.

The carrying out of the gas-chromatography analysis gave the next composition of fatty acids:

- Saturated acids: butyric (C4), caproic (C6), caprilic (C8), capric (C10), lauric (C12), miristic (C14), palmitic (C16), stearic (C18), arachidic (C20)

- Mono-unsaturated acids: palmitoleic (C16:1), oleic omega 9 (C18:1/9), vaccenic omega 7 (C18:1/7)

- Poly-unsaturated acids: linoleic omega 6 (C18:2/6), linolenoic acid (C18:3)

Butyric, caproic and caprilic acids were typical of few milk samples only.

Statistical analysis

As the objective is to have an idea of the variability of fatty acid composition with only at least one sample in each cell region, species and season, the variance analysis was not applicable. The analysis of the fatty acid profiles was achieved with multivariate analysis (principal components analysis and cluster analysis). In order to compare the present results to those of the literature on camel milk, a principal components analysis was also achieved (meta-analysis) using the Winstat software (CIRAD ©).

Results

On average, according to standard-deviation (SD), the milk and shubat samples showed a high individual variability in the quantitative composition of fatty acids (Table 1). The main fatty acids in camel milk are C10, C14, C16, C18 and C18:1. It is remarkable to note that there is only a small amount of short chain fatty acids, usually very common in animal milks.

The main studied variation factors were the regions, the species and the season. As the number of samples in each cluster (region, species, season) is generally 1 only, the results expressed each factors separately.

Variations according to the regions

For each region (Almaty, Atyrau, Aralsk and Shymkent), some differences were observed and can be explained by a heterogeneous distribution of farms and different climatic conditions, but as the animal types (dromedary, bactrian and their hybrids) were not present in each region, the variation part can be due to species also (Table 2). The main features are: at Atyrau, the milk is richer in C16 and C18, at Shymkent in C10, in Aralsk in C14 and C18:1/9, and at Almaty in unsaturated fatty acids C18:1/7, C18:3 and C20. In all the cases, the richness in C18:2 is very important (18 to 27%).

Variations according to the species

The composition of fatty acids in bactrian milk seemed slightly different than to dromedary milk (table 3). Bactrian milk is richer in C14, C16 and C18:1(n-9) compared to dromedary milk which is richer in C10, C18 and C18:1(n-7). The hybrid milk composition is not really intermediate between bactrian and dromedary as we could expect. The hybrid milk is richer in C10:0 and C18:1.

Table 2. Centesimal fatty acid composition of camel milk from different regions of Kazakhstan.

	Almaty	Atyrau	Aralsk	Shymkent
C 4:0	0.07	0.02	0,32	0.25
C 6:0	0.05	0.1	0,05	0.08
C 8:0	0.1	0.09	0,10	0.12
C 10:0	8.97	3.37	6,79	25.63
C 12:0	1.17	1.02	1,31	0.90
C 14:0	13.94	11.45	16,86	10.96
C 16:0	24.94	27.25	20,64	22.01
C 16:1	7.56	4.92	10,94	6.86
C 18:0	17.41	24.64	17,06	14.82
C 18:1(n-9)	11.35	18.07	21,86	12.01
C 18:1(n-7)	6.87	3.97	2,03	3.95
C 18:2	2.70	2.71	2,04	1.80
C 18:3	0.87	0	0	0
C 20:0, C20:1	1.34	0	0	0
Residues	15.60	5.53	0	4,54
Total	100	100	100	100

Table 3. Centesimal fatty acids composition of camel milk from different species in Kazakhstan.

	Bactrians	Dromedaries	Hybrids	Mixed crude milk
C 4:0	0.29	0.03	0.35	0.04
C 6:0	0.06	0.08	0.20	0.07
C 8:0	0.09	0.12	0.19	0.09
C 10:0	8.24	14.57	23.96	6.17
C 12:0	1.21	0.93	0.80	1.04
C 14:0	15.06	11.01	8.86	12.96
C 16:0	27.35	22.95	24.45	21.89
C 16:1	7.86	6.34	6.23	7.62
C 18:0	16.94	18.66	12.29	25.60
C 18:1(n-9)	16.91	12.52	16.76	14.19
C 18:1(n-7)	3.73	6.15	3.20	4.32
C 18:2	1.94	2.54	2.19	2.91
C 18:3	0	0.87	0	0
C 20:0. C20:1	0	1.34	0	0
Residues	1.61	16.72	0	7.82
Total	100	100	100	100

Table 4. Centesimal fatty acids composition of camel milk harvested in different season in Kazakhstan.

	Winter	Spring	Summer	Autumn
C 4:0	0.11	0.15	0.04	0
C 6:0	0.13	0.06	0.06	0.05
C 8:0	0.14	0.16	0.07	0.08
C 10:0	23.23	25.59	4.97	6.76
C 12:0	1.04	0.80	1.14	1.12
C 14:0	11.30	9.11	13.63	14.35
C 16:0	23.54	22.81	25.21	23.95
C 16:1	6.04	5.84	7.66	7.74
C 18:0	13.04	11.39	21.49	23.12
C 18:1(n-9)	16.17	14.41	18.15	10.60
C 18:1(n-7)	2.46	7.09	4.20	4.66
C 18:2	2.21	2.18	2.68	2.11
C 18:3	0	0.77	0	0.97
C 20:0. C20:1	0	1.34	0	0
Residues	2.30	0	2.291	15.15
Total	100	100	100	100

Table 5. Centesimal fatty acid patterns in the different types of camel milk identified by classification (N.B: Only one sample contained C18:3 and C20, it is not represented here).

	Types							
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**
C 4:0	0.12	0.34	0.01	0.05	0.72	0.04	0.00	0.62
C 6:0	0.00	0.11	0.07	0.13	0.00	0.06	0.00	0.18
C 8:0	0.00	0.18	0.08	0.19	0.00	0.05	0.00	0.28
C 10:0	8.44	58.06	5.94	2.20	7.52	3.56	8.56	14.50
C 12:0	1.72	0.72	0.84	1.20	0.00	0.99	1.70	1.58
C 14:0	21.24	5.39	10.31	14.61	6.80	10.42	22.35	18.54
C 16:0	0.00	13.03	27.84	33.15	26.26	26.43	38.51	32.18
C 16:1	14.19	3.26	6.42	8.33	6.32	1.93	11.63	8.30
C 18:0	36.08	6.05	17.28	16.43	15.43	37.73	11.10	7.90
C 18:1	0.00	9.43	25.07	17.75	27.72	2.57	0.00	12.24
C 18:1	8.03	1.76	3.65	3.20	9.23	5.73	3.39	2.13
C 18:2	5.64	1.06	2.53	2.38	0.00	3.35	2.75	1.55
Residues	4.53	0.00	0.00	0.33	0.00	7.15	0.00	0.00

***(n-9)**

****(n-7)**

Variations according to the season

The fatty acid composition varied according to the season (Table 4). The content of unsaturated fatty acids decreased in winter. That is certainly due to the animal feed which is quite poor and composed mainly of cellulose. It was noted the increasing of content in vaccenic (C18: n-7) in spring. The arachidic acid (C20) is only present in spring. The quantity of capric acid (C10) increased strongly in winter and spring and decreased highly in summer and autumn. The summer milk is little bit richer in palmitic acid (C16) which remains anyway high all over the year. Stearic acid (C18) is higher in summer and autumn milks.

Fatty acid composition of shubat

The determination of fatty acid composition gave similar results in the five shubat samples (Fig. 1). Short chain fatty acids are absent in all samples. The content of miristic (C14), palmitic (C16), stearic (C18) and oleic (C18:1) acids were very high. Only one shubat sample (AL001 from Almaty region) contained a high quantity of a capric acid (C10). Linoleic acid (C18:2) was present in all shubat samples while it was absent in crude milk.

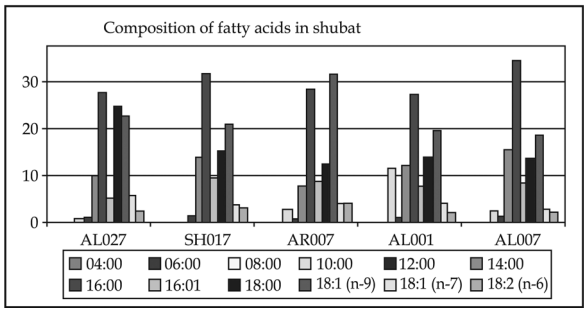

Fig 1. Centesimal fatty acid composition of fermented milk (shubat) from Almaty (AL), Aralsk (AR) and Shymkent (SH) regions.

Multivariate analysis

The principal components analysis (PCA) allows giving a graphical representation of the correlation matrix. The figure 2 is a correlation circle expressing the projection of the variables (fatty acids) on the factorial plan (F1, F2) i.e., the main factors. Roughly, short chain fatty acids (C4, C6, C8) are correlated (they are in close relation in the correlation circle at the right-low part). Similarly, long chain fatty acids (C18, C18:1/7, C19:2) are also correlated. The fatty acids with medium chain (C12, C14, C16:1) are also correlated in opposition to C10 and C18:1 (n-9) (Fig 2).

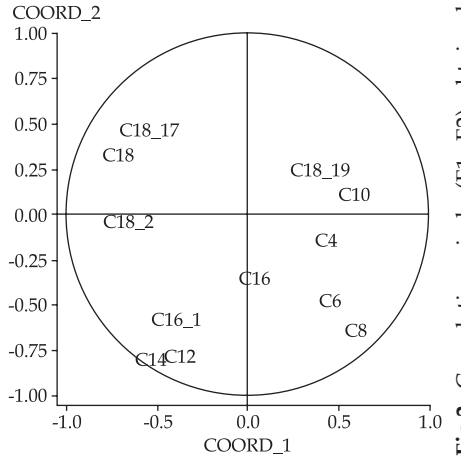

Fig 2. Correlation circle (F1, F2) obtained by the analysis of the 31 camel milk samples

After classification of the 31 camel milk samples (by ascending hierarchical classification method using usual Euclidian distance), 8 types of fatty acid patterns were identified. According to the results of correlation circle, it was easy to conclude that the type 1 was rich in C18:2, the type 2 in C10, the type 3 was mostly composed of milk with mean percentage of fatty acids except in C18:1 (n-9), the type 4 was a little bit richer in C16, the type 5 included samples particularly poor in C12 and C14, the type 6 was rich in C18 and C18:2, the type 7 in C16 and C14 and the type 8 in C12 (Fig 3).

The mean fatty acid patterns allowed to better understand the differences between the samples (Table 5).

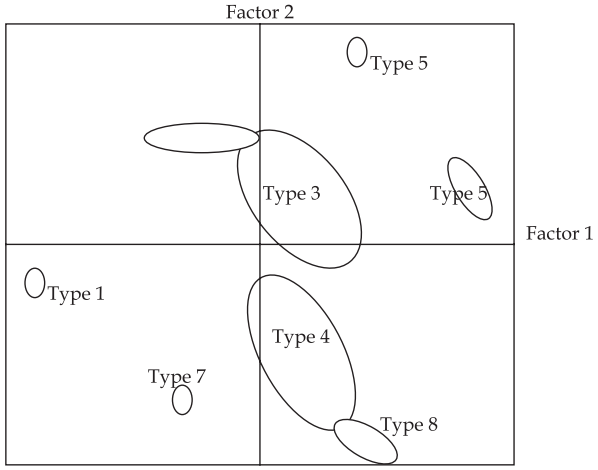

Fig 3. Graphical representation of the 8 camel milk types on the factorial plan (F1,F2).

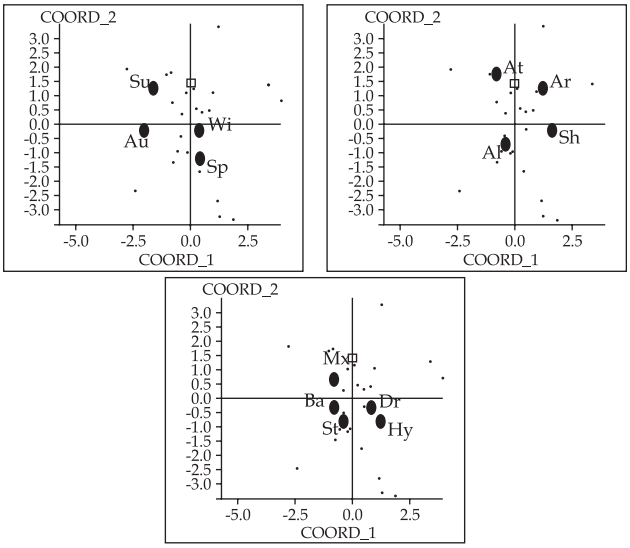

Fig 4. Projection of the different seasons (Su=summer; Wi =winter; Sp=spring; Au=autumn), regions (At=Atyrau; Ar=Aralsk; Al=Almaty; Sh=Shimkent) and species (Ba=bactrian; Dr=dromedary; Hy=hybrid; Mx=milk mixture; St=shubat) on the factorial plan

However, those patterns were not clearly linked to a region, a season or a species. Indeed, the projections of the variation factors on the factorial plan were closed to the gravity centre (Fig 4).

It seems anyway that season and region play a more important role in the variability of fatty acid composition than species. The milk samples from Atyrau or collected in summer were richer in long chain fatty acids. On the contrary, milk samples from Shimkent or collected in winter or from dromedaries or hybrids were richer in short chain fatty acids. The milk from Almaty or collected in autumn or from bactrian seemed richer in C16.

Discussion

The fatty acid composition of camel milk was not well documented. The most important review was proposed by Farah (1993). The comparison of the current results was difficult because the analytical methods were generally different and the variability due to environmental factors (feeding system, climate) or to physiological factors (stage of lactation, genetic differences) was rarely described (Zhang *et al*, 2005) However, the comparison of our results with those of the literature can be approached by a meta-analysis using principal components analysis.

The general fatty acid compositions given by Abu-Lehia (1989), Cardak *et al* (2003), Farah *et al* (1989), Jardali (1988), Mohamed (1990), Sharmanov *et al,* (1978), Gnan and Sheriha (1986) were closed to our results. Only the results of Gorban and Izzeldin (2001) were not correlated with the other observed patterns, mainly because those authors had determined other odd fatty acids as C5, C9, C11, C13, C15 (Fig 5).

Our results confirm that short-chain fatty acids (C4-C12) are present in small amounts in camel milk fat compared to those of cows' milk fat (Abu-Lehia, 1989). At the opposite, the concentration of long-chain fatty acids is relatively high. The unsaturated fatty acids are in wide concentration and represent as the whole, 303% of the fatty acids in bactrian camel and 275% in dromedary camel. Those results are correlated to the observations of Zhang *et al* (2005) made on bactrian camel and Gorban and Izzeldin (2001) made on dromedary camel.

The sampling design aimed to have a wide variability. So, it is not surprising to identify a great number of fatty acid patterns (n=8) in our study because the sampling method had maximised the variation factors and few samples were comparable. Therefore, only general trends could be observed However, it was clear that the general composition in fatty acids was mainly under the influence of environmental conditions (here the region which was the reflection of feeding conditions, and the season) than genetic factors. It was notable for example that bactrian milk was not very different than dromedary milk.

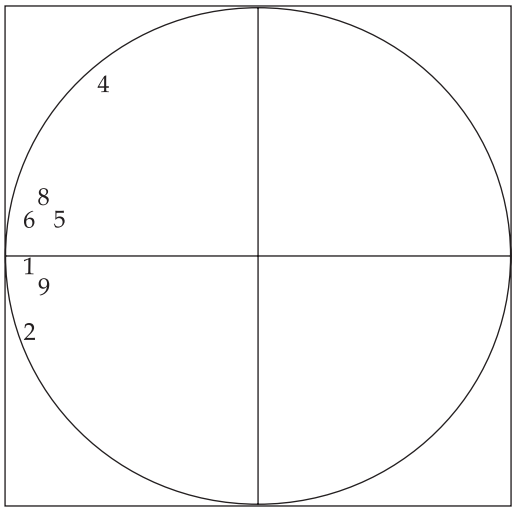

Fig 5 Correlation circle obtained by the analysis of fatty acid composition of camel milk published by Abu-Lehia (1), Cardak (2), Farah (3), Gorban (4), Jardali (5), Mohamed (6), Sharmanov (7), Gnan and Sheriha (8) and our results (9)v

No data were available in the literature about shubat fat composition. The main feature is the disappearing of short chain fatty acid as butyric acid and sometimes caproic and caprilic acid, and the presence of linoleic acid which was not observed in crude milk. In addition, the relative high quantity of oleic acid could support the idea of the health effect attributed to shubat fat. That could be interesting to study the metabolism of lactic acid bacteria and to see if these bacteria have an influence on the shubat lipid composition.

Conclusion

Our results obtained on the fatty acid composition of camel milk fat from Kazakhstan are comparable to results of the literature, in particular the highest content of unsaturated fatty acids of these milks compared to cow milk. However, a high variability is observed between the animals, even if the variation factors like genetic (dromedary, bactrian and hybrids), season or region seem to have a low effect in the context of the present study. More information is needed on the physiological status of the animals and of the bacteria involved in shubat fermentation to achieve a convenient conclusion.

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