

Fatty Acids Content in Milk of Dromedary Camel (*Camelus dromedarius*) from Farming and Pastoral Systems in Sudan

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Running title: Fatty acids in milk of *Camelus dromedarius* from Sudan.

Abstract: The content of fatty acids was determined in milk from camel (*Camelus dromedarius*), under farming system and Natural pasture, by gas chromatography-mass spectrometry (GC). Milk from farming and pastoral system, respectively, contained (84.3 and 85.7 mg/g) total fatty acids, where, saturated fatty acids formed 67.5% and 63.8%, unsaturated fatty acids formed 32.5% and 36.2%, USFA/SFA was 0.48 and 0.57, respectively. Monounsaturated acids (MUFA) formed 29.8% and 34.4%, polyunsaturated acids (PUFA) formed 2.7% and 1.8%, respectively. Palmitic acid (C16:0) and Stearic acid (C18:0) were the major SFA, Oleic (C18:1n9c) and Palmitoleic (C16:1) acids were the major MUFA, Linoleic acid (C18:2n6c) was the major PUFA. Short chain Caproic acid (C6:0) was 0.13% in milk from farming system and 0.2% in milk from pastoral system, medium chains (MCFA) was 8.9% and 10.7%, and long chains (LCFA) 90% and 89% in milk of the two systems, respectively. Omega 3 and 6 (N-3/ N-6) ratio was 0.17 and 0.08, respectively. The content of fatty acids in milk of *Camelus dromedarius* was comparable to other mammalian milk, and the results indicated that camel milk from different raising systems is a good potential source of essential fatty acids and can provide the daily requirement of healthy diet.

Keywords: *Camelus dromedarius*, farming system, fatty acids, milk, pastoral system, Sudan.

1. Introduction

Camel milk has an important role in human nutrition in the hot regions and arid and semi-arid countries including. Camel milk is also widely exploited for medication and human health [1], [2]. Camel sustains its productivity in difficult conditions and comparatively less affected by the adverse factors like lack of feed, water, season and length of lactation. Some factors such as type of food, age and parity are expected to affect the quality and composition of camel milk [3], [4]. However, geographical origin and seasonal variations were found to be the most effective factors in camel milk composition [5]. The Camel (*Camelus dromedarius*, one humped) is a very important resource of milk for humans in several arid and semiarid regions of Sudan, where it represents the only protein source. Now camels are raised under farming systems in Sudan to improve the suitability of raw milk through adjustment of feed composition.

Milk composition and quality are important characteristics that determine the nutritive value and consumer acceptability. Very rare references on various quantitative traits of milk from different parities and under different productive systems are available [6], [7], [8], [9]. Some studies were conducted to investigate the relationship of lactation stage and body condition with milk yield and composition [10], as well as the effect of seasonal and parity on milk composition [11], [12] [13]. Camel milk was found to contain all the essential nutrients found in bovine milk, [14], [15], [16]. The composition of fatty acids in camel's milk is one of the aspects related to human health [17]. However, the fatty acid composition of camel milk is not well documented [5]. Polyunsaturated fatty acids (PUFA) of

the omega-6 and especially of omega-3, family are recognized essential biochemical components of human diet. The study of fatty acids composition of camel milk is of importance for conclusions on their properties as a source of the essential components for humans.

Thus, the aim of the present study is to exploit the fatty acids composition of milk from (*Camelus dromedarius*, one humped), raised under different productive systems (traditional pastoral and farming systems) by gas chromatography/mass spectrometry, to find better ways of sustaining this old industry for the conservation of important animal resource in the near future. The variation provided can be used successfully in the future strategies of the milk yield and improvement.

2. Material and Methods

Study animals and milk collection

The study was conducted on 46 lactating camels *Camelus dromedarius* aged 7-13 years (23 camels from a traditional pastoral herd and 23 camels from a dairy farming system in Khartoum North during the dry season. The dominant vegetations of the natural pasture are *Acacia tortilis*, *Maeura crassifolia*, *leptodania pyrotechnica* and *Acacia seyal*. The diet of the farming system composed of ground nut cake and molasses-based diet plus good water supply. Camels ranging from primiparous to camels in their 5th parity, were selected from each of the two herds for this study.

Samples of milk (40ml) were collected from each lactating "Naga" early morning at milking time (8:00) in clean glass bottles, thoroughly mixed and immediately transferred to the laboratory for analysis at room temperature. All samples of

the two groups came from herd and same parity. Milk samples of the same parity in the two groups were collected every week to get a strictly 7-day interval.

Chemical and statistical analysis

The chemical components of camel milk, solid nonfat (SNF), crude fat (CF), crude protein (CP) and lactose were determined weekly after parturition by automatic milk analyzer device (Lactosan MCC), calibrated for camel milk. Density and temperature of milk were also reported. Gross energy was obtained for each parity. Data was statistically analyzed using STATISTIX software (Version, 10). Mean and standard deviation (SD) were reported weekly and correlations between the different components of the milk in different parities of each raising system were calculated.

Fatty acids analysis with gas chromatography

Fatty acids were analyzed as their methyl esters with a gas chromatography-mass spectrometry (GC-MS; Hewlett-Packard 5890 GC), according to the procedure of [18]. The different fatty acids in the camel milk were obtained by comparing the retention times of the fatty acids under study and those of a mixture of methyl esters (Supelco, PUFA-3). The concentration of individual fatty acid was calculated using heneicosanoic acid (C21:0) as internal standard. The results were calculated both as concentration (mg/g) and (%) of total fatty acids.

3. Results and Discussion

Twenty-four fatty acids of different saturation levels were detected in camel milk (Table 1), where 13 were saturated (SFA) and 11 were unsaturated fatty acids (USFA). Milk from farming and pastoral system, respectively, contained 67.5% and 63.8% saturated fatty acids (SFA), 29.8% and 34.4% monounsaturated acids, and 2.7% and 1.8% polyunsaturated acids (Table 2). The major SFA were Palmitic acid (C16:0) and Stearic acid (C18:0), the major MUFA were Oleic (C18:1n9c) and Palmitoleic (C16:1) acids and the major PUFA was Linoleic acid (C18:2n6c). The predominant fatty acids were Palmitic acid (C16:0), Stearic acid (C18:0), Oleic acid (C18:1n9c), where they formed 72.5% and 76.1% of total fatty acids in milk from farming and pastoral system, respectively. The short-chain fatty acids (SCFA) which was represented by Caproic acid (C6:0) only (Table 3) was 0.13% in milk from farming system and 0.2% in milk from pastoral system. The proportion was 8.9% and 10.7% for medium chains (MCFA), 90% and 89% for long chains (LCFA) in milk of the two systems, respectively. The omega 3 and 6 (N-3/ N-6) ratio was 0.17 and 0.08 for milk from farming and pastoral system, respectively.

Different contents of (66.1%) saturated fatty acids and (30.5%) unsaturated fatty acids were reported in camel milk [14], compared to the present results. This could be due to difference in feed intake by the camel and to difference in breeds, geographic locality, lactating stage and the environment. [5], [19] determined the fatty acid composition and cholesterol content in camel's milk of Bactrian, dromedary and hybrids from different regions of Kazakhstan, and in different seasons. Great differences in fatty acid composition occurred between regions.

The short-chain fatty acids (SCFA) was represented by Caproic acid (C6:0) only in both systems, and the proportion for medium chains (MCFA) was higher in pastoral system, while, the long chains (LCFA) had almost same value in milk of the two systems. Short-chain fatty acids (C8:0 and C10:0) were found to have higher proportion in camel's milk in spring [20], and long-chain fatty acids (C17:0 and C17:1) were higher in autumn. A high content of medium chain fatty acids is usually considered as beneficial for human health as they are more easily absorbed and metabolized. As can be seen in (Figure 1) milk of farming system contained more SFA and less USFA compared to pastoral system, but there was more PUFA in farming system. The ratio USFA/ SFA was higher in pastoral system compared to in farming system, but N-3/N-6 (Figure 2) in farming system was 0.17 doubled the ratio 0.08 in pastoral system. According to [20] the ratio unsaturated fatty acids/saturated fatty acids is a good indicator of the nutritional quality of milk. This ratio was 0.57 for dromedary milk from pastoral system and 0.48 for farming system in the present study, compared with 0.30 for cow's and 0.32 for goat's milk [21]. Fatty acid composition also showed that the content of many of them varied between the two systems. The variation observed indicated that variation in food intake and management can affect the quality of camel milk. These results confirmed that environmental and farming conditions allowed modulation of the lipid composition of camel's milk. However, the content of fatty acids in camel milk is importance for human nutrition and health [17], [22], [23].

4. Conclusion

The present results indicated that milk of *Camelus dromedarius* is comparable to other mammalian milk, and that camel milk from different raising systems is a good potential source of essential fatty acids and can provide the daily requirement of healthy diet. The results also showed that traditional pastoral system can provide milk with better nutritional contents compared to the farming system. This could be explained by the fact that natural pasture is more variable in plants and vegetations preferred by the camels than the commercial feed of the farm management system. However, more work is needed to study the effects of breed differences, lactation stage, parity and body condition as well as seasonal changes on fatty acids composition in camel milk. The composition of fatty acids in camel milk is important to determine the nutritional value of camel milk as a source of the essential fatty acids for humans.

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Table 1: Fatty acid composition (mg/g) and profile (%) of camel milk from farming and pastoral systems.

Fatty acids	Farming system		Pastoral system	
	Mg/g	%	Mg/g	%
Caproic acid (C6:0)	0.11	0.13	0.17	0.2
Capric acid (C10:0)	0.11	0.13	0.1	0.12
Lauric acid (C12:0)	0.3	0.35	0.35	0.41
Tridecanoic acid (C13:0)	0.08	0.09	0.11	0.13
Myristic acid (C14:0)	6	7.11	7.23	8.43
Pentadecanoic acid (C15:0)	0.7	0.83	0.9	1.05
Palmitic acid (C16:0)	23.5	27.92	26.34	30.74
Heptadecanoic acid (C17:0)	0.43	0.51	0.57	0.67
Stearic acid (C18:0)	18.63	22.11	18.09	21.11
Arachidic acid (C20:0)	0.51	0.6	0.41	0.48
Behenic acid (C22:0)	0.24	0.28	0.21	0.24
Tricosanoic acid (C23:0) IS	3.37	3.99	0.1	0.11
Lignoceric acid (C24:0)	2.89	3.43	0.12	0.14
Myristoleic acid (C14:1)	0.3	0.36	0.5	0.58
Palmitoleic acid (C16:1)	4.86	5.77	6.69	7.81
Heptadecanoic acid (C17:1)	0.23	0.27	0.35	0.4
Elaidic acid (C18:1n9t)	0.69	0.82	1.07	1.25
Oleic acid (C18:1n9c)	18.91	22.44	20.74	24.21
Eicosenoic acid (C20:1)	0.14	0.17	0.11	0.13
Linolelaidic acid (C18:2n6t)	0.2	0.11	0.11	0.12
Linoleic acid (C18:2n6c)	1.19	1.41	1.2	1.4
Linolenic acid (C18:3n3)	0.12	0.14	0.11	0.13
Docosadienoic acid (C22:2)	0.76	0.9	0.11	0.13
Eicosapentaenoic (C20:5n3)	0.1	0.12	0	0

Table 2: Concentration of fatty acids groups (mg/g) in camel milk from farming and pastoral systems

Fatty acid groups	Farming system		Pastoral system	
	Mg/g	%	Mg/g	%
TFA	84.27	100	85.7	100
SFA	56.89	67.51	54.7	63.83
MUFA	25.13	29.82	29.47	34.38
PUFA	2.25	2.68	1.53	1.78
USFA	27.38	32.5	31	36.16
USFA/ SFA	0.48		0.57	
N-6	1.28	1.31	1.52	1.52
N-3	0.22	0.11	0.26	0.13
N-3/N-6	0.17		0.08	

Table 3: Fatty acid composition (%) of camel milk compared to some mammalian species.

Fatty Acids	Camel	Cow	Sheep	Goat
Short Chain				
C4:0	0	11	8	8
C6:0	(0.13 - 0.2)	5	5	5
C8:0	0	1	4	4
Medium Chain				
C10:0	(0.12 - 0.13)	3	6	13
C12:0	(0.35 - 0.41)	3	5	7
C14:0	7.1 - 8.4	10	10	12
Long Chain				
C16:0	27.9 - 30.7	23	22	24
C18:0	21.1 - 22.1	10	10	12
C18:1	22.4 - 24.2	29	22	17
C18:2	1.4	2	4	3
C18:3	(0.13 - 0.14)	<1	<1	<1

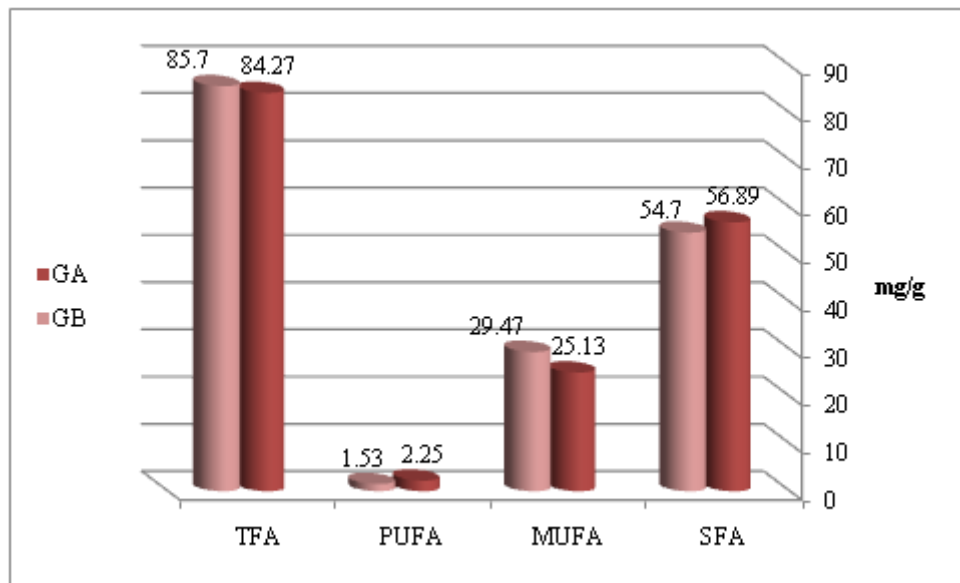


Figure 1: The contents (mg/g) of major groups of fatty acids in camel milk from farming system (GA) and pastoral system (GB)

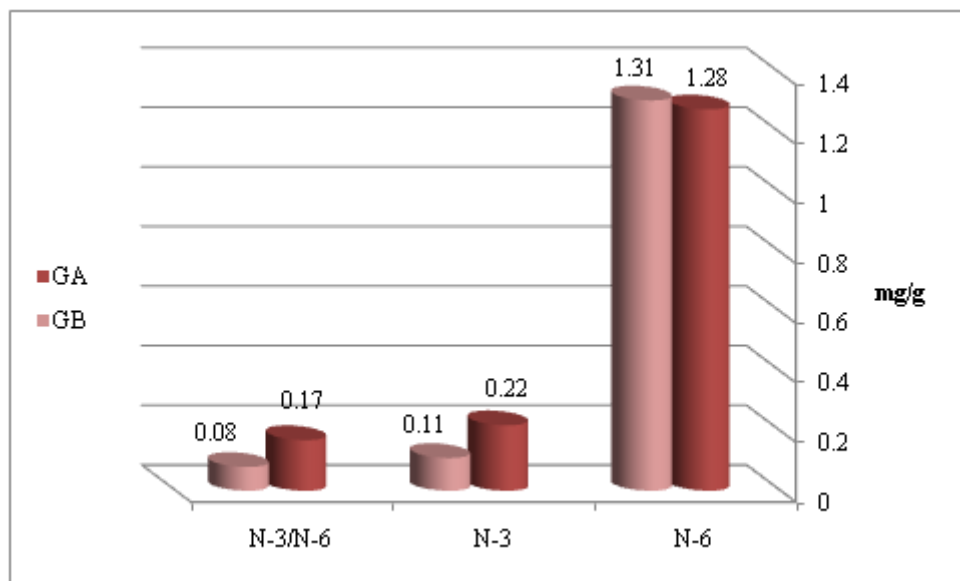


Figure 2: The contents (mg/g TFA) of omega-3 and omega-6 fatty acids and N-3/N-6 ratio in camel milk from farming system (GA) and pastoral system (GB)