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Research Article

Omega-3 Fatty Acids in Milk Fat of Some Sudanese Camels

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Abstract

Omega-3 fatty acids are alpha-lionlenic acid (ALA) (C18:3n3), eicosapentaenoic acid (EPA) (C20:5n3) and docosahexaenoic (DHA) (C22:6n3). Omega-3 fatty acids are essential for structural development of the brain and eyes in the infants and maintenance of normal vision and neural functions in adults. Fish-derived omega-3 fatty acids EPA and DHA have been associated with fetal development, cardiovascular function and Alzheimer's disease. This study was conducted to investigate omega-3 fatty acids in camel milk fat of Sudanese Arabi camel managed under two production systems (traditional nomadic and semi-intensive). Bulk milk samples (n=105) were collected from different production systems (35 samples/system) with different camel breeds (Nefidia, Butana and Kenani) in Khartoum and Sennar states during July to August 2013 and were subjected to fat extraction and fat analysis by using GCMS. The ALA content was found as 0.14% and 0.32% of total fatty acids of milk at for Butana and Kenana camel, respectively. The EPA content revealed values of 0.08% and 0.14% of the total fatty acids for Butana and Nefidia camel milk fat, respectively. The DHA content varied with non significant ($P>0.05$) differences as it revealed 0.20% and 21% of the total fatty acids in camel milk fat for Butana and Kenana camel milk fat, respectively. Also the study reported significant ($P<0.05$) differences on omega-3 fatty acids among she camels in the different parity orders and stages of lactation. The study concluded that breed, parity and stage of lactation have significant effect on omega-3 fatty acids composition of camel milk fat.

Keywords: ALA; Camel Milk; DHA; EPA; Omega-3 fatty acids; Production Systems; Sudan

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Introduction

Interest in camel milk quality and quantity has grown steadily in recent years. In general, the number of camels in Sudan was 4.6 million heads in 2011 [1]. Variation in chemical composition of camel milk and camel milk fat may be due to breed, age, the number of calving, nutrition, management, the stage of lactation and ecological area [2-11]. The health effects of camel milk components have been recognized as a component of interest due to their therapeutic properties such as anti-bacterial [12], anti-viral [13] and anti-inflammatory [14], anti-diabetic [15] and anti allergic [16]. The hydration status of the animals and the type of forage eaten would determine the fat content of the milk [17].

Camel milk fatty acids composition was found to vary in different stages of lactation [18]. The changes occurring in camel milk during the 1st month of lactation is a useful nutritional attribute since saturated **fatty acid**s are rapidly metabolized by camel tissue before they have a chance to be excreted in the milk and constitute an energy source and induces excessive β-oxidation and subsequently a superfluous synthesis of ketone bodies, which may enhance the absorption of calcium, magnesium and **amino acids** [19].

Some studies have been reported on camel milk fat [17-23] indicated that milk fat is mainly composed of triacylglycerols with a broad variety of fatty acids composition. The complexity of its composition originates from the extreme diversity of its fatty acids with respect to chain lengths, position and number of double bonds and branching. Moreover milk fatty acids composition is one of the aspects linked to the discussion on the health effects of camel's milk and milk products [24]. Camel's milk proved to be very different from other mammalian milk for human consumption in types of fatty acids composition and the lower content of long chain fatty acids, which confirmed it's nutritional and health value [18].

Triacylglycerols of camel milk contained saturated fatty acids (66.1%) and unsaturated fatty acids (30.5%), the predominant saturated fatty acids in camel milk were 16: 0 (34.9%), 14: 0 (14.5%) and 18: 0 (9.7%) [20]. The ratio of unsaturated to saturated fatty acids was more favourable in camel's milk compared with that of cows or other mammalians, although it had a higher content of cholesterol (37.1 mg·100 g^{-1}) than cow's milk [17]. Milk fat percentage is a quantitative trait that was determined by collective effect of multiple genes and environmental factors. The fat percentage in camel milk was estimated to be 1.2 to 6.4 according to the worldwide published data on camel milk [25].

The milk fat content of omega-3 fatty acids are of special interest because these fatty acids are essential for growth development and are beneficial in the maintenance of human health and prevention of chronic diseases including CVD, inflammatory diseases and neurological disorders [26]. Omega-3 fatty acids have anti-inflammatory properties and, therefore, might be useful in the management of many diseases including coronary heart disease and major depression [27]. As deficiency in dietary omega-3 fatty acid has been also shown to have some roles in the pathophysiology of several major psychiatric disorders [28]. The content of the colostrums, transitional and mature milk of the Northern Sudanese women whose traditional diet is high in carbohydrate and low in fat revealed arachidonic acid content of 0.87±0.28%, 0.89±0.29% and 0.48±0.12%, respectively and the DHA level were 0.13±0.07%, 0.13±0.06% and 0.06±0.05%, respectively [29]. 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 [23].

Milk fat content of omega-3 fatty acids is generally very low (less than 0.55 of total fatty acids) and this is mainly α-linolenic acid (ALA) [30]. The α-linolenic acid (ALA) is functional for some processes, but its conversion to very long chain omega-3 fatty acids (e.g. eicosapentaenoic acid (EPA) and docosahexaenoic acid (DHA)) is essential for many physiological effects including the prevention of chronic diseases [31-32]. Omega-3 fatty acids, known for their health benefits since the 1930s, came to prominence after the discovery an unusual fatty acid, now identified as Docosahexaenoic acid (DHA), in the surveillance of blood from the Arctic's Inuit (Eskimo) known globally for highly healthy heart functions with extremely low high failure rates. Docosahexaenoic acid, an omega-3 fatty acid with a 22-carbon chain, occurs in salmon and other fish sources, which the Inuit hunt and ingest as staple food [33]. The present study aimed to evaluate the omega-3 fatty acids in camel milk fat of camel managed under traditional nomadic and semi-intensive systems.

Materials and Methods

Source of milk samples

Camel milk samples were collected from three different areas in central Sudan (Sinnar; Moya Mountain, and Gezira State; Al Neb; Al Butana) and Khartoum State (Khartoum North locality and Eastern Nile locality). Milk samples were collected from three indigenous camel breeds; Nefidia (n=35) and Butana (n=35) in traditional nomadic system and Kenani (n=35) in semi intensive system. In total, 105 milk samples were collected into dry clean bottles (60 ml). The samples were labeled and transferred in an icebox to the Dairy Chemistry laboratory of the Faculty of Animal Production, University of Khartoum for chemical analysis. According to parity, the collected samples were divided into five categories; first, second, third, fourth and fifth. The stages of lactation was also divided into four stages; first (from birth to 3 months), medium (from 4 to 6 months), late (from 7 to 9 months) and latest (from 10 to the end of lactation) stages.

Milk fat extraction and methylation

Milk fat extraction was performed using the method described [34] with some modifications (Centrifugation at 6000 rpm for 35 minutes at 44 °C. After centrifugation one ml of N-Hexane was added to extract enough amount of fat). Ten ml milk samples were taken in a 30 ml conical plastic tube and subjected to centrifugation (Centrifuge EBA 20, Germany) at 6000 rpm for 30 minutes at 4 °C. An aliquot (1.5 g) of the fat cake layer was transferred to a 5 ml tube and placed at room temperature (20-25 °C) for approximately 30 minutes till the melting point. The sample was then centrifuged at 13000 rpm for 15 minutes at room temperature using centrifuge. After centrifugation, milk sample was separated into three layers: the top layer of lipid; the middle layer of protein, fat and other water insoluble solids; and the bottom layer of water. Methyl esters of the lipid extract were prepared according to Wang et al. [35].

Analysis of FAME by GCMS

Fatty acids methyl esters were quantified using a Shimadzu Gas Chromatography Model 14-A (Shimadzu Co., Japan) fitted with a methyl lignose rate coated (Film thickness= 0.25 µm), polar capillary column SP-2330 (30 m × 0.32 mm), using the following conditions:

Injector temperature:	250 °C
Column oven temperature:	140 °C (5 min.), 4 °C /min. to 240 °C (2 min.)
Detector temperature:	250 °C
Detector:	FID (Flame Injection Detector)
Carrier gas:	hydrogen, 40cm/sec @ 175 °C
Injection of sample:	1 µL, split 100:1
Liner:	4 mm I.D split, cup design

Under the same chromatographic conditions, the peaks were identified using standard mixture of known fatty acids and the retention time of unknown samples were compared with the standard for identification.

Statistical analysis

The statistical analysis for omega-3 fatty acids composition of camel milk fat was done using the General Linear Model (GLM) procedure in SPSS (version.17, 2009). Differences among means were estimated using Duncan's Multiple Range Test (DMRT) at $P<0.05$.

Results and Discussion

Camel milk fat omega-3 fatty acids composition (%) of the samples obtained from semi-intensive system in Khartoum North (Khartoum State) and traditional nomadic system around El Butana (Gezira State) and Moya Mountain (Sennar State); are influenced by breed are shown in table 1. ALA revealed mean values of 0.32±0.25, 0.14±0.43 and 0.25±0.53 for Kenana, Butana and Nefidia camel, respectively. EPA showed 0.10±0.07, 0.08±0.21 and 0.14±0.21 respectively, and the values for DHA were 0.21±0.33, 0.20±0.74 and 0.21±0.33, respectively. Omega 3 and 6 (N-3/ N-6) ratio was 0.17 and 0.08, respectively [23]. Camel milk contains less short-chain FA than cow, sheep and buffalo milks [16]. The content of fatty acids in milk of *Camelus dromedarius* could be a good potential source of essential fatty acids and can provide the daily requirement of healthy diet [23]. Moreover the camel milk has low milk fat content with increased PUFA proportions, thus being compatible with human milk [16]. The results revealed significantly ($P<0.05$) higher ALA for camel milk fat samples obtained from semi-intensive system compared to that collected from traditional nomadic system. On the other hand, EPA percentage was significantly ($P<0.05$) higher in camel milk fat samples from traditional nomadic system (Moya Mountain). This might be because camels reared at Moya Mountain enjoy the good pasture in addition to the irrigated crop residues after harvest and availability of the water [18,36]. However DHA content revealed non significant (P>0.05) variation between Kenana and Butana camels as the same value (0.21±0.33%) was found for camels in the semi-intensive and traditional nomadic systems. This might be because camels under semi-intensive system receive adequate quality of feed concentrates [9]. It was also concluded that availability of high feed quality explains the variations in milk content between different production systems [37]. It was 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 [23]. On the other hand the arachidonic acid and DHA levels of the colostrums, transitional and mature milk of the Northern Sudanese women were very low because of the fatty acid deficient diet [29].

The present results showed that under traditional nomadic system (Nefidia), camel produce more EPA in milk fat compared to those received concentrates in semi-intensive. In this study, the total of omega-3 fatty acids of camel milk fat samples from Kenana, Butana and Nefidia breeds revealed 0.24, 0.10 and 0.21 %, respectively. Table 2 showed the effect of parity number on omega-3 fatty acids content, the results showed significant differences (P<0.05) in ALA, EPA and DHA percentage for she camels in different parities. Whereas she camels in the fourth parity was distinguished with high mean value of ALA (0.32 %) and DHA (0.45 %) while she camels in the third parity showed the high mean value of EPA (0.15 %). Variations in the fat content were reported previously for she camels in different parity orders [10,11]. Although no significant differences in camel milk fatty acids composition during the different parities were observed, parity order contribute to the variations in camel milk fat composition [18].

Table 3 showed the effect of stages of lactation on omega-3 fatty acids composition. The results indicated significant (P<0.05) differences for ALA, EPA and DHA percentage for she camels in the different stages of lactation whereas those in early (1-3 months) stage of lactation showed higher mean values for ALA, EPA and DHA (0.32 %, 0.63 % and 0.30 %, respectively). During the medium stage, there a decreasing trends. However she camels in the late stages of lactation (7-9 months) showed the higher value of DHA (1.46 %).

Ecotypes	ALA			EPA			DHA		
	Mean± SD	Min	Max	Mean± SD	Min	Max	Mean± SD	Min	Max
Kenana	0.32±0.25*	0.02	00.87	0.10±0.07	0.01	0.36	0.21±0.33	0.01	1.19
Butana	0.14±0.43	0.01	02.69	0.08±0.21	0.00	1.11	0.20±0.74	0.00	3.31
Nefidia	0.25±0.53	0.01	03.26	0.14±0.21*	0.00	0.78	0.21±0.33	0.00	1.81
Total	0.24±0.42	0.01	03.26	0.10±0.18*	0.00	1.11	0.21±0.51	0.00	3.31

Table 1: Omega-3 fatty acids (%) in milk of three ecotypes of Sudanese Arabi camels under different production systems.

*Significantly (P<.05)

Parity	ALA			EPA			DHA		
	Mean±SD	Min	Max	Mean±SD	Min	Max	Mean± SD	Min	Max
(1-2)	0.20±0.21	0.02	0.87	0.06±0.07	0.00	0.38	0.08±0.13	0.01	0.52
3	0.25±0.54	0.02	3.26	0.15±0.26*	0.00	1.11	0.20±0.56	0.00	331
4	0.32±0.55*	0.01	2.69	0.13±0.16	0.00	0.51	0.45±0.75*	0.00	3.28
5	0.17±0.15	0.03	0.46	0.04±0.05	0.00	0.15	0.15±0.35	0.01	1.19
Total	0.24±0.42	0.01	3.26	0.10±0.18	0.00	1.11	0.21±0.50	0.00	3.31

Table 2: Omega-3 fatty acids (%) in milk as influenced by lactation stages of three ecotypes of Sudanese Arabi camels under different production systems.

* Significantly (P<0.05)

L/Stage	ALA			EPA			DHA		
items	Mean±SD	Min	Max	Mean±SD	Min	Max	Mean±SD	Min	Max
(1-3)	0.32±0.27	0.00	01.23	0.63±1.75*	0.01	9.67	0.30±0.33	0.01	3.02
(4-6)	0.53±1.02	0.00	05.27	0.54±1.22	0.01	5.78	0.12±0.74	0.01	0.42
(7-9)	0.42±0.42	0.00	01.70	0.38±0.64	0.00	2.30	1.46±0.33*	0.01	41.0
(≥10)	1.21±3.44*	0.00	16.82	0.59±1.49	0.00	7.11	0.97±0.18	0.02	3.18
Total	0.57±1.65	0.00	16.82	0.53±1.34	0.00	9.67	0.62±3.89	0.01	41.0

Table 3: Omega-3 fatty acids (%) in milk as influenced by parity order of three ecotypes of Sudanese Arabi camels under different production systems.

*Significantly (P<0.05)

Similar trends were reported for DHA in milk from Sudanese women [29]. Camel milk fatty acids composition was found to vary between the stages of lactation as the proportions of short chain fatty acids were high at early and late stage of lactation compared to middle stage of lactation [18].

Triglycerides and percentage medium chain fatty acids increased whereas tocopherols, cholesterol and percentage long chain polyunsaturated fatty acids decreased. These changes reflect augmented de novo synthesis of fatty acids (12:0, 14:0, 16:0 and 18:0) in the mammary gland and a tendency of increasing fat globule size as milk mature [19]. Also, it appears that biohydrogenation of polyunsaturated fatty acids is less extensive in the rumen of the camel and polyunsaturated fatty acids was high in colostrums of camel milk, All these factors may contribute to be the specific needs of growing neonates and increased speed of growth during the first month of life [19]. This because the omega-3 fatty acids EPA and DHA are essential for proper fetal development, and supplementation during pregnancy has also been linked to decreased immune responses in infants including decreased incidence of allergies in infants [38]. Hence this study encourages utilization of camel milk especially those from she camels that enjoyed rich natural pasture due to its nutritional and health benefits as well as functional properties. Based on a definition of functional food, camel milk is considered as functional food because it has important nutritional and functional values and it could provide particular health benefits [39]. Omega-3 fatty acid consumption has been associated with improved cardiovascular function in terms of anti-inflammatory properties, PAD, reduced major coronary events, and improved anti-platelet effects in the face of aspirin resistance or clopidogrel hypo responsiveness [38].

Conclusion

This work demonstrated that camel milk fat has a wide range of variation in the levels of omega-3 fatty acids. This study recommended that milk fat from Nefidia camel; which enjoyed rich pasture content; could be considered as a rich source of the omega-3 fatty acids, this might have a role in lowering human serum lipids and decreasing the incidence of lipid-related cardiovascular diseases. The lower level of the omega-3 fatty acids in Butana camel milk fat may reduce the organoleptic properties of camel milk. Further research is needed and should include more detailed of camel milk fat analysis, and more information about camel nutrition and feed intake.

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