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Chemical Composition and Fatty Acids Profile of Camels Milk in Middle Darfur State, Sudan

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Article History: Recieved: 18/10/2016
Accetpted: 27/12/2016

Abstract
The aim of this study was to determine the chemical composition and fatty acids profile of camel milk from four different areas in Middle Darfur state, Sudan the period from July to August - 2014. Forty camel's milk samples were obtained from four different areas in Middle Darfur state; Garsilla, Nertety, Abata and Sullo, ten samples from each area. The collected milk samples were analyzed using ANOVA and Least significant different (LSD) for means separation for chemical composition and fatty acids profiles. The results presented that total solids contents was significantly different (P <0.05). While no significant variations (P >0.05) were found in protein, fat, titratable acidity and ash contents of the camel milk samples in the four areas. The highest values of milk protein contents were recorded in Sullo and Abata areas (3.64±0.18% and 3.64±0.14%, respectively), while the highest value of fat contents were recorded in Garsilla area (3.81±0.29%). Garsilla, Abata and Sullo areas were recorded highest values of acidity (0.14±0.01%), while the highest values of ash contents were recorded in Garsilla area (0.95±0.17%). The results showed that significant variations (P <0.05) were found in ecosenoic and heptadecenoic fatty acids profile of the camel milk in the four areas. While no significant differences (p> 0.05) were reported in most saturated fatty acids (SFA). The Protein, fat, ash and titratable acidity of camel milk in Middle Darfur state showed no significant variations while the total solids was significantly different. The unsaturated fatty acids profile of the camel milk samples showed significant difference wile no significant variations were found in saturated fatty acids.
Keywords: Middle Darfur, Camel, Milk, fatty Acid, Chemical Composition

Introduction
Camels are considered to be a good source of milk and meat and are used for other purposes such as transportation and sport racing (Salih and Hamid, 2012). Sudan is one of the largest camel populated countries in the world. Its population is about 4.6 millions (MARF, 2010).Sudan and Somalia have 70% of the total African camels and 55% of that of the world camel's population. The camels were, and still are, valued as riding, baggage, draught animals, hair hides and as well as the best food

providers in the arid areas (Tigani et al., 2007). The general composition of camel milk varies in various part of the world with range of 3.07-5.50% fat, 3.5-4.5% protein, 0.7-0.95% ash and 3.4-5.6 % lactose, 12.1-15% total solid (Salih and Hamid, 2012). El Zubeir et al., (2008) found that the general composition of camel milk varies in various parts of the world with a range of 3.5 to 4.5% protein, 3.4 to 5.6% lactose, 3.07 to 4.5% fat, 0.7 to 0.95% ash and 12.1 to 15% total solids, These wide variations in the constituents of milk were attributed to some factors such as age, number of calving, management, stage of lactation, the sampling technique used and feed quality. The composition of milk varies widely and contains 2.9-5.5% fat, 2.5-4.5% protein, 2.9-5.8% lactose, 0.35- 0.95% minerals and 8.9-14.3% solids-not-fat(Khan et al., 2004). Mal and Pathak, (2010) mentioned that the percent value of moisture, total solids, fat, SNF, protein, casein, ash, acidity and pH ranged from 88.55-90.15, 9.85-11.45, 2.60-3.20, 7.25-8.25, 3.73-3.89, 2.90-3.02, 0.82-0.85, 0.12-0.14 and 6.36-6.58 respectively. Mohamedy (2010) mentioned that the milk protein content of camel milk ranges from 2 to 5.5 percent. The total protein in camel milk is similar to that of cow milk. Milk proteins perform a variety of functions in living organisms ranging from providing structure to reproduction. The main components of milk proteins are casein and whey. The fat content of camel's milk varies between 2.9% and 5.4% and the average size of the fat globules is about the same as cow's milk fat globules. The variation in the fat content is associated with the type of breed, stage of lactation and feeding condition as described by Webb *et al.*, (1980). The changes in camel milk composition could be due to several factors including analytical measurement procedures, camel diet, climate, water availability, livestock management and other factors (Suliman, 2012). The fatty acids are divided according to the linkage of the carbon atoms into saturated and unsaturated fatty acids. Haasmann, (1998) mentioned that the fatty acid composition of camel milk is characterized by a lower proportion of saturated short chain fatty acids, e.g. butyric acid, and higher concentrations of some long chain fatty acids, e.g. stearic acid and palmitoleic acid, in comparison to cow milk. Elobied (2015) reported that the percent values of saturated fatty acids caproic, caprylic, capric, lauric, tridecanoic, myristic, pentadecanoic, palmitic, heptadecanoic, stearic, arachidic, henicosanoic, tricosanoic and hetracosanoic in different seasons were ranged 2.41, 2.41, 7.90, 11.68, 12.03, 11.00, 10.65, 12.03, 4.81, 3.44, 6.87, 3.09, 1.03 and 0.69 respectively in summer season and the percent values of mono unsaturated fatty acids Myristoleic, Palmitoleic, Oleic, Eicosenoic, Erucic, and Nervonic ranged 4.4, 7.4, 48.5, 14.7, 8.8, 0.00 respectively in summer season.

Materials and Methods

Study area: Middle Darfur state is in Darfur region; in western part of the Sudan, between latitudes 12°30' and 13° 30' North and longitudes 23°30' and 23°45' west. To the north of it lays North Darfur state and to the east is East Darfur state. To the west is West Darfur and to the south is South Darfur state. The Middle Darfur states its unique position because it is surrounded by many valleys for example Azum valley in the west, Aryebu and Touro on the other side. In addition to its location, it is in western part of Jebel Marra which has

wet climate, fertile soil and available water resources which is used for the different types of agricultural activities (Ali, 2012).

Milk sampling and storage: Forty she-camels were selected from four herds belonging to Abbala tribe (different camel breeds) from different location, ten samples were taken from each herd (The herd populations are about 600 she camels). Milk samples were collected from these camels and transferred to the Dairy laboratory of Animal Department, Faculty of Agricultural, University of Zalingei. At the laboratory, the samples were carried and stored in a refrigerator at 4-5 C° for later analysis.

Chemical composition determination of camel milk: Fat content was determined using Gerber Method (Marshall, 1993). The protein content was determined using Formol titration method according to Chang (1998).Total solids content, titratable acidity and the ash content of camel milk samples were determined according to the method described in AOAC (1990).

Determination of Fatty Acids Profiles: The milk fat was extracted from milk in liquid form by hexane. One gram of fat was dissolved in 5 ml hexane. Fatty acids were determined after methylation by gas chromatography and were confirmed by mass spectrometry for each milk sample. A Varian 3400 gas chromatograph was equipped with a non polar DB-Wax capillary column (molten silica) of 60 m length, 0.32 mm diameter and 0.25 μm film thicknesses (Faye *et al.,* 2008).

Statistical Analysis: The data of the present study was statistically analyzed using SPSS software (Statistical Package for Social Sciences, version 16). In this experiment ANOVA was used. Least significant different (LSD) was used for mean separation of the chemical composition and fatty acids of camel milk. The levels of significance $p<0.05$ was used in this study.

Results

Chemical composition of camel milk: Results in Table (1) show the chemical composition of camel milk obtained from four different areas in Middle Darfur state.

The average total solids content of camel milk samples collected during this study from Garsilla, Nertety, Abata and Sullo found to be 11.95±0.93%, 11.10±0.66%, 11.21±0.41%, 11.10±0.26% respectively were significantly different ($P<0.05$).
The protein contents of camel milk samples collected from Garsilla, Nertety, Abata and Sullo were not significantly varied ($P>0.05$) between these areas. The values average found to be 3.56±0.24, 3.56±0.23, 3.64±0.14 and 3.64±0.18 percent respectively.

No significant variation ($P>0.05$) was found in the fat contents of camel milk samples among the four areas.

The average titratable acidity of camel milk samples collected from these areas found to be 0.14±0.01 in Garsilla, 0.13±0.01% in Nertety, 0.14±0.01% in Abata and 0.14±0.01% in Sullo, not significant differences ($P>0.05$) were found among the different areas.

The ash contents of camel milk samples obtained from Garsilla, Nertety, Abata and Sullo, were found to be 0.95±0.17%, 0.87±0.07%, 0.94±0.13%, 0.89±0.08% respectively also no significant differences ($P>0.05$) were reported.

Table 1: Chemical composition of camel milk from four different areas in Middle Darfur state

Area	Chemical composition% of camel milk in Middle Darfur state				
	Protein	**Fat**	**Titratable acidity**	**Ash**	**Total solids**
Garsilla	3.56±0.24	3.81±0.29	0.14±0.01	0.95±0.17	11.95±0.93a
Nertety	3.56±0.23	3.60±0.21	0.13±0.01	0.87±0.07	11.10±0.66b
Abata	3.64±0.14	3.72±0.21	0.14±0.01	0.94±0.13	11.21±0.41b
Sullo	3.64±0.18	3.68±0.24	0.14±0.01	0.89±0.08	11.10±0.26b
LS	NS	NS	NS	NS	*

Mean values bearing different letters within colums are significantly different (P<0.05).
LS = Levels of significance

Fatty acids profile of camel milk: Results in Table (2) showed the fatty acids profile of camel milk obtained from four different areas in Middle Darfur state.

The capric acid of camel milk samples from Garsilla, Nertety, Abata and Sullo were not significantly different (P>0.05). The average values found are; 0.01±0.01%, 0.003±0.01%, and 0.033±0.06 %, for Garsilla, Nertety and Sullo respectively, while were not detected in Abata. The results demonstrated that the lauric acid of camel milk samples in the four areas were not significantly different (P>0.05).The tridecanoic acid of camel milk samples was only found in Garsilla area (0.05±0.03%).While was not detected in milk samples from Nertety, Abata and Sullo.

No significant variations (P>0.05) were found in the myristoloic acid content of camel milk samples in the four areas. Results showed that the oleic acid of camel milk samples were not significantly different (P>0.05) in the four areas. The eicosenoic acids of camel milk samples collected from Garsilla, Abata and Sullo were significantly different (P<0.05). While was not detected in Nertety. The results indicated that no significant variations (P>0.05) were reported in the caprylic acids contents in the four areas, the average values were 0.01±0.o2, 0.003±0.01, 0.06±0.10 and 0.003±0.01 percent in Garsilla, Nertety, Abata and Sullo respectively.

The palmitoleic acid of camel milk samples showed no significant differences (P>0.05) in the four areas. The highest values (0.14± 0.21%) were in Garsilla, while the lowest one (0.003± 0.01%) was in Sullo. The heptadecenoic acids of camel milk samples collected from Garsilla, Abata and Sullo were significantly different (P<0.05). However, it was not detected in Nertety. The stearic acid of camel samples obtained from Garsilla, Nertety, Abata and Sullo revealed no significant variations (P>0.05).The arachidic acid of camel milk samples were not significantly different (P>0.05). The average values found are; in Abata 016±0.24% and Sullo 0.32±0.31%. While was not detected in Garsilla and Nertety.

The eicosadenoic acid of camel milk samples were not significantly different (P>0.05). The average values found to be 0.03±0.03% in Abata and 0.13±0.12% in Sullo. While was not detected in Garsilla and Nertety. The average values of palmitic acid found

are; in Abata 0.01±0.02% and Sullo 0.02±0.03%. While was not detected in Garsilla and Nertety. However, no significant variations (P>0.05) were found. The average values of linoliec acid of camel milk samples found to be only in Abata area (1.64±2.84%).The linolenic acid of camel milk samples were not significantly different (P>0.05). The average values found are; in Abata (0.19±0.26%) and Sullo (0.02±0.03%), while in Garsilla and Nertety areas were not detected.

The averages values of Erucic, tricocenoic and nervonic acids found to be only in Abata area (0.25±0.44%, 0.08±0.13% and 0.06±0.10% respectively, while in Garsilla, Nertety and Sullo areas were not detected. The behenic acid of camel milk samples only found in Sullo area, the average is 0.02±0.04%, while in Garsilla, Nertety and Abata areas were not detected.

Table 2: Concentration (%) of fatty acids profile of camel milk samples from four different areas in Middle Darfur state

Name of acids (Mean+Sd)	Areas				LS
	Garsilla	Nertety	Abata	Sullo	
Capric	0.01±0.01	0.003±0.01	ND	0.033±0.06	NS
Lauric	0.02±0.03	0.003±0.01	4.16±7.21	0.003±0.01	NS
Tridecanoic	0.05±0.03	ND	ND	ND	NS
Myristoloic	0.03±0.03	0.01±0.01	ND	0.017±0.02	NS
Oleic	0.42±0.49	0.08±0.10	13.59±21.86	0.010±0.02	NS
Eicosenoic	0.06±0.09[b]	ND	0.15±0.26[b]	1.21±0.94[a]	*
Caprylic	0.01±0.02	0.003±0.01	0.06±0.10	0.003±0.01	NS
Palmitoleic	0.14±0.21	0.04±0.02	0.13±0.22	0.003±0.01	NS
Heptadecenoic	0.01±0.01[b]	ND	0.06±0.05[a]	0.02±0.03[b]	*
Stearic	ND	0.04±0.04	2.94±3.84	1.23±1.77	NS
Arachidic	ND	ND	016±0.24	0.32±0.31	NS
Eicosadenoic	ND	ND	0.03±0.03	0. 13±0.12	NS
Palmitic	ND	ND	0.01±0.02	0.02±0.03	NS
Linoliec	ND	ND	1.64±2.84	ND	NS
Linolenic	ND	ND	0.19±0.26	0.02±0.03	NS
Erucic	ND	ND	0.25±0.44	ND	NS
Tricocenoic	ND	ND	0.08±0.13	ND	NS
Nervonic	ND	ND	0.06±0.10	ND	NS
Behenic	ND	ND	ND	0.02±0.04	NS

Mean values bearing different letters within rows are significantly different (P<0.05).
LS = Levels of significance
ND = Not Detected

Discussion

Chemical Composition of Camel Milk:

Total solids contents of the camel milk samples collected from four different areas in Middle Darfur state were significantly different (P<0.05) (Table 1). The highest total solid was found in the milk samples in Garsilla area this could be due to stage of lactation and feeding conditions. These results were in agreement with those reported by Suliman, (2012) who found that the total solids content of the camel milk ranges between 10.2-13.9%, this might be related to the availability of drinking water.

The results showed that no significant variations (P>0.05) were found in the

protein contents of camel milk samples (Table 1). These results agreed with those of Salih and Hamid (2012) and Mohamedy (2010) who reported that milk protein content of camel milk ranges from 3.5-4.5 and 2 to 5.5 percent respectively. The fat contents of camel milk samples were not significant differences (P>0.05). However, relatively highest fat contents in the camel milk were recorded in Garsilla area (Table 1). The variation in the fat content is associated with the type of breed, stage of lactation and feeding condition as described by Webb *et.al*. (1980). Similar results were reported by Farah (1993) who found that fat content of camel's milk varies between 2.9% and 5.4%.

The results showed that the titratable acidity of the camel milk samples also were not significantly different (P>0.05) (Table 1). These results were consistent with those reported by Mal and Pathak (2010) who found that acidity of camel milk ranged from 0.12-0.14. The results indicated that no significant differences (P>0.05) in the ash contents of camel milk samples were observed (Table 2). These results confirmed the findings of Salih and Hamid (2012) and Khan et al. (2004**)** who reported that ash ranged from 0.7-0.95% and 0.35- 0.95% respectively.

Fatty Acids Profile of Camel Milk: The fatty acid composition of camel milk fat samples collected from four different areas in Middle Darfur state (Table 2) was comparable with results mentioned by Mal and Pathak (2010), in particular the caprylic, capric, lauric, myristic, myristoleic, palmitic, palmitoleic, oleic, linoleic and arachidic was lower.While results of the stearic was similar to those reported by Mal and Pathak (2010). However these results were in agreement with those reported by Haasmann (1998) who found the fatty acid profile of camel milk is characterized by a lower proportion of saturated short chain fatty acids, and higher concentrations of some long chain fatty acids. The results showed that most SAT fatty acids caprylic, capric, lauric, tridecanoic, myristic, pentadecanoic, palmitic, heptadecanoic, stearic, arachidic and tricosanoic were lowest; these results were not in agreement with those reported by Elobied (2015). This might be due to the availability of different types of browsers plants which might be rich in these types of fatty acids. The results showed that most of monounsaturated (MUSAT) fatty acids myristoleic, palmitoleic, oleic, eicosenoic, erucic, nervonic and polyunsaturated (PUSAT) fatty acids Linoliec, were lowest than those mentioned by Elobied (2015), this might be due to high content of fat in the browser plants that dominant in the studied area and an increase of feed intake.

Conclusion

It has been concluded that chemical composition of the milk samples from different areas (Garsilla, Nertety, Abata and Sullo) in Middle Darfur state showed no significant differences except in the total solids content. However, higher total solids, fat and ash were recorded in Garsilla area. The results demonstrated that the fatty acids profile of the camel milk samples in the four areas seem to be similar except ecosenoic and heptadecenoic fatty acids.

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التركيب الكيميائي و الاحماض الدهنية في لبن الابل في ولاية وسط دارفور السودان

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المستخلص :

أجريت هذه الدراسة لمعرفة التركيب الكيميائى وقطاعات الأحماض الدهنية للبن الإبل فى أربعة مناطق بولاية وسط دارفور. تم جمع اربعون عينة من اربعة مناطق قارسيلا ونيرتتى وسولو وابطا فى ولاية غرب دارفور تم تحليل العينات إحصائياُ بإستخدام تحليل التباين وأقل فروقات معنوية للفصل بين متوسطات العينات للتركيب الكيميائى و قطاعات الاحماض الدهنية. أوضحت النتائج ان هنالك فروقات معنوية فى الجوامد الكلية فى المناطق الاربعة بينما لا توجد فروقات معنوية فى كل من البروتين والدهون والحموضة والرماد. حيث كانت اعلى نسبة بروتين فى العينات التى كانت فى سولو و ابطا (3.46±0.18 % و 3.46 ± 0.14 % على التوالى) . كانت أعلى نسبة دهون فى العينات التى جمعت من قارسيلا (3.81 ± 0.29%) بينما كانت اعلى نسبة حموضة للعينات التى جمعت من قارسيلا وأبطا وسلو.د (0.14 ±0.01%) ، كانت نسبة الرماد عالية فى العينات التى جمعت من قارسيلا (0.95 ±0.17 %). أبانت النتائج وجود فروقات معنوية فى قطاعات الأحماض الدهنية فى المناطق الأربعة. أشارت النتائج الى عدم وجود فروقات معنوية فى معظم قطاعات الأحماض الدهنية المشبعة بينما هنالك فروقات معنوية فى قطاعات الاحماض الدهنية الغير مشبعة. خلصت الدراسة انه لا توجد فروقات معنوية فى كل من البروتين والدهون و الحموضة و الرماد للبن الإبل فى المناطق الاربعة بولاية وسط دارفور بينما كانت هنالك فروقات معنوية فى الجوامد الكلية.أيضاً كانت هنالك فروقات معنوية فى قطاعات الأحماض الدهنية الغير مشبعة للبن الإبل فى العينات المختلفة.