Emir. J. Food Agric. 2013. 25 (8): 618-624
doi: 10.9755/ejfa.v25i8.16095
http://www.ejfa.info/

**ANIMAL SCIENCE**

# Seasonal and physiological variation of gross composition of camel milk in Saudi Arabia

**Abdelgadir M. Musaad[1], Bernard Faye[1,2 *] and Sallal E. Al-Mutairi[1]**

[1]*Camel and range Research Center, P.O. Box 322, Al-Jouf, Sakaka, Saudi Arabia*
[2]*CIRAD-ES, Campus international de Baillarguet TA C/dir B, 34398 Montpellier, France*

**Abstract**

Weekly milk samples from ten lactating she camels (*Camelus dromedarius*) were analyzed regularly for 11 months after parturition. The main values for all samples were 2.54 ± 0.72g/100g fat matter, 3.07 ± 0.30g/100g protein, 4.21 ± 0.37g/100g lactose and 0.76 ± 0.10g/100g ash. Fat content decreased from 3.41% at the first week to 2.29% at 36th week post-partum with rising at the end to 2.95% while protein decreased from 3.44% at week 1 to 2.79% at the end of lactation, and lactose from 4.48% to 3.90%. Ash increased from 0.72% to 0.82% then decreased down to 0.71%. Regarding seasonal variation, maximum level of fat was observed in January (3.46%) and minimum at summer time (2.29% in July). Protein content was maximum in February (3.32%) and minimum in October (2.76%). For lactose, the maximum mean value was 4.38% in February and the minimum in September (3.83%). The ash content was quite variable in January then stable all over the year. All components were highly positively correlated, except between fat and ash content which was not significant. No significant effect of parity, gestation length, calf body weight at birth or adult weight on all milk content. The average total milk production was 1207 L for 11 months range between 875 and 1616 L. The correlation between milk production and milk components are significantly negative.

*Key words*: Camel milk, Milk components, Seasonal variation, Physiological stage, Milk yield

## Introduction

The camel milk has a good nutritive quality and can be a convenient source of nutrient in human diet in arid and semi-arid zones. A lot of information is still to be generated about camel milk as a source of food (Igbal and Younas, 2001). Camel milk is a complex mixture of fat, protein, lactose, minerals, and vitamins and miscellaneous constituents dispersed in water. Wide variation in constituents of camel milk is attributed to some factors such as parity, season and physiological stage. The data of physiological change of the main components of camel milk are very scarce (Konuspayeva et al., 2009a) and generally based on monthly reported data. In the present study, data on week basis were regularly reported. Thus, the objectives of the study were (i) to determine in camel milk, the individual chemical composition (fat, protein, lactose and ash), (ii) to assess the changes during lactation and season, and (iii) to study the relationships between milk yield and milk constituents.

## Material and Methods

### Location and animals

This study was carried out in Al -Jouf 'Camel & Range Research Center' located in north-west Saudi Arabia, 950 km from Riyadh. Average annual temperature was 20°C, ranging from 12°C to 27°C, and average annual rainfall were 55 mm. The herd was composed by camels of four ecotype breeds (Malhah, Wadhah, Hamrah and Safrah) and their crosses (Abdallah and Faye, 2012). Camels were kept indoor throughout the year and housed in pens. Their diet was composed of alfalfa, barley, and salt and wheat bran.

For each animal, the following parameters were reported: parity (primiparous or multiparous), gestation length, calf weight at birth and adult weight at calving date. The quantitative data were shared into 2 modalities for statistical analysis (Table 1).

Received 09 January 2013; Revised 24 February 2013; Accepted 02 March 2013; Published Online 01 June 2013

*Corresponding Author

Bernard Faye
CIRAD-ES, Campus international de Baillarguet TA C/dir B, 34398 Montpellier, France

Email: faye@cirad.fr

Table 1. Modalities of the explaining factors of the milk components in ANOVA model.

| Factors | Modalities | values | Mean |
|---|---|---|---|
| Gestation length | Short | < 389 days | 378 days |
| | Long | > 390 days | 395 days |
| Calf weight | Low | <39 kg | 36 kg |
| | High | >40 kg | 43 kg |
| Adult weight | Low | <600 kg | 575 kg |
| | High | >601 kg | 700 kg |
| Parity | Primiparous | 1 | 1 |
| | Multiparous | 2 and more | 5.1 |
| Breed | Safrah | | |
| | Waddah | | |
| | Homor | | |
| | Majaheem | | |

**Milk sampling**

Milk samples were collected early morning at milking time (6:00 in winter and 5:00 in summer) in clean plastic bottles (40 ml). After thoroughly mixing for getting homogeneous sample, they were immediately transferred to laboratory close to the farm for analysis at the temperature of air-conditioned room. The time between sampling and analysis did not exceed one hour. All the samples came from 10 she-camels with different breeds, parity, gestation length, weight, calf body weight and age. The milk sampling was achieved every week at the same day in order to get a strictly 7-d interval.

**Milk analysis**

Chemical component of milk percentage of fat, total protein, lactose and ash was determined weekly for 10 months after parturition by automatic milk analyzer device (lactoscan MCC) calibrated for camel milk. Density and conductivity were also reported. The ultrasonic technology used by Lactoscan allowed direct measurement of fat, proteins, lactose and salts (see http://www.lactoscan.com/products_MCC.html). Lactoscan determined also the freezing point of each sample and the quantity of added water. The freezing point was calculated automatically from the components it depends on. The measuring range and the accuracy of the apparatus are reported in Table 2.

**Statistical analysis**

Physiological and seasonal changes (mean and SD) were studied at weekly and /or monthly basis. The correlations between the different components of the camel milk were calculated using Pearson correlation. The effects of some parameters were investigated as parity, gestation length, breed and body weight by ANOVA procedure. The differences between modalities reported in table 1 were investigated by Fisher test (LSD).

The data of present study was analyzed by using XLSTAT software (2010, 2.02 version, Addinsoft ©).

Table 2. Measuring range and accuracy of the apparatus Lactoscan MCC for the different milk parameters.

| Parameter | Measuring range | Accuracy |
|---|---|---|
| Fat | 0,01– 45% | ±0,06% |
| Solids-non-fat (SNF) | 3% – 40% | ±0,15% |
| Density | 1000 – 1160 kg/m$^3$ | ±0,3kg/m$^3$ |
| Protein | 2% – 15% | ±0,15% |
| Lactose | 0.01% – 20% | ±0,2% |
| Added water | 0% – 70% | ±3% |
| Milk sample t° | 5°C – 40 °C | ±1% |
| Freezing point | –0.4°C — –0.7°C | ±0,005% |
| Salts | 0,4% – 4% | ±0,05% |
| pH | 0 – 14 | ±0,05% |
| Conductivity | 2 – 14 [mS/cm] | ±0,05% |
| Total solids | 0 – 50% | ±0,17% |

**Results**

The mean values for all samples were 2.54 ± 0.72 g/100g fat matter, 3.07 ± 0.30 g/100 g protein, 4.21 ± 0.37 g/100 g lactose and 0.76 ± 0.10 g/100g ash.

**Weekly change of fat, protein, lactose and salt**

Regarding the weekly change along the lactation stage, the fat content was regularly decreasing, passing from 3.41% at the first week post-partum to 2.29% at the 36$^{th}$ weeks post-partum, but with a rising at the end of lactation up to 2.95% at the 43$^{th}$ week (Figure 1).

Different patterns were observed for protein, showing a regular decreasing from 3.44 % at week 1 to 2.79 % at the end of lactation, and lactose (from 4.48 to 3.90 % Figure 1).

The ash content was low after parturition (0.72%) with an important increase, up to the lactation peak (2 months after delivery), then a regular decreasing down to similar level of post-partum period (0.71%) (Figure2).

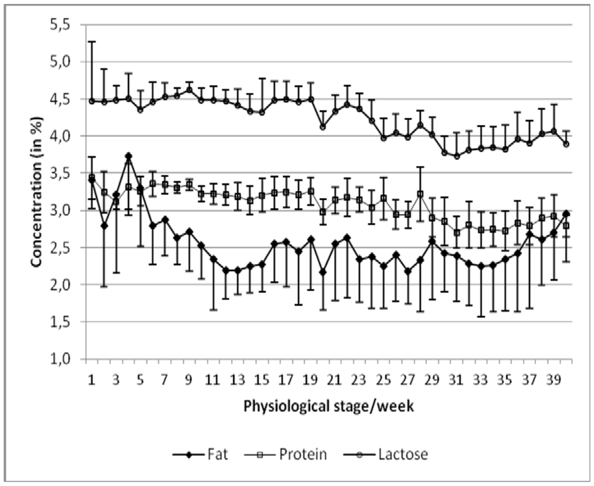


Figure 1. Weekly changes all along the lactation of fat, protein and lactose in camel milk.

**Seasonal variation**

The fat content decreased regularly all along the year with a maximum level (3.46 %) in January and a minimum at the summer time (2.29% in July, i.e at the warmest month). At autumn, corresponding to colder time and to the end of lactation, the fat content increased again to reach similar value than in February (2.73%). Protein and lactose showed a quite different pattern with a slight increase from January to February, then a high decrease in autumn. The protein content was maximum in February (3.32%) and minimum in October (2.76%). For lactose, the maximum mean value was 4.38% in February and the minimum occurred in September (3.83%) (Figure 3).

The ash content was quite variable in January (very high standard-deviation) and relatively stable all along the year with a slight decrease in autumn (Figure 4).

**Correlation between all parameters**

All components (fat, protein, lactose and ash) and density were highly positively correlated ($P < 0.0001$) except between fat and ash content and between fat and density which were not significant (table 2). The correlation of each parameter with the conductivity was negatively highly significant ($P < 0.001$) also (Table 3).

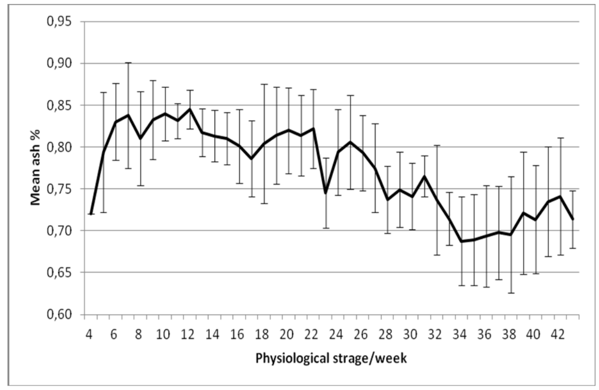


Figure 2. Weekly change after delivery in ash content of camel milk.

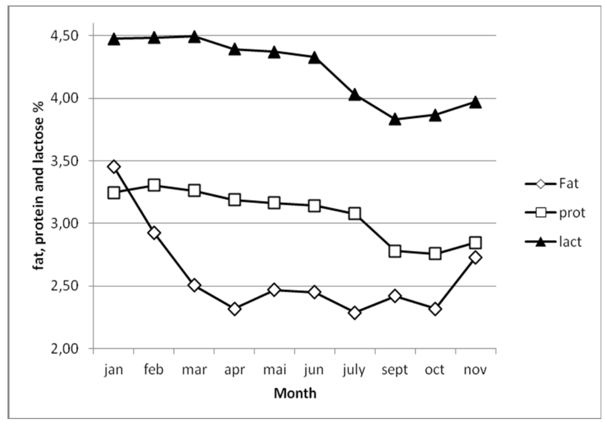


Figure 3. Seasonal variation of fat, protein and lactose content in camel milk.

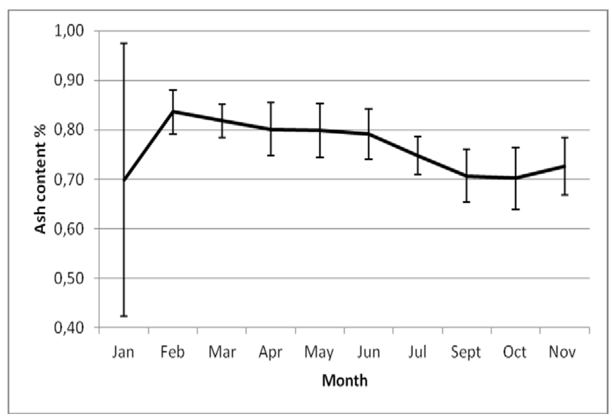


Figure 4. Seasonal variation of salt in camel milk.

Table 3. Matrix of correlation coefficient (r) between chemical and physical parameters of the camel milk (n = 347).

| Variables | Fat | Density | Lactose | Ash | Protein | Conductivity |
|---|---|---|---|---|---|---|
| Fat | **1** | 0,042 | **0,350** | 0,205 | **0,326** | **-0,371** |
| Density | 0,042 | **1** | **0,511** | **0,899** | **0,509** | **-0,406** |
| Lactose | **0,350** | **0,511** | **1** | **0,579** | **0,916** | **-0,760** |
| Ash | 0,205 | **0,899** | **0,579** | **1** | **0,584** | **-0,460** |
| Protein | **0,326** | **0,509** | **0,916** | **0,584** | **1** | **-0,734** |
| Conductivity | **-0,371** | **-0,406** | **-0,760** | **-0,460** | **-0,734** | **1** |

*The values in bold are at P < 0 .05 significant level.*

Table 4. Mean and SD of the main components of camel milk (in %) according to parity, breed, calf weight at birth, mother weight and length of lactation (all differences were no significant).

| Variation factor | Parameter | | | | |
|---|---|---|---|---|---|
| | | Fat | Protein | Lactose | Ash |
| Parity | Primiparous | 2.66±0.72 | 3.22±0.27 | 4.37±0.32 | 0.80±0.06 |
| | Multiparous | 2.45±0.61 | 3.11±0.25 | 4.26±0.34 | 0.78±0.06 |
| Breed | Homor | 2.36±0.58 | 3.06±0.25 | 4.18±0.35 | 0.77±0.06 |
| | Majaheem | 2.48±0.72 | 3.15±0.26 | 4.33±0.32 | 0.79±0.22 |
| | Safrah | 3.01±0.64 | 3.23±0.30 | 4.36±0.36 | 0.81±0.07 |
| | Waddah | 2.36±0.57 | 3.16±0.36 | 4.34±0.31 | 0.79±0.06 |
| Calf weight | High | 2.42±0.57 | 3.07±0.27 | 4.20±0.34 | 0.77±0.06 |
| | Low | 2.56±0.69 | 3.18±0.28 | 4.34±0.33 | 0.80±0.06 |
| Adult W | High | 2.47±0.69 | 3.15±0.24 | 4.25±0.33 | 0.78±0.06 |
| | Low | 2.54±0.61 | 3.18±0.28 | 4.33±0.35 | 0.79±0.07 |
| Gestation length | Long | 2.49±0.67 | 3.15±0.27 | 4.31±0.33 | 0.78±0.06 |
| | Short | 2.54±0.61 | 3.11±0.26 | 4.26±0.35 | 0.79±0.06 |

**Effect of parity and gestation length, calf body weight at birth, adult weight and breed**

No significant effect of parity, gestation length calf body weight at birth or adult weight on all parameters in milk was reported (Table 4). The between-camel variability was higher for fat content, the mean individual value varying from 2.00 to 2.98 % according to the camel. The ranges were 2.91 to 3.22 for protein, 4.02 to 4.41 for lactose and only 0.74 to 0.82 % for ash content.

**Relationships with dairy yield**

The total milk production (not including the part milked by the camel-calf) was on average 1207 L for 11 months of lactation with a range between 875 and 1616 L. The lactation curve on week basis (Figure 5) showed a classical pattern with a lactation peak starting on 13$^{th}$ week with a plateau up to 24$^{th}$ week. The persistence coefficient was high with an ascending period between 160.6 (2$^{nd}$ month/first month of lactation) and 100.6% (6$^{th}$ month/5$^{th}$ month) and a descending period starting at 98.7% (7$^{th}$ month/6$^{th}$ month) to 87% (11$^{th}$ month/10$^{th}$ month).

As usual, the correlation between milk production and concentration of the different milk components were significantly negative (P<0.001). However, the total quantity of exported components in milk was mainly depending of the total milk production (Figure 6). The total quantity of fat varied on average from 54 g at the first month of lactation up to 152 g at the month 6. The minimum and maximum values for protein quantity (54g and 195g) were observed at the same time than fat component. For lactose (74 g and 274g), the maximum was observed at month 5 as for ash quantity (14g and 50 g respectively).

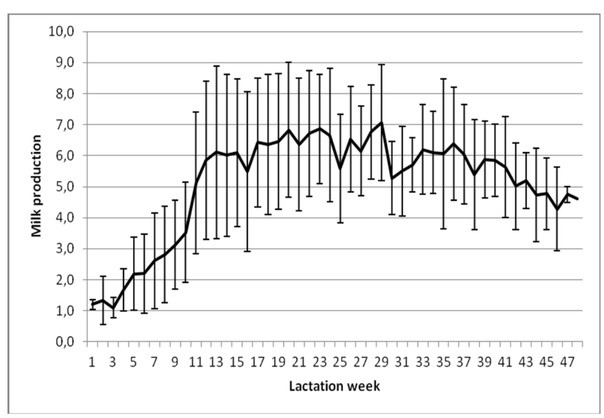


Figure 5. Lactation curve of camel on weekly basis (mean daily production in l).

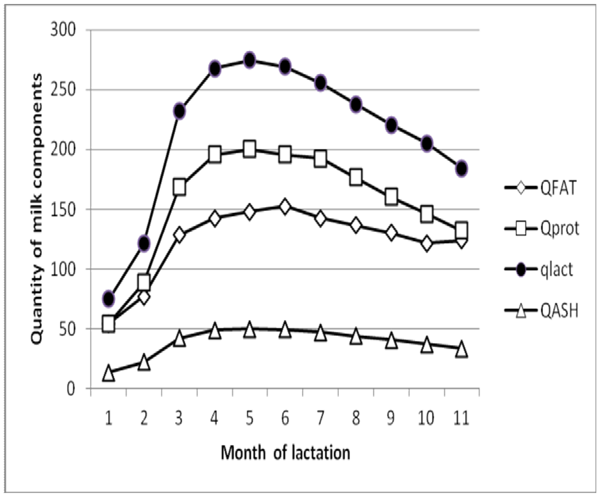


Figure 6. Physiological variation monthly basis of total quantity of fat (Qfat), protein (Qprot), lactose (Qlact) and ash (Qash) exported in camel milk (in g).

## Discussion

### Milk composition

In general, the present study showed a wide variation in the gross composition of camel milk. The values of the main components observed in our study were in the range of the study of Khaskheli (2005) and Mint Meiloud et al. (2011) except the ash content which was appeared lower than in these two references. The variation in mineral reflects many genetic and environmental factors such as the system of feeding and browsing of different plants. The mean content of fat and protein in our study shows a lower results compared to those reported by Konuspayeva et al. (2009b), Igbal et al. (2001) and Zeleke (2007), but otherwise close to results reported by Farah and Fisher (2004). This wide variation in the milk constituents is generally attributed to some factors such as breed, herd management, sampling technique used and feed quality (Al-Shaikh and Salah, 1994).

### Seasonal and physiological variation

As the calving season in camel is generally grouped within 2-3 months, the seasonal variation in milk composition is a combination of physiological stage, feeding system and climatic conditions. In our study, the calving season occurred between December and February. The highest variability was observed for milk fat. Protein and lactose are also affected by season (Bakheit et al., 2008). Shuiep and Elzubeir (2008) and Haddadin et al. (2008) reported a minimum fat content in camel milk at the hot season while it was in autumn for protein and lactose. In our study, the fat percentage dropped to a lower level during the hot months (April to September), this period corresponding in the same time to the maximum of lactation. Similar observations were reported by Igbal (2001). Indeed, the fat component is the most sensitive parameter to the dilution effect linked to the production increase (Firkins and Eastridge, 1992).

The ash content showed quite variable pattern in same line to that reported by Zhang (2005) on Bactrian camel.

The higher concentration of organic milk components at the early stage of lactation was also reported by Zeleke (2007) and was regarded as in higher level than in late stage at the opposite of the results reported by Sahani et al. (1998).

### Effect of parity and other animal characteristics

In our study, there was no significant difference between primiparous and multiparous camel contrary to Zeleke (2007) reporting that parity had significant effect on fat, protein and dry matter of camel milk in Eastern Ethiopia. In his study, the highest percentage composition of protein, fat, and dry matter was recorded from camels at the 3$^{rd}$ parity. In our study the number of different parities was not sufficient to detect any significant statistical effect.

El-Mougy (1995) revealed wide variation in milk composition between three breed in Saudi Arabia (Majaheem, Waddah and Hamra) likewise Gaili et al. (2000) reported difference in Saudi Arabia between two Saudi camel breeds namely Majaheem and Waddah. The absence of effect due to parity, breed, gestation length, and adult weight on all parameters in milk may need probably a larger number of animals for analysis.

### Effect of milk yield

The mean milk yield reported in our study was closed to data recorded by Salla *et al*, (2010) and Gaili et al. (2000) on similar camel population in Saudi Arabia. Regarding the whole production at lactation level, the mean of 1207 l observed in our farm appeared lower than the values recorded by many authors (for example Aslam et al., 2002). However, based on 5 years monitoring, the average dairy yield reported in the same farm than the present study was 1970 l (Musaad et al., 2013). In the Arabian Emirates, the average milk yield was set around 2000 litres per lactation (Quandil and Oudar, 1984). Sohail (1983) reported that, on average, Arabian camels can produce up to 2 275 litres of milk per year. Shareha (1985) reported in Syria 7.3 to 12.2 litres daily when the udder was completely milked. According to Qureshi (1986), a camel may produce on average 8 to 20 litres of milk daily, but under intensive management conditions it may produce from 15 to 40 litres daily. In Kuwait, a good, a medium and a poor camel milk producer can produce 9030, 3185 and 805 litres respectively in 350 days (Ibnoaf, 1987). In Saudi Arabia, the average milk yield ranges from 2.4 to 7.6 litres daily (Basmaeil and Bakkar, 1987). El-Naggar (1998) reported that the camel can yield about 2 700 to 3 666 litres per lactation. These differences could be partly attributed to the data collection procedure. Indeed, the estimations of camel milk yield available in the literature mention the quantities produced per lactation or year. In most of the cases, the authors did not specify if the yield included or not the part drunken by the young camel which represents about 40% of the entire production, sometimes even 75% under certain conditions (Faye, 2005). In our study, the part taken by the young camel was not included.

The peak of lactation in our study (third to six months of lactation) did not agree with the observation of Khan and Iqbal (2001) who observed a peak yield during the second to the third month of lactation.

The correlation between milk production and milk components was significantly negative due to the dilution effect, widely described already in other dairy animals.

## Conclusion

Camel milk composition showed a wide variability in its constituents depending on the physiological, genetic and environmental factors. However, more studies with larger number of animals and ecotypes must be generated for a better evaluation of the management factors. The contribution of the camel to the world milk supply is marginal but essential for human populations in arid and semi-arid areas. However, available data on the camel's production potential and composition are not sufficient. The great variation in camel milk production may be attributed to the methods employed to determine yield as it has been suggested above. Further investigations and probably standardization of the methods are necessary to point out the importance of camel milk production for the food security of desert areas in the world.

The international scientific community has to turn its attention to a good performance control of dairy production in camels. Specific tools for dairy yield monitoring are necessary.

## Acknowledgements

This study has been achieved within FAO project UTF/SAU/021/SAU with the support of Camel and range research Center (CRRC). The authors thank Dr. Mohamed Bengoumi, Animal production and health officer (FAO) for his encouragements and support. We are grateful also for the farm labors (Hassan Mohamed, Suresh Kumar and Mohamed Hussein) for their contribution in the camel management.

## References

Abdallah, H. R. and B. Faye. 2012. Phenotypic classification of Saudi Arabian camel (*Camelus dromedarius*) by their body measurements. Emir. J. Food Agric. 24(3):272-280.

Almutairi, S. E., I. Boujenane, A. Musaad and F. Awad-Acharari. 2010. Genetic and non-genetic effects for milk yield and growth traits in Saudi camel. Trop. Anim. Hlth. Prod. 42:1845–1853.

Aslam, M., M. Nawaz, M. Ali and M. A. Zia–ur – Rahman. 2002. Determination of productive and reproductive traits in mountain camel, Appl. Livest. Prod. 30:549-552.

Alshaikh, M. A. and M. S. Salah. 1994. Effect of milking interval on secretion rate and composition of camel milk in late lactation. J. Dairy Res. 61:451-456.

Bakheit, S. A., A. A. Majid and A. M. Nikhala. 2008. Camels (*Camelus dromedarius*) under pastoral systems in North Kordofan, Sudan: Seasonal and parity effects on milk composition. J. Camelid Sci. 1:32-36.

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

Basmaeil, S. M. and M. N. Bakkar. 1987. Milk production of Majaheem camels in Saudi Arabia during the first lactation season. In the Proc. Saudi Biol. Soc., Jeddah, 10:75-79.

El-Mougy, A. 1995. Milk composition of Majaheim, Wadah and Hamra camels in Saudi Arabia. Food Chem. 52(2):115-122.

El-Naggar, M. A. 1998. The camel is the goal animal in arid zones and dry lands for the coming 21st century. In the Proceedings of the third annual meeting for Animal Production under arid conditions, 2-3 may 1998, Al-Ain, UAE, 1:87-92.

Farah, Z. and A. Fischer. 2004. Milk and Meat from the camel: Handbook on Products and Processing, ETH publ., Zurich, Switzerland.

Faye, B., 2005. Productivity potential of camels. In the Proceedings of the International Workshop: Desertification combat and food safety: the added value of camel producers", Ashkabad (Turkménistan), 19-22 April 2004. In "Vol. 362 NATO Sciences Series, Life and Behavioural Sciences". B. Faye and P. Esenov (Eds.). pp.127-134. IOS press Publ., Amsterdam, The Netherlands.

Firkins, J. L. and M. L. Eastridge. 1992. Replacement of forage or concentrate with combination of soy hulls, sodium bicarbonate, or fat for lactating dairy cows. J. Dairy Sci. 75:27-52.

Gaili, E. S. E., M. M. Al-Eknah and M. H. Sadek. 2000. Comparative milking performance of three types of Saudi camels (*Camelus dromedarius*). J. Camel Pract. Res. 7(1):73-76.

Haddadin, M. S. Y., S. I. Gammoh and R. K. Robinson. 2008. Seasonal variations in the chemical composition of camel milk in Jordan. J. Dairy Res. 75:8-12.

Ibnoaf, M. 1987. Towards a better understanding of our domestic livestock: camels of Kuwait. Technical report, Kuwait Institute for scientific Research, Safat, Kuwait.

Igbal, A., R. A. Gill and M. Younas. 2001. Milk composition of Pakistani camel (*Camelus dromedarius*) kept under station /farmers conditions. Emir. J. Agric. Sci. 13:7-10.

Khaskheli, M., M. A. Arain, S. Chaudhry, A. H. Soomro and T. A. Qureshi. 2005. Physicochemical quality of camel milk. J. Agric. Soc. Sci. 1-2:164-166.

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

Konuspayeva, G., B. Faye, G. Loiseau, A. Ivashehenko, A. Meldebkova and S. Davletov. 2009b. Physiological change in camel milk composition 1- Effect of lactation stage. Trop. Anim. Health Prod. 42:495-499.

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

Musaad, A., B. Faye, and A. Abu-Nikhela. 2013. Lactation curves of dairy camels in an intensive system. Trop. Anim. Health Prod. 45:1039–1046.

Qreshi, M. H. 1986. The camel. Seminar on camel production and health, 20-23 October 1986. FAO, Rome, Italy.

Quandil, S. S. and J. Oudar. 1984. Etude bactériologique de quelques cas de mammites chez la chamelle dans les Emirats Arabes Unis. Rev. Méd. Vét. 135:705-707.

Sahani, M. S., M. Rahinasabapathy, S. Gorakhmal and N. D. Khanna. 1998. Effect of milking techniques on milk production potential in Indian camel breeds under farm conditions. In the Proceedings of the 3rd Animal Production under Arid Conditions, 1:52-58.

Shareha, A. M. 1985. Effect of the presence of early weaning on milk secretion and growth rate of the young dromedary camels. In the proceedings of the International Conference on Animal Production in Arid zones, 7-12 Dec. 1985, Damascus, Syria.

Shuiep, E. S., I. E. M. Zubeir, O. A. O. El Owni and H. H. Musa. 2008. Raw camel (*Camelus dromedarius*) milk in Khartoum state, Sudan. Trop. Subtrop. Agroecosyst. 8:101-106.

Sohail, M. A. 1983. The role of the Arabian camel in animal production. World Rev. Anima. Prod. 19:38-40.

Zeleke, Z. M. 2007. Non genetic factors affecting milk yield and milk composition of traditionally managed camels (*Camelus dromedarius*) in Eastern Ethiopia. Liv. Res.. Rural Develop, 19(6), Article #85. http://www.lrrd.org/lrrd19/6/zele19085.htm

Zhang, H., J. Yao, D. Zhao, H. Liu, M. Li and M. Guo, 2005. Change in chemical composition of Alxa Bactrian camel milk during lactation. J. Dairy Sci. 88:3402-3410.