East African Scholars Journal of Agriculture and Life Sciences
Abbreviated Key Title: East African Scholars J Agri Life Sci
ISSN 2617-4472 (Print) | ISSN 2617-7277 (Online)
Published By East African Scholars Publisher, Kenya

Volume-6 | Issue-9 | Sep-2023 | DOI:10.36349/easjals.2023.v06i09.001

OPEN ACCESS

Original Research Article

Seasonal Variations of Chemical Composition and Microbiological Quality of Camels Milk in Transhumance Nomadic Production System in Shandi Area, Northern Sudan

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Article History
Received: 03.08.2023
Accepted: 10.09.2023
Published: 13.09.2023

Journal homepage:
http://www.easpublisher.com

Quick Response Code

Abstract: Transhumance production system is characterized by seasonal movement of the herders to make use of free-range pasture. In this study camel milk samples were collected during different seasons from different she camels' rearing in transhumance system. The camel milk samples (n= 150) were collected from Western and Eastern Shandi, River Nile State, Sudan. The chemical composition (protein, lactose, total solids and density) and microbiological loads (total bacterial, coliform and yeast and mould) of camel milk were determined. The results showed that overall means for the total solids, protein and lactose content and density of camel milk samples collected from Eastern and Western Shandi during different seasons revealed 12.98±12.84%, 3.58±3.43% and 4.77±4.69% and 1.035±1.030 gm/cm^3, respectively. The age and parity number of the she camel revealed highly significant (P<0.01) correlations when compared with total solids, protein, lactose and density. The milk yield was higher in camel reared in Eastern Shandi during winter and Western Shandi during autumn. Also, there were significant (P<0.05) differences in total bacterial, coliform and yeast and mould counts in camel milk collected from Western and Eastern Shandi during the different seasons. However non-significant (P>0.05) differences were found between the two locations in the microbial quality of camel milk. This study concluded that parity number, age of camel, seasons and pasture content are important factors contributing to the variations in camel milk chemical composition. Moreover, the transhumance production system of camel sustains uniform chemical composition of milk, while variations in the microbiological quality are observed.

Keywords: Camel, Transhumance system, Milk, Season, Chemical composition, Microbiological quality.

INTRODUCTION

Camels are well adapted to arid areas by producing milk and other means of survival in those harsh environments (Bekele *et al.*, 2002; Farah *et al.*, 2007; Bekele *et al.*, 2011; Shuiep *et al.*, 2014; Dowelmadina *et al.*, 2015). Camel milk is one of the most valuable food resources for nomads in Sudan that can contribute to a better income for pastoralists because milk consumption among the urban population was increasing (El Zubeir and Ehsan, 2006; Shuiep *et al.*, 2014; Dowelmadina *et al.*, 2015). However, variations in camel milk yield and composition in the different regions and production systems in Sudan were reported previously (Bakheit *et al.*, 2008; Shuiep *et al.*, 2008; Babiker and El-Zubeir, 2014; Dowelmadina *et al.*, 2014; Shuiep *et al.*, 2014; Elhassan *et al.*, 2015; Mohamed and El Zubeir, 2020). The reasons could be because of differences in nutrition and feed, amount of drinking water, stage of lactation, breed, management conditions and season. Environmental contamination is of importance in the hygiene of raw camel milk than initial bacterial contamination of the camel milk under pastoral production conditions (Younan, 2004). Investigations showed that camel milk is highly contaminated (Aly and Abo-Al-Yazeed, 2003; Khedid *et al.*, 2003; Shuiep *et al.*, 2007; Mohamed and El Zubeir, 2014; Makgoeng *et al.*, 2018). Warsma and El Zubeir (2015) reported that generally the quality of milk obtained from farms and collection points was good during the winter season, while a high bacterial load

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was found during summer. Moreover, raw camel milk may contain microorganisms, which may contain potential pathogenic for man (Younan *et al.*, 2001; Khedid *et al.*, 2003; Shuiep *et al.*, 2007; Shuiep *et al.*, 2009; El-Demerdash and Al-Otaibi, 2012; Yam *et al.*, 2014; Samy *et al.*, 2017). The transhumance production systems are widely distributed in Sudan, where camel herders practice seasonal movement searching for free pastures and water during the dry seasons. They settle in their homelands during the rainy season to practice the cultivation of food crops. The objectives of this study are to determine and compare the chemical composition and some microbial load of camel milk and its associated factors in camels reared by transhumance hereders in the different area of Shandi.

MATERIALS AND METHODS

This investigation was carried out on herds of camels (*Camelus dromedaries*) during three seasons; November and December to represent autumn, January and February during winter and April to May during summer.

The study area

The area of study was around Shandi, the River Nile State. The samples were collected from camel herds that browse in the natural grass land and trees without any supplementary feeding. The camel owners practice some seasonal movement to utilize the free natural pasture, while during the settlement the herders practice cultivation of some food crops to ensure their food security. East Shandi and Western Shandi were selected. The town of Shandi lies on the east bank of the Nile River between latitude 18-17° north and longitude 24-23° east longitude. Shandi prevails desert climate, where the temperature is high during May and June (35°C). The temperature drops during November- March where the lowest rate (22°C) is reported in January. The winds blowing on the city from north to northeast loaded with dust. The highest rate of rain is not more than 54 mm (2 inches) in August and an annual average of 100 mm (3.9 inches).

Milk samples

Milk samples (n= 150) were collected randomly from healthy lactating she camels during the autumn (50), winter (50) and summer (50) seasons. The samples were from the Western (75) and Eastern (75) Shandi. The collected samples (triplicate) were immediately kept in an ice container and transferred to the laboratory of the Department of Dairy Production, University of Khartoum for analysis.

Chemical analysis

Chemical analysis of camel milk samples was determined by using Lactoscan Milk Analyzer (Milkotronic LTD, Europe) according to the manufacturer's instructions.

Microbiological analysis

The camel milk samples were microbiologically examined for total bacterial count (TBC), coliform count and yeast and moulds counts. Plant count agar (Merck, 1-05463) was obtained from Merck (Darmstadt, Germany). It was used to determine the total bacterial count. MacConkey agar (Biomark, B770) was obtained from Biomark Laboratories, Pane 411011 India. It was used to determine the coliform bacterial count as it is a selective differential medium. Yeast extract agar (Biomark, B821) was obtained from Biomark laboratories 411011, India; it was used to examine the growth of yeast and moulds. Sterilization was done according to (Marshall, 1992). The glass wares such as Petri dishes, test tubes, volumetric flasks and pipettes were sterilized using a dry heat oven regulated at 170-180°C for 2 hours. The media, automatic pipette, tips and distilled water were sterilized using a steam autoclave at 121°C for 15 minutes.

Preparation of media and culturing method

All media were obtained in dehydrated form and were prepared according to the manufactures' instructions. The serial dilutions prepared were 10^{-1} to 10^{-7} (Marshall, 1992). The culturing was done by transferring 1 ml of the suitable dilutions onto solidified media in labeled plates in duplicate (Marshall, 1992). The plates were allowed to solidify, then inverted and incubated aerobically at the stated temperature for the suitable time according to Marshall (1992). The counting was done manually by using a colony counter and reported as colony forming unit per milliliter (cfu/ml). The total number of colonies in the selected dilution was multiplied by the reciprocal of the dilution (Marshall, 1992). The media for the total bacterial count was incubated at 33 for 2 days (Ravanis and Lewis, 1995). The media for coliform count was incubated at 37ºC for 24 hours. Yeast and moulds count media were incubated at 25°C for five days (Marshall, 1992).

Statistical analysis of the data

The data generated from the composition and microbiological examination were subjected to analysis of variance using a complete randomized design. The data were analyzed by SPSS (version, 15) using analysis of variance (ANOVA). Also, Duncan's Multiple Range Test (DMRT) was used for means separations. The parity number of the same she camels and their age were included to calculate the correlation coefficient between these 2 factors on the raw camel milk constituents

RESULTS

Comparison of the chemical composition of camel milk in Shandi

Total solids

Table 1 showed the total solids content of camel milk samples collected from Western and Eastern

Shandi were 12.76±0.21% and 12.56±0.27% respectively, and the overall mean revealed 12.98±12.84. The present data (Table 1) showed non-significant differences in the total solids content in the milk samples collected from Western and Eastern Shandi during different seasons. However, the values for the total solids of milk samples during the different seasons in Western and Eastern Shandi were similar.

Protein contact

The protein content of camel milk collected from Western and Eastern Shandi revealed 3.52±0.06% and 3.38±0.05%, respectively. The data showed non-significant differences between camel milk samples collected from Western and Eastern Shandi during the different seasons, the overall mean was 3.58±3.43% (Table 1). Moreover, the result showed non-significant differences in the protein content of camel milk during the three seasons, in Western and Eastern Shandi.

Lactose content

Table 1 showed non-significant differences (P>0.05) in lactose content for camel milk samples collected from Western Shandi during different seasons. The lactose content of camel milk samples collected from Western and Eastern Shandi were 4.71±0.06% and 4.63±0.06%, respectively.

Density

Non-significant (P>0.05) differences were obtained between the means of the density of camel milk samples collected from the two locations during the different seasons. The mean value of density of camel milk samples collected from Western and Eastern Shandi revealed 1.031±0.00 gm/cm^3 and 1.030±0.00 gm/cm^3, respectively. The overall mean of samples collected revealed 1.035±1.030 gm/cm^3 (Table 1).

Table 1: Corelation of birth numbers and age on camels' milk composition

Parameters	Total solids (%)	Protein (%)	Lactose (%)	Density (gm/cm^3)
Age	0.202*	0.115	0.218*	0.194*
Pairty number	0.293**	0.241**	0.364**	0.345**

Effect of birth number and age of camel on milk composition

Table 2 showed the correlation coefficient between age and parity number of camel on the raw camel milk constituents collected from the Eastern and Western Shandi. The results showed a significant (P<0.05) positive correlation of age with total solids (r= 0.202), protein (r= 0.115), lactose (r= 0.218) and density (r= 0.194). There were also a positive correlation for parity number and each of total solids (r =0.293), protein (r= 0.241) and density (r= 0.345, P<0.01) and negative correlation with lactose (r= -0.364). These correlations were highly significant (P<0.01). The effect of the age of she camels on chemical composition collected from Western and Eastern Shandi (Table 2) showed significant positive correlations (P<0.05) with total solids, protein, lactose and density.

Table 2: The chemical composition of camel milk in Shandi during different seasons

Locations	Season	Protein (%)	Total solids (%)	Lactose (%)	Density (gm/cm^3)
Western Shandi	Autumn	3.290.05	12.440.39	4.500.07	1.0290.01
	Winter	3.510.07	13.580.30	4.780.11	1.0310.02
	Summer	3.640.14	12.070.38	4.740.07	1.0310.01
	Sub total	3.520.06^a	12.760.22^a	4.710.06^a	1.0310.02^a
Eastern Shandi	Autumn	3.500.11	12.900.57	4.800.14	1.0310.02
	Winter	3.320.05	12.760.38	4.520.07	1.0290.01
	Summer	3.340.06	11.890.47	4.590.08	1.0300.02
	Sub total	3.380.05^a	12.560.27^a	4.630.06^a	1.0300.01^a
Total		3.583.43	12.9812.84	4.774.69	1.0351.030

Means bearing different letters in column are significantly different (P<0.05)

Variations of microbial load of camel milk

Total bacterial count (TBC)

Table 3 showed higher mean values for the total bacterial count in camel milk samples collected during the autumn and winter seasons in Western Shandi. These results revealed significant (P<0.05) variations between the samples during the different seasons. The mean values of total bacterial count in Western and Eastern Shandi were log 1.675 cfu/ ml and 2.202 cfu/ ml, respectively. However, the result revealed a non-significant difference (P>0.05) in the total bacterial count between the milk samples collected from Western and Eastern Shandi (Table 3). However, the total bacterial count of camel milk collected from Eastern Shandi revealed higher values during winter compared to the samples collected during autumn and summer (Table 3).

Table 3: Variations of microbial count (log cfu/ml) for camel milk in Shandi area during thedifferent seasons

Locations	Seasons	Total bacterial count	Coliform count	Yeast and moulds counts
West Shandi	Autumn	1.3609[b]	7.9281[a]	4.0738[a]
	Winter	1.3786 [b]	6.4268[a]	4.7464[b]
	Summer	3.4556[a]	1.6247[a]	1.6280[b]
	Sub total	1.6751 [a]	1.0540 [b]	1.730 [b]
East Shandi	Autumn	1.3105[b]	6.7600[a]	2.8500[b]
	Winter	3.6149[a]	000[b]	1.1707[a]
	Summer	1.1405[b]	4.5250[a]	3.0600[b]
	Sub total	2.2094 [a]	3.3191 [a]	6.5588 [a]

The same superscript letter in the same column indicate non-significant differences (P>0.05)

Coliform count

The results of the coliform count of camel milk samples revealed significant (P<0.05) variations between the samples collected from Western and Eastern Shandi during the different seasons (Table 3). The mean value of milk samples of coliform count in Western Shandi (log 1.0546) was significantly lower than those collected from Eastern Shandi (log 3.3191). The coliform count of camel milk samples from Western Shandi revealed non-significant variations between the samples during the different seasons. However, the coliform count of camel milk collected from Eastern Shandi revealed significant (P<0.05) variations between the samples during the different seasons.

Yeast and moulds counts

The results of yeast and mould counts of camel milk showed significant differences (P<0.05) between the samples collected from Western and Eastern Shandi during the different seasons (Table 3). The mean value of yeast and moulds counts for milk samples collected from Western Shandi (log 1.730) was significantly lower than that collected from Eastern Shandi (log 6.559). However, the yeast and mould counts of camel milk samples obtained from Eastern Shandi were high during winter and lower during autumn and summer (Table 3).

DISCUSION

The obtained values of the total solids content of camel milk samples collected from Western and Eastern Shandi supported those reported previously (El-Amin *et al.*, 2006; Nabag *et al.*, 2006). However lower values were also had been reported (El Hag *et al.*, 2002; Hassan *et al.*, 2007; Shuiep *et al.*, 2008; Faraz *et al.*, 2020). Moreover, Barela camel appears particularly rich in milk constituents and the average for the SNF and total solids revealed 9.02% and 13.28%, respectively (Faraz *et al.*, 2020). However, Mohamed and El Zubeir (2020) reported a higher value for the total solids (14.89±0.75%) content in the milk of she camels kept in the natural pasture at Western Omdurman. These differences could be due to differences in locations, feeding conditions, breeds of camels in addition to other factors including milking frequency, stage of lactation and parity numbers (Shuiep *et al.*, 2008; Ayadi *et al.*, 2009; Dowelmadina *et al.*, 2014; Elhassan *et al.*, 2015; Mohamed and El Zubeir, 2020). The obtained values for the protein content of camel milk collected from Western and Eastern Shandi supported by those reported by El-Hag *et al.* (2002) and Nabag *et al.* (2006). Similarly, Shuiep *et al.* (2014) found the average means for camel milk protein was 3.51±0.13%. However, higher average value of protein content (3.65±0.16%) of milk samples was obtained for camels browse in the natural pasture at Western Omdurman (Mohamed and El Zubeir, 2020). Also, Faraz *et al.* (2020) reported a slightly higher value (3.62%) for milk obtained from the Barela breed in Pakistan.

The result of protein content for camel milk during winter was similar to those reported by Babiker and El Zubeir (2014), while during summer it agreed with the values reported by Aljumaah *et al. (*2012). The non-significant differences might be because the camel herders practice a transhumance mode of movement where they enjoy various types of pasture. Babiker and El Zubeir (2014) suggested the importance of grazing in rearing the camels. However Shuiep *et al.*, (2014) indicated that the higher protein content was obtained from the semi-intensive system, where camels received an adequate quantity of feed including concentrates.

The mean milk lactose collected during the different seasons was 4.77±4.69%. The present study indicated that means of lactose in camel milk from both Western and Eastern Shandi during different seasons were comparable to that reported by Nabag *et al.* (2006) and Babiker and El Zubeir (2014). However, it was higher than that reported earlier (El Hag *et al.*, 2002; El-Amin *et al.*, 2006; Shuiep *et al.*, 2008; Shuiep *et al.*, 2014). Higher milk lactose (4.90±0.23%) was produced by she camels reared in the natural pasture at Western Omdurman (Mohamed and El Zubeir, 2020). In Pakistan, Faraz *et al.* (2020) found the lactose of camel milk was 4.84%. The lower lactose content of camel milk in Eastern Shandi (Table 1) might be due to the long walking distance by camels searching for water and pastures as this exercise might cause more energy dissipation (Shuiep *et al.*, 2008). Similarly, Ehlayel *et al.* (2011) reported that camel milk contained low lactose of small molecules and was easily digested and metabolized by the human body.

The means of density for camel milk in Western Shandi during the three seasons were similar to that reported previously (Derar and El Zubeir, 2013; Hessain *et al.*, 2013; Babiker and El Zubeir, 2014). The means of the density of camel milk in Eastern Shandi during different seasons was similar to those reported by El Hag *et al.* (2002) and Mohamed and El Zubeir (2014). Similarly Mohamed and El Zubeir (2020) reported 1.032±0.001 gm/cm^3 as a mean for the density of camel milk. Similar to the present study, Babiker and El Zubeir (2014) found significant (P<0.05) differences for parities number on camel milk yield, SNF, protein and lactose. This result also supported those reported by Haddadin *et al.* (2008) and Shuiep *et al.* (2008). The obtained correlations between parity number with total solids, protein, lactose and density were in accord with the findings reported previously (Faye *et al.*, 2008; Ayadi *et al.*, 2009; Dowelmadina *et al.*, 2014). The milking order as well as stage of lactation affects milk yield and its composition. These constituents became concentrated as lactation proceeded, and protein was substituted by fat (Jemmali *et al.*, 2016).

The means of the total bacterial count of camel milk samples collected from Western Shande were high during summer and lower during autumn and winter (Table 3). This could be due to the high temperature during summer as cooling of milk is not practiced as was reported by Shuiep *et al.* (2007). The low total bacterial count was similar to those reported by Mohamed and El Zubeir (2014).

Warsma and El Zubeir (2015) found that the TBC of camel milk samples were higher during the summer season (log10 4.6±0.08). Also, Samy *et al.* (2017) indicated that the number of bacteria in summer was higher than those in spring, autumn and winter. They added that the highest number of bacteria may be due to higher temperatures during the storage and distribution of milk in summer. Moreover, Samy *et al.* (2017) reported that the range for the total viable count of bacteria revealed log 1.34 to 2.9 and the total viable count of bacteria varied significantly according to the site and the season of collection. However, a high mean for the total aerobic mesophilic bacterial count was reported in the Qasim region, Saudi Arabia that showed log 5 and a maximum value of log 7.15 (El-Ziney and Al-Turki, 2007). El-Demerdash and Al-Otaibi (2012) reported that the total bacterial count of raw camel milk samples collected from different zones was 1.3×10^3 - 1.3×10^6 cfu/ml. The total counts were found to range from log 5.46 to 5.69 cfu/ml with a mean of log 5.56 for camel milk in Golestan Province, Iran (Yam *et al.*, 2014). They concluded that these differences showed that TBC depends on several parameters such as the milk itself, contamination of the camel's udder, milking personnel and other considerations such as transportation and containers. The high total bacterial count in camel milk samples (Table 3) were in accord with the finding of Semereab and Molla (2001) and Shuiep *et al.* (2007). The differences might be due to the fact that TBC depends on contamination of the camel udder and contamination of milking personnel, containers and milking conditions of the camel (Younan, 2004).

Higher coliform count (log10 3.4±0.09) in camel milk samples during the summer season were also found (Warsma and El Zubeir, 2015). The non-significant variations of the coliform count of camel milk samples during the different seasons in Western Shandi supported Benkerroum *et al.* (2003). The high coliform count of camel milk samples collected from some places in Eastern Shandi might be due to the lack of proper handling and hence contamination by microorganisms as most camel owners practice less hygiene during milking and storage of their milk (Shuiep *et al.*, 2007; Samy *et al.*, 2017). The high coliform count of camel milk were in accord with the findings of Semereab and Molla (2001); Shuiep *et al.* (2007); Mohamed and El Zubeir (2014). On the other hand, Suliman and El Zubeir (2016) reported a high occurrence of coliform bacteria when surveying the traditional fermented camel milk produced by nomadic camel women herders in Al Gaderif State. The fecal contamination of the samples is one of the main causes of the high coliform count.

The obtained result for yeast and moulds counts in camel milk samples was similar to that reported by Mohamed and El Zubeir (2014). Similarly, Samy *et al.* (2017) reported that yeast and mould numbers varied significantly according to the season and site of collection. On the other hand, Omer and Eltinay (2008) found that the rate of isolation of yeasts from all samples was 14.9%. The range for total yeast and mould counts for camel milk samples was log 1.95 to 3.77 (Yam *et al.*, 2014). The higher counts for yeast and mould in camel milk from Eastern Shandi compared to those obtained during autumn and summer supported Shuiep *et al.* (2007) and Mohamed and El Zubeir (2014). Also, Makgoeng *et al.* (2018) reported that the microbial quality of camel milk produced in Tsabong, Botswana is generally poor. They suggested that strict hygienic measures during production and handling should be applied and there is a need for heat treatment of the milk in order to improve the quality and safety of camel milk produced.

CONCLUSION

According to the chemical composition data, the camel milk collected from Western and Eastern Shandi showed no differences for collected samples during the different seasons. The total solids of camel milk were high during winter in Western Shandi and lower in Eastern Shandi during summer. However, there was significant (P<0.05) differences in the total bacterial count, coliform count and yeast and mould counts in camel milk samples collected from Western

and Eastern Shandi during the different seasons. The study emphasized that the variations in camel milk chemical composition could be attributed to more factors such as parity number, age of camel, seasons and pasture content.

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Cite This Article: Mohammed, R. H. A. & El Zubeir I. E. M. (2023). Seasonal Variations of Chemical Composition and Microbiological Quality of Camels Milk in Transhumance Nomadic Production System in Shandi Area, Northern Sudan. *East African Scholars J Agri Life Sci, 6*(9), 157-163.