



Characteristics and Composition of Camel (*Camelus dromedarius*) Milk: The White Gold of Desert

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Abstract | Camel milk (CaM) have therapeutic characteristics with fortified nutritive values and is well known for these peculiar features. The fat portion in camel milk is properly emulsified with very fine globules and doesn't form a typical layer over surface. The fat is present in evenly distributed small micelles throughout the milk. CaM has very handsome share of protein and lactose percentage which is well tolerant to humans and doesn't cause lactose allergy. So, the CaM can easily be used in lactose intolerant cases. The SNF and solids of CaM are in almost same proportion as in cattle milk, so it is healthier enough. There are different antibodies, insulin, antioxidants and antimicrobial properties which gives special characteristic features to it. Thus; CaM is being used as remedial purposes in the treatment of many diseases and may also as quality aphrodisiac. It is enriched in α -lactalbumin and lacks protein β -lacto globulins and is healthier having \uparrow proportion of C_{14} - C_{18} fatty acids. With ample clue from the literature data; the current study was planned to investigate the milk and colostrum composition of Pakistani dromedary camel and to relate with the reported values by other scientists. The CaM samples were taken from Thal Desert in natural habitat. The milk fat, protein, lactose, solids-not-fat and total milk solids % were found to be 4.79, 3.56, 4.92, 9.09, 13.88 and 2.02, 4.4, 6.4, 11.78, 13.8 in regular milk and colostrum, respectively. The data obtained will be a useful addition to build the country's database for future studies of this field.

Keywords | Camel, Milk, Composition, Desert, Pastoral

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INTRODUCTION

CaM is famous for having good proteins with potential protective and anti-microbial properties (Wernery, 2006). The water contents in CaM varies from 84 to 90 %, severely affects the composition. Camel is special creature that provides enough nutrition to its dependents especially in the deep deserts; the dehydrated camel is of remarkable feature to maintain lactation having over 90% water contents to provide necessary fluids to calf even in drought conditions (Yagil and Etzion, 1980). The amount of nutrients in CaM are very similar to that of cow milk

and the fat percentage is affected by water contents. While the fat in CaM is evenly distributed in the form of very small micelles throughout the milk; hence doesn't forms a layer over surface and this is the quality which makes its digestion very easier. The C_{14} - C_{18} proportion of longer chain fattyacids are greater than shorter chain; imparts the healthier benefits to CaM (Stahl, 2005).

The average pH and density of CaM is 6.56 and 1.029; a bit \downarrow than that of cow's milk (Farah and Bachmann, 1987). CaM contains protective enzymes and proteins having especial anti-bacterial and anti-viral features such

as lactoferrin, lacto-peroxidase and PGRP- peptidoglycan protein; thus, inhibits the growth of microorganisms (El-Agamy et al., 1992). According to Agrawal et al. (2003) CaM have insulin so can be used for the cure of *Diabetes-mellitus*. The insulin present in CaM (42 μ U/ml) is not so much than of cow's milk but is protective which is not degraded in forestomach; bypass to intestines and cause reduction in blood glucose levels (Wernery, 2006).

Keeping in view these peculiarities, it is need of the hour to study camel milk quality. As Pakistan has a sizable population of 1.1 million heads and ranks 8th in the world (GOP, 2019-20; FAO, 2019). But unfortunately, the camel in Pakistan is mostly a neglected specie and a very few attempts have been made to characterize its production potential in natural habitat i.e. desert conditions (Faraz et al., 2019a). In deserts, the camel is the only source of livelihood for cameleers because it seems very difficult for other livestock species to survive and produce (Faraz et al., 2019b). It is our duty to conserve these indigenous genetic resources; which could play a pivotal role in the national economy and food security of the pastoralists (Faraz et al., 2019c). Hence; this study was planned to look into the quality of dromedary CaM in Thal Desert to quantify its worth which is termed as "white gold of desert".

MATERIALS AND METHODS

The study area (Thal Desert) is classified as zone III of agro-ecological region having arid climate, with highest temperature as 45.6 °C falling from 5.5 to 1.3 °C in severe winter. The rainfall is increasing from south to north and ranges between 150 to 350 mm (Rahim et al., 2011).

Purposive sampling technique was used to select about 100 households owning adult she-camels. The camels were examined before sampling and only physically healthy were included in the trial. The animals of 2nd to 6th parity in mid lactation stage were selected. All animals were milked twice daily on equal time intervals. The animals suckled by their calves so one right side was offered to calf and left side was milked. The animals were allowed grazing/browsing daily for 10 hours without their calves while fed with gram straw as manger feeding. The salt lumps were put in mangers and the animals were watered twice a day. Milk samples were taken from field and examined in duplicate at Dairy Lab of Camel Breeding and Research Station (CBRS) Rakh-Mahni Tahsil Mankera District Bhakkar, Punjab. The composition of regular milk and colostrum including percent fat, percent protein, percent lactose, SNF and percent total milk solids was determined by using Milky-Lab-Analyzer. The data obtained was subjected to ANOVA for statistical analysis (Steel et al., 1997).

RESULTS AND DISCUSSION

The mean values and range of milk fat, milk protein, milk lactose, SNF and milk solids of dromedary camel at Desert Thal were found to be 4.79±0.48, 3.56±0.06, 4.92±0.05, 9.09±0.06, 13.88±0.09 and 3.95-4.98, 2.85-3.96, 3.91-5.08, 7.62-9.67, 12.52-14.85, respectively (Table 1). Regarding colostrum composition, the milk fat, milk protein, milk lactose, SNF and milk solids were found to be 2.02, 4.4, 6.4, 11.78 and 13.8 %, respectively in Pakistani dromedary she-camel (Table 2). Unlike bovines; the camel colostrum is slightly clear and diluted like normal-milk (Farah, 1993) and converts in 7-10 days (Wernery, 2006). Abu-Lehia et al. (1989) reported colostrum composition in Saudi-Arabian camel while Sestuzheva (1958) in Russian camels (Table 2). The CaM composition is different from other animals; the reported values of milk fat, protein, calcium, phosphorus and iron were 3.8 %, 2.7-4.7 %, 1000-1400 mg/ml, 0.650-1.10 mg/L and 0.3-0.8 mg/L respectively (Kappeler et al., 1998). The fat percentage of CaM ranges from 2.5 to 5.9 while lactose from 4.8 to 5.8 %, ↑ than cow's milk; ash from 0.6 to 0.8 % and protein is 2.8 %. Various factors including genetics, specie, breed, management, body weight, nutritional profile, age, parity, physiological condition, milking methods and season generally affect milk composition (Bencini and Pulina, 1997; Antunac and Havranek, 1999) while it is chiefly influenced by lactation stage (Gonzalo et al., 1994; Fuertes et al., 1998; Fenyvessy and Javor, 1999).

Table 1: Milk composition of dromedary She-camels at Thal Desert Punjab, Pakistan.

Parameters	Average	Range
Fat %	4.79±0.48	3.95-4.98
Protein %	3.56±0.06	2.85-3.96
Lactose %	4.92±0.05	3.91-5.08
SNF %	9.09±0.06	7.62-9.67
Total solids %	13.88±0.09	12.52-14.85

Table 2: Average contents of colostrum (%) in camels from KSA, Kazakhstan and Pakistan.

Contents	Saudi Arabia		Kazakhstan		Pakistan
	At par-turition	3 days post-partum	3 hr post partum	2 days post partum	2 days post partum
Fat	0.20	1.5	0.20	5.8	2.02
Protein	13	4.7	19.4	3.6	4.4
Lactose	2.7	4.4	7.2	7.2	6.4
SNF	20.3	12.1	30.2	12.6	11.78
Total solids	20.5	13.6	30.4	18.4	13.8

Source: Saudi Arabia (Abu-Lehia et al., 1989); Kazakhstan (Sestuzheva, 1958); Pakistan (Current study).

In current study; % fat and protein were found to be 4.79 ± 0.48 and 3.56 ± 0.06 and the results are in agreement with reported by Kappeler et al. (1998), Iqbal et al. (2001) and Khaskheli et al. (2005) who respectively reported range of fat percentage as 3.95 to 4.98 % and protein percentage as 2.85 to 3.96 %. Literature meta-analysis revealed the percentage of fat and protein as 2.4 to 5.5 and 2.5 to 4.5, respectively in CaM. Iqbal et al. (2001) reported mean concentrations of fat and protein % as 3.57 ± 0.09 and 2.85 ± 0.036 respectively in Pakistani camels. Reported fat and protein % were to be 2.63 and 4.01 respectively in dromedary Kohi white camel (Raziq et al., 2011). In a recent study, Faraz et al. (2018) reported fat and protein percentage as 4.44 ± 0.46 and 3.42 ± 0.04 respectively in milk of Marecha dromedary she-camels under extensive conditions in Desert Thal.

Reported fat and protein percentage was to be 3.15 and 2.81 in milk of Saudi Arabian camel (Elamin and Wilcox, 1992). In another study, Mehaia et al. (1995) reported fat and protein percentage as 3.22 and 2.91 in Majaheim, 2.85 and 2.52 in Hamra and 2.46 and 2.36 in Wadah CaM respectively in KSA. Reported percentages of milk fat, milk protein, SNF, milk lactose, milk ash and water were 5.5, 4.5, 8.9, 3.4, 0.9 and 85.6, respectively in Ethiopian camel (Knoess, 1976) while it is readily digested being less fatty than cow milk (Negate, 2002). While in recent study, Faraz et al. (2020) investigated milk yield and composition of Barela dromedary camel under extensive conditions in Desert Thal and reported fat and protein percentage as 4.26 ± 0.36 and 3.62 ± 0.06 respectively.

Guliye et al. (2000) postulated 4.81 % lactose concentration in Bedouin camels which is very close to present study result of 4.92 ± 0.05 % lactose while Konuspaveva et al. (2009) reported in contrast value of lactose as 4.46 ± 1.03 %. Iqbal et al. (2001) documented range of lactose percentage as 3.91 to 5.08 % in dromedary CaM. Reported percentage concentrations of fat, protein, SNF, lactose, ash and water were to be 4.3, 4.6, 14.3, 4.6, 1.01 and 85.7 in normal while 1.1, 2.5, 8.8, 2.9, 0.96 and 91.2 in dehydrated camels, respectively (Yagil and Etzion, 1980). In seasonal water shortage; there is physiological mechanism in camels of changing water contents in milk for availability of fluids to calf in severe drought conditions (Yagil, 1982). Kebebew and Baars (1998) reported the percent milk fat: 4.2 ± 1 ; milk protein: 3.0 ± 0.6 ; SNF: 8.7 ± 1.6 ; milk total solids: 12.8 ± 1.6 and casein: 2.4 ± 0.5 respectively in the Error valley. Moreover, the reported milk protein, milk fat, ash and milk total-solids were 2.79, 3.39, 0.77 and 11.5 % respectively in Bedouin camel (Guliye et al., 2000).

Khaskheli et al. (2005) documented range for components as total-solids: 7.76-12.13; SNF: 5.56-8.29; fat: 1.8-5; protein: 1.8-3.2; casein: 0.78-2.76; lactose: 2.9-4.12

and ash: 0.85-1 gm/100 gm. Konuspaveva et al. (2009) reported the average CaM composition as fat: 3.82 ± 1.08 ; lactose: 4.46 ± 1.03 ; protein: 3.35 ± 0.62 ; ash: 0.79 ± 0.09 and total solids: 12.47 ± 1.53 , respectively. Kamoun and Jemmali (2012) reported average total solids: 116.76 ± 11.32 , fat: 35.67 ± 7.61 ; lactose: 43.82 ± 5.68 ; ash: 8.21 ± 0.64 and total protein: 29.45 ± 3.29 gm/L, respectively in Tunisian dromedary camel. Nagy et al. (2013) reported average concentrations as fat: 2.51 ± 0.03 ; protein: 2.60 ± 0.01 ; lactose: 4.03 ± 0.03 ; total solids: 9.98 ± 0.03 and solids-not-fat: 7.56 ± 0.03 %, respectively in intensive kept dromedary camels in UAE. CaM is enriched in Vitamin C, B₁ and B₁₂ and this higher level of vitamin C is very important for nomadic pastorals who usually face shortage of vegetables and fruits (Knoess, 1979).

Documented range of fat and protein % was 2.60 to 3.20 and 3.73 to 3.89 respectively in Indian CaM (Mal et al., 2006, 2007). While Mal and Pathak (2010) reported 5.5 % fat and 3.87 % protein in milk of Bactrian Indian camel. Meiloud et al. (2011) postulated fat and protein % as 2.92 ± 0.59 and 2.50 ± 0.10 respectively in milk of Mauritanian dromedary camel. According to the findings of Aljumaah et al. (2012); the Shoel breed, 1st lactation-stage and settled-system depicted \uparrow fat concentration while Soffer breed, 1st lactation-stage and semi-nomadic-system faced greater protein concentration. Reported lactose percentage range was to be 2.9 to 5.10 % in Pakistani CaM (Iqbal et al., 2001). Elamin and Wilcox (1992) found lactose percentage as 4.16 in milk of Majaheim camel of KSA. Mehaia et al. (1995) stated 4.43, 4.46 and 4.44 % lactose in milk of Majaheim, Hamra and Wadah Saudi Arabian dromedary camels, respectively. Morin and Rowan (1995) confirmed fat and sugar % as 2.7 and 6.5 in milk of Llama camel of USA.

Meiloud et al. (2011) postulated lactose value as 4.91 ± 0.61 % in milk of Mauritanian dromedary camel. Aljumaah et al. (2012) found that Soffer breed, 1st lactation-stage and semi-nomadic system depicted \uparrow concentration of lactose and this value was \downarrow by subsequent parity. The percentage range of SNF and total milk solids were found to be 8.9 to 14.3 and 11.5 to 17.8, respectively in camel milk. Iqbal et al. (2001) documented mean values for SNF and total milk solids as 9.00 ± 0.13 and 12.36 ± 0.19 % respectively in Pakistani dromedary camels. Reported percentage concentrations were to be as lactose: 4.82 ± 0.04 ; SNF: 8.96 ± 0.07 and total solids: 13.38 ± 0.08 , respectively in milk of Marecha dromedary she-camels under extensive conditions in Desert Thal (Faraz et al., 2018). While in recent study, Faraz et al. (2020) investigated milk yield and composition of Barela dromedary camel under extensive conditions in Desert Thal and reported concentrations of components as lactose: 4.84 ± 0.08 , SNF: 9.02 ± 0.09 and total solids: 13.28 ± 0.06 , respectively.

Iqbal et al. (2001) documented percentage ranges for SNF and total milk solids as 7.62 to 9.67 and 12.52 to 14.85 % respectively and these results are in agreement with present study findings of SNF and total milk solids percentages as 9.09 ± 0.06 and 13.88 ± 0.09 , respectively. Current results are in agreement with the reported results of Elamin and Wilcox (1992) who postulated SNF as 7.8 % and total milk solids as 10.95 % in milk of Majaheim dromedary camel of KSA. Mehaia et al. (1995) stated SNF and total milk solids concentration as 8.13 and 11.35 % in Majaheim; 7.78 and 10.63 % in Hamra; 7.61 and 10.07 % in Wadah camel milk respectively in KSA. Mal et al. (2006, 2007) documented ranges for SNF and total milk solids as 7.25 to 8.25 and 9.85 to 11.45 % respectively in Indian camel. Documented SNF and total milk solids % were to be 9.18 and 14.68 % respectively in milk of Bactrian camel (Mal and Pathak, 2010). Meiloud et al. (2011) confirmed SNF and total milk solids as 8.88 ± 0.08 and 11.80 ± 1.0 % in milk of Mauritanian dromedary camel. Soffer breed, 1st lactation-stage and semi-nomadic system depicted \uparrow SNF and total milk solids which \downarrow by the subsequent parity as reported by Aljumah et al. (2012) in KSA. The comparison of CaM composition with cow's milk is shown in Table 3.

Table 3: Composition comparison of CaM with cow milk.

Parameters (Units)	Camel's milk	Cow's milk
Water (%)	87-91	87
Total Solids (%)	9-13	13
Fat (%)	1.8-3.8	3.8
Protein (%)	2.7-4.0	2.7-4.7
Lactose (%)	3-5	3.7
Ca (mg/100 ml)	100-160	100-140
Cu (mg/L)	1.3-1.8	0.1-0.2
Fe (mg/L)	1.3-2.5	0.3-0.8
Na (mg/L)	360-620	350-600
K (mg/L)	600-2100	1350-1550
Mg (mg/L)	75-160	100-150
Mn (mg/L)	0.08-0.2	0.04-0.2
Zn (mg/L)	4.4-5	3.5-5.5
Vit C (mg/L)	24-36	3-23
Folic acid (mg/L)	0.004	0.01-0.1
Niacin (mg/L)	4.6	0.5-0.8
Pantothenic acid (mg/L)	0.88	2.6-4.9
Vit A (mg/L)	0.1-0.15	0.17-0.38
Vit E (mg/L)	0.53	0.2-1.0
Vit B1 (mg/L)	0.33-0.60	0.28-0.9
Vit B2 (mg/L)	0.42-0.80	1.2-2
Vit B6 (mg/L)	0.52	0.4-0.63
Vit B12 (mg/L)	0.002	0.002-0.007

Source: (Wernery, 2006).

CONCLUSION

CaM is of great importance due to its therapeutic worth so considered as complete food for infants. It is being used in people having allergies and lactose-intolerance very safely. CaM can be used for the cure of some diseases like diabetes, liver disorders, long bone pain, joint problems and also as an aphrodisiac worldwide. By getting awareness, the CaM is becoming a peculiar diet; now need of time is to recognize the place of camel among farm animals and to shift from the notion "ship of desert" to "future food animal". The CaM has composition alike cow's milk having additional therapeutic peculiarities; hence, its use should be encouraged among people.

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AUTHORS CONTRIBUTIONS

All authors contributed to make the completion of this manuscript possible. AF conducted research and wrote the paper. MSN helped in conduct of research. AW and RHM helped in analysis. NAT helped in write up. HMI reviewed the paper.

CONFLICT OF INTEREST

There is no conflict of interest.

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