

# CAMEL MILK AND MILK PRODUCTS

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The dromedary camel is an important component of the dry land and desert ecosystem, it is not only an important economic means of short distance transport to the rural and urban societies inhabiting in arid and semi-arid zones; but also serves as a source for milk in some of areas of the camel rearing societies namely "Raikas/Rabaris" since centuries. Indian camels possess milk production potential and camel keepers consumed fresh camel milk daily. The lactation length in camels extends upto 14-16 months and the average daily milk production in indigenous Bikaneri, Jaisalmeri and Kachchhi camels is  $3.22 \pm 0.15$ ,  $2.17 \pm 0.16$  and  $3.94 \pm 0.13$  liters/day without any supplementary feeding (Sahani et al. 1998). Camel milk is supposed to have nutritive (Knoess, 1984) as well as medicinal properties (Yagil, 2000).

## Camel milk composition:

Camel milk is opaque white in color with normal odor and salty taste. 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 (Mal et al. 2006b and 2007). Moisture and protein have been found to be higher in camel milk compared to cow milk. Comparative low percentages of total solids and fat in camel milk have definite positive benefits of drinking camel milk over cow milk. Post partum changes in gross chemical composition of camel milk showed an increase in fat from 0.10 to 3.78 while protein decreased from 17.62 to 2.66 percent after 27 days of parturition (Singh et al. 2006).



Milking of camel



Fresh camel milk

In late phase of lactation the ash, fat and total solids were significantly higher than in the early phase of lactation. The fat is present in fixed amount in milk and its percentage changes according to the water content. Hence a fall in water content will increase the fat percentage while an increase in water will decrease it. In the desert high water content with low fat percentage is a definite advantage. The higher ash contents during late lactation suggest that camel milk can provide a satisfactory level of minerals (Mal et al. 2007).

## Mineral profiles:

Average values of Na, K, Ca, P and Mg in milk of early lactating camels were  $29.70 \pm 0.53$  mEqL<sup>-1</sup>,  $50.74 \pm 0.51$  mEqL<sup>-1</sup>,  $94.06 \pm 0.75$  mg%,  $41.68 \pm 0.55$  mg% and  $11.82 \pm 0.22$  mg% respectively. In late lactation period, the corresponding levels were  $35.49 \pm 0.89$  mEqL<sup>-1</sup>,  $71.86 \pm 1.43$  mEqL<sup>-1</sup>,  $97.32 \pm 0.51$  mg%,  $47.14 \pm 0.52$  mg% and  $13.58 \pm 0.31$  mg % respectively (Mal et al. 2007) in Indian dromedary camels. The levels of Ca, P and Mg were found to range between 74.1-200.2 mg%, 2.1-92.9 mg% and 5.9-115 mg% respectively in Somali camels (Onjoro et al. 2003). Khamsi et al. (2001) reported  $120.6 \pm 16.6$  mg%,  $82.1 \pm 10.4$  mg%,  $11.2 \pm 2.0$  mg% Ca, P and Mg in South Morocco camels respectively. The differences in macro-minerals levels reported by various research groups might be due to breed differences or as a result of environmental conditions such as feed and soil. Different breeds of camels have different capacities to deposit minerals in their milk (Wangoh et al. 1998). The concentration of Fe, Zn and Cu were  $1.00 \pm 0.12$ ,  $2.00 \pm 0.02$ ,  $0.44 \pm 0.04$  mg/dl respectively (Singh et al. 2006) in Indian dromedary camels. The values of trace minerals viz. Fe, Zn, and Cu were significantly higher in camel milk as compared to bovine milk.

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### Camel milk vitamins:

The levels of vitamin A, E and B<sub>1</sub> were reported to be low in camel milk compared to the cow milk (Stahl et al. 2006). These workers reported vitamin A, E and B<sub>1</sub> as 20.1±10.0 µg%, 32.7±12.8 µg% and 19.6±6.4 mg% in camel milk and 60.9±25.6 µg%, 171.0±114.4 µg% and 34.7±8.1 mg% in cow milk. Cow milk contains 99.6±62.0 µg% β-carotene and it is not detected in camel milk. The concentration of vitamin C in camel milk in early and late lactation has been reported 5.26±0.47 and 4.84±0.20 mg% (Mal et al. 2007). The vitamin C content in camel milk is two to three folds higher in camel milk compared to cow milk. The levels of vitamin A, E and B<sub>1</sub> were higher in camel colostrum than mature camel milk. However, the vitamin C content remains higher in mature camel milk. The higher vitamin C content may be attributed to the more synthetic activity in the mammary tissues during early phase of lactation that declined as lactation advanced. The low pH due to the vitamin C content stabilizes the milk and can be kept for relatively longer periods.

The availability of a relatively higher amount of vitamin C in raw camel milk is of significant relevance from the nutritional point as vitamin C has a powerful anti-oxidant action. Camel milk can be an alternative source of vitamin C under harsh environmental conditions in the arid and semi-arid areas.

### Fatty acid patterns:

The percent by weight values of butyric, caproic, caprylic, capric, lauric, myristic, myristoleic, palmitic, palmitoleic, stearic, oleic, linoleic and arachidic acids were ranged from 0.31-0.75, 0.2-0.6, 0.2-0.3, 0.2-0.4, 1-1.8, 15.9-25.2, 1.7-4.5, 25-29.5, 6.1-19.1, 1.9-11.7, 6.8-24.9, 0.9-2.0 and 0.6-3.4 respectively (Singh et al. 2006). Higher content of long chain fatty acids (C14-C18) and lower content of short chain fatty acids (C4-C12) are present in camel milk compared to cow milk (Narmuratova et al. 2006).

### Camel milk enzymes:

The activities of aspartate aminotransferase (AST), alanine aminotransferase (ALT), gamma glutamyl transferase (γ-GT), acid phosphatase (ACP), alkaline phosphatase (ALP) and lactate dehydrogenase (LDH) was found to varies between 7.98-9.21 IU/L, 9.49-11.00 IU/L, 254.00-296.00 IU/L, 2.74-3.08 IU/L, 16.04-24.93 IU/L and 132.00-168.00 IU/L in Indian dromedary camels (NRCC, 1997-98). The activity of catalase was ranged from 0.083-0.193 moles/min/gm of protein in Indian dromedary camels. Milk enzymes play an important role in the keeping quality of camel milk. γ-GT can be used as an indicator for the proper heat inactivation of camel milk (Wernery, 2007) because it is destroyed between 10 to 20 minutes at 72 °C.

### Camel milk protective proteins:

Camel milk contains a number of protective proteins viz., lysozyme, lactoferrin, lactoperoxidase, peptidoglycan recognition protein (PGRP) enzyme etc. Lysozyme activity was ranged from 0.03-0.65mg/dl (Singh et al. 2006). The concentration of lactoferrin in camel milk was 95-250mg/dl. The camel milk/colostrum contains higher concentration of lactoferrin and lysozyme than bovine milk. The activity of lactoperoxidase was found to be 2.23±0.01 units/ml of milk. Peptidoglycan recognition protein (PGRP) has been detected in camel milk but not in cow milk. This enzyme has broad antimicrobial activity and has ability to control the cancer metastasis. Camel and cow milk contains 65% and 39% β-casein and 5% and 14% κ-casein respectively. The concentration of β-lactalbumen is 3.5mg/ml and 1.2mg/ml in camel and cow milk respectively (Wernery, 2007).

### Effect of heat treatment on camel milk whey proteins:

Camel milk is consumed raw by the camel keepers and there may be risk of developing milk borne infections. It is generally thought that heating of camel milk will destroy the important active and beneficial constituents present in the camel milk viz., whey proteins. Consumption of total whey proteins in the diet has been associated with the retardation of chemically induced cancers in several animal models.

Average whey proteins concentration in raw camel milk during early (2-3 months) lactation were 0.90±0.04, 1.31±0.01 and 0.95±0.03 percent respectively in Bikaneri, Jaisalmeri and Kachchhi camels. In cow milk it was found to be 0.44±0.03 percent only. Denaturation of camel and cow milk whey proteins was varied at different temperatures. In Jaisalmeri, Bikaneri, Kachchhi and cow milk samples, whey proteins denaturation at 63°C was 5.34, 18.89, 23.15 and 18.18 % respectively. At 90°C, highest whey proteins loss was observed in Kachchhi followed by Bikaneri and Jaisalmeri camels (Mal and Pathak, 2009a).

Average whey proteins concentration in raw camel milk during mid (6-7 months) and late (12-13 months) lactation were 0.92±0.03, 1.23±0.01 and 0.96±0.01 percent and 1.00±0.06, 1.29±0.04 and 1.05±0.02 percent respectively in Bikaneri, Jaisalmeri and Kachchhi camels. In Kachchhi, Bikaneri and Jaisalmeri milk samples, whey proteins denaturation during mid and late lactation at 63°C was 7.29, 10.87 and 23.58% and 10.48, 12.00 and 19.38% respectively. In boiled camel milk, average whey proteins concentration were 0.32±0.01, 0.60±0.02 and 0.43±0.01 percent and 0.28±0.04, 0.50±0.02 and 0.37±0.01 percent respectively in Bikaneri, Jaisalmeri and Kachchhi camels during mid and late lactation. Whey proteins denaturation during mid and late lactation in boiled camel milk was 55.20, 65.21 and 51.22% and 64.76, 72.00 and 61.24% respectively in Kachchhi, Bikaneri and Jaisalmeri camels (Mal and Pathak, 2010).

### Keeping quality of camel milk:

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Acidity and pH of the pure fresh camel milk and milk diluted with water (1:1) stored at room temperature were  $0.12 \pm 0.03$ ,  $6.42 \pm 0.18$  and  $0.09 \pm 0.02$ ,  $6.65 \pm 0.22$  respectively. Other parameters viz. clot on boiling, alcohol and alizarin alcohol tests were observed negative in fresh camel milk. The study indicated that pure and milk diluted with water (1:1) can be stored for 8 and 10 hours respectively at room temperature (Mal et al. 2006b).

Lactoperoxidase system in fresh camel milk was activated with in half an hour of the milking using various levels of thiocyanate and hydrogen peroxide (10-70:10-70 ppm ratios) and efficacy was evaluated. The best lowest activation level 20:20 was found to be effective in preserving raw camel milk up to 18-20 hours at 37°C (Singh et al. 2006).

### Medicinal properties of camel milk:

There is reports that camel milk has medicinal properties (Yagil, 1982) suggesting that this milk contains protective proteins which may have possible role for enhancing immune defence mechanism. Camel milk also contains higher amount of zinc. The rapidly dividing cells of the immune system are sensitive to zinc deficiency. The role of Zn in the development and maintenance of a normally functioning immune system has been well established (Hansen et al. 1982). Antibacterial and antiviral activities of these proteins of camel milk were studied (El-Agamy et al. 1992). Camel milk lysozyme showed a higher lysis value towards *Salmonella typhimurium* compared to egg white and bovine milk lysozymes. The inhibition of pathogenic bacteria by camel's milk was also observed (Barbour et al. 1984). Camel milk is used for treating dropsy, jaundice, spleen ailments, tuberculosis, asthma, anemia and piles (Rao et al. 1970). The patients suffering from chronic hepatitis had improved liver functions after drinking of camel milk (Sharmanov et al. 1978). Camel milk has insulin like activity, regulatory and immunomodulatory functions on  $\beta$  cells (Breitling, 2002). Camel milk exhibits hypoglycemic effect when given as an adjunctive therapy, which might be due to presence of insulin/insulin like protein in it (Agrawal et al. 2003) and possesses beneficial effect in the treatment of diabetic patients. Camel milk has been used for the treatment of food allergies (Shabo et al. 2005) and autism (Shabo and Yagil, 2005). Camel milk can be used for the treatment of different types of tuberculosis (Mal et al. 2000, 2001 and 2006a). Camel milk possesses medicinal properties to treat different ailments such as multiple sclerosis, psoriasis, lupus, allergies-asthma (Wernery, 2006). Camel milk drinking has shown good effect for treating crohn's disease (Shabo et al. 2008).

### Camel milk products:

Value additions of camel milk can be an alternative to make it more important in daily life; bye-products can be prepared and stored for longer period for transportation. Camel milk is consumed by the camel keepers of Rajasthan, Gujarat and Haryana. Camel keepers utilize milk either raw, boiled or for tea preparation. Camel milk is also used for the preparation of kheer and it is very much famous among the Raika's community of Rajasthan. Various camel milk products were prepared and commercialized at NRC on Camel, Bikaner viz. ice cream/kulfi with different flavors, flavored milk, fermented milk, cheese, tea and coffee. Recently, camel milk skin cream has been developed and it can be used as an emollient agent.

### Camel milk tea and coffee:

Camel milk tea and coffee were prepared in variable ratios of water added to milk (milk: water) and offered to different peoples to carry out the blind trials. It was observed that tea prepared from camel milk in 1:2 ratios can be taken regularly and 85.71 % peoples reported very well for the smell and 77.50 % for the taste. 72.00 % peoples were interested to take this tea regularly. Like wise, cow milk tea was prepared in different proportions and found that tea prepared from the cow milk in 1:3 ratios was observed to be best in terms of smell, taste and acceptability. Coffee can be used regularly when prepared from the camel milk in 1:1 ratio and its acceptability was 66.67 %. The acceptability for cow milk (1:1) coffee was 75.90 %. No fat layer formation was observed after keeping the camel milk tea and coffee undisturbed as compare to cow milk, which might be due to low fat percent with small micelles in camel milk.

### Fermented milk/curd, butter and ghee:

Fresh camel milk was filtered, boiled for 15 minutes and allowed to cool to 40°C and 45°C and inoculated with 3 % lactic starter culture. Post-inoculated milk samples were incubated at 30°C till the desired fermentation occurred. The curdling time was  $29.6 \pm 1.62$  hours and  $26.2 \pm 2.23$  hours at 40°C and 45°C respectively. The chemical composition of curd contains water %  $89.12 \pm 2.15$ , protein %  $3.61 \pm 0.64$  and fat %  $3.15 \pm 0.18$  were with in the range typically found for the curd available in India from other species. The consistency of curd remains thin due to improper coagulum formation which might be due to small micelles size of the fat globules.

Camel milk curd was churned in a mixer and grains of butter appeared on the top were skimmed off. As butter is the intermediate step for the preparation of ghee and ghee is a clarified milk fat obtained by heat desiccation of butter. The process incorporates distinctive flavor and aroma to butter and ghee obtained from the curd. Butter was allowed to boil in a large container and after clarification ghee was obtained. The recovery of butter and ghee was  $3.48 \pm 0.25$ ,  $2.25 \pm 0.14$  % for 40°C milk and it was  $3.90 \pm 0.36$ ,  $2.57 \pm 0.23$  % respectively for 45°C milk. The moisture and free fatty acids (FFA) content of camel ghee were  $0.66 \pm 0.13$  % and  $2.25 \pm 0.15$  % respectively. Moisture and free fatty acids levels were comparable to that of cow milk.

### Camel flavored milk:

Camel milk was filtered and heated to 45°C. Afterwards, 0.1 % stabilizer and 6 % sugar was added followed by the addition of food color. After homogeneous mixing, camel milk was allowed to boil and in cooled milk different type of flavors/essences such as pineapple, vanilla and kesar (0.6 ml/liter) can be used. The prepared camel milk was stored at 4-6°C. Moisture and fat was 82-83 % and 2-3 % respectively.

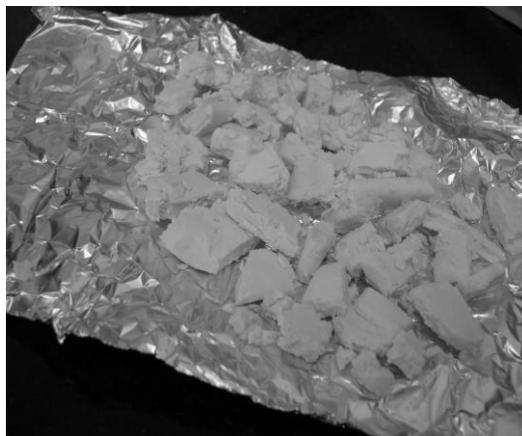
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### Camel milk paneer:

Milk samples were filtered and heated to 82°C-85°C for 5 minutes and cooled to 70°C. Different concentrations of citric acid and  $\text{CaCl}_2$  solutions were added to the camel milk as coagulants. 0.5-1.0 % citric acid along with 0.1-0.2 %  $\text{CaCl}_2$  yields a good quality paneer with a recovery of 9-10 %. The moisture and fat content in camel milk paneer were  $51.24 \pm 5.21$  % and  $18.52 \pm 3.40$  % respectively.



Camel flavored milk



Camel milk paneer

### Camel milk cheese:

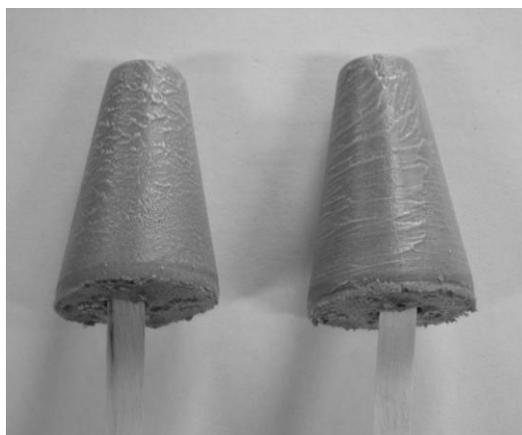
The camel/cow milk was filtered and heated to 72°C/15 seconds  $\text{CaCl}_2$  (0.02 %) or  $\text{CaSO}_4$  (0.015 %) was added with continuous shaking. Afterwards allowed cooling up to 40°C and 1 % starter culture was added. The temperature was maintained for 35°C-40°C and after 30 minutes different concentrations of rennet/pepsin were used for the coagulation of milk and 600 mg/L rennet/pepsin was found to be sufficient for the coagulation of camel milk. At this concentration, coagulation time was found to range between 1.5-2 hours for rennet and 10-15 minutes for pepsin. Further coagulated milk was kept for 2 hours at 40°C and afterwards cutting was done. After cutting the cheese curd, cooking was performed at 40°C till the whey gets separated. Moisture, fat and yield of cheese were 38-45 %, 18-22 % and 7-9 % respectively.

### Camel milk kulfees:

Kesar kulfee was prepared from boiled and concentrated camel milk to 2:1 ratio followed by the addition of 9-10 % sugar, 2 % custard powder with continuous stirring and after that it was kept for cooling. Milk concentrate was added with 0.0025 % saffron, 1-3 % dry fruits and 1-2 drops of essence. It was mixed and filled in cones and kept for freezing. Camel milk chocolate and sugar-free kulfees were also introduced for sale through centre camel milk parlour. Moisture and fat contents in camel milk kulfees were 48-50 % and 8-9 % respectively (Mal and Pathak, 2009b).



Camel milk cheese



Camel milk chocolate kulfi

### Camel milk khoa/mawa:

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Khoa is a partially desiccated product, prepared by the rapid boiling of the milk in an open vat until the volume of the milk is reduced to about 75-80 %. During boiling the milk is continuously stirred by using a broad metal spatula. Hot mawa has butter-like consistency, after cooling; it turns into semi-solid dough. No change in taste has observed up to 30 days at refrigerated temperature. After addition of sugar, it can be kept for longer periods. Camel milk khoa is light brown in color. Moisture, fat and yield of mawa were 25-30 %, 17-20 % and 15-20 % respectively.

### Camel milk gulab Jamun:

Gulab jamun was prepared from camel milk khoa/mawa. Khoa and fine wheat flour (maida) was mixed in 9:1 ratio, made into balls, fried in pure ghee and dipped in concentrated sugar syrup. Moisture and fat contents in gulab Jamun were 21-23 % and 2.0-3.5 % respectively.



Camel milk mawa



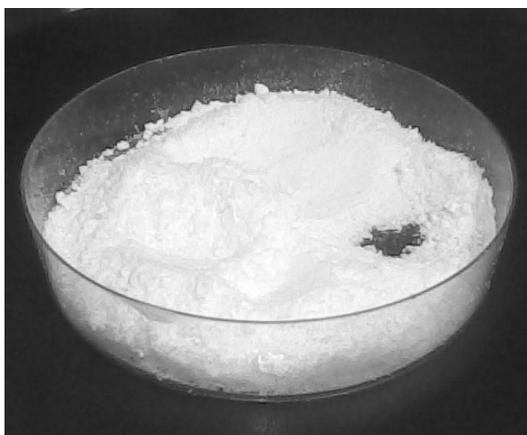
Camel milk gulab jamun

### Camel milk powder:

Camel milk powder was prepared by lyophilizing the camel milk. Camel milk powder is white in color with normal odor and salty taste. The percent value of moisture and fat in milk powder were 6-7 % and 21-23 % respectively. A yield of 9-10 % was observed by this method.

### Camel milk skin cream:

Camel milk cream prepared by NRCC, Bikaner can be used as a moisturizing cream. This was concluded on the basis of an open pilot study conducted in 50 test group patients and 50 control group patients for 6 months. Moisturizing effect with glowing/shining of skin was observed after using the camel milk skin cream. Similar findings were also observed in control group. The claims for anti-ageing/anti-wrinkling property of camel milk skin cream are still to be proved.



Camel milk powder



Camel milk skin cream

### Commercial viability of the camel milk products:

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Camel milk and milk products were sold through camel milk parlour. An increasing trend in sale and profit was observed during 2007-08 and 2008-09. Milk and milk products were sold out for Rs. 1,37,032 and Rs. 2,30,242 during 2007-08 and 2008-09 respectively. Net profit of Rs. 59,712 and 1,22,500 was observed during these years. The profit was found to be more than double during 2<sup>nd</sup> year since its inception.

Camel milk products may be one of the easy economical ways to improve the social life of camel owners. These products are gaining popularity among the peoples and in future these products would be highly demanding.

### Milk production and composition of bactrian camel:

The bactrian camels in India are found in Nobra valley of Ladakh, Jammu & Kashmir. Bactrian camel is an important component of the cold desert ecosystem and to the people inhabiting in region. Bactrian camel milk is an important source of milk supply for people living in the Gobi and desert steppe area of Mongolia. Milk production potential of bactrian camel varies, generally it is considered to be low in milk production (0.5–1 liters/day) as compared to dromedaries where as the data of milk production of bactrian camel of Kazakhstan is as high as 6-7 liters/day, which is more than that produced by local cows and dromedaries. The lactation length varies from 14-18 months and lactation yield varies from 500-1254 liters. Peak milk yield is at around 3-4 months after parturition. The milk is rich in vitamin-C & milk composition of bactrian camel is as follows:

Parameters	Concentrations
Moisture (%)	85.32
Total solids (%)	14.68
Fat (%)	5.50
Protein (%)	3.87
Casein (%)	0.89
Ash (%)	0.97
Calcium (%)	0.11
Phosphorus (%)	0.09
Vitamin A (µg/ml)	7.57
Vitamin B <sub>2</sub> (µg/ml)	3.10
Vitamin C (mg/ml)	7.50

The bactrian camel's milk is high in fat because these animals live in a cold environment and more energy is required by their calves. The fat quantity in milk also depends upon the availability of water (Mal et al. 2007). The composition of fatty acids in bactrian camel showed slight differences than to dromedary milk. Dromedary milk contains higher amount of C10, C18 and C18:1(n-7), while bactrian milk is richer in C14, C16 and C18:1(n-9) (Narmuratova et al. 2006).

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