International Journal of Food Science and Agriculture, 2022, 6(2), 200-207
https://www.hillpublisher.com/journals/jsfa/
ISSN Online: 2578-3475
ISSN Print: 2578-3467

# A Comprehensive Review on the Properties of Camel Milk and Milk Products

**Dasharath Patel[1], Suneeta Pinto[1], Mahendra Pal[2,*]**

[1]Department of Dairy Technology, SMC College of Dairy Science, Anand -388110, Gujarat, India.
[2]Narayan Consultancy on Veterinary Public Health and Microbiology, Anand-388001, Gujarat, India.

**How to cite this paper:** Dasharath Patel, Suneeta Pinto, Mahendra Pal. (2022) A Comprehensive Review on the Properties of Camel Milk and Milk Products. *International Journal of Food Science and Agriculture*, 6(2), 200-207.
DOI: 10.26855/ijfsa.2022.06.010

**Received:** April 20, 2022
**Accepted:** May 16, 2022
**Published:** June 17, 2022

***Corresponding author:** Mahendra Pal, Narayan Consultancy on Veterinary Public Health and Microbiology, Anand-388001, Gujarat, India.
**Email:** palmahendra2@gmail.com

## Abstract

Camel (*Camelus dromedaries*) milk is an important source of proteins for the people living in the arid lands of the world. Globally, 2.9 million tones of camel milk are produced annually. Camel milk has been recognized for its extraordinary medicinal properties. It is known to have a therapeutic potential against many diseases including diabetes, anemia, jaundice, arthritis, and cancer. Epidemiological surveys have indicated that people who are consuming camel milk have low prevalence of diabetes. Various researchers have worked on the compositional aspects of camel milk. The milk of camel is a good source of vitamins, minerals, and immunoglobulins. The manufacturing of dairy products, such as butter, ghee, cheese, and yoghurt from camel milk is difficult due to the unique structural and functional properties of the milk components. However, attempts have made for preparing several dairy products like cheese, butter, yoghurt, ice cream, paneer, and others from camel milk. As milk is extremely susceptible to spoilage by microbes present in the environment, therefore, it is imperative that good hygienic practices must be followed during the production and processing of milk and dairy products. The people in camel raising areas should be educated to avoid the consumption of raw milk to prevent milk borne diseases.

## Keywords

Camel milk, Dairy products, Human health, Nutritional profile, Medicinal properties

## 1. Introduction

Camel (*Camelus dromedaries*) is a versatile domesticated ruminant that serves a vital source of milk, meat, hair, hide, and draught power is some regions of the world [1]. The milk of camel contains all the macro and micronutrients that are needed for human health. Camel milk and its products may be one of the economical ways to improve the social life of camel owners. Camel milk can be considered as a good food of high nutritive and therapeutic applications. It is pertinent to mention that camel milk is a staple food of desert nomad tribes [1]. It is estimated that there are 25.89 million camels in the world [1]. In India, camels are mainly confined to the States of Rajasthan (81.4%), Gujarat (7.6%), Haryana (4.7%), Bihar (2.2%), and Uttar Pradesh (2.0%). The major reduction in the camel population has been during the last two decades when it reduced from 0.9 to 0.4 million [2]. In India, Ethiopia, Sudan, and other camel rearing countries, camel milk is mainly consumed in raw state by the camel keeping societies. In this context, Pal [3] has described many milk-borne diseases, such as brucellosis, listeriosis, coxiellosis, campylobacteriosis, tuberculosis, staphyloccosis, yersiniosis, streptococcosis, toxoplasmosis, and others. This highlights the importance of pasteurization of milk in order to prevent the milk-borne diseases.

The annual world production of camel milk is estimated to be 2.9 million tonnes. The Indian main camel breeds, viz. Bikaneri, Jaisalmeri, Kachhchi, and Mewari, are shown to produce 3,105-4,190 kg milk per lactation at the rate varying

from 3.8 to 10.8 kg/day [4]. The lactation period in the Indian camels can last up to 14-16 months depending upon the time of weaning of the newborn. The average daily milk production by 2 and 4 teat stripping is highest during the 6th month of lactation and with machine milking during the 4th month of lactation. Milking by all three methods indicated morning production to be 12-27% higher over the evening production, and various factors, such as month of lactation, parity, breed and method of milking affect daily milk production [5].

The milk of camel has been acknowledged for its amazing medicinal properties. Camel milk has therapeutic potential as it helps in many diseases, such as diabetes, jaundice, anaemia, malaria, dropsy, problem of spleen, flatulence, tuberculosis, HIV, cirrhosis of the liver, cancer, rickets, arthritis besides it can detoxify snake venom [6,7,1]. Camel milk is considered to have anti-cancer, hypo-allergic, and anti-diabetic properties [8, 9, 10, 11, 1]. It has long been utilized for its beneficial effect in broad range of disease conditions, such as insulin-dependent diabetes mellitus (IDDM) [12], infant diarrhea [13], hepatitis [14], allergy [10], lactose intolerance [15], autism [16], and alcohol-induced liver damage [17]. The benefits of camel milk can be attributed to the presence of many immunologically important molecules, such as lysozymes, lactoferrin and lactoperoxidase [1]. Camel milk contains extraordinarily high levels of insulin-like molecule [12]. In this context, Agrawal and co-investigators [18] have reported the effect of camel milk on residual b-cell function in recent onset type 1diabetes. There are evidences to believe that communities using camel milk have low prevalence of diabetes [1]. Moreover, camel milk has been reported to possess medicinal value against various ailments, such as dropsy, jaundice, spleen ailments, diabetes, tuberculosis, asthma, anemia, piles, and food allergies [19, 1]. It is shown that camel milk has a beneficial action on chronic liver patients, in chronic fatigue, and as a supplement to mother's milk [20]. Camel milk is characterized by a relatively powerful protector system compared to milk of other species [4]. Shelf life of raw camel milk is 8-9 h at 37°C and more than a week at 4-6°C. Lactoperoxidase system in fresh camel milk was activated within 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 is found to be effective in preserving raw camel milk up to 18-20 h at 37°C [21]. The aim of this communication is to present a comprehensive review on the current knowledge on camel milk and various camel milk products.

## 2. Chemical composition

Various researchers have worked on compositional aspects of camel milk [22, 23, 12, 24, 14, 25 26, 27, 28, 29, 30]. The total protein content of camel milk varies from 2.1 to 4.9% [24]. Casein constitutes about 52-87% of the total proteins. The casein content ranges from 1.63 to 2.76%. The amino acid sequence of some of the camel milk protein is rich in half cysteine, which has similarity with insulin family of peptides [31, 32]. Camel milk does not form the coagulum in the stomach or the acidic media which prevents degradation of insulin in the stomach. This allows the camel milk to pass rapidly through the stomach and can contribute to the hypoglycemic effect in type 1 diabetes in humans [12].

Whey proteins constitute about 20-25% of the total proteins and ranges from 0.63 to 0.80% of the milk [33]. The ratio of whey protein to casein is higher in camel milk than in cow milk. This may explain why the coagulum of camel milk is softer than that of cow milk. The antioxidant activity of camel a-lactalbumin was greater than that of bovine alpha-lactalbumin because it contains higher antioxidant amino acids residues, in addition to the differences in conformational features of both proteins [26].

The fat content of camel milk is between 1.2 and 5.4% [34] with an average of 3.2%, which depends upon level of nutrition, stage of lactation, breed, season, etc. [21]. Camel milk fat contains a lesser content of carotene as compared to bovine milk. Camel milk fat has a lower content of short-chain fatty acids (C4-C12) compared to cow milk. Camel milk fat is a rich in long-chain fatty acids (92-99%) and unsaturated fatty acids, which have been reported to reduce human serum lipids and decreases the incidence of lipid-related cardiovascular diseases [22, 25, 28].

The lactose content of camel milk ranges from 2.40 and 5.80%, and total ashes from 0.60 to 0.90% [34]. Camel milk is a rich source of chloride, which is one of the reasons of salty taste of milk [35, 33, 36]. Camel milk is rich in Zn, Fe, Cu and Mn. The values of trace minerals, viz. Fe, Zn and Cu, reported in camel are 1.37, 2.19 and 0.44 mg/dl, respectively. The ratio of C to P is 1.5 for camel milk verses 1.29 and 2.1 for cow and human milk, respectively. The high phosphate content in cow milk based infant formula has been implicated in hyperphosphatemia, and low serum calcium [29].

Camel milk contained three to five times [37] more vitamin C as compared to bovine milk. The proximate vitamin C concentration present in camel milk is 34.16 mg L-1. Vitamin B1, B2, folic acid, and pantothenic acid are low in camel milk, while B6 and B12 content is quite similar to that of cow milk but higher than in human milk. The content of vitamin A (100-380 lg/L) in camel milk is reported to be lower than that of bovine milk [29]. Vitamins A, E, and B1 was 20.1 ± 10.0 lg%, 32.7 ± 12.8 lg%, and 19.6 ± 6.4 mg% in camel milk, respectively. The concentration of lysozyme, lactoferrin, and immunoglobulins in camel milk is higher than in bovine or buffalo milk [23, 14].

## 3. Camel Milk Products

The manufacturing of products like butter, ghee, yoghurt, and cheese from camel milk is still not well developed and

standardized [38]. The main reason for the difficulty of product making from camel milk is due to the unique structural and functional properties of the milk components. Camel milk contains low amounts of kappa casein resulting in a weak casein network that is destroyed during cutting and the loss of dry matter of cheese to the whey [39]. Many products, such as butter, paneer, yoghurt, ice cream, cheese, etc. prepared from camel milk can be found in the literature.

## 4. Butter

Butter is one of the oldest dairy products that is commonly prepared from cow's milk, and is consumed worldwide [40]. It is a good source of the fat soluble vitamins, such as A, D, E, and K [40]. Although butter can be made from pure camel milk, a longer churning time and fermentation time is required [41]. At lower temperatures the cream of the camel milk is difficult to churn. Butter can be produced from camel cream using a high churning temperature of 20°C-25°C. The churning temperatures normally used for bovine butter milk range from 8°C to 12°C [42].

In order to reduce the churning time, Asresie and co-workers [43] had blended camel milk with goat milk in different proportions viz. T1 (100% camel milk), T2 (75% camel and 25% goat milk), T3 (50% camel and 50% goat milk), T4 (25% camel and 75% goat milk), and T5 (100% goat milk). It was found that the fermentation time (11.33 days), churning time (121.7 min) and churning temperature (28°C) of T1 were significantly ($P<0.001$) higher than the other milk samples. T1 had significantly ($P<0.001$) lower churning pH (4.13) and butter yield (49.3 g/L) than the other samples. The coliform count, enterobacteriaceae count, lipolytic bacteria count, and yeast and mould count of T1 was significantly ($P<0.001$) higher than the other butter samples. The fermentation time, churning time and churning temperature of T5 were significantly ($P<0.001$) lower than the rest and T5 required significantly ($P<0.001$) higher churning pH than the other milk samples. These investigators concluded that blending camel milk with goat milk improved churning efficiency, and microbial quality of butter made from camel milk.

## 5. Paneer

Paneer is an important indigenous dairy product that represents one of the soft varieties of cheese, and is an excellent source of protein, minerals, and vitamins [44]. It is a heat and acid coagulated milk product, which is very popular in the Indian subcontinent [44]. Paneer has a firm, cohesive, close knit body, and texture. Since camel milk does not coagulate easily it is difficult to make fermented dairy products such as cheese and yoghurt from camel milk [45]. Prajapati [46] conducted studies to assess the textural analysis of camel and goat milk paneer incorporated with spices. The formation of paneer was done by using different ratio of camel and goat milk and incorporation of spices viz. black pepper, and cardamom in single or in combination was done. The overall textural profile of paneer showed a wide difference in value of texture parameters like hardness, springiness, cohesiveness and adhesiveness indifferent proportions of milks used. Use of a blend of 30% goat milk and 70% camel milk with or without spices incorporation gave a good textural structure of paneer.

Mal and Pathak [47] described a method for preparing paneer from camel milk. In this method, milk was heated to 82°C-85°C for 5 min and cooled to 70°C. From amongst different concentrations of citric acid and $CaCl_2$ solutions, it was found that 0.5-1.0% citric acid along with 0.1-0.2% $Cacl_2$ yields a good quality paneer with a recovery of 9-10%. The moisture and fat content in camel milk paneer were 51.24 ±5.21% and 18.52± 3.40%, respectively.

## 6. Yoghurt and fermented milks

Camel milk produces watery texture when it is processed to yogurt. It does not form a desirable curd by lactic acid fermentation process. The fermented camel milk products have a watery consistency and have a fragile and poor structure [48]. Since camel milk does not coagulate easily it is difficult to make fermented dairy products such as cheese and yoghurt from camel milk [45]. In one study, camel milk was fermented using four different lactic starter cultures, viz. dahi culture, yogurt mix culture, and *Lactobacillus acidophilus.* It was observed that rate of development of acidity was comparatively slow in camel milk than in cattle milk for all the four lactic strains [21].

The preparation of yoghurt from camel milk using the same procedure as has been standardized for cow milk does not give an acceptable product. Several research workers have utilized camel milk for the preparation of yoghurt [49, 50, 51, 52, 53, 54, 55, 56].

Use of microbial transglutaminase MTGase preparation at can be an effective way to solve this problem. Abou-Soliman and co-workers [54] had treated camel milk with MTGase preparation, which was added simultaneously with starter culture at a concentration of 0.4%. They reported that it significantly enhanced the consistency/viscosity of the coagulum hence improved the quality of set-type yogurt.

Since fermentation of camel milk results in a product with weak consistency, Kamal-Eldin and others [56] studied the influence of supplementing bovine milk with increasing levels of camel milk (0-60%) on different properties of yogurt. Fresh raw camel and bovine milks were heated separately at 85°C for 5 min and mixed before fermentation with lactic

acid bacteria. It was found that addition of camel milk to bovine milk led to larger and less differentiated casein micelles. After fermentation, the pH of all yogurts was 4.5-4.6 and it decreased to 4.3 after 2 weeks of storage suggesting that the soft gels caused by the addition of camel milk is due to the structure and concentration of its proteins rather than limitations related to bacterial growth.

In another study conducted in 2016 by Kavas [53] yoghurt was produced from camel milk incorporated with whey protein isolate (3% w/v) and fortified with 3% (w/v) traditional samphire molasses (TSM) (Y-TSM), 3% (w/v) TSM+0.1% (w/v) κ-carrageenan (Y-TSMC) or 3% (w/v) TSM+0.05% (w/v) xanthan gum (Y-TSMX). It was found that sample containing 3% traditional samphire molasses and 0.1% κ-carrageenan i.e. Y-TSMX was superior to the other samples in terms of physicochemical, textural, microbiological and sensory properties.

In a similar study carried out by Ahmadoon [50], yoghurt was made from camel milk and camel milk substituted with cow milk (50%: 50% v /v). Starter culture was added at rate of 3% (v: v) and preserved for 10 days at 4°C. Admixture of camel milk with cow milk resulted in improved the chemical composition and sensory characteristics.

Yogurt was produced using camel milk. Stabilizers (CMC, pectin, gum acacia, or alginate) were added at 0.6% to improve the texture and acceptability of camel milk yogurt. The pH (4.59-4.63) and titratable acidity (0.71-0.87 %) of camel milk yogurt product were different from cow milk control yogurt. Yogurt prepared from camel milk contained 10.6 mg/mL of lactic acid based on HPLC. The separated whey (33.5%) of camel milk yogurt with alginate was higher than for control cow milk yogurt (23.8%), indicating a weaker water holding capacity. Stabilizers did not improve the consistency and coagulum of camel milk yogurt, compared with bovine milk yogurt [51]. Hashim and co-investigators [49] developed an acceptable quality set-type yoghurt was using alginate plus calcium. Addition of 0.75% alginate, and 0.075% calcium could be used to produce acceptable plain or flavored camel milk yogurt.

Yoghurt of acceptable consistency was made from camel milk using 1.2% gelatin, 5% bovine skim milk powder, 1.5 ml/L of calcium chloride, 40 ml/L of maple strawberry syrup, and 6% yoghurt culture (YF-L811) and by incubating the milk at 42$^{o}$C for 18 h. The average values for moisture, ash, syneresis, pH, titratable acidity, and total solids of camel milk yoghurt were 83.4%, 1.13%, 58%, 4.37, 1.255% lactic acid, and 16.7%, respectively. The corresponding values for cow milk yoghurt were 80.6%, 0.71%, 56%, 4.67, 0.865% lactic acid and 19.5%, respectively [55].

Three stabilizers blend viz. A (gelatin E441, mono and diglyceride of fatty acids E471), B (guar gum E412, sodium carboxymethyl cellulose E466 and mono and diglyceride of fatty acids E471) and C (modified starch E1422 and mono and diglyceride of fatty acids E471) are used. The addition rate of stabilizers to camel milk was 0.5%, 1.0% and 1.5%, w/w. Addition of stabilizers significantly ($P \leq 0.05$) decreased the syneresis, and increased viscosity and water holding capacity of camel milk yoghurt resulting in an acceptable quality product. From amongst the different blends studied, it was found that stabilizer blend A (gelatin E441, mono and diglyceride of fatty acids E471) at a level up to 1.5%, to camel milk yoghurt could stabilize the texture without affecting overall acceptability of the product [52].

Freshly prepared preserved 'Shubat', a fermented camel milk drink used in Kazakhstan, has been reported to possess virucidal and virus-inhibiting properties against ortho- and paramyxoviruses [57]. Rahman and co-investigators [58] analyzed seven samples of shubat and reported that lactic acid bacteria and yeasts were the dominant microorganisms with the number ranging from log 6.8 to 7.6 cfu/ml and from log 4.3 to 4.7 cfu/ml, respectively. *Lactobacillus* and *Enterococcus* as well as *Kluyveromyces* were the predominant genera, with the most frequently isolated species being *Lactobacillus sakei* and *Enterococcus faecium* as well as *Kluyveromyces maxius*, respectively. It is possible to produce good quality fermented camel milk with good flavour, body and texture, appearance and colour by adding of (cinnamon and doum) extracts as a good functional foods [59].

## 7. Ice-cream

Ice cream is a frozen desert that is consumed by all sections of the people worldwide [40]. It is an excellent source of fat, protein, vitamins (vitamin A, E, riboflavin, and niacin) and minerals (calcium, phosphorus). Ice cream can be produced successfully from camel milk using ice cream mix containing 12% fat, 11% milk solids not fat and 37% total solids [22]. Medium fat camel milk ice cream (6% fat) was prepared using three different flavouring i.e. vanilla, strawberry and pineapple. All the three experimental ice creams ware compared with control regular ice cream (10% milk fat) with vanilla as flavouring. Compared to control, all the camel milk ice cream mixes had significantly ($P<0.05$) lower viscosity. The experimental ice cream had lower melting resistance and higher overrun compared to control ice cream. Pineapple flavor helped in enhancing the acceptability of medium fat camel milk ice cream compared to the other two flavor studied viz. strawberry and vanilla [60]. Ice cream was prepared from camel milk using natural additives viz. honey and gum arabic and flavored with vanilla, coconut and their combination. The mix was prepared by incorporation of 105 g of gum arabic (0.7%), 1,350 g of honey (9%), 900 g of sugar (6%), and 1,650 g low fat powder cream (11%) with 10.995 kg camel milk for the manufacturing of ice cream. Four g of vanilla and 80 g grated coconut were used as flavoring. The processed ice cream was packed into plastic cups and stored at -18°C for eight weeks [61].

## 8. Traditional Indian dairy products

Parmar [62] prepared ghee (butter oil) from camel, cow and buffalo milk by direct creamery method in which cream was heated to 115°C with no hold. The average yield of ghee obtained from camel, cow and buffalo milk was 3.52, 3.82 and 5.49 per cent, respectively. The physical properties for camel ghee were: melting point 43 C, solidification point 33.40 C, BR readings 44.6, refractive index 1.4561 and density 0.941 g per $cm^3$. The chemical characteristics for camel ghee were: moisture content 0.248 percent, FFA content 0.125 per cent oleic acid, RM value 9.60, Polenske value 1.10, saponification value 231.89, and iodine value 33.90.

Khoa, a heat-concentrated milk product, is used as a base material for the manufacture of many popular sweets. Khoa was prepared by traditional open pan evaporation method from camel, cow and buffalo milk. The average yield of khoa obtained from camel, cow and buffalo milk was 17.24, 20.04 and 25.52 per cent, respectively. Khoa obtained from camel milk had very loose and highly sticky body. Its consistency and finish was in accordance with dhap variety of khoa. Khoa prepared from the camel milk had the higher moisture, ash, acidity, soluble nitrogen, free fatty acids, and peroxide value, but lower in fat, protein, and lactose contents compared to khoa prepared from the cow and buffalo milk samples. The average moisture, fat, protein, lactose and ash content of khoa prepared from camel milk were 36.43, 24.0, 19.34, 15.40, and 5.18 per cent, respectively. There was no significant ($P>0.05$) difference in 5-hydroxymethyl furfural between khoa samples prepared from the three milks [63].

Lad and co-workers [64] had prepared the gulabjamun from camel milk. The objectionable flavor of the gulabjamun from camel milk khoa could be successfully masked by the addition of cardamom extract prepared from 1.0 g of cardamom in 20 ml of water and used for 125 g formulation along with 54° brix sugar syrup as an extract of cardamom (3 g per liter) for soaking the gulabjamun.

Camel milk powder supplemented kulfi was prepared. The chemical composition showed that the percentage of fat, protein, carbohydrate, ash and total solids increased by increasing the amount of camel milk powder with respect to physical properties, melting resistance, and hardness in kulfi samples decreased with increasing level of camel milk powder compared to control which was prepared without addition of camel milk powder. The fat 14%, protein 8.37%, ash 1.91%, carbohydrate 26.71%, total solids 50.99%, acidity 0.31% LA, melt down time 24.37, anti-oxidant 4.50 mg ascorbic acid, and whey nitrogen index 2.34% were observed in optimized kulfi [65].

## 9. Cheese

Cheese is a highly nutritious fermented dairy product that is consumed globally [40]. It is a good source of protein, fat, calcium, phosphorus, riboflavin, and other vitamins. Currently, more than 200 types of cheese are available in the world [40]. It is difficult to prepare cheese from camel milk since camel milk does not coagulate easily milk [45]. Camel milk exhibits a two to three fold longer rennet coagulation time compared with bovine milk [66, 67]. This has been attributed to the structure of camel milk casein micelles. The low content of kappa-casein and the large size of casein micelles of camel milk compared with cow milk contribute to prolong the coagulation time [68, 27]. Presence of several natural antimicrobial agents in camel milk, such as lysozyme, lactoferrin, lactoperoxidase, and immunoglobulin could also limit the effect of lactic acid bacteria [39].

There are several reports in literature, which indicate the possibility of production of cheese from camel milk [69, 70]. Khan and co-investigators [69] reported that camel milk coagulated by starter culture addition (13.22±4.487) gave higher cheese yield as compared to cheese prepared by direct acidification (11.70±2.345). The cheese prepared by using starter culture also had higher amounts of total solids, protein and fat. Mbye and others [67] opined that soft cheese with weak structures can be prepared from camel milk. Cheeses manufactured from camel milk were significantly lower in hardness and rheological properties than bovine milk cheeses ($P<0.05$). These authors investigated the coagulation properties of camel milk and bovine milk, and the resulting soft un-ripened cheeses obtained by treatment with chymosin (1000 IMCU/ML milk) or citric acid or acetic acid (30% acid/L milk).The coagulation time for camel was longer than that for bovine milk and the specific coagulation behavior of camel milk was attributed to differences between the composition of the casein fraction in camel milk and that in bovine milk.

Mihretie and co-workers [70] evaluated the coagulating effects of lemon juice for making soft cheeses from camel milk. They reported that addition of lemon juice to camel milk could offer an economically suitable means for producing coagulated milk cheese. In another study, soft cheese of an acceptable quality could be produced by adjusting the fat content of camel milk to 1.82%, total solid level to 14% and using rennet powder at a ratio of 1.5mg (100g)-1. The yield of the cheese was 14.57% [71]. In this context, Qadeer [72] reported that camel milk pasteurized at 65°C, having pH 5.5, and $CaCl_2$ 0.06% before the cheese making showed the higher yield, fat, protein contents, and firm texture as compared the other combinations of processing parameters. They found that addition of buffalo milk (10%) with thermophilic starter cultures (*L. bulgaricus and Strep. Thermophillus*) produced the cheese, which was acceptable regarding the chemical and sensory quality of cheese.

## 10. Conclusion

Camel is an important dairy animal in arid and semi arid areas of the world. The milk of camel is called as 'white gold' of the desert. Camel milk is higher in vitamin C, iron, and potassium, and lower in fat and lactose. It can be used in many ailments including food allergy, jaundice, diabetes, anaemia, arthritis, fever, rickets, asthma, fever, cancer etc. It is suggested that camel milk can serve as an alternative for individual who are intolerant to lactose of cow's milk. As consumption of raw milk is known to cause several diseases including tuberculosis, brucellosis, therefore, it is imperative that milk must be properly pasteurized or boiled from food safety point of view. Further research should be conducted to develop several value added dairy products from the milk of camel. It is emphasized that the role of camel milk should be further investigated in other clinical disorders of humans.

## Acknowledgements

The authors are very thankful to Prof. Dr. R. K. Narayan for going through the manuscript. This paper is dedicated to all the scientists who made significant contribution in milk and dairy products.

## References

[1] Pal, M. (2017). Nutrional and medicinal value of camel milk. Food and Beverages Processing, 3: 20-22.

[2] DAHDF. (2014). Livestock census of India. 19th edition. All India report, published by: Ministry of Agriculture Department of Animal Husbandry, Dairying and Fisheries, Krishi Bhawan, New Delhi, pp. 26. http://dahd.nic.in/dahd/WriteReadData/Livestock.pdf.

[3] Pal, M. (2007). Zoonoses. Second Ed. Satyam Publishers, Jaipur, India.

[4] Mal, G., Suchitrasena, D., Jain, V. K., and Sahani, M. S. (2006). Therapeutic value of camel milk as a nutritional supplement for multiple drug resistant (MDR) tuberculosis patients. Israel Journal of Veterinary Medicine, 61(4): 88-94.

[5] Mehta, S. C., Bissa, U. K., Patil, N. V., and Pathak, K. M. L. (2011). Importance of camel milk and production potential of dromedary breeds. Indian Journal of Animal Science, 81(11): 1173-1177.

[6] Habib, H. M., Ibraham, W. H., Stock, R. H., and Hassan, H. M. (2013). Camel milk reduces the proliferation of colorectal cancer cells and exerts antioxidant and DNA damage inhibitory activities. Food Chemistry, 141(1): 148-152.

[7] Pal, M. and Sabir, M. (2015). Major milk-borne microbial diseases of camels. Haryana Veterinarian, 54: 93-98.

[8] Agrawal, R. P., Swami, S. C., Beniwal, R., Kochar, D. K., Sahani, M. S., Tuteja, F. C., and Ghouri, S. K. (2003). Effect of camel milk on glycemic control, risk factors and diabetes quality of life in type-1 diabetes, a randomized prospective controlled study. Journal of Camel Practice Research, 10(1): 45-50.

[9] Magjeed, N. A. (2005). Corrective effect of milk camel on some cancer biomarkers in blood of rats intoxicated with aflatoxin B1. Journal of Saudi Chemistry Society, 9(2): 253-263.

[10] Shabo, Y., Barzel, R., Margoulis, M., and Yagil, R. (2005). Camel milk for food allergies in children: Immunology and allergies. Israel Medical Association Journal, 7(12): 1-3.

[11] Konuspayeva, G., Lemarie, E., Faye, B., Loiseau, G., and Montet, D. (2008). Fatty acid and cholesterol composition of camel's (Camelus bactrianus, Camelus dromedaries and hybrids) milk in Kazakhstan. Dairy Science Technology, 88(3): 327-340.

[12] Agrawal, R. P., Beniwal, R., Kochar, D. K., Tuteja, F. C., and Ghorui, S. K. (2005). Camel milk as an adjunct to insulin therapy improves long-term glycemic control and reduction in doses of insulin in patients with type-1 diabetes A 1 year randomized controlled trial. Diabetes Research and Clinical Practice, 68(2): 176-177.

[13] Yagil, R. and Etzion, Z. (1980). Effect of drought condition on the quality of camel milk. Journal of Dairy Research, 47(2): 159-166.

[14] El-Fakharany, E. M., Tabil, A., El-Wahab, A. A., Haroun, B. M., and Redwan, E. M. (2008). Potential activity of camel milk amylase and lactoferrin against hepatitis C virus infectivity in HepG2 and lymhpocytes. Hepatitis Mon, 8(2): 101-109.

[15] El-Agamy, E. I., Nawar, M., Shamsia, S. M., Awad, S., and Haenlein, G. F. W. (2009). Are camel milk proteins convenient to the nutrition of cow milk allergic children? Small Ruminant Research, 82(1): 1-6.

[16] Shabo, Y. and Yagil, R. (2005). Etiology of autism and camel milk as therapy. International Journal of Disability and Human Development, 4(2): 67-70.

[17] Ahmed, A. S., Abdalbagi, N. H., Mustafa, H. A., Idris, A. A. A., Eltayb, A. M. A., and Ismail, R. (2011). The role of camel milk in the reactivation of liver damaged by Sudanese liquor (Aragi). Journal of Public Health, 6(4): 157-163.

[18] Agrawal, R. P., Saran, S., Sharma, P., Gupta, R., Kochar, D. K., and Sahani, M. S. (2007). Effect of camel milk on residual b-cell function in recent onset type 1 diabetes. Diabetes Research and Clinical Practice, 77(3): 494-495.

[19] Hamad, E. M., Abdel-Rahim, E. A., and Romeih, E. A. (2011). Beneficial effect of camel milk on liver and kidneys function in diabetic Sprague-Dawley rats. International Journal of Dairy Science, 6(3): 190-197.

[20] Sharmanov, T. S. and Kadyrova, R. D. (1978). Changes in the indicators of radioactive isotope studies of the liver of patients with chronic hepatitis during treatment with whole camels' milk and mares' milk. Voprosy Pytaniya, 1: 9-13.

[21] Raghvendar, S., Ghorui, S. K., and Sahani, M. S. (2006). Camel milk: properties and processing potential. In: Sahani MS (ed) The Indian Camel. Publisher National Research Center on Camel, Bikaner, India, pp. 59-73.

[22] Abu-Lehia, I. H., Al-Mohizea, I. S., and El-Behry, M. (1989). Studies on the production of ice cream from camel milk products. Australian Journal of Dairy Technology, 44(2): 31-34.

[23] Li, H. and Papadopoulos, V. (1998). Peripheral-type benzodiazepine receptor function in cholesterol transport. Identification of a putative cholesterol recognition/interaction amino acid sequence and consensus pattern. Endocrinology, 139(12): 4991-4997.

[24] Konuspayeva, G., Faye, B., Loiseau, G., and Levieux, D. (2007). Lactoferrin and immunoglobulin contents in camels milk (Camelus bactrianus, Camelus dromedarius, and hybrids) from Kazakhstan. Journal of Dairy Science, 90: 38-46.

[25] Haddadin, M. S. Y., Gammoh, S. I., and Robinson, R. K. (2008). Seasonal variations in the chemical composition of camel milk in Jordan. Journal of Dairy Research, 75(1): 8-12.

[26] Salami, M., Yousefi, R., Ehsani, M. R., Razavi, S. H., Chobert, J. M., and Haertle, T. (2009). Enzymatic digestion and antioxidant activity of the native and molten globule states of camel a-lactalbumin: possible significance for use in infant formula. International Dairy Journal, 19(9): 518-523.

[27] Al-haj, O. A. and Al-Kanhal, H. A. (2010). Compositional, technological and nutritional aspects of dromedary camel milk. International Dairy Journal, 20(12): 811-821.

[28] Khalil, I. E., Muhammad, H. A., Hana, A. A., Inteaz, A., and Taha, R. (2011). Comparison and characterization of fat and protein composition for camel milk from eight Jordanian locations. Food Chemistry, 127(1): 282-289.

[29] Wang, S. Y., Liang, J. P., Shao, W. J., and Wen, H. (2011). Mineral, vitamin and fatty acid contents in the camel milk of dromedaries in the anxigansu China. Journal of Camel Practice and Research, 18(2): 273-276.

[30] Yoganandi, J., Mehta, B. M., Wadhwani, K. N., Darji, V. B., and Aparnathi, K. D. (2015). Evaluation and comparison of camel milk with cow milk and buffalo milk for gross composition. Journal of Camel Practice and Research, 21(2): 259-265.

[31] Beg, O. U., Bahr-Lindstrom, H. V., Zaidi, Z. H., and Jornvall, H. (1986). A camel milk whey protein rich in half cystine. Primary structure, assessment of variations, internal repeat patterns, and relationships with neurophysin and other active polypeptides. European Journal of Biochemistry, 159(1): 195-201.

[32] Hull, S. J. (2004). Camel's milk to treat diabetes. Nature, 363: 446-448.

[33] Khaskheli, M., Arain, M. A., Chaudhry, S., Soomro, A. H., and Qureshi, T. A. (2005). Physicochemical quality of camel milk. Journal of Agricultural Society of Science, 2: 164-166.

[34] Konuspayeva, G., Faye, B., and Loiseau, G. (2009). The composition of camel milk: a meta-analysis of the literature data. Journal of Food Composition Annals, 22(2): 95-101.

[35] Yagil, R. (2000). Lactation in the desert camel (Camelus dromedarius). In: Gahlot TK (ed) Selected topics in camelids. The Camelid Publishers, Bikaner, India. Pp. 61-73.

[36] Zhang, H., Yao, J., Zhao, D., Liu, H., and Guo, M. (2005). Changes in chemical composition of Alxabactrian camel milk during lactation. Journal of Dairy Science, 88(10): 3402-3410.

[37] Stahl, T., Sallman, H. I., Duehlmeier, R., and Wernery, U. (2006). Selected vitamins and fatty acid patterns in dromedary milk and colostrum. Journal of Camel Practice and Research, 13(1): 53-57.

[38] Farah, Z. (1996). Camel milk properties and products. Published: SKAT, Swiss Centre for Developments Cooperation in Technology and Management, Vadianstrasse-42, CH—9000 St. Gallen, Switzerland, pp. 19-61.

[39] Ramet, J. P. (2001). The technology of making cheese from camel milk (Camelus dromedarius). FAO Animal Production and Health Paper – 113, ISBN, 92-5-103154-1.

[40] Pal, M., Devrani, M. and Pintoo, S. (2018). Significance of hygienic processing of milk and dairy products. Madridge Journal of Food Technology, 3: 133-137.

[41] Shalash, M. R. (1979). The production and utilization of camel milk. In The Camelid. An all-purpose animal. In: Proceeding of Khartoum Workshop on Camels. Pp. 196-208.

[42] Ruegg, M. W. and Farah, Z. (1991). Melting curves of camel milk fat. Milchwissenschaft, 46(6): 361-362.

[43] Asresie, A., Seifu, E., and Kurtu, M. Y. (2013). Churning efficiency and microbial quality of butter made from camel milk alone and blending it with goat milk. Net Journal of Agricultural Science, 1(3): 75-80.

[44] Pal, M. (2019). Paneer: A very popular milk product in Indian subcontinent. Beverage and Food World, 46: 23-25.

[45] Breulmann, M., Boer, B., Wernery, U., Wernery, R., El Shaer, H., Alhadrami, G., and Norton, J. (2017). The camel from tradition to modern times. A proposal towards combating desertification via the establishment of camel farms based on fodder production from indigenous plants and halophytes. United Arab Emirates: UNESCO Doha Office.

[46] Prajapati, A. (2019). Development and quality evaluation of spices incorporated camel and goat milk paneer. International Journal of Chemistry Science, 7(3): 3885-3888.

[47] Mal, G. and Pathak, K. M. L. (2010). Camel milk and milk products. SMVS Dairy Year Book, pp. 97-103.

[48] Rahman, I. E. A., Dirar, H. A., and Osman, M. A. (2009). Microbiological and biochemical changes and sensory evaluation of camel milk fermented by selected bacterial starter cultures. African Journal of Food Science, 3(12): 398-405.

[49] Hashim, I. B., Khalil, A. H., and Habib, H. (2009). Quality and acceptability of a set-type yogurt made from camel milk. Journal of Dairy Science, 92(3): 857-862.

[50] Ahmadoon, H. G. A. (2012). Quality changes in yoghurt made from camel milk and mixed camel milk with cow milk during preservation. Red Sea University Journal, 2: 24-37.

[51] Al-Zoreky, N. S. and Al-Otaibi, M. M. (2015). Suitability of camel milk for making yogurt. Food Science and Biotechnol.

[52] Ibrahim, A. H. and Khalifa, S. A. (2015). The effects of various stabilizers on physiochemical properties of camel's milk yoghurt. Journal of American Science, 11(1): 15-24.

[53] Kavas, N. (2016). Yoghurt production from camel (Camelus dramedarius) milk fortified with samphire molasses and different colloids. Dairy, 66(1): 34-47.

[54] Abou-Soliman, N. H., Sakr, S. S., and Awad, S. (2017). Physico-chemical, microstructural and rheological properties of camel-milk yogurt as enhanced by microbial transglutaminase. Journal of Food Science Technology, 54(6): 1616-1627.

[55] Galeboe, O., Seifu, E., and Sekwati-Monang, B. (2018). Production of camel milk yoghurt: physicochemical and microbiological quality and consumer acceptability. International Journal of Food Studies, 7(2): 51-63.

[56] Kamal-Eldin, A., Alhammadi, A., Gharsallaoui, A., Hamed, F., and Ghnimi, S. (2020). Physicochemical, rheological, and micro-structural properties of yogurts produced from mixtures of camel and bovine milks. NFS Journal, 19(20): 26-33.

[57] Chuvakova, Z. K., Beisembayeva, R. U., Puzyrevskaya, O. M., Saubenouva, M. G., Shamenova, M. G., Glebova, T. I., Popova, E. I., Baizhomartova, M. M., and Baimenov, E. K. (2000). Chemical composition, microbial control and antiviral properties of freshly made and conserved Shubat ''Bota''. In: Park YW (ed.), Bioactive components in milk and dairy products. Wiley, Hoboken, 2009, pp. 171-172.

[58] Rahman, N., Xiaohong, C., Meiqin, F., and Mingsheng, D. (2009). Characterization of the dominant microflora in naturally fermented camel milk shubat. World Journal of Microbiology and Biotechnology, 25(11): 1941-1946.

[59] El-Deeb, A., Dyab, A., and Elkot, W. (2017). Production of flavoured fermented camel milk. Ismailia Journal of Dairy Science of Technology, 5(1): 9-20.

[60] Prajapati, J. P., Pinto, S. V., Trivedi, M. M., Patel, A. B., and Wadhwani, K. N. (2012). Utilization of kachchhi camel milk for manufacture of medium fat ice cream. Journal of Camel Practice and Research, 19(2): 249-253.

[61] Ahmed, A. S. M. and El-Zubeir, I. E. M. (2015). Processing properties and chemical composition of low fat ice cream made from camel milk using natural additives. International Journal Dairy of Science, 10(6): 297-305.

[62] Parmar, N. B. (2013). Characterization of ghee prepared from camel milk and evaluation of its shelf life during storage. Master Thesis submitted to Dairy Chemistry Department, SMC College of Dairy Science, Anand Agricultural University, Anand, Gujarat, India.

[63] Chaudhary, M. J., Mehta, B. M., Patel, D. H., Darji, V. B., and Aparnathi, K. D. (2016). Characterization and comparison of khoa prepared from camel milk with that from cow and buffalo milk. International Journal of Dairy Technology, 70(2): 253-260.

[64] Lad, S. S., Mehta, B., Pinto, S. V., Aparnathi, K. D. (2017). Improvement in flavor of Gulabjamun prepared from camel milk khoa. International Journal of Current Microbiology and Applied Science, 6(6): 1168-1175.

[65] Gupta, D. K. (2020). Studies on camel milk powder supplemented kulfi. Chemistry Science Review Letter, 9(34): 329-336.

[66] Farah, Z. and Bachmann, M. R. (1987). Rennet coagulation properties of camel milk. Milchwissenschaft, 42(11): 689-692.

[67] Mbye, M., Sobti, B., Al-Nuami, M. K., Al- Shamsi, Y., Al-Khateri, L., Al-Saedi, R., and Kamal-Eldin, A. (2020). Physicochemical properties, sensory quality, and coagulation behavior of camel versus bovine milk soft unripened cheeses. NFS Journal, 20(20): 28-36.

[68] Kappeler, S., Farah, Z., and Puhan, Z. (2003). Flanking regions of camel milk genes are highly similar to homologue regions of other species and can be divided into two distinct groups. Journal of Dairy Science, 86(2): 498-508.

[69] Khan, H. A., Athar, I. H., and Aslam, M. U. (2004). Evaluation of cheese prepared by processing camel milk. Pakistan Journal of Zoology, 36(4): 323-326.

[70] Mihretie, Y., Tadesse, N., Amakelew, S., and Fikru, S. (2018). Cheese production from camel milk using lemon juice as a coagulant. Journal of Environmental and Agricultural Science, 17: 11-19.

[71] Habtegebriel, H. and Admassu, S. (2016). Optimization of the Production process of soft cheese from camel milk using linear programming technique. Optimization, 49: 35-41.

[72] Qadeer, Z. (2017). Optimization of Processing Parameters for Camel Milk Cheese Production. Doctoral Dissertation, University of Agriculture, Faisalabad, Pakistan.