International Archive of Applied Sciences and Technology
Int. Arch. App. Sci. Technol; Vol 8 [3] September 2017: 74-83
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[ISO9001: 2008 Certified Organization]
www.soeagra.com/iaast.html

IAAST
ONLINE ISSN 2277- 1565
PRINT ISSN 0976 - 4828

CODEN: IAASCA **REVIEW ARTICLE**

DOI: .10.15515/iaast.0976-4828.8.3.7483

Camel Milk An White Gold Of Dessert- A Review

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ABSTRACT
Camel milk is greatly esteemed for playing an important role in the diet of the people in rural areas of Africa, Asia and the Middle East, with scarce agricultural areas, high temperatures and small amount of rainfall. The camel produces handsome amount of milk compared to other species in those harsh climatic conditions. The goal of the overview is to present the chemical composition of camel milk, its medicinal value and products made from camel milk. Camel milk is more similar to human milk; it differs from other ruminant milk in its composition and has claimed to have medicinal properties. Ayurveda has referred medicinal value of camel milk under the classification of "DugdhaVarga" (Milk Classification).Camel milk has a high vitamin and mineral content and unique protective proteins. It has proven to possess beneficial effect in the treatment of diabetic and coronary artery diseases. Differences between camel and bovine milk composition had routed to some difficulties in manufacturing derived dairy product. Despite of difficulties many camel milk products have been developed throughout the world.
Key words: camel, camel milk, chemical composition, medicinal value, camel milk products

Received 11/07/2017 Revised 20/08/2017 Accepted 01/09/2017

Citation of this article
Korlepara. Raja Gopal, Adarsh M.Kalla, Vyshnavi Manthani, And Srikanth Keerthi.Camel Milk An White Gold Of Dessert- A Review. Int. Arch. App. Sci. Technol; Vol 8 [3] September 2017. 7483.

INTRODUCTION

The world food economy is being increasingly driven by the shift of diets towards animal-based products such as meat, milk and dairy. Globally livestock production is the largest user of agricultural land and therefore also leaves a significant imprint on the environment. The livestock reared throughout the world include cattle, sheep, goat, pigs, buffaloes and camels for their milk or meat. The camels have been reared from many decades and are considered to be a good source of milk and meat, and are used for other purposes such as transportation, as baggage animals and for agricultural purposes. Many researchers indicated that the camels originated in the North American continent during the Eocene period or 45-50 million years ago, when land masses were still joined and were no larger than hares[40]. Camels are multipurpose animals with females used primarily as milk producers, the males for transport or draught and both sexes providing meat as tertiary product. The family of camels, *Camelidae*is divided into 3 genera: The old world camels (genus *Camelus*) and the new world camels (genus *Lama* with the species *L. glama, L. guanicoe*, *L. pacos*and genus *Vicugna* with the species *V. vicugna*) [80]. The two domesticated species of old world camels still exist, the dromedary or one-humped camel (*Camelusdromedarius)* and The Bactrian or twohumped camel (*Camelusbactrianus).* The dromedary camel is the most important livestock animal in the semiarid areas of Northern and Eastern Africa as well as in the Arabian Peninsula and Iran. It is a multipurpose

animal and used for milk, meat, hides and transport. The Bactrian or two-humped camel (*Camelusbactrianus)* exist in the cold deserts and dry steppes of Asia.The dromedary is more numerous than the Bactrian camel and represents almost 90% of the genus Camelus. Hence this paper reviews mainly finding on milk production from dromedary.

The dromedary camel is one of the most important domestic animals in the arid and semi-arid regions as it is equipped to produce high quality food at comparatively low costs under extremely harsh environments [45, 86].Camel can produce more milk for a longer period of time than any other domestic livestock species. Milk is the main food obtained from the herd of camels [18].It provides a good source of nutrients and playsan important role in the preclusion of malnutrition in hot and arid zones of world where there is a shortage of food and water. The camel has great tolerance to high temperatures, high solar radiation and water scarcity. It is the one of the animal not only to survive but also to benefit human.Camel milk so called white gold of the desert has valuable nutritional properties as it contains a high proportion of antibacterial substances and higher concentration of vitamin C in comparison with cow milk [12]. Camel milk is much more nutritious than that of cow milk because it is low in fat and lactose contents, and higher in potassium, iron and vitamin C [35]. It is evident from the studies that camel milk has medicinal properties and is used since ancient times [33].It contains protective proteins which may have possible role for enhancing immune defense mechanism. Camel milk also contains higher amount of zinc. The rapidly dividing cells of the immune system are sensitive to zinc deficiency. The ability of camel milk to inhibit growth of pathogenic bacteria and its relation to whey lysozyme has been demonstrated by [11].Camel milk is consumed by the camel keepers of Rajasthan, Gujarat and Haryana in India, and plays an important role in the diet of this population in rural areas. Camel keepers utilize milk either raw, boiled or for tea preparation. Camel milk is used for preparation of various products throughout the world. Camel milk kheer is very much famous among the Raika's community of Rajasthan. The national research center on camel, Bikaner, Rajasthan is continuously working on camel milk, and has prepared and commercialized various camel milk products.

Chemical composition of camel milk

Camel's milk is generally opaque white in color and has a faint sweetish odor and bit salty taste[1].The composition of camel milk varies due to difference of geographical origin and other factors such as the physiological stage, feeding conditions, seasonal or physiological variations, genetic or health status of camel have also a paramount importance[46].In general the average composition of camel milk is given in below table with acidity and pH in the range of 0.12-0.14 and 6.36-6.58 respectively[52].

Fat

The camel milk is naturally homogenized milk whose milk fat ranges between 2.6 to 3.2%[52] and has a size with anaverage diameter of 2.99 μm which is less than the size of bovine milk fat globules[54]. It has an advantage from the point of view of the physiology of nutrition as there is better fat adsorption and improved digestibility of milk.In comparison with bovine milk, camel milk fat contains a lower concentration of short-chain fatty acids [3] but a higher concentration of long-chain fatty acids [47], due to which melting point and solidification temperature were found to be higher in camel milk fat. The camel milk fat contains a lower concentration of carotene and appears prominently white in Colour [78].The cholesterol content (34.5 mg/100g) was found to be higher than that reported for bovine milk fat(25.63 mg/100g) [36].

Protein

The Milk proteins are a heterogeneous group of compounds [35] and those obtained from different species differ in their composition, structure and properties from each other. The camel milk contains 3.73 to 3.89 % of total protein (table. 1)containing two main components casein and whey protein. Casein is the major protein in camel milk constituting around 52 -87% of total protein of which β- is 65%, α_{s1} casein22%, α_{s2} casein 9.5% and k-casein 3.5%[43].

Whey protein is the second principal fraction of camel milk protein which covers 20 to 25% totalprotein [48].It contains mainly α-lactalbumin (α-La), serum albumin, lysozyme, lactoferrin, peptidoglycan recognition proteins, lactoperoxidaseand immunoglobulins. The camel milk is deficient in betalactoglobulin similar to human milk [25] and α-La is the main

component whereas in bovine milk whey proteins, beta-lactoglobulin (β-Lg) is the main component (55%) and α-La is the second (20%) [23].

The α_{s1} is the predominant casein causing protein allergen [77, 17]. The human casein does not contain the αs1-fraction, but cow and buffalo milk contain greater amount ofα_{s1} casein 38.4% and 30.2% of total casein, respectively [87].The β-Lg is another major protein allergen; human milk is free of β-Lg similar to camel milk, which also has no β-Lg. On the contrary, β-Lg is a major whey protein in cow, buffalo, sheep, and goat milk [23].Since camel milk contains lower amount α_{s1} casein andβ-Lgit may be suggested as a new protein source for the nutrition of children allergic to cow milk and can be used as such or in a modified form.

Lactose

The lactose content of camel milk varies from 2.40to 5.80% [38, 85] and wasfound to have approximately the same range for both hydrated and dehydrated animals [83].The reason for variation could be due to the feed or type of plants eaten in the deserts [43].Sestuzheva found that the lactose content of camel milk remained unchanged from the first months up to the end of lactation[75].However, in some dromedary varieties of the world lactose contents found to be changed slightly over a period of time [1].

Minerals and vitamins

The mineral content of camel milk is expressed as total ash and varies from 0.82-0.85% (Table 1). The Variations in mineral content reported by various research groups might be attributed to breed differences, feeding, analytical procedures and water intake [39, 57].Camel milk is a good source of various minerals like Na, K, Ca, P and Mg which play an important role in physiological body functions.Camel milk is a rich source of chloride [43] because camels usually prefer to feed onhalophilic plants such as Atriplex, Salosa and Acacia to meet their physiological requirements of salts [82]. The values of trace minerals viz. Fe, Zn, and Cu were found to be significantly higher in camel milk as compared to bovine milk [76].

The camel milk was reported to contain various vitamins, such as vitamin C, A, E, D and B group [31, 39]. Camel milk is known to be a rich source of vitamin C (34.16 mg/L) and was reported to be three times to five times [78] higher than that in bovine milk. Hence, raw and fermented camel milk could be a good source of vitamin C with a powerful anti-oxidant action for the people living in the desert area where vegetables and fruits are scare [71]. The low pH due to the vitamin C content stabilizes the milk and can be kept for relatively longer periods.The content of vitamin A and riboflavin (B2) in Dromedary camel milk was reported tobe lower than that of bovine milk [31,78].

Medicinal Values of Camel Milk

The camel milk has been used for a number of medical problems since from historic times [82].The camel milk is not only an excellent source of nutrients but also has valuable medicinal properties as it contains a high proportion of antibacterial substances and higher concentration of vitamin C in comparison with cow milk [12].The camel milk contains number of bioactive components which are reported to exist naturally in milk such as peptides and proteins that have proven beneficial health benefits such as digestion, absorption, growth and immunity [63].Camel milk has proven to possess beneficial effect in the treatment of diabetic patients [5]. The camel milk contains several protective proteins like lysozyme, lactoferrin, lactoperoxidase, NAGase, PGRP, IgG and IgA among them effective one is lysozyme which has the ability to inhibit growth of pathogenic bacteria [29]. Camel milk also contains higher amount of zinc which helps in the development and maintenance of normal functioning of immune system.Camel milk has been acknowledged to provide a potential treatment for a series of diseases such as dropsy, jaundice, tuberculosis, asthma, and leishmaniasis or kala-azaretc [10]. Currently the status of camel milk has taken a pioneer route in terms of medicinal value and seems to have a vast scope in therapeutic and functional food industry.

Hypocholesterolaemic Effect

The cholesterol is required by body to build cell membranes, make certain hormones, and produce compounds that aid in fat digestion. However too much cholesterol, lead to a condition called Hypercholesterolemia and associated with developing a form of heart disease called coronary artery disease. Thus, much attention has been given to the

relationship between diet and blood cholesterol levels.Fermented dairy products have been recommended as dietary supplements because of their hypocholesterolaemic effect in humans [53]and rats [79]. Abdel-Gawad reported that buffalo milk yoghurt or soymilk yoghurt containing *bifidobacterium* reduced the level of plasma and liver cholesterol[2].Numerous investigations have been conducted to study have the effect of fermented product (bovine milk) especially yoghurt on reduction of cholesterol level using the strains such as *Bifidobacteriumbifidum, B.Longum* and *lactobacillus acidophilus* [13, 73]. However the hypocholesterolaemic mechanism of camel milk is still unclear, but different hypotheses have been proposed, including: interaction between bioactive peptides derived from camel milk proteins and cholesterol which result in cholesterol reduction [49, 74], and the presence of orotic acid in camel milk which is thought to be responsible for lowering cholesterol level in human subjects [16] and in rats [66].

Anti-diabetic effect

Diabetes mellitus is a long-term condition that causes high blood sugar levels. There are two types of diabetes the more severe form is type 1, or insulin-dependent diabetes. It's sometimes called juvenile diabetes. It is fatal unless treated with insulin, approximately 10% of all diabetes cases are type-1.Intype-2 Diabetes the body does not produce enough insulin for proper function. Approximately 90% of all cases of diabetes worldwide are of this type.Camel milk consumption has been reported to provide effective management for patients with type-1 diabetes [7].Various researchers have found the following possibilities for the antidiabetic effect of camel milk which include (i) the presence of high concentration of insulin/insulin like substances in camel milk [7].Thecamel milk whey protein is rich in half-cystine which has superficial similarities with the insulin family of peptides[14](ii) immuno-modulatory effect of camel milk on beta cell function [6] (iii) the human, bovine, goat and camel milk all contain insulin but only camel milk insulin is resistant to acid environment of stomach and doesn't form coagulum [7,4] It is thought to be encapsulated in nanoparticles (lipid vesicles) that make possible its passage through the stomach and entry into the blood stream.Areport on feeding of camel milk to streptozotocin-induced diabetic rats hasshown anti-hyperglycemic effects and consequently hasreduced liver and renal damage associated with rats [42].Sbouistudied the effect of heat treatment(raw, pasteurized and boiled) on anti-diabetic property of camel milk in Alloxan- induced diabetic dogs. He reported that raw and pasteurized camel milk can be used as solution to treat diabetic dogs but boiled camel milk last its therapeutic property.Pasteurization not only helps to store the camel milk but also preserves its therapeutic particularity[72].

Anti-bacterial effect

Camel's milk has natural inhibitory systems, which is reported to be stronger than the cow's milk [26]. It is found that camel milk contains various protective proteins, mainly immunoglobulins (Ig's), lysozyme (LZ), lactoferrin(LF), lactoperoxidase (LP) [68] Peptidoglycan recognition protein(PGRP) and N-acetyl-β-D-glucosaminidase (NAGase)that exhibit antibacterial and immunological properties. The levels of lysozyme and lactoferrins are reported to be two and three times higher than those of cow's milk, respectively [11, 19].Lysozymes exert a broad spectrum of antimicrobial action. It targets bacterial cell wall containing peptidoglycan, which is the specific site for lysozyme action. It has muramidase activity against Gram positive bacteria and Streptococcus [61].The antibacterial activity spectrum of camel milk LZ is similar to that of egg whiteLZ, and differed from bovine milk LZ[26].Thelactoferrin is an iron binding protein and divests the microorganism from iron by binding to it and hence possess a bacteriostatic effect against variety of infectious agents including both Gram-positive and Gram-negative bacteria, viruses, protozoa and fungi [8].Howeverit was reported that E.coli strains produce siderophores that help them counter the Fe-binding activity of the LF[69, 37]. The Citrate ions also compete for Fe with LF and high levels of citrate in milk reduce the inhibitory effect of LF [68]. Since camel milk contains less citrate than does cows' milk [24], the in vivo activity of camel LF would be expected to be high. The Camellactoperoxidase is bacteriostatic against Gram-positive cultures, but is highly bactericidal against Gram-negative strains. The camel LP exhibits the same activity pattern as that of bovine LP [26]. It provides the protection of the udder from microbial infections [58]. The camel milk contains various immunoglobulins mainly IgM, IgG, IgA and IgD [4].The small size, high affinity and specificity of camel Igs, allow them to penetrate dense tissues and reach the antigens and also easily pass from camel

milk into the human blood. Hence camel immune system is stronger than that of humans. As immunoglobulins are found in camel milk throughout lactation, drinking milk will improve the immune system. The peptidoglycan recognition protein (PGRP)enzyme was first discovered in camel milk, and is present in higher concentrations in camel milk[60]. It has apparent effect on breast cancer [44] and exhibits broad antimicrobial activity.The camel milk is used to treat tuberculosis and combined with PGRP have a quick and positive effect on the crohn's disease[81].TheN-acetyl-β-D-glucosaminidase (NAGase)is the most reliable lysosomal enzyme in milk for diagnosis of mastitis. However the camel milk is rich in in NAGase, but it is established to have antibacterial activity [60].

Camel milk products

Camel milk and its products play an important role in the diet of the people living in dry areas where raw milk and fermented products are important source of energy and nutrients [15].It has been reported that camel milk is only suitable for drinking [84]. However, the composition of camel milk does not allow for making some of the accepted products that are made from cow, sheep and goat milk. Nevertheless, milk products are made from camel milk, and the milk itself is used for purposes other than simply nutrition. In India at national research center on camel Various camel milk products have been developed and commercialized viz. ice cream/kulfi with different flavors, flavored milk, fermented milk, cheese, tea and coffee. The camel milk kheer is very much famous among the Raika's community of Rajasthan [51]. Various other products like fermented products, butter are also produced in other parts of world.

Fermented milk products

The raw camel milk does not stay for long time and its fermentation appears to be a means to preserve it for a longer period of time. Fermented products have various names in various parts of the world [9] like yoghurt, kefir, matzoon, dahi, gioddu, lehben,Tarag, Unda, Shubat (Chal), Suusac (Susa) andGariss. These products vary in the way they are produced and the starter cultures used. The chal is prepared by diluting the milk with warm water in the ratio 1:1 and then stored in goat skin or ceramic containers and inoculated with 1/3 or 1/5 of previously fermented milk. Incubation takes 3 to 4 hours at 25-30 °C, but is usually left for 8 hours at the same temperature to obtain its typical taste. The suusacis prepared by placing Fresh milk into previously smoked pumpkin vessels and left for 2 days at a temperature of 25 to 30 °C in order to ferment [50]. The obtained product is variable in taste and aroma.The gariss is another fermented camel milk product which is prepared by placing raw milk into goat skin bag which is hung on camel's saddle. The bags are usually covered with green grass or dry grass moistened with water and wrapped in a firm net made of palm leaves. Owing to a specifically rough camel walk, during the journey the milk is shaken and stirred and resulting in oxygen enrichment of the milk influencing significantly the fermentation.

Butter

The pastoralists from many countries who rear camels have found difficult to churn the camel milk to make butter [82]. The traditional churning methods used for cow milk have also been unsuccessful to obtain butter.The difficulty in churning has been revealed by many researchers claiming that, the camel milk shows little tendency to cream up because fat is distributed as small micelle-like globules in the milk [67, 20 &83] and the fat in camel milk is firmly bound to the protein. The high melting point of camel milk fat (41- 42 °C) also makes it difficult to churn the cream at temperatures used for churning cow milk (8-12 °C) [15]. Although it is difficult to make butter from camel milk, reports revealed that Nomads produce butter from camel milk in several ways. In the area of north-eastern Kenya they use methods by which only small amount of camel milk fat is obtained. On a fire, few rocks are heated and the vessel with raw milk is kept over it. Drops of fat are formed and appear on the surface. After cooling, milk is churned until fat drops turn into butter grains. Whereas in Sahara butter is being produced by leaving camel milk in goat skin at room temperature for 12 hours in order to ferment. Subsequently the goatskin is inflated with air and closed, hung on a tent pole and swung fast forth and back. At the end of churning, some cold water is added which helps in forming butter[82].TheFresh butter is not eaten as such, but is often used as a base for medicines. The fresh butter is difficult to preserve as it is not limpid and becomes rancid rapidly. The Touaregs (nomadic tribe of Sahara) improve the shelf life by melting down the camel milk butter and transforming it into clarified butter

oil called "Shmen" / "semma". The butter is melted at 100–120˚C for 30 minutes. A clarifying agent is added to hot butter and it is stirred with a wooden spoon. An experiment was conducted for industrial production of butter in the rural part of north-eastern Kenya. Milk was heated to 65 °C and then centrifuged. The percentage of fat in cream was standardized to 20-30 %. Afterwards, it was churned at temperatures between 15 and 36°C. After churning, butter was flushed with water at room temperature of 27°C. Best results were obtained by churning cream with 22.5 % fat and 25°C. Churning time was 11 minutes[32].The camel butter is characteristically rich in polyunsaturated fatty acids. There are only traces of fatty acids with chains shorter than C-12 lauric acid. The butter does contain normal amounts of C-16 palmitic acid, and has very high content of the polyunsaturated C-18 oleic and linoleic acids, when compared with butter obtained from milk of other animals [34].

Cheese

The processing of camel milk into cheese is said to be difficult even impossible [82].It appears that the camel milk is technically more difficult to process than compared to other dairy animals. However, researchers claim that nomadic pastorals have produced some variety of cheeses but have not been commercialized. There are number of problems associated with production of cheese such as, long coagulation time, the rennet coagulation time of camel milk is two to four times slower than cow's milk [64, 30& 59].This unusual behavior may be attributed to specific casein micelle composition characterized by a low proportion of k-casein; the average content of k-casein in camel milk is only about 5% of total casein compared with 13.6% in cow's milk[41].Camels milk casein also differs in terms of micellar size, they are about double the size of cow's milk casein [30, 28]. The larger size caseins with lower amount of K-casein had reduced the ability to coagulate and significantly reduced the firmness of curd [21,62]. Camel milk forms a weak curd; the firmness of curd depends on the total solids content in which casein has the major role. Higher the casein content stronger is the formation of micelle network. Since camel milk has lower total solids hence forms a weaker curd [22, 65 & 56].Another reason for weaker curd rigidity is the small size of fat globules [20, 27].Farah & Bachmannstudied the effect of temperature, pH and calcium chloride on coagulation time and reported thatcoagulation time reducedby decreasing pH and by increasing temperature and added calcium[30].Hence camel milk alone cannot be coagulated with rennet. However, Rao and Yagil reported that cheese can be successfully produced from camel milk, but only after it was mixed with milk of other species (goat, sheep or buffalo)[67, 82].Moreover several studies were able to produce different varieties of camel cheeses that include semi hardcheeses and hard cheese [59, 65];Domiati type, which is a fresh soft white cheese [55]; and processed soft un-ripenedcheese [70]. However, most of those procedures require a longer time for fermentation, coagulation and drainage of the whey.To solve the problem of long time coagulation, the FAO has developed and approved a coagulating agent called "Camifloc" used to curdle camel milk it contains calcium phosphate and vegetable rennet.It is sold in small and easy-to-use packets, in Mauritania, Mali and the United Arab Emirates[22].

Other products

At National Research Center on Camel, Bikaner in India has developed various indigenous camel milk products like Camel milk paneer, Camel milk kulfi with variants viz kesar kulfi chocolate and sugar-free kulfi which were prepared from boiled and concentrated camel milk to 2:1 ratio and camel milk gulabjamun was prepared from camel milk khoa/mawa.

Table 1. Chemical composition of camel milk

Components	Average (%)
Moisture	88.55-90.15
Total solids	9.85-11.45
Fat	2.60-3.20
SNF	7.25-8.25
Protein	3.73-3.89
Casein	2.90-3.02
Ash	0.82-0.85

CONCLUSION

The people living in hot and dry lands greatly depend on camel which is a vital animal for dessert dwellers as a source of food, transportation and its milk providing medicinal properties.Camel milk and milk products are good source of nutrition and income for people living in dessert. Camel milk could soon become the new super food due to its high nutritional value, easy digestibility (suitable for people with lactose intolerance) and low share of fat. Camel milk is unique containing various protective proteins like lysozyme, lactoferrin, lactoperoxidase, immunoglobulins which exert antioxidatives, antibacterial, antiviral, antifungal, hypoglycaemic, antiparasitic, growth promotion and aging prevention. Camel milk contains high levels of insulin or insulin like protein which pass through the stomach without being destroyed. Camel´s milk cures severe food allergies, skin diseases and hepatitis.To extend the limited storage life of camel milk, it is being processed into several products such as fermented milk, butter, cheese, kulfee, paneer and gulabjammun. Many camel milk products have been standardized and commercialized in some parts of the world. The aim of the present review has been to bring together as much information as possible on the properties and therapeutic value of camel milk with processing and technology of various camel milk products.

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