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Nutritional and therapeutic value of camel milk

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Abstract

Camel milk has been consumed for centuries as food and medicine by nomads; therefore, its composition, medicinal value, and processing have been investigated. The low fat and cholesterol level contained in camel milk makes it healthier than milk from other ruminants. Several studies have revealed the medicinal effects of camel milk upon consumption. Diseases such as diabetes, autism, constipation, and tuberculosis can be cured by camel milk. Additionally, this latter has the potential to prevent and cure allergies as well as several immune diseases. In recent years, consumers have become conscious about the benefits promoted by camel milk, and hence it has been introduced into the national as well as international market. Camel milk production has seen an exponential development as its growth exceeded 8% between 2009 and 2019. The increase in demand prompted industries to process camel milk into various products. Different processing techniques are being applied to camel milk to prolong its shelf life and formulate a variety of products. Due to its composition, pasteurization of camel milk possesses its indicators, and the formulation of acceptable cheese remains a challenge.

Keywords: Camel milk, shelf life, medicinal properties, dairy products

1. Introduction

Milk is considered a complete food because it contains a variety of nutritional and bioactive components (Chauhan *et al.* 2021) ^[1]. Camel milk has been consumed for centuries by the nomads. People in the desert would spend more than a month consuming nothing but camel milk because of its similarity to human milk (Gul *et al.* 2015) ^[2]. Considered as a complete food, it has intrigued researchers due to its rich nutrient composition and its potential health benefits. Camels are mainly classified into two species namely Bactrian (*Camelus bactrianus*) characterized by two humps and Dromedary (*Camelus dromedarius*) characterized by one hump (Mihic *et al.* 2016) ^[3]. They are originally from northern America and migrated later in the tertiary to Asia and Africa (Farah 1993) ^[4]. Over the years, this traditional milk has undergone plenty of processes from pasteurization to fermentation and drying to preserve it and formulate various products. As per FAO (2014) statistics, there are 27 million camels in the world (Faye 2014) ^[5]. For many years, camel milk is being administered to children who suffer from nutrition deficiencies in different parts of the world thus it has emerged as a new super food with a large number of health benefits (Kumar 2015) ^[6]. It is nowadays considered as a potential cure for several diseases including diabetes, allergies, autism (Kumar 2015) ^[6]. These health benefits can be explained ultimately by the presence of protective proteins that lead to anti-microbial and anti-viral activities of camel milk. In comparison with milk from other species, “camel milk is more like human milk since it contains low cholesterol, low sugar, abundant minerals (sodium, potassium, iron, copper, zinc, and magnesium), high L-ascorbic acid, protective proteins namely lactoferrin, lactoperoxidase, immunoglobulins, lysozyme” (Yadav *et al.* 2015) ^[7]. Additionally, a protein similar to insulin is found in camel milk, it is known to provide health benefits. This review summarizes the nutritional, therapeutic, and industrial applications of camel milk as illustrated in Figure 1.

2. Chemical composition of camel milk

Camel milk is the nutrient-dense product. Its composition may vary due to different factors including season, feed, breed, milking stage, etc. Drinking water is also a major factor influencing the composition of milk. The medicinal advantages of camel milk are for the most part portrayed by its low fat and cholesterol level.

Like milk from other ruminants, Camel milk contains a high amount of moisture and protein and it is a dense source of enzymes, vitamins, minerals, fatty acids, (Kumar 2015) [6]. The composition of mammalian milk varies by species, as well as environmental and internal factors including genetic makeup also alter the composition of milk and its derivatives (Mehra, Singh, *et al.* 2021; Mehra *et al.* 2022) [8, 9].

Table 1. Composition of milk from camel, in comparison with cow, buffalo, sheep, goat, and human

Proximate	Water%	Protein%	Fat%	Ash%	Lactose%
Camel	86-88	3.0-3.9	2.9-5.4	0.6-0.9	3.3
Cow	85-87	3.2-3.8	3.7-4.4	0.7-0.8	4.8-4.9
Buffalo	82-84	3.3-3.6	7.0-11.5	0.8-0.9	4.5-5.0
Sheep	79-82	5.6-6.7	6.9-8.6	0.9-0.1	4.3-4.8
Goat	87-88	2.9-3.7	4.0-4.5	0.8-0.9	3.6-4.2
Human	88-89	1.1-1.3	3.3-4.7	0.2-0.3	6.8-7.0

Source: Alhaj and Kanhal 2010; Mehra, Sangwan, and Garwhal 2021 [12, 13]

2.1 Protein

Protein is present in milk in a relatively high amount. Milk proteins are defined as a heterogeneous group of compounds that contrast in properties and composition (Gizachew, Teha, and Tessema 2014) [10]. The major groups of protein found in camel milk are casein, whey protein, and a variety of protective proteins. The latter consists of enzymes and exert immunological as well as antibacterial activities (Yadav *et al.* 2015) [7]. A portion of the regular healing properties of camel milk is underscored by the presence of protective proteins in it (Kappeler 1998) [11]. “Casein addresses the fundamental protein in milk. Dromedary camel milk has 1.63 to 2.76 percent of casein protein which establishes 52 to 87 percent of complete milk protein. Whey protein is the second most significant protein in milk which covers around 20% of camel milk protein. The milk of the dromedary camel has a whey protein in the scope of 0.63 and 0.80 percent”.

2.2 Fat

Camel milk contains 2.9-5.4% (Table 1) of fat substances which are for the most part constituted of omega fats and fatty acids (Gul *et al.* 2015) [2]. Generally, milk fat provides essential fatty acids, occurs as a dissolvable for fat-solvent vitamins, and serves particularly as an energy source. When compared with the milk of cow-like, the milk fat of dromedary camels conveys a lower concentration of carotene and a lesser amount of short-chain fatty acids (Stahl *et al.* 2006) [14]. In addition, camel milk fat is found to have a relatively higher level of cholesterol (34.5 mg.100 g-1) (Konuspayeva *et al.* 2014) [15]. However, the effectiveness of the human immune system may be boosted by the effect of fatty acids presents in camel milk (Kumar 2015) [6].

2.3 Lactose

Lactose is the principal carbohydrate found in camel milk and it ranges from around 3.3% (Table 1). The change in lactose content may be caused by the varieties of feed consumed by the animal. According to several researchers, the adjustment of lactose fixation would account for the milk being described as sometimes sweet and other times bitter. Lactose present in the milk does not deliver indications of lactose intolerance in people as it is promptly processed by the human catalyst lactase.

2.4 Vitamins and minerals

Dromedary camel milk is found to contain a great number of vitamins including vitamin A, C, D, E, and vitamins of the B group. Camel milk is highly rich in vitamin C and hence it is known to possess a powerful antioxidant activity. As a result, its low pH balances out the milk, and along with this fact, camel milk can be stored for a moderately long period without the development of a cream layer. Different minerals, for example, Na, K, Ca, P Mg Fe, Zn, and Cu are available in camel milk. The physical state and stability of milk proteins are impacted by milk minerals, especially the caseinate, which is exceptionally reliant upon the organization of the salt system.

3. Therapeutic value of camel milk

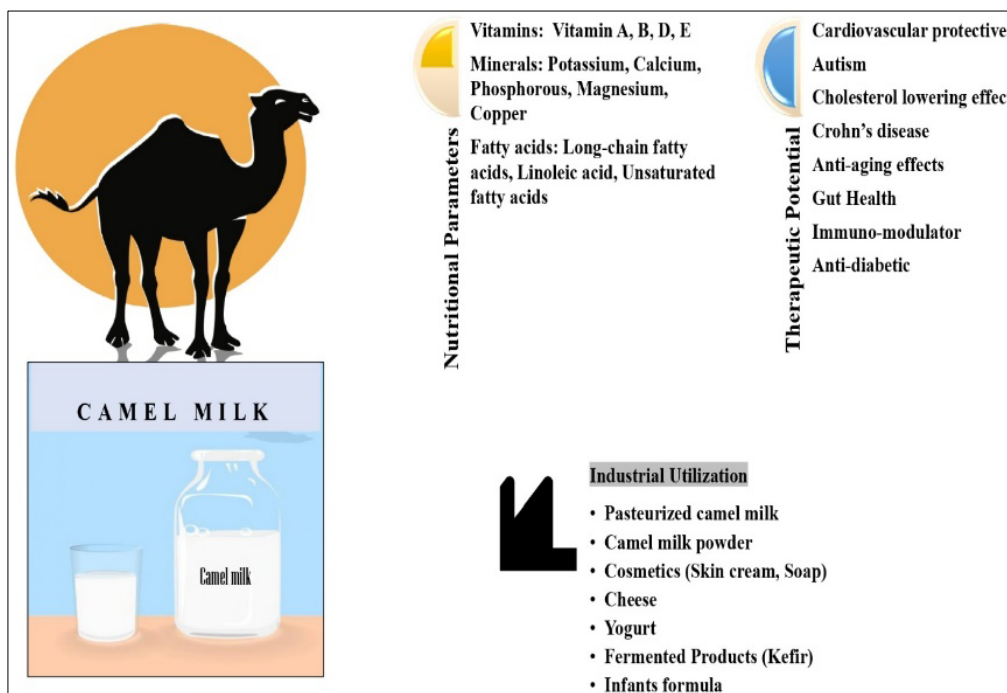


Fig 1: Nutritional, therapeutic, and industrial application of camel milk

Camel milk has been consumed for a long time by individuals from the deserts. It is rich in nutrients and provides functional properties. Camel milk's medicinal properties have been investigated and it is found that camel milk has the potential to treat several diseases including "IDDM (insulin-dependent diabetes mellitus), Crohn's disease, autism cirrhosis of the liver, constipation, tuberculosis, and a few autoimmune diseases". Moreover, Camel milk has been recognized for a long time in various regions of the planet to provide an expected treatment to a progression of infections like "dropsy, jaundice, tuberculosis, asthma, and leishmaniasis".

3.1 Camel milk for diabetes

Camel milk is acknowledged to be beneficial for individuals who suffer from diabetes as it contains insulin-like proteins. When compared with cow's milk (17.01 ± 0.96 UL), it is plenty of insulin concentrations (58.67 ± 2.01 UL) (Mullaicharam, A. R. 2014) [16]. It is a rich source of vitamins and minerals and it is low in cholesterol and fat content. This milk rich in insulin quickly passes the stomach into the digestion tracts, therefore, tissue repairing proteins in camel milk act as a remedy to increased blood and urine glucose caused by lack of insulin. "The review directed by India's Bikaner Diabetes Care Research Center in 2005, noticed advantageous impacts of camel milk utilization on type-1 diabetes as it fundamentally diminished insulin doses required to maintain long-term glycemic, or blood sugar levels under control". On the other hand, concluded that insulin present in camel milk is emphatically influencing glucose and lipid profile of patients with type 2 diabetes.

3.2 Camel milk against allergies

Adults and children are suffering from different food allergies in every part of the world. The proteins β -lactoglobulin and β -casein found in milk from different ruminants cause allergies to humans. However, camel milk does not contain β -lactoglobulin and its β -casein is different from the one that is present in milk from other species. Immunoglobulins similar to those in human milk are contained in camel milk. According to a study carried out by Ehlal et al. (2011) [17], camel milk can be regarded as a more secure option than goat milk in the greater part of children with side effects caused by milk allergies. Therefore, camel milk may be recommended as a cure for children's allergic reactions and also as a source of protein for allergic individuals.

3.3 Camel milk against Autism

Autism or autism spectrum disorder is a complex developmental disorder that is related to symptoms such as restricted, repetitive patterns of behavior, interests, and activities, along with communicative and social interactive issues. Autism is principally caused by excessive oxidative stress and weak immunity. The usage of camel milk in children experiencing autism resulted in a decrease in symptoms and worked on facilitated abilities, language, comprehension, joint coordination, and skin health. This can be explained by the powerful antioxidant activity provided by camel milk. Researchers recommended that "camel milk could assume a significant part in the decrease of oxidative stress by an increase in antioxidant enzymes and non-enzymatic antioxidant molecule levels, as well as show improvement of autistic behavior in children". The

immunological properties of camel milk also play a major role in treating autism.

3.4 Antibacterial and Antiviral effects

Camel milk possesses anti-microbial enzymes namely lactoferrin and lactoperoxidase in higher concentrations and hence it acts as an anti-microbial agent. Lactoferrin can actively react as a bacteriostatic as well as a bactericidal agent (Al-Majali et al. 2007; Harish Kumar et al., 2014) [18, 19]. Gizachew et al. (2014) [20] outlined that "Iron-saturated lactoferrin (from week 2 of lactation) participates in the primary immune system which focuses on targeting structures common to attacking pathogenic agents and it also prevents microbial growth in the gut". The human immune system may be boosted by protective proteins such as caseins, and immunoglobulins found in camel milk and hence they help in fighting auto-immune diseases including Crohn's disease and multiple sclerosis. Moreover, camel milk antibodies have the potential to selectively inhibit the viral enzyme system.

4. Processing of camel milk

Fresh raw camel milk has been consumed for several years by nomads. Recent discoveries on its medicinal value have prompted the incorporation of camel milk into the dairy industry. For instance, according to FAO stat (2021), the growth of camel milk production is assumed to have exceeded 8% between 2009 and 2019 (Konuspayeva and Faye 2021) [21]. Its processing will enhance a wide variety of functional products with longer shelf life. Camel milk differs from milk from other species in terms of distribution, composition, and molecular structure, consequently, its processing contains specific properties.

4.1 Pasteurization of camel milk

Milk pasteurization involves heating milk for a specific period and temperature to kill bacteria and prolong the shelf life. It is used in countries that are abundant in camels to render camel milk safer for consumption. Pasteurized camel milk is commonly sold in local markets from Algeria, United Arab Emirates (UAE), Niger, Saudi Arabia, Mauritania, Kazakhstan, Tunisia, and Morocco (Konuspayeva and Faye 2021) [21]. Industries follow different conditions to pasteurize camel milk although the aim is to achieve a product safe for consumption and at the same time avoid nutrient losses due to heating temperature. Pasteurization of camel milk has its indicators due to its particular composition. (Elagamy 2000; Mehra et al., 2021) [22, 9] indicated alkaline phosphatase, which is generally used as an indicator for the pasteurization of cow milk (Kumar Harish et al. 2015) [23]. Is still active at 90 °C. Therefore, it has been suggested to consider glutamyl transpeptidase (75 °C for 30 s) or leucine arylamidase (75 °C for 28 s or 80 °C for 7 s) as an indicator of pasteurization for camel milk (Loiseau et al. 2002) [24].

4.2 Fermentation of camel milk

Fermentation is a technique generally used for food preservation. Fermentation of milk including camel milk is an antiquated practice where lactose is converted into lactic acid by the normal microflora in milk overwhelmed by lactic bacteria and, sometimes, by yeasts. Lactic acid is considered to preserve significant constituents found in milk (Mehaia 1993; Kumar, H. et al. 2014) [25, 26], It additionally

diminishes the pH which influences the actual properties of casein, and finally facilitates the digestibility in humans (Solanki and Hati 2018) ^[27]. According to Bahobail, Ali, and Alyan (2014) ^[28] fermentation of camel milk enhances an increase in the concentration of amino acids, fatty acids, and organic acid hence an improvement in the nutritional value of fermented camel products. Camel milk can be fermented into a variety of products including yogurt and cheese. However, due to its antimicrobial activity, fermented camel milk is reported to remain consistently stable for a longer period when compared to fermented milk from other species (Berhe *et al.* 2017) ^[29].

4.3 Manufacture of yogurt from camel milk

The suitability of processing yogurt from camel milk has been discussed by several scientists. Traditional cultures (*Lactobacillus bulgaricus* or *Streptococcus thermophilus*) and other bacterial cultures were used as inoculum (Mehra, Kumar, *et al.* 2021) ^[30]. Food containing probiotics is becoming more popular throughout the world as a result of the constant generation of studies revealing their potential health advantages to consumers, and the development of camel milk-based products has recently been documented in the literature (Dogra *et al.* 2021; Yadav *et al.*, 2016) ^[31, 32]. Yogurt from camel milk is practically dense in nutrients, however, its texture has received low appreciation by consumers due to stickiness (Berhe *et al.* 2017) ^[29]. In this regard, authors have suggested the addition of gelatin, alginate, or calcium (Hashim, Khalil, and Habib 2009) ^[33]. The addition of xanthan gum may be a solution to an unsatisfactory texture of yogurt. On the other hand, researchers have attempted to mix camel milk with milk from other ruminants to improve the texture of camel milk yogurt (Shamsia 2009) ^[34]. In the end, camel milk is more suitable for drinking yogurt.

4.4 Manufacture of cheese

The manufacture of camel milk cheese is ambiguous although this process can enhance the therapeutic and nutritional values of camel milk during ripening. The uniqueness of camel milk properties and composition results in lower yield and obtention of a less firm coagulum during cheese manufacturing (Berhe *et al.* 2017) ^[29]. Currently, the studies are limited to soft unripened cheeses processed at high cooking temperatures, with bovine chymosin and mesophilic cultures (Baig *et al.* 2022) ^[35]. Hence, camel milk cheese is not available in the commercial market. Baig *et al.* (2022) ^[35] proposed certain solutions to overcome the challenges that occurred during cheese processing and concluded that utilizing recombinant camel chymosin helps in coagulating camel milk, however, the degree of its hydrolysis relies upon a few variables like fermentation, pH, calcium and gelation time. Whey is the by-product generated from the cheese industry, which is an excellent source of major and minor proteins including beta-Lactoglobulin, lactoferrin, α -Lactalbumin, BSA, glycomacropeptide (GMP) (Jain *et al.* 2022) ^[36], recently camel whey is exploited as a dietary ingredient in the prevention of numerous chronic disorders (Badr *et al.* 2017) ^[37].

5. Conclusion

Due to the presence of low fat and cholesterol levels, as well as a substantial amount of antimicrobial peptides, camel

milk has been shown to have nutritional and therapeutic value in a recent study. The global market for camel milk and camel milk products is quickly developing due to the number of nutrients and bioactive elements in camel milk. Scientists should investigate ways to solve the obstacles that arise during the manufacturing of camel dairy products because processing camel milk into diverse products might be regarded as a means of preservation. Furthermore, numerous researches on the therapeutic effects of camel milk on human patients are needed, as well as strong international regulations to prevent adulteration of this valuable product.

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