

# Growing Importance of Camel Milk in Human Health

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## Abstract:

Milk is considered as a complete food as it is rich in proteins, fats, minerals, and vitamins that are essential for human nutrition. Camel milk, a dietary staple in hot and arid regions for millennia, has recently gained attention for its nutritional richness and therapeutic properties. With a global camel population of 35 million, countries in East and Central Africa harbor the largest populations, with Ethiopia ranking second in production after Somalia. Beyond its significance in pastoralist communities, camel milk exhibits diverse health benefits, including anti-aging, anti-inflammatory, and immunomodulatory effects. Its unique chemical composition, including high levels of vitamin C, essential minerals, and protective proteins like lactoferrin, lactoperoxidase, immunoglobulins, and lysozyme, makes it a potential alternative to bovine milk. Camel milk lacks  $\beta$ -lactoglobulin, which causes allergic to cow milk proteins. Notably, camel milk's role in managing conditions such as diabetes, allergies, autism, cancer, tuberculosis, hepatitis, and arthritis. Moreover, its hypoallergenic nature and antimicrobial properties make it a promising functional food. Insulin-like proteins, which imitate insulin's role in controlling blood sugar levels and hence improve glucose uptake, contribute to its efficacy. Camel milk has cosmetic effects due to the presence of  $\alpha$ -hydroxy acids, which help to plump the skin and smooth fine lines. Despite its importance, camel milk remains underappreciated, necessitating further research and awareness efforts to unlock its full therapeutic potential and promote its consumption. This paper aims to shed light on the diverse health benefits of camel milk.

**Key words:** camel; health benefits; milk; nutritional value

## 1. Introduction

Milk is a rich source of macronutrients and micronutrients, which are imperative for good health. Camel milk has long been a staple in the diets of people living in hot regions and arid parts of the world for millennia. Its nutritional richness and therapeutic effects have garnered increasing interest, positioning it as a potential alternative to bovine milk [1]. With an estimated global camel population of 35 million, primarily consisting of dromedaries (one-humped) and a smaller proportion of Bactrian camels, countries in East and Central Africa, including countries like Somalia, Chad, Sudan, Ethiopia, and Kenya, harbor the largest populations [2]. Ethiopia stands out as a key player in camel milk production, ranking second globally next to Somalia, with an annual production estimated at 75,000 tons [3]. This milk production is vital for food security for pastoralist in arid and semi-arid regions of Africa and Asia [4], notably in eastern Ethiopia [5].

Camel milk's significance extends beyond mere numbers. In regions like India, Ethiopia, Sudan, and other camel rearing countries, camel milk is primarily consumed raw by camel-keeping societies [6]. Current studies showed that it has high nutritional value and health benefits compared to milk from other species [7]. It is known for its anti-aging properties, cosmetic benefits, and immunity against diseases and detergents. It also treats multiple diseases, such as diarrhea, cow milk allergy, diabetes, hepatitis, cancer, psoriasis, malnutrition, and bacterial and viral infections [8].

Camel milk has a unique chemical composition compared to milk from ruminant animals like cows, sheep, and goats. This includes low levels of beta-casein and a lack of beta-lactoglobulin, making it suitable for individuals allergic to or intolerant to cow milk proteins [9]. Furthermore, it contains lower sugar and cholesterol levels while boasting higher

vitamin C content and essential minerals like zinc, iron, manganese, and copper compared to bovine milk. Additionally, camel milk is rich in protective proteins like lactoferrin, immunoglobulin, lactoperoxidase, and lysozyme [10]. Despite its potential, details about camel milk's significance in human nutrition and health benefits were a little limited. Therefore, this paper aims to address this gap by compiling information on the growing importance of camel milk in promoting human health.

### 1.1. Chemical composition and nutritional attribute of camel milk

Camel milk's nutritional and physiological benefits have garnered increasing interest, positioning it as a promising alternative to bovine milk. Its unique composition enhances digestibility within the human gastrointestinal system, attributed to smaller milk-fat globules and hypoallergenic properties [11]. Camel milk contains less saturated fat and higher levels of vitamins, particularly B1, B2, and C. Notably, its Vitamin C content (24–52 mg/kg) is three to five times greater than cow's milk and 1.5 times that of human milk, making it a crucial dietary element in desert areas with scarce fruit and vegetable access [12]. Furthermore, Bentsen [13] observed that camel milk is rich in unsaturated fatty acids, linoleic acid, and long-chain fatty acids, which are beneficial for cardiovascular and cognitive health.

Similar to cow's milk, camel milk is a valuable supply of several nutrients, particularly salt, calcium, magnesium, potassium, and phosphorus. Ca, P, and Mg levels in particular are comparable between camel and cow milk minerals. The primary change is in the mineral content—camel milk contains higher quantities of Na, K, Cu, Fe, Mn [14], and Zn [15]. Geographical origin and seasonal variations significantly influence camel milk composition; with East African camels displaying a higher fat

content than their counterparts elsewhere [4]. Camel milk's higher iron content can help prevent iron-deficiency anemia. Manganese is necessary for numerous enzymes, including those that protect cells from free radical damage, even though it plays a crucial role in cellular metabolism [16].

Proteins from camel milk have a different makeup than proteins from other mammals and from milk from cows. They are classified as caseins and whey proteins, making up 73.1% and 26.9% of all proteins, respectively [17]. Caseins are highly digestible in the colon and are vital for supplying critical amino acids that are necessary for the growth and development of newborns. Comparing camel milk to bovine milk, the protein composition of camel caseins is different; camel milk has more  $\beta$ -casein and less  $\kappa$ - and  $\alpha$ S1-casein [18]. As in human milk, dromedary camel and Bactrian whey lack  $\beta$ -lactoglobulin, this is a major whey protein in bovine milk, and instead contains higher levels of  $\alpha$ -lactalbumin, camel serum albumin (CSA), and lactoferrin [17]. Camel  $\alpha$ -lactalbumin is considered more nutritious than its bovine counterpart due to its higher concentration of essential amino acids, higher concentration of  $\beta$ -casein and lack of  $\beta$ -lactoglobulin, which contributes to the higher digestibility rate of camel milk and a lower incidence of allergies in infants [19]. Lactoferrin, lysozyme, immunoglobulin, lactoperoxidase, peptidoglycan, lactoalbumin, serum albumin, and peptidoglycan recognition proteins are the main constituents of camel milk [20].

In terms of nutritional content, camel milk typically contains 3.4% protein, 4.4% lactose, 0.79% ash, 87% water, and 3.5% fat, with variations in thickness (1.026-1.035) and pH (6.2-6.5) (Table 1). During dry conditions, the water content in camel milk can increase, making it helpful in treating dehydration in humans [21]. The physicochemical properties of camel milk along with other species of mammals is presented in Table 1.

Composition	Camel	Mithun	Cow	Goat	Human
Total protein %	2.4–4.2	4.4–9.8	3.2 3.1–3.3	1.10– 3.18	0.9–1.9
Total solids %	10.6–11.3	20.94–22.62	10.8–12.3	12.60–15.17	10.7–12.9
Total fat %	2.0–6.0	7.72–10.25	3.3–5.4	3.9– 5.7	2.1–4.0
Lactose %	3.5–4.9	4.36–4.60	4.9–5.6	4.0–5.5	6.3–7.0
Ash %	0.69–0.9	0.9–0.93	0.7–0.8	0.8–0.9	0.2–0.3
Solids-not-fat %	8.6	13.40–13.70	9.1	8.75	8.9
Reference	[22, 23]	[24, 25]	[23, 26, 27]	[28, 29]	[23, 27, 30]

**Table 1:** Physicochemical properties of camel milk in different species of mammals

### 1.2. Role of camel milk in human health

Several diseases were traditionally treated at home with camel milk. People who live in pastoral areas have long recognized their medical benefits. However, recent studies have illuminated the particular components of camel milk that provide its health benefits. Milk of camel contains antimicrobial properties, including, antiviral, antibacterial, and antifungal. Antibacterial and antiviral activities of camel milk proteins have been investigated. Additionally, camel milk is recognized for its role in managing various health conditions, including diabetes, allergies, autism, hepatitis, and arthritis [31].

#### 1.2.1. Potential benefits for brain conditions and autism treatment

Al-Ayadhi and Halepoto [32] described that autism is a complicated neurodevelopmental condition marked by difficulties with social interaction, communication, and repetitive activities. Reduced oxidative stress is one of camel milk's benefits for people with autism. An imbalance between free radicals and antioxidants in the body can lead to oxidative stress, which has been linked to the etiology of a number of neurological conditions, including autism. Antioxidants, including

vitamins A, C, and E, along with minerals like zinc and magnesium, are abundant in camel milk and may help lessen the negative effects of oxidative stress on brain function [33].

Additionally, camel milk is distinguished by its ability to boost the immune system. Camel milk contains antibodies similar in size to human immune antibodies, which could potentially modulate the immune system and support brain development. These antibodies, along with the lower content of  $\beta$ -casein and absence of  $\beta$ -lactoglobulin found in camel milk compared to cow's milk, may contribute to its suitability for individuals with Autism, as they reduce the likelihood of forming opioids like casomorphin, which can exacerbate cognitive and behavioral symptoms [9]. Several studies have reported behavioral improvements in children with Autism following the consumption of camel milk. These improvements include enhanced motor skills, language abilities, cognition, joint coordination, and skin health [29]. Furthermore, some anecdotal evidence suggests that camel milk may lead to remarkable improvements in behavior and dietary habits among autistic children [34].

#### 1.2.2. Role of camel milk against blood sugar and insulin

People with diabetes, both type 1 and type 2, may benefit from camel milk [34, 35]. Insulin-like proteins, which imitate insulin's role in controlling blood sugar levels and hence improve glucose uptake, contribute to its efficacy [34]. More insulin (152 U/ML) is present in camel milk than in cow or goat milk [31], which may improve glycemic control and lower insulin resistance. Research in India by Agrawal [36] found that individuals with diabetes who consumed camel milk experienced significantly reduced blood sugar and HbA1C levels compared to those on conventional treatment alone. This can be attributed to camel milk's insulin-like activity and its regulatory and Immunomodulatory functions in cells [37]. Additionally, the high zinc content in camel milk may enhance insulin sensitivity, further bolstering its anti-diabetic properties [35].

### 1.2.3. Role camel milk against cancer

Different clinical examinations have shown that drinking camel milk can lead to a decline in the formation of disease cells, indicating its potential in combating cancer [1]. Both fermented and unfermented camel milk have demonstrated remarkable impacts on curing cancer, with the research highlighting its ability to inhibit tumor and malignant cells across various cancers, including hepatocellular carcinoma, colon carcinoma, human glioma cells, lung cancer cells, and leukemic cells [38]. This therapeutic effect can be attributed to the rich composition of camel milk, which includes high levels of lactoferrins, immunoglobulins, iron-binding glycoproteins, lactoperoxidase, and peptidoglycon recognition protein, all collectively contributing to its anti-tumor properties.

Muthukumar [34] indicated that camel milk lactoferrin can inhibit about 50% of colon cancer cells and significantly reduce DNA damage. Additionally, camel  $\alpha$ -lactalbumin has demonstrated significant anti-cancer activity against various cancer cell lines, particularly breast cancer cells, by forming the CAMLET complex. This complex induces selective apoptosis, leading to cell cycle arrest [39].

Camel milk also contains highly active antibodies that can selectively bind to and kill cancer cells while preserving healthy cells [40]. Aside from these direct anti-cancer mechanisms, camel milk can generate nitric oxide, stimulate mucus production, inhibit neutrophil adherence to endothelial cells, and increase blood flow to the gastric mucous membrane. The antimicrobial and antioxidant activities of camel milk also help reduce liver inflammation, while its nutrient-rich composition supports healthy liver function [40]. Additionally, camel milk's potential thrombolytic action inhibits coagulation and fibrin formation, thereby hindering the spread and growth of metastatic tumor cells [41].

### 1.2.4. Camel milk against allergy treatment

Camel milk may offer health benefits by reducing allergenicity, particularly in children allergic to cow's milk. This allergy, primarily affecting infants, stems from hypersensitivity to bovine milk proteins, notably  $\beta$ -lactoglobulin ( $\beta$ -LG) and alpha-casein ( $\alpha$ s1-CN). In vitro and in vivo experiments have demonstrated that camel milk is hypoallergenic and holds promise as a substitute for children allergic to bovine milk [34]. Camel milk's amino acid composition differs from that of bovine milk, with higher levels of  $\beta$ -CN, lower levels of  $\alpha$ s1-CN, and the absence of  $\beta$ -LG, aligning more closely with human milk. This similarity suggests that camel milk could serve as a suitable alternative protein source for children unable to tolerate cow's milk. Camel milk's immunoglobulins, similar to those in human milk, can mitigate allergic symptoms in children [9]. The IgE of children allergic to cow's milk does not react with camel's milk; therefore, camel's milk immunoglobulins decrease allergic symptoms [15].

### 1.2.5. Camel milk against Immunomodulatory effect and anti-microbial treatment

Camel milk's reported ability to remain stable for longer periods at room temperature compared to milk from other animals adds to its appeal as a functional food. Its longer shelf life and protective (antimicrobial) effect attributed to the presence of antimicrobial agents like lysozyme, lactoperoxidase, lactoferrin, and immunoglobulins [6, 34], enhance its potential as a natural remedy for maintaining health and combating infections. The presence of lactoferrin, in particular, seems to play a significant role in the antimicrobial activity of camel milk. Studies have shown that camel milk exhibits antibacterial and antiviral activity against various pathogens, including *Escherichia coli*, *Salmonella*, *Staphylococcus*, *Bacillus*, *Listeria monocytogenes*, and rotavirus [7]. Notably, research indicates that regular consumption of camel milk can lead to faster clinical and radiological improvement in patients with multiple drug-resistant tuberculosis [42].

In a study about pasteurized camel milk, the results found that camel milk exerts antimicrobial activity against foodborne pathogens (*Listeria monocytogenes* and *E. coli* O157:H7). Furthermore, the observed antimicrobial effect of raw camel milk and heated milk suggested that pasteurization has no effect on antimicrobial activity [43]. Pastoralists consume camel milk afresh or in varying degrees of sourness in the raw state without heat treatment [5]. Camel milk supplementation in patients with hepatitis C was found to be effective in improving liver function and blood parameters. Reports indicated that camel lactoferrin inhibits the activity of hepatitis C virus, and it has a higher antiviral activity against hepatitis C virus than human, sheep, and bovine lactoferrin [44]. Camel milk was also found to strengthen the cellular immune response and promote the recovery of chronic hepatitis B patients by inhibiting replication of the viral DNA [15]. Antifungal and antiparasitic activities in camel milk have also been reported [7].

### 1.2.5. Camel milk against skin disease treatment and cosmetic application

Camel milk is emerging as a promising ingredient in skin care due to its numerous beneficial components. Camel milk contains alpha-hydroxyl acids (AHAs), which have anti-aging properties by promoting the removal of dead skin cells, reducing wrinkles, and improving dry skin conditions [29]. Furthermore, camel milk contains high vitamin C, a powerful antioxidant that is essential for protecting the skin from free radicals and promoting the production of collagen. Additionally, liposomes found in camel milk offer advantages in cosmetic products, particularly for their anti-aging effects. Apart from maintaining the beauty of the skin, it has the potential to treat a range of skin conditions, including psoriasis, dermatitis, acne, and eczema [45].

## 2. Conclusion and recommendations

Camel milk stands as a nutritional powerhouse with significant therapeutic potential. Its unique composition, including lower levels of beta-casein and absence of beta-lactoglobulin, makes it suitable for individuals allergic to cow milk proteins. Moreover, camel milk boasts higher levels of essential nutrients like vitamin C, zinc, iron, manganese, and copper; long shelf life; large amounts of insulin/insulin-like protein; therapeutic properties; high digestibility; and higher nutritional value than bovine milk. Regular intake of camel milk helps control blood sugar levels. Scientific research has highlighted its role in managing conditions like diabetes, allergies, and autism and its potential in combating cancer and promoting skin health. Its immunomodulatory properties, antimicrobial activity, and antioxidant effects contribute to its efficacy in addressing various health concerns. Furthermore, camel milk's

hypoallergenic nature and ability to enhance digestive health suit individuals with specific dietary requirements or sensitivities. Although camel milk has such values, it is less appreciated thus its consumption is restricted to pastoral areas. Based on conclusions, the following recommendations are forwarded:

- Camel milk should be given to people with lactose intolerance and diabetic patients as adjunctive with insulin therapy.
- Governments, healthcare professionals, and nutritionists should promote awareness of camel milk's nutritional value and health benefits, among populations with limited access to healthcare resources.
- Countries like Ethiopia, with its significant camel population potential, should prioritize further research into the medicinal value of these animals.

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### Contribution of authors

All authors contributed during the preparation of the manuscript.

### Conflict of interest

There was no conflict of interest.

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