Review

Medicinal, Physiological, and Nutritional Benefits of Camel Milk

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Highlights

- The "white gold of the desert" is a term used to describe camel milk
- Camel milk has very little of lactose and casein that cause lactose intolerance
- Camel milk is good for maintaining the immune system
- Camel milk lacks beta-lactoglobulin and has a different beta-casein
- Camel milk has anti-aging benefits because of its high vitamin C content

Abstract: Background and importance: Immunoglobulins, lactoalbumin, lactoperoxidase, casein, lysozyme, lactoferrin, and amylase are just a few of the proteins found in camel milk. Camel milk appears to be safe and effective in enhancing long-term glycemic control and also acts as a facilitator in lowering the insulin demand by 30% for type 1 diabetes mellitus patients, therefore, it can be utilized as an alternative to insulin therapy. Alpha-hydroxyl acids, which are utilized to help exfoliate dead skin cells and enable skin renewal and new cell creation, are more concentrated in camel milk. The two main components of camel milk are lactoferrin and immunoglobulins, which provide the milk with its immune-stimulating qualities. **Aims of the study:** The goal of this review is to discuss the medicinal, physiological, and nutritional advantages of camel milk for people's health. **Methodology:** For the purpose of this review article, the author evaluated 56 different published articles. Access to published publications from databases like PubMed, the Scopus database, and the Cochrane database was made possible by using the Google search engine. **Discussion:** Because the milk of immunized camels contains neutralizing antibodies, it can provide passive immunity to individuals who have SARS-CoV-2. Lactoferrin, the primary iron-attaching protein in camel milk, is effective in preventing the growth of cancer by 56%. Camel milk has a lot of ascorbic acids, which help improve liver function. **Conclusion:** Camel milk has numerous therapeutic benefits, including antibacterial, anticarcinogenic, antioxidant, anti-hypertensive, and anti-diabetic properties.

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Introduction

The camel is a desert mammal that is a member of the Camelidae family and the Artiodactyla suborder. The Bactrian two-humped camel (Camelus bactrianus) and the Arabian or dromedary one-humped camel (Camelus dromedarius) are the two varieties of camels [1]. More people are raising camels for both milk and meat [2]. Both breeds of camels produce milk that is rich in minerals and vitamins and high in unsaturated fats and proteins, with some macronutrient variations depending on the location [3]. According to estimates from the Food and Agriculture Organization (FAO), there are 19 million camel populations globally, with 15 million of them located in Africa and 4 million in Asia [4]. The "white gold of the desert" is a term used to describe milk, a significant byproduct of camels [5]. Camel milk is dark white and has a harsh, salty flavor and a pungent odor. The taste of camel milk varies based on the camel's breed, diet, health, and water intake. When kept at a temperature of 2°C, camel milk preserves its quality for up to 12 days, as opposed to cow milk, which

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only does so for two to three days [6]. Raw camel milk lasts for 8–9 hours at 37°C and for more than a week at 4-6°C [7]. Camel milk has a variety of possible health benefits, including antibacterial, antiviral, antidiabetic, anti-aging, and anti-carcinogenic properties. Protective proteins found in camel milk may have therapeutic benefits and may be essential for enhancing the immune defense system [8]. High levels of antioxidants found in camel milk assist in preventing cell damage that can result in major illnesses including cancer, diabetes, and heart disease. As camel milk is a great source of vitamins and minerals, drinking it may aid in the body's general growth and development [9].

Literature Review

Camel milk is a nutrient-rich food that is thought to be particularly excellent for health and wellbeing, and as a result, it has been drawing attention from all over the world due to its enormous health advantages. In traditional medicine, local healers have asserted that a mixture of camel milk and pee has the medicinal ability to treat several types of cancer [10,11]. Camel milk has numerous therapeutic benefits, including antibacterial, anticarcinogenic, antioxidant, anti-hypertensive, and anti-diabetic properties [1].

Following are some examples of the therapeutic, physiological, and nutritional advantages of camel milk:

Therapeutics Benefits of Camel Milk

Diabetes mellitus: Diabetes mellitus is a chronic condition that results in elevated blood sugar levels when the pancreatic beta cells are unable to release any insulin, secrete inadequate insulin, or the body is unable to utilize insulin properly [12]. Camel milk helps to improve fasting blood glucose, glycosylated hemoglobin, serum anti-insulin antibodies, and mass body index while lowering the amount of insulin needed to induce glycemic control [13]. Chronic hyperglycemia and abnormalities in the metabolism of carbohydrates, fats, and proteins are hallmarks of type 1 diabetes mellitus, an autoimmune condition that affects just one organ. These symptoms are linked to an insulin shortage [14]. Camel milk has sufficient amounts of insulin as well as an insulin-like protein with a 52 microunit/ml concentration that is used to sustain and prevent diabetes mellitus [15]. The casein concentration of camel milk was unusual, and it looked to include an insulin-like protein that resists intestinal digestion and absorbs more quickly into the blood [16]. Peripheral insulin resistance and insufficient insulin production by pancreatic beta cells are two characteristics of type 2 diabetes mellitus. Camel milk can aid in reducing insulin resistance and blood sugar levels [12]. Zinc minerals are abundant in camel milk, which may assist in increasing insulin sensitivity [17]. When people with type 2 diabetes mellitus consume camel milk on a regular basis, their blood sugar levels are adjusted due to changes in their lipid profile, blood pressure, and insulin levels. Additionally, the casein protein, which is found in milk in the form of big granules, acts to prevent the Boisson stomach enzyme pepsin and insulin molecules, which are responsible for acidity in the stomach, from being broken down [18].

In autism spectrum disorder: The term "autism spectrum disorder" is used to describe a number of neurodevelopmental problems that can affect social interaction and result in recurrent aberrant behaviors. Numerous autoimmune diseases, which affect an intestinal enzyme involved in the production of amino acids from the milk protein casein, are the primary cause of many autistic disorders. Casomorphine, a potent opioid, can occasionally form from the original betacasein and beta-lactoglobulin in casein. Due to brain injury, this opioid causes standard cognitive and behavioral side effects [19]. Camel milk is good for maintaining the immune system and promoting brain development due to its lower beta-casein level, absence of beta-lactoglobulin, and presence of protective proteins [20]. When camel milk is consumed regularly by autistic people, it can help with the development of motor behavior, the enhancement of behavioral and cognitive abilities, the reduction of oxidative stress, the enhancement of social behavior, the ability to communicate, as well as an improvement in speech and language [21–23].

Management of Crohn's disease: As an inflammatory response by the body, Crohn's disease is defined as a condition that results in inflammation of the gastrointestinal tract or gut. Weight loss,

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stomach discomfort, vomiting, or diarrhea are just a few of the signs and symptoms of Crohn's disease. It can also lead to other health issues like eye inflammation, fatigue, poor focus, skin rashes, and arthritis [4]. By limiting the overexpression of pro-inflammatory cytokines in the colon, camel milk can reduce the inflammatory response. In order to reestablish the function of the intestinal barrier, camel milk also increased the expression of occludin and claudin [24].

Anti-bacterial and antiviral properties: Lactoferrin, which is present in camel milk and has an activity range of 95 to 250 ml/dl (higher than that of other ruminants), has antimicrobial and immune system effects [25]. Because camel milk contains enzymes with anti-bacterial and antiviral properties like lactoferrin, which can inhibit the growth of microorganisms in the gut; lactoperoxidase, which is used to reduce gram-negative bacteria and is effective in raw milk for the first four days, and peptidoglycan recognition protein (PGRP), which acts as a broad anti-microbial activity that stimulates the immune system [26,27]. Lactoferrin in camel milk inhibits the growth of Salmonella typhimurium by binding to iron and preventing it from being used for growth [7]. Staphylococcus aureus also has a damaging effect on the cell walls of bacteria, and camel milk lactoperoxidase demonstrated a bacteriostatic action against Lactococcus latis [28]. It has been noted that camel milk has therapeutic benefits for treating various tuberculosis subtypes, empyema, chronic pulmonary, and multidrug-resistant tuberculosis patients [7]. Camel milk is an adjuvant dietary supplement that can be used by tuberculosis patients who are multidrug resistant. In children younger than 59 months, rotavirus is the most frequent cause of diarrhea. Anti-rotavirus antibodies found in camel milk have the ability to reduce diarrhea [29]. Both secretory immunoglobulin A (sIgA) and immunoglobulin G (IgG) extracted from camel milk have been shown to be effective against rotaviruses obtained from bovine or human sources [7]. IgG in colostrum contributes to significant anti-rotavirus activity, although sIgA levels in regular milk are high [7]. This suggests that human rotavirus can be effectively inhibited by raw camel milk.

Support against COVID-19: Camel milk contains antiviral characteristics that can help the body fight sickness. Due to the neutralizing antibodies in camel milk, it can provide passive immunity and be used to treat COVID-19 patients as well as provide prophylaxis for people who are at risk of contracting SARS-CoV-2. As a result of lactoferrin's ability to bind to heparin sulfate and prevent viral infections and pandemics, camel milk has a high concentration of lactoferrin, which works to block SARS-CoV-2 entry and infection into host cells [30].

Therapeutic effects on cancer, tumors, and ulcers: By acting on thyroid peroxidase enzymes that are naturally present in camel milk, the lactoperoxidase enzyme inhibits the formation of tumors and is linked to the iodination of thyroid hormones. The highest concentration of these enzymes is also affecting the reduction of breast cancer cell metastasis [9,31]. Camel milk can treat cancer by binding to the tumors and eliminating the malignant cells without harming healthy tissue. Due to its high concentrations of the vitamins C, A, B2, and E (and its acid pH), as well as the minerals magnesium and zinc, camel milk has been proven to possess antiulcer qualities. Camel milk considerably reduced indomethacin-induced stomach ulcers, demonstrating an anti-ulcerogenic action associated with its gastro-protective function [32,33].

Natural anti-inflammatory effect: Omega-6 fatty acids, which are bad for you, increase inflammation in the body. Camel milk contains significant amounts of omega-3 fatty acids, which naturally reduce inflammation [34]. Camel milk contains vitamins C, A, and B2, has a high level of vitamin C, and is abundant in zinc and magnesium, all of which have anti-inflammatory properties against several viral disorders [4]. These vitamins are helpful in reducing oxidative stress brought on by a hazardous substance. Magnesium is vital for the manufacture of glutathione, which protects cellular components from damage brought on by free radicals, peroxides, and heavy metals, as well as for the uptake and metabolism of vitamins such as vitamins B, C, and E. At the moment, magnesium significantly speeds up the antioxidant defense system [35].

Stimulates circulation and treats iron deficiency anemia: High levels of iron found in camel milk help prevent iron deficiency anemia. Red blood cells, which are crucial for the transport of oxygen and the creation of deoxyribonucleic acid, must include iron. Camel milk can considerably aid in preserving health and well-being after childbirth, damage, or a time of malnutrition [36]. In

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addition to saliva, bronchial mucus, tears, and other bodily secretions, lactoferrin is an iron-binding glycoprotein that is a small component of whey proteins. It is also found in large concentrations in the breast secretions of non-lactating dairy animals. Its structure consists of two lobes, each of which can reversibly bind two atoms of iron (one for each lobe). One bicarbonate ion is synergistically linked to each lobe [37].

Therapeutic effect on hepatitis: Camel milk contains fats that calm the liver and help treat chronic liver disease adjuvantly. Improved liver function may be assisted by camel milk's high ascorbic acid content. Both hepatitis B and hepatitis C can be cured with camel milk. Hepatitis C and B viruses can be inhibited by the lactoferrin found in camel milk, which stops them from replicating in cells. Camel milk can treat hepatitis B because it boosts the immune system and prevents the virus' DNA from replicating [38].

Anti-schistosomal effects: Schistosomamansoni can be eradicated by the anti-parasitic properties of lactoferrin found in camel milk. Colostrum and mature camel milk are given to the patient to encourage a specific immune response that protects against Schistosoma mansoni. The body's level of glutathione-transferase (GST), which is improved as a result of the immunoprotective phenomenon, detoxifies the body more effectively. This led to the announcement that camel milk that is mature and colostral has a preventive effect against schistosomiasis infection [38].

The angiotensin-I-converting enzyme (ACE) has inhibitory activity: ACE, a dipeptidylcarboxypeptidase, catalyzes the transformation of the inert angiotensin I peptide into the powerful vasoconstrictor angiotensin II peptide. The increase in salt levels caused by angiotensin II increases blood pressure [1]. The ACE-inhibitory activity of camel milk protein hydrolysates has been examined, and it has been found that camel whole casein and camel b-CN have increased ACE inhibitory activities after enzymatic hydrolysis of camel milk proteins. After hydrolysis with pepsin alone and after hydrolysis with pepsin followed by trypsinolysis and chymotrypsinolysis, camel whole casein and b-CN showed strong ACE-inhibitory actions [7]. They discovered seven fermented camel milk samples with the highest ACE inhibitory efficacy using lactic acid bacteria (LAB) strains, along with a relationship between the level of hydrolysis and ACE inhibition. Reversed-phase HPLC (RP-HPLC) can be used to identify the ACE inhibitory peptides, and triple mass spectrometry can be used to measure their concentration (HPLC-MS3). [1]

Improve food and milk allergies: Because camel milk has the following characteristics, its proteins are crucial for avoiding and treating food allergies. While camel milk lacks betalactoglobulin and has a different beta-casein, it does contain immunoglobulins that are identical to those found in mother's milk, which lessen allergy reactions in children and improve their ability to respond to foods in the future [39].

Health Benefits of Camel Milk

Enhance the health of the human heart: Omega-3 fatty acids, which may play a role in lowering cholesterol and preventing the development of cardiovascular illnesses, are abundant in camel milk. Orotic acid, a component of camel milk, lowers cholesterol by reducing bad cholesterol in the body; it also aids in lowering high blood pressure and reduces the incidence of atherosclerosis, heart attacks, and strokes [40].

Renewing (rejuvenating) properties: Camel milk contains a higher concentration of alpha-hydroxy acids, which aid in exfoliating dead skin cells, encourage their regeneration, and encourage the formation of new skin cells. These products include high concentrations of lactic acid, an alpha-hydroxy acid subtype thought to be the most gentle on sensitive skin. Lactic acid exfoliates dead skin cells and leaves the skin appearing clean and fresh. This acid allows the skin to create ceramides and aids in moisture retention, giving the skin a plumper, redder, and healthier-looking appearance. Aside from these anti-aging ingredients, camel milk also contains lanolin, collagen, and elastin, which help to firm, tighten, and elasticize skin as well as aid in moisture retention [41,42]. Camel milk has anti-aging benefits because of its high vitamin C content, which protects collagen and has antioxidant and tissue-repairing properties. A water-soluble vitamin that supports the immune system is vitamin C. Vitamin C improves the resilience and structural support of the skin, which aids in the healing of

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skin damage. Antioxidant vitamin C decreases the rate of free-radical damage, which results in wrinkles and dry skin [43]. Additionally, the liposome found in camel milk has a cosmetic component that is employed to enhance the anti-aging effect [44]. Lanolin and other moisturizing ingredients in the milk have a calming and soothing effect on the skin [45]. Because it contains elastin, vitamin C, and lanolin for next-level moisture, brightness, and baby-soft skin, camel milk has also grown in popularity as a component in lotions, ointments, and masks [46].

In lactose intolerance: The illness known as lactose intolerance is classified as being brought on by a lack of lactase, the enzyme needed to break down the lactose found in dairy products. Bloating, diarrhea, and gastrointestinal difficulties after consuming dairy products are symptoms of lactose intolerance [47]. Camel milk has very little of the lactose and casein that cause lactose intolerance. The two most frequently associated allergenic proteins in cow milk—A1 casein and lactoglobulin—are absent from camel milk. A lactase-producing enzyme that the body secretes enables the body to digest sugar. This enzyme is absent in some people, which causes insufficient breakdown of lactose sugar. Only a small amount of lactose, which can be easily digested by those with lactose intolerance, is present in camel milk. Additionally, there is a minor amount of A1 casein, which is indigestible to people with lactose intolerance or dairy product allergies [48,49].

Enhance height growth: Camel milk contains significant amounts of calcium, vitamins, and minerals that are essential for overall body growth, including greater height. Methionine, valine, phenylalanine, arginine, and leucine are some of the amino acids that are present in camel milk in sufficient amounts to support healthy growth and development. For example, the amino acid phenylalanine "plays a key role in the biosynthesis of other amino acids and is significant in the structure and function of many proteins and enzymes," according to the US National Library of Medicine website. One of the most fundamental parts of the body is protein, and camel milk is a good source of it [50,51].

Natural immunity-booster: Compounds found in camel milk appear to combat a number of microbial-based disorders. The two primary components of camel milk are lactoferrin and immunoglobulins; it is possible that these two components are what give camel milk its immunestrengthening qualities [52]. Microorganisms associated with serious illnesses, such as Escherichia coli, are prevented from multiplying by lactoferrin. The disease-fighting properties of immunoglobulins help to reduce allergy symptoms. Targeting foreign invaders and chemicals like antigens, antibody proteins work to eliminate them from the immune system [53].

Natural probiotics: Probiotics are beneficial microorganisms that reside in the gastrointestinal tract and promote gut health. Because it contains a variety of healthy bacteria, camel milk is a great source of probiotics. Probiotics with physiological activity in the digestive system include lactoferrin and a camel milk protein that contains iron [54].

Nutritional Benefits of Camel Milk

Rich in nutrients: Camel milk contains minerals like calcium, iron, zinc, folate, and potassium, as well as vitamins B and C. Camel milk is a fantastic source of long-chain and unsaturated fatty acids, which promote brain and heart health. The milk also offers antioxidants, which are an effective solution for reducing oxidative stress and free-radical damage [55]. In addition to being the main source of carbohydrates, camel milk also contains a modest number of various oligosaccharides that shield young children from viruses, encourage the growth of the Bifidobacterium environment, and aid in nervous system development [1]. Camel milk ranges in total protein content from 2.15 to 4.90%. Camel and cow milk both contain a similar amount of casein (as1, as2, and casein), but they differ in the amount of whey proteins. As a result, cow milk has a greater casein to whey protein ratio than camel milk. Camel milk creates a softer gel than cow milk because of the effect this has on the coagulum's hardness [1]. Camel milk has a greater ascorbic acid concentration. Calcium and iron are both abundant in camel milk. In comparison to cow milk, camel milk contains higher levels of insulin, whey acidic protein, peptidoglycan recognition protein, B-lactose albumin, casein micelles, whey, and omega-7 [4]. Camel milk ranges in total protein content from 2.1 to 4.9 percent. Camel milk has a fat percentage ranging from 1.2 to 5.4%, with an average of 3.29%. Camel milk contains somewhere

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between 2.40 and 5.80% lactose. In dromedary camel milk, the total mineral concentration of total ash ranged from 0.60 to 0.90%. Due to the forage camels eat, including Atriplex and Acacia, which often have a high salt content and may be one of the causes for the salty flavor of milk, camel milk is a rich source of chloride. Fe, Zn, and Cu concentrations were found to be 1.37, 2.19, and 0.44 mg/dl and 0.05, 0.35, and 0.02 mg/dl, respectively, in camel and bovine types of milk. In accordance with the 2009 United States Drug Act report, 250 ml of camel milk gives an adult around 15.5% of the daily recommended intake of cobalamin (B12), 8.25% of riboflavin (B2), 5.25% of vitamin A, and 10.5% of each of ascorbic acid (C), thiamin (B1), and pyridoxine (B6) [7].

Table 1. Listed below are the nutrients included in a half cup (120 ml) of camel milk.

Constituents of camel milk									
Grams (%)				Daily Value (%)					
Calories	Protein	Fat	Carbohydrate	Thiamine	Riboflavin	Calcium	Potassium	Phosphorus	Vitamin C
50	3	3	5	29	8	16	6	6	5

Identical to a human mother's milk: Colostrum and breast milk share the same qualities as camel milk. As a healthy alternative to new-born formula, many parents supplement it with camel milk. Kids will love it. Camel milk is particularly distinctive and full of immunoglobulins, which are defense proteins that bolster the immune system's resistance to illness. Because they are smaller than human immunoglobulins, the immunoglobulins found in camel milk can more readily enter bodily tissues [56].

Conclusion

Camel milk has a dark white color, a harsh, salty flavor, and a pungent odor. The taste of camel milk varies based on the camel's breed, diet, health, and water intake. With low cholesterol, low glucose, high minerals (sodium, potassium, iron, copper, zinc, and magnesium), high vitamin C, and high insulin concentrations, camel milk differs from other ruminant milks like cow, sheep, and goat milk. In those with diabetes mellitus, camel milk can help reduce blood sugar levels, reduce insulin resistance, and increase insulin sensitivity. Camel milk has been found to be useful in treating autoimmune illnesses because it has strong antibacterial qualities and works quickly to promote healing when paired with peptidoglycan recognition protein. Colostrum and mature camel milk are fed to the patient to trigger an immune response that protects against Schistosoma mansoni. A high concentration of iron found in camel milk is utilized to prevent iron deficiency anemia. Camel milk has a cosmetic benefit because it contains hydroxyl acids, which are known to smooth out wrinkles and fill in the skin.

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