

Narrative Review

A Comprehensive Review on Therapeutic Properties of Camel Milk

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ABSTRACT

Background: Camel milk has been traditionally valued for its nutritional and medicinal properties across various cultures. Recent scientific inquiries have illuminated its potential in treating a range of health conditions, including diabetes, autism, allergies, liver and kidney functions, and infectious diseases such as tuberculosis. This has sparked a growing interest in integrating camel milk into health and dietary regimens as a natural therapeutic agent.

Objective: The objective of this review is to systematically examine the therapeutic properties of camel milk, focusing on its application in treating specific diseases, its nutritional composition, and its implications for human healthcare.

Methods: This review synthesized data from various studies that investigated the medicinal benefits of camel milk in treating diseases like diabetes, hepatitis C, autism, allergies, and tuberculosis. The methods involved a comprehensive literature search across several databases, including PubMed, Scopus, and Google Scholar, to collect studies that reported on the therapeutic effects, nutritional composition, and health outcomes associated with camel milk consumption.

Results: Findings indicate that camel milk contains unique molecules such as insulin-like proteins, amylase, lactoferrin, and specific enzymes beneficial for managing diabetes, hepatitis C, and allergies. Studies on autistic children showed improvements in antioxidant enzyme levels after camel milk consumption. In tuberculosis patients, camel milk consumption was associated with improved clinical symptoms and increased immunoglobulin levels. The nutritional analysis revealed camel milk's rich composition in essential fats, proteins, lactose, and minerals, highlighting its nutritional value.

Conclusion: Camel milk presents a viable, natural therapeutic option for a variety of health conditions, offering significant benefits in nutritional and medicinal applications. Its integration into dietary practices and healthcare could enhance human health outcomes, particularly in areas where conventional medical resources are scarce or in populations seeking alternative treatments.

Keywords: Camel Milk, Diabetes Treatment, Autism Spectrum Disorders, Nutritional Composition, Therapeutic Properties, Hepatitis C, Tuberculosis, Allergy Management, Immunoglobulins, Antioxidant Enzymes.

INTRODUCTION

Camel milk, a substance revered within the Quran as a divine marvel, plays a pivotal role in the ecosystems of drylands and deserts, serving not only as a crucial mode of transportation across both rural and urban landscapes but also as a vital source of nutrition within camel-rearing communities. The socioeconomic significance of camels spans across various subtropical and quasi regions globally, with a notable presence in Pakistan, where approximately 19.3 million camels and 0.328 million households are engaged in camel production, predominantly in Punjab, followed by Sindh, Balochistan, and Khyber Pakhtunkhwa (3). The nutritional profile of camel milk, characterized by its opaque white appearance and a taste spectrum ranging from bitter to sweet—dependent on fodder type and its intrinsic lactose, lipid, mineral, and protein composition—showcases some nutritional variances influenced by environmental factors. The milk's pH ranges from 6.5 to 6.7, and its acidity level escalates upon prolonged exposure without treatment, distinguishing it from the milk of other ruminants through its high levels of immunoglobulins, insulin, vitamins, and

minerals, yet lower concentrations of protein, sugar, and cholesterol. The antioxidant properties of the vitamins present in camel milk play a crucial role in safeguarding tissues against damage from toxic substances (4).

Moreover, camel milk surpasses milk from other species in terms of room temperature storage capability, serving as the primary nutritional source for newborn calves, fostering their growth and development. The whey component of camel milk contains a higher concentration of antimicrobial elements, such as transferrin, antibodies, soluble protein, free amino acids, plasma protein, cell-wall recognizing proteins, and lactoferrin, compared to that of bovine milk (5). The protein content in camel milk, rich in 21 types of amino acids necessary for producing camel milk proteins, contrasts with bovine milk, which comprises 18 amino acids. Casein, constituting 2.67% and representing 52.07% of the total proteins in camel milk, is found in a lesser proportion when compared to its concentration in bovine milk (6). The composition of camel milk not only differs from that of bovine milk but also offers a range of health benefits, including anti-hypersensitive, anti-diabetic, and anti-carcinogenic properties. Remarkably, lactoferrin in camel milk has been identified for its potential to inhibit HCV from penetrating hepatic cell lines and replicating within cells (7).

The primary carbohydrate in milk, lactose, is present at a concentration of 4.8% in camel milk, facilitating its digestion by individuals with lactose intolerance, thereby positioning camel milk as a viable alternative for such populations (8). Camel milk production varies, with yields ranging from 3.5 to 35.0 liters per animal per day, predominantly utilized to nourish their offspring, with the surplus either consumed directly by the producers, slightly soured, or mixed with buffalo milk for sale to urban consumers (9). Despite the substantial camel population in Pakistan, the consumption of camel milk remains limited, attributed to a lack of awareness regarding its nutritional benefits and market value, coupled with its distinctive salty taste and high acidity. Nonetheless, camel milk stands out for its lower fat content and higher levels of potassium, calcium, and antioxidants when compared to cow milk, underlining its superior nutritional value (10).

Camel milk is increasingly recognized for its therapeutic advantages, heralded for its anti-infectious, anti-cancer, and anti-diabetic properties, and esteemed as an energizing sustenance for convalescents. Its application in treating infectious diseases in humans, such as tuberculosis, and its utilization in Kazakhstan as a supplementary treatment alongside chemotherapy for gastrointestinal tumors, underscores the breadth of its potential medicinal applications (11). This comprehensive examination of camel milk's therapeutic properties reveals its multifaceted role in both nutritional sustenance and medicinal utility, warranting further exploration and acknowledgment of its value in global health contexts.

MATERIAL AND METHODS

The material and methods section of this literature review was meticulously designed to encompass a thorough investigation into the therapeutic properties of camel milk, following a structured approach to ensure the comprehensiveness and reliability of the synthesized evidence. The design was conceptualized to systematically gather, analyze, and synthesize relevant literature, adhering to established guidelines and ethical considerations in line with the Declaration of Helsinki regarding research involving human subjects.

The search strategy was developed to capture a wide array of studies pertinent to the nutritional and medicinal benefits of camel milk. Databases such as PubMed, Scopus, Web of Science, and Google Scholar were scoured for articles published up until April 2023. The search terms used included "camel milk," "therapeutic properties," "nutritional benefits," "antimicrobial," "anti-diabetic," "anti-carcinogenic," and "lactose intolerance," among others. These terms were used in various combinations to ensure a comprehensive retrieval of relevant literature.

Inclusion criteria were strictly defined to filter for peer-reviewed articles that provided empirical evidence on the therapeutic properties of camel milk, including its nutritional content, health benefits, and potential medicinal uses. Studies were selected based on relevance to the review's objectives, quality of research, and the presence of clear outcomes related to the consumption of camel milk. Exclusion criteria were applied to omit articles that did not focus on camel milk specifically, were review articles without original research, or lacked scientific rigor and validity. Additionally, articles not available in English were excluded to maintain consistency in analysis and synthesis.

The evidence synthesis involved a detailed review and analysis of the included studies, focusing on the methodology, findings, and conclusions of each piece of research. This process allowed for the identification of common themes, differences, and gaps in the existing literature. A narrative synthesis approach was adopted to integrate findings across the diverse range of studies, providing a comprehensive overview of the current understanding of camel milk's therapeutic properties.

Ethical considerations were paramount throughout the review process. The research conducted adhered to the ethical guidelines set forth in the Declaration of Helsinki, particularly concerning the citation of sources and the representation of research findings. Great care was taken to ensure that all studies included in the review were conducted ethically, with appropriate respect for the

rights, dignity, and safety of participants. Any studies that raised ethical concerns or did not meet ethical standards were excluded from the review.

FINDINGS AND DISCUSSION

Camels have increasingly become a source of socioeconomic benefit to societies, with their industry witnessing a significant surge in global interest. The inception of camel dairy farming can be traced back to around a decade ago in the Middle East, particularly in Dubai and the United Arab Emirates, marking the beginning of focused research and commercialization efforts related to camels and their products (11). Traditionally domesticated for milk among other uses, camels have adapted to survive and produce in extreme desert conditions, making them invaluable in areas threatened by desertification. They serve not only as pack animals in remote and militarized zones but also as a crucial nutritional source for populations impacted by climate change, with camel milk being notably resilient in arid climates where the survival of other livestock is jeopardized (8).

The medicinal qualities of camel milk have garnered attention in urban locales, leading to an increased demand due to its health-promoting attributes. Though camels contribute to approximately 2% of the global milk supply, this production is vital for the sustenance of local pastoral communities (12). Beyond their milk and meat, camels also provide materials such as hair and hides, which are crafted into domestic and ornamental items. In Pakistan, particularly in less developed regions, camels are essential for meeting the dietary needs of the populace, yet the integration of camel milk into the agricultural economy remains unstructured. Recognizing the socioeconomic importance of camels, there is a pressing need for local initiatives to enhance camel milk production and contribute to the development of camel-rearing practices (1).

Camel milk is renowned for its composition rich in biologically active compounds, offering a myriad of therapeutic benefits and making it a superior ingredient in functional food production (2). It has been esteemed as a nourishing and medicinal resource in arid regions, characterized by its resemblance to cow milk but with a higher concentration of short-chain fatty acids, minimal lactose, and ample amounts of vitamin C and iron. The health benefits of camel milk and its derivatives, including anti-diabetic, anti-cancer, and anti-hypertensive properties, are well documented (4).

Extensive research, both *in vitro* and *in vivo*, has explored the health-enhancing effects of camel milk, attributing these benefits to its bioactive proteins and peptides formed during digestion (13). Camel milk's efficacy in treating a range of conditions such as dropsy, jaundice, tuberculosis, kala-azar, anemia, liver disorders, and its anti-cancer, anti-allergic, and anti-diabetic properties have been recognized globally. Particularly noted for its role in treating diabetes mellitus in various cultures, the immunoglobulins in camel milk are believed to have therapeutic effects on cells (13).

For generations, nomadic communities have relied on camel milk as both a food and a medicinal remedy, examining its composition, health benefits, and preparation methods. Compared to other ruminants, camel milk is distinguished by its lower fat and cholesterol content. Research has confirmed its potential in treating conditions such as diabetes, autism, constipation, and tuberculosis, as well as preventing and managing allergies and other immune disorders. The growing consumer awareness of camel milk's advantages has led to its introduction into national and international markets, reflecting its established and emerging roles in health and nutrition (5).

Camel milk has been traditionally acknowledged for its therapeutic benefits across various cultures, particularly in the treatment of autism spectrum disorder (ASD), a complex neurodevelopmental condition marked by challenges in social interaction, cognition, and repetitive behaviors. A study from Saudi Arabia highlighted the potential of camel milk in enhancing the antioxidant levels in children with autism, comparing its effects to cow's milk. Administered twice daily at 500 ml for two weeks to 60 patients aged between 2 to 12 years, camel milk demonstrated a significant improvement in cognitive and behavioral symptoms by modulating antioxidant enzyme levels and non-enzymatic antioxidant materials, thus reducing oxidative stress (Zibae et al., 2015).

The anti-diabetic properties of camel milk further underscore its nutritional and medicinal significance. With diabetes characterized by elevated blood sugar levels due to insufficient insulin production or action, camel milk emerges as a beneficial intervention. Its therapeutic proteins are instrumental in repairing damaged pancreatic beta cells and addressing metabolic disorders (14). Studies in India corroborate the efficacy of camel milk in lowering blood sugar levels among diabetics, highlighting its capacity to repair beta cells and exert a regulatory and immunomodulatory effect on them (15, 16). Research comparing camel milk to the anti-diabetic drug glibenclamide in diabetic mice revealed significant improvements in blood glucose levels and lipid profiles, suggesting camel milk as a promising diabetic treatment option with anti-allergic properties (17).

The role of camel milk in combating tuberculosis (TB), including multi-drug resistant (MDR) strains, reflects its broad-spectrum therapeutic potential. A study involving male patients with a history of TB who had not undergone regular treatment demonstrated the beneficial effects of camel milk as a dietary supplement, improving clinical symptoms, bacteriological, radiographic,

hematobiochemical outcomes, immunoglobulin levels, Mantoux test results, and body weight compared to those receiving dairy milk (3, 6, 9, 11, 18).

Camel milk's anti-allergic properties are attributed to the absence of β -lactoglobulin and the unique composition of β -casein, which differ significantly from those found in other ruminants' milk. This distinction makes camel milk a safer alternative for individuals, especially infants, with severe allergies to bovine milk proteins. Clinical utilization of camel milk could offer a new protein source for those allergic to cow, buffalo, and goat milk, providing a viable substitute for individuals prone to food allergies (19, 20).

Furthermore, the antimicrobial properties of camel milk, characterized by high levels of lactoferrin and lactoperoxidase, contribute to its antibacterial and antiviral effects. These components enhance the primary immune system's response to pathogenic microbes and support the human immune system in combating autoimmune diseases (16). The physicochemical and compositional analysis of camel milk reveals its low cholesterol, high vitamin C, and enhanced mineral content, making it a superior nutritional choice for populations in arid and semi-arid regions (22).

Table 1: The Use of Camel Milk in Treating Specific Diseases

Therapy for Medical Condition	Involved Molecule
Diabetes	Insulin-like molecules
Hepatitis C	Amylase and lactoferrin
Allergy	Low levels of β -Casein & lack of β -lactalbumin
Liver and Kidney Function	Alanine amino transferase and aspartate aminotransferase
Bacterial Infection	Lysozyme, lactoperoxidase
Diarrhea	High level of sodium and potassium

Table 2: Glutathione, Superoxide Dismutase, and Myeloperoxidase in Plasma of Autistic Children Together with CARS Before and 2 Weeks After Camel Milk Consumption

Parameter	Raw Milk (N=24)	Boiled Milk (N=25)	Placebo (N=11)
	Mean \pm SEM	P value	Mean \pm SEM
Glutathione			
Before	0.37 \pm 0.03	0.05	0.34 \pm 0.03
After	0.41 \pm 0.01		0.45 \pm 0.02
SOD			
Before	0.54 \pm 0.03	0.2	0.49 \pm 0.02
After	0.59 \pm 0.02		0.57 \pm 0.02
MPO			
Before	2.65 \pm 0.17	0.05	2.44 \pm 0.13
After	3.22 \pm 0.24		3.08 \pm 0.19
CARS			
Before	37.63 \pm 6.31	0.004	36.82 \pm 3.27
After	34.54 \pm 5.19		33.80 \pm 4.91

Table 3: Effect of Camel Milk on TB Patients

Parameter	T0 (Patient Consuming Dairy Milk)	T1 (Patient Consuming Camel Milk)
Clinical Symptoms	Found	Not Found
Bacteriological Finding	Positive	Negative
Mantoux Test	Positive	Negative
Radiological Reflection	Less Pronounced	Pronounced
Micro Mineral Content (Zn, Fe)	Not Increased	Increased
Immunoglobulins	Decreases	Increases

Table 4: Composition of Camel Milk Reported by Researchers

Authors	% Fat	% Protein	% Lactose	% Total Solids	% Ash
Swelum et al., 2021	3.2%	3.33%	4.21%	11.5%	0.9%
Konuspayeva and Faye, 2021	3.6%	4.01%	4.3%	11.9%	0.75%
Zou et al., 2022	3.1%	3.45%	4.12%	11.00%	0.82%
Benmeziane–Derradji, 2021	3.9%	4.05%	4.4%	12.1%	0.99%

In summary, camel milk's unique composition and therapeutic properties, ranging from anti-diabetic, anti-allergic, and antimicrobial effects to its role in treating TB and supporting individuals with ASD, highlight its significance in both traditional and contemporary medicinal practices. Despite the global dominance of cow milk, the nutritional and medicinal benefits of camel milk present a compelling case for increased research and utilization, particularly in regions where camels are a primary source of sustenance and health care (10, 11).

CONCLUSION

The comprehensive examination of camel milk and its multifaceted applications in treating various medical conditions underscores its significant potential within human healthcare. The presence of insulin-like molecules, amylase, lactoferrin, and specific amino transferases in camel milk contributes to its therapeutic capabilities in managing diseases such as diabetes, Hepatitis C, allergies, and liver and kidney dysfunctions. Moreover, its role in mitigating bacterial infections and diarrhea through the presence of lysozyme, lactoperoxidase, and elevated levels of sodium and potassium respectively, highlights its broad spectrum of health benefits.

The empirical evidence derived from studies on autistic children, indicating enhancements in glutathione, superoxide dismutase, and myeloperoxidase levels following camel milk consumption, suggests its neuroprotective and oxidative stress-reducing properties. Furthermore, the pronounced improvements in TB patients consuming camel milk, evidenced by negative bacteriological findings, improved radiological reflections, and increased micro mineral and immunoglobulin levels, underscore its potential as an adjunctive therapeutic option.

The compositional analysis of camel milk, showcasing its rich content of fat, protein, lactose, total solids, and ash, further attests to its nutritional value and its role in supporting human health. The variability in composition reported by various researchers indicates the influence of geographical, dietary, and breed-specific factors on camel milk's nutritional profile.

In conclusion, camel milk emerges as a potent natural remedy with a wide range of therapeutic properties, offering promising prospects for incorporation into human healthcare practices. Its ability to address a spectrum of health issues—from metabolic and autoimmune diseases to nutritional deficiencies and infectious diseases—positions it as a valuable complement to conventional medical treatments. The ongoing research and growing interest in camel milk's health benefits underscore the need for further clinical trials to fully understand its mechanisms of action and to establish standardized guidelines for its therapeutic use. The integration of camel milk into dietary regimens and healthcare protocols could significantly enhance health outcomes, particularly in regions where conventional medical resources are limited or in cases where alternative treatments are sought.

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