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# Application of camel and mare milk in medical practice

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## ABSTRACT

Camel and mare milk are a necessary source of protein for people living in arid countries of the world. It is a fact that these milk have similarities to breast milk and the lack of the necessity for thermal treatment. Raw camel milk and fermented milk can be readily regarded as sources of potential probiotic strains. It is proven that milk-fermented products have high nutritional value and biomedical properties because of its unique physical and chemical composition. A great number of research articles have been analyzed. They are touching upon the applicability of mare and camel milk, as well as its products in medical practice. The article is made within the framework of the project "The state of cellular immunity and intestinal microbiota in patients with COVID-19 when using Saumal" IRN: 0122РКИ0051. Some natural foods, such as camel and mare's milk, can strengthen the immune system and suppress viral infection. Both have lysozyme, immunoglobulin and lactoferrin, which have antioxidants and membrane-stabilizing properties. Camel milk has its advantages in terms of treating cancer, as it promotes the elimination of carcinogenic compounds from the mice model. It is also effective against the diabetes. Mare milk has immunostimulant effects that protect the human body from pathogenic bacteria and viruses due to its positive effect on gut microbiome. Mare and camel milk can also be used in the treatment of the Hepatitis C. It is feasible to use mare and camel milk for the treatment of many illnesses in medical practice. To create efficient treatment alternatives for ailments that can result in severe complications, it is crucial to perform top-notch research, such as randomized clinical trials. Additional studies are required to get a better grasp of the situation that concentrate on the use of natural foods with a host of beneficial qualities as the main approach to treatment.

**Keywords:** Camel milk, Mare milk, Nutrition, Pathology, General practice.
**Article type:** Review.

## INTRODUCTION

Natural dairy foods are intricate combinations of nutrients, minerals, bioactive compounds, food structures, and other factors (such as phospholipids, prebiotics, and probiotics) that have complex effects on human health. Some foods that have been studied for these properties include mare and camel milk (Yagil 2013; Ghaderi *et al*. 2019; Asghar *et al*. 2019; Musaev *et al*. 2021; Azizi *et al.* 2021; Iqbal *et al.* 2021; Nasiri *et al*. 2022; Darzi Lemraski *et al*. 2023). Both are traditional nutritious food and healthy drink, which has been consumed for thousands of years. The inhabitants of Central Asia, Iran, and the Middle Eastern countries have been using them as a valuable, therapeutic, and preventive drink to date. It is worth emphasizing that camel and mare milk can rejuvenate the body, improve the functionality of the gastrointestinal tract, and strengthen the immune and nervous systems, i.e.

it is a valuable natural dietary drink acceptable for a lot of issues (Shamsia 2009). Products made from camel and mare milk are considered therapeutic, hypoallergenic, and dietary. According to various research, comparing different types of animal milk, a significant difference in the physical and chemical composition of mare and camel milk has been revealed. Camel and mare milk have more polyunsaturated fatty acids compared to cow milk. Also, β-lactoglobulin, which is proven to be allergenic to the human body, was not discovered in mare and camel milk (Zibaee *et al*. 2015) .The purpose of this study is to review the use of camel and mare milk in medicine.

**MATERIALS AND METHODS**

For the preparation of this literature review, we used the search of scientific articles in Scopus, Web of Science, PubMed, and Cochrane. A total of 89 articles were found on this topic, of which 37 were included in this review. 27 articles did not explain the importance of natural food descriptors. 25 articles lacked descriptive statistics, making the statistical validity of these products unclear.

**RESULTS AND DISCUSSION**

In 1992, Hamers-Casterman and others described the immunity of camels as stronger in comparison with many other mammals. The camel immunoglobulins IgG2 and IgG3 are made from only two heavy chains. Conventional antibodies have an incomplete neutralizing activity against bacteria. Camel IgG, on the contrary, has a complete neutralizing activity against tetanus toxin, since it is part of the enzyme structure. Partial neutralizing activity is also observed against streptococci and staphylococci. The main disadvantage in the development of immunotherapy is the size of antibodies. Camel antibodies have the same antigen, identical to humans, but ten times less. However, immunoglobulins and antibodies are well absorbed in the bloodstream by absorption through the intestines. There are many "protective proteins" of camel milk, which have immunological, bactericidal, and viricidal properties. The most well-known of them are lysozymes, lactoferrin and lactoperoxidase (Hamers-Casterman *et al*. 1993). Lysozymes, lactoferrin, lactoperoxidase, IgG, and secretory IgA, are contained in camel milk, have bacteriostatic activity against gram-positive strains and bactericidal activity against gram-negative cultures (el Agamy *et al*. 1992). The antibacterial and antiviral properties of camel milk were also explained in a study conducted by Latin American scientists. Special biophysical and pharmaceutical features of immunoglobulins of camel milk, called nanobodies, increased stability to DNA and RNA of pathogenic bacteria and viruses, and the ability to recognize antigens and eliminate them. These biomolecules can bypass several limitations of the diagnostic system, especially those related to the size and stability of conventional immunoglobulins, currently used in enzyme immunoassays, polymerase chain reactions, and electrochemical and imaging assays (Brilhante-da-Silva *et al*. 2021). Camel milk is one of the traditional medicines widely used by patients infected with viral hepatitis in Egypt. It has displayed the ability to improve both the well-being of patients and their liver functionality: Alanine transaminase was reduced in ~88% of patients, and aspartate transaminase was reduced in all respondents after consuming camel milk for four months. The majority of patients positively reacted to treatment with camel milk; the viral load of RNA decreased by 76.47%. Noteworthy, one patient had undetected viremia before its treatment, which may be witnessed as an antiviral effect of camel milk. In conclusion, it should be taken into consideration that camel milk treatment demonstrated its effectiveness in vivo; the viral load in most serums of patients was reduced, and the IgG isotype profile was converted into Th1 immunity (El-Fakharany *et al*. 2017). Results of an investigation presented in Norway showed that camel milk can serve as a substitute if a certain person has an allergy to cow's milk. The immunogenicity and sensitizing ability of camel and cow's milk, as well as cross-allergic reactivity, were studied. As a result, it was found that camel milk has low parameters of sensitization and immunogenicity due to the fine dispersion of the protein structure. Taking this fact into account, camel milk can also serve as a basis for the preparation of infant formulas (Maryniak *et al*. 2018). Apparently, the protein P-casein, which is contained in camel milk, is structurally very different from the similar protein of cow's milk. Ultimately, if a person has an allergy to cow's milk, its replacement with camel milk is a reasonable and justified decision (El-Agamy *et al*. 2009). Camel milk may be used in the treatment of diabetes by the reason of decreases the tolerance of pancreatic cells to insulin. Moreover, there is the presence of insulin-like proteins, as well as the inhibitory effect on the p-subtype of pancreatic cells, revealed in camel milk (El-Agamy *et al*. 2006; Ayyash *et al*. 2018). The materials of three randomized trials involving rats with artificially induced diabetes using streptozocin were studied. The results of these studies have reliably shown a positive effect of camel milk in the treatment of diabetes. The rats who received camel milk had

a lower blood glucose level, as well as a lower need for insulin. Liver enzymes had also been undergone favorable changes. There was a tendency to restore the balance of fats and kidney function (Korish 2014; Korish & Arafah 2013). A randomized trial done by Rajendra Prasad Agrawal revealed a significant decrease in the level of glycated hemoglobin, insulin requirements, and blood glucose levels in people (Agrawal *et al*. 2011). This trend was confirmed by a study led by Mohamad *et al.*, which was also conducted in India. The study involved 54 people with a confirmed diagnosis of type 1 diabetes mellitus. A significant decrease in the level of glycated hemoglobin, the need for insulin, and the level of glucose in the blood was revealed, similar to the previous study. Unfortunately, there was no statistical analysis between the study and control groups. Therefore, despite the favorable result, this issue requires further research (Mohamad *et al*. 2009). In the case of preventing diabetes, the effect of camel milk was also studied. The group of people from the Raica community of 1055 people living in northern India was taken as a study group. The use of camel milk in their diet was widespread. The comparison group was formed by people who were not part of this community, in the number of 1044 people. It was found that the frequency of glucose tolerance disorders was reduced by 57% in the study group ($p < 0.05$; Agrawal *et al*. 2011). Overall, the given data have shown that owing to the application of camel milk the control of glycemia, reducing glucose levels, as well as insulin resistance, and improving the lipid profile in patients with diabetes can be seen in clinical practice (Mansour *et al*. 2017; Mirmiran *et al*. 2017). The effect of camel milk on the degree of angiogenesis in pre-infected mice was investigated by Abdulqader A. Alhaider and others. Three groups of mice were selected depending on the amount of consumed camel milk. Researchers reported that there is a link between the concentration of camel milk and angiogenesis. The degree of vascularization in mice that received more camel milk was lower than in those received less amount of it (Alhaider *et al*. 2014). A randomized study published in Saudi Arabia, in which the potential protective role of camel milk against the genotoxic effect of cisplatin was investigated in five groups of 10 mice. Cisplatin was administered at doses of 0.5 mg $kg^{-1}$ in three groups and 2.5 mg $kg^{-1}$ in two other groups. The mice received camel milk orally in a volume of 33 mL $kg^{-1}$. The results showed a significant decrease in the frequency of micronucleated polychromatic erythrocytes and an increase in the mitotic index of healthy erythrocytes in the groups receiving camel milk, regardless of the dose of injected cisplatin (Salwa & Lina 2010). Roopesh Krishnankutty and others reported the antitumor effect of camel milk against HCT-116 colorectal cancer cells and MCF-7 breast cancer. The study was conducted *in vitro* by adding various amounts of camel milk to the cultures of the aforementioned cells. The authors found that the cell cultures treated with the largest amount of camel milk withstood the maximum exposure (72 h) exhibited morphological alterations, mainly due to the loss of the integrity of the cell membrane along with extensive vacuolization. There were also found proteins characterizing processes of autophagy (Krishnankutty *et al*. 2020). One of the possible methods of treating human forms of cancer was investigated by a group of scientists from the Middle East. The exosomes derived from camel milk were administrated. This method showed a better antitumor effect, however, a lower immune response than treatment with camel milk. In addition, local injection of exosomes led to a more significant immune response than oral administration. These data indicate that camel milk and its exosomes have an antitumor effect, possibly due to the induction of apoptosis and inhibition of oxidative stress, inflammation, angiogenesis, and metastasis in the tumor microenvironment. Thus, camel milk and its exosomes can be used as an antitumor agent for the treatment of cancer (Badawy *et al*. 2018). Treating human forms of cancer, only remains to be seen. Nevertheless, according to the successful results mentioned above, it is possible to do research regarding the use of camel milk against the forms of cancer. Supplementation of mare's milk has been shown to aid in the recovery of gut microbiota following intrapartum and postnatal antibiotic therapy by reducing antibiotic resistance gene load and through pre/probiotic and immunomodulatory effects. Antimicrobial and antiviral activity of mare's milk is associated with a high content of lysozyme, immunoglobulins, lactoperoxidase and lactoferrin. In addition, it contains biologically active substances that are important for the intestinal microbiota, and the biochemical composition is close to mother's milk (Suez *et al*. 2018; Pärnänen *et al*. 2018). Researchers from Kazakhstan have suggested that consuming mare's milk could enhance microbial diversity after antibiotic treatment. This study aimed to compare the effects of administering mare's milk during antibiotic treatment and the recovery phase to antibiotic treatment alone on the diversity of the gut bacterial community. The method used to conduct the study was library sequencing of the V1-V3 region of the 16S rRNA gene on the Illumina MiSeq platform (Su *et al*. 2018). The study included six children between the ages of 4 and 5, who had been diagnosed with bilateral bronchopneumonia. Three out of the six patients were told to consume 40 g of freeze-dried mare's milk mixed with warm water throughout the day. These children were randomly

divided into two groups: the main group that received freeze-dried mare's milk along with standard therapy, and the control group that received only antibiotics. In the control group, parents were instructed not to give their children any probiotics, prebiotics, or other functional foods during the study period (60 days). Additionally, the researchers advised parents to avoid giving their children probiotics for 60 days during biomaterial collection.

Although the sample size was small, clear trends were observed throughout the study period, enabling the researchers to evaluate the impact of the intervention on the abundance of specific bacteria in the gut (Kushugulova *et al*. 2021). Analysis of the bacterial microbiome showed that antibiotic therapy was positively correlated with an increase in bacteria of the genus Firmicutes [$p < 0.05$; False Discovery Rates (FDR) < 0.30], mainly due to a negative correlation with bacteria of the genus Clostridiales ($p < 0.05$, FDR < 0.39) and Bacteroidetes ($p < 0.05$, FDR < 0.41). The concentration of bacteria of the genus *Erysipelotrichia*, which is one of the main beneficial bacteria of the gut microbiome, decreased after antibiotic exposure ($p < 0.02$, FDR < 0.43) and remained reduced by the end of the study period of 50-60 days (FDR < 0.33). Deltaproteobacteria abundance increased on antibiotic therapy compared to baseline (FDR < 0.36) and maintained a decreasing trend until the end of the study period (FDR < 0.35). The numbers of bacteria of the genera *Hungatella* ($p < 0.02$; FDR < 0.44) and *Lachnoclostridium* ($p < 0.03$, FDR < 0.91) tended to decrease. The researchers also observed a negative correlation between antibiotic use and the abundance of unclassified Bacteroides ($p < 0.005$, FDR < 0.67), genera of the Gastranaerophilales family ($p < 0.05$; FDR < 0.67), and a positive correlation for the genera *Escherichia* and *Shigella* ($p < 0.04$, FDR < 0.67; Ge *et al*. 2021). In the primary group, there was a noticeable increase in the quantity of Coriobacteria, which are part of the actinobacteria phylum and comprise two families, i.e., Coriobacteriaceae and Atopobiaceae. Coriobacteriales are a type of commensal microorganisms that are usually found in the oral cavity, gastrointestinal and genital tracts. In the intestine, members of the Coriobacteriales order are the Coriobacteriaceae family, which play important roles such as converting bile acid salts and steroids into digestible substances, as well as activating food polyphenols that aid in the digestion of food (Zhuang *et al*. 2021). The immune status of these patients was also analyzed. In the group receiving mare's milk, there was a significant decrease in vascular endothelial growth factor ($p < 0.05$, FDR < 0.10), IL-3 ($p < 0.03$, FDR < 0.11), IL-8 ($p < 0.002$, FDR < 0.005) and TNF-α ($p < 0.02$, FDR < 0.07), which indicates active anti-inflammatory activity in the body. This pilot study of the effects of mare milk consumption has shown that it is well tolerated by children who are simultaneously treated with antibiotics and suggests a positive effect on the restoration of the intestinal microbiome. For a more detailed understanding of the effect of mare's milk on the protection and restoration of the microbiome, as well as on the immunological response beyond the age category under study, further studies with a large sample number will be required (Inoue *et al*. 2018). The aim of the next study, also conducted in Kazakhstan, was to determine the effect of freeze-dried mare's milk on the intestinal microbiome of patients with hepatitis C. This disease significantly reduces the biodiversity of the intestinal microbiome, which affects the level of immune protection of the body. The decrease in biodiversity, in turn, directly affects the induction of regulatory T cells in the colon, which suppress the inflammatory process in these patients (Musayev *et al*. 2020). A study was conducted with 11 participants who consumed 20 mg of freeze-dried mare's milk. After consumption, the number of bacteria producing SCC, including *Subdoligranulum*, *Fusicatenibacter*, I*ntestinibacter*, *Streptococcus*, and Peptostreptococcaceae increased. On the other hand, the number of bacteria belonging to the genera Prevotellaceae, Veillonellaceae, Oscillospiraceae, Ruminococcaceae, Collinsella, and Aerostipes decreased. These changes were found to be positively correlated with the clinical picture of patients with hepatitis C ($p<0.05$; Nielsen *et al*. 2014). Scientists from Beni Suef University in Egypt conducted a randomized controlled study that found mare's milk to be beneficial to patients diagnosed with viral Hepatitis C (HCV). During the study, liver function enzymes, albumin, total bilirubin, prothrombin time, international normalized ratio, lipid profile, and viral load were assessed at baseline and the study's conclusion. The results showed that the administration of mare's milk led to significant clinical improvements in HCV patients, reducing viral load, improving liver function, and positively affecting the lipid profile (Morsy *et al*. 2014). Mare's milk and probiotics contained in it can modulate the immune system to suppress infections caused by viruses (hepatitis C, influenza, rotaviruses, etc.; Table 1). Antiviral mechanisms include increased production of macrophages, increased phagocytosis, elevated production of differentiation cluster-positive (CD4+), CD8+, IgG and IgA immunoglobulins, B cells, T cells, neutrophils, as well as cytokines [for instance, interleukins (IL) IL-2, IL-12, y-interferon]. Mare's milk can act as an anti-inflammatory agent, reducing the expression of IL-6, IL-1, TNF-α, and γ-interferon (Miguel *et al*. 2010; Adiloğlu *et al*. 2013).

**Table 1.** Probiotic microorganisms in mare's milk and their antiviral activity

| Microorganisms | Antiviral activity |
|---|---|
| Lactobacillus casei | Rotavirus |
| Lactobacillus brevis | Herpes simplex virus type 2 (HSV-2) |
| Lactobacillus plantarum | Echovirus E7 and E19, H1N1 influenza virus, Coxsackie virus, seasonal influenza viruses |
| Lactobacillus acidophilus | Hepatitis C, influenza virus, Rotavirus, Coxsackie virus |
| Lactobacillus gasseri | Influenza A virus, respiratory syncytial virus (RSV) |
| Lactobacillus crispatus | HSV-2 |
| Lactobacillus amylovorus | Echovirus E7 and E19 |
| L. rhamnosus | Influenza virus, HSV-1, Coxsackie |
| L. sakei | Salmonid viruses |
| Lactococcus lactis | Feline calicivirus, norovirus |
| Leuconostoc spp | Adenovirus type 5 |
| Leuconostoc mesenteroides | Salmonid viruses, avian and seasonal influenza viruses |
| Ganoderma lucidum | Enterovirus 71 |
| Penicillium sp. Vega 347 | Dengue fever virus |

Researchers in Turkey conducted a study about the effects of consuming mare's milk on the human immune system. The study involved 18 healthy participants who were given mare's milk for 6 weeks. The researchers measured the serum levels of various factors including TNF-α, IL-1, IL-5, IL-8, transforming growth factor-β, haemoglobin, creatinine, and alanine aminotransferase. The results showed that mare's milk increased the polarization of immune response by type Th1, decreased the reaction by type Th2, and reduced allergic responses. Additionally, consuming mare's milk decreased the expression of IL-8, which can help control inflammatory responses by inhibiting neutrophil chemotaxis. On the other hand, an increase in the expression of IL-5 may enhance the secretion of IgA in the gastrointestinal tract's mucous membrane, leading to a more effective immune response in the intestinal lumen (Vinderola *et al*. 2006).

## CONCLUSION

The given data appear to suggest that there is a possibility of using camel and mare milk as an auxiliary therapy in the treatment of various diseases. However, despite the favorable research results, an in-depth study of this topic with the participation of people is necessary to have further confirmation. The analysis of the data showed that camel milk has both good physical and chemical composition. Furthermore, the significant immunomodulatory and hypoallergenic effects of camel milk may lead to a huge range of applications in medicine, including infectious diseases. The nanobodies contained in the immunoglobulins of mare milk, as well as lysozyme, lactoferrin, and lactoperoxidase, have an antibacterial and antiviral effects. However, its effectiveness in terms of oncological and endocrine diseases needs to be further exploited. To develop effective treatment options for diseases that can lead to serious complications, it is important to conduct high-quality studies, such as randomized clinical trials. To gain a better understanding of the situation, further studies are needed that focus on the use of natural foods with numerous beneficial properties as the primary method of treatment. Although there are still many unknowns regarding the use of camel and mare milk, it can be confidently stated that promoting its use in medicine can lead to improved health outcomes for the population.

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