

Camel Milk - A Nutritious Superfood for Health Complications

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Abstract

The camel is an essential food resource for arid and semi-arid environments in food security conditions. Camel milk is a unique source of nutrients with therapeutic properties. The amount of vitamins C, B3, Mn, iron, Cu, and Zn in camel milk is higher than in cow milk. It is a suitable substitute for human milk for kids allergic to cow milk due to the lack of β -lactoglobulin. Also, camel milk has a high amount of unsaturated fatty acids for heart health. Probiotic bacteria of camel milk may de-conjugate bile salts, preventing reabsorption and reducing cholesterol absorption from the intestine. Camel milk contains insulin-like proteins, which do not form coagulum in the acidic condition of the stomach, can be absorbed from the intestine, and may treat diabetes. The small size of immunoglobulins in camel milk enhances the immune system and anti-inflammatory responses. Camel milk lactoferrin is antiviral and antibacterial agent against infections, and lactic acid bacteria are effective on gut health. Camel milk benefits stomach disorders, cancer, food allergy, autism, and viral Hepatitis. Therefore, camel milk is not only food but also a fantastic superfood for many health complications.

Keywords: Camel milk, health, superfood, cardiovascular, diabetes

Introduction

Camels produce 0.36 % of the world's milk production, approximately 2.91 million tons annually [1]. The protein of camel milk is 3.4 %, lactose 4.4 %, fat 3.5 %, total solids 7.9 %, ash 0.79 %, and 87 % water [2]. Camel milk has unique benefits for health. Calcium, magnesium, iron, copper, and zinc in camel milk are more than in cow milk [2]. Chemical composition of camel milk given in Fig.1. The amount of vitamin C in camel milk is about 40 to 50 mg/kg, which is higher than cow's milk (10 mg/kg) [4]. The small size of nanobodies of camel milk stimulates immune responses and prevents food allergies [5]. The protective proteins of camel milk include lactoferrin, lactoperoxidase, lysozyme, immunoglobulin, and peptidoglycan recognition protein [5]. Lactoferrin has antibacterial, antiviral, and anti-inflammatory properties [1, 6]. Lactoperoxidase is against Gram-positive and harmful bacteria [7]. Camel milk antibodies act against cancer cells, Alzheimer's, HIV, and hepatitis C [8]. Insulin-like proteins of camel milk do not destroy the stomach. Camel milk regulates blood sugar by the effect on signaling in the insulin-sensitive tissues, receptors, and beta-cells function. It has

been proved that camel milk is effective against diabetes complications and heart failure [4]. Camel milk has anti-inflammatory, antimicrobial, and immune-stimulating properties and has the highest amount of lactoferrin against viral and bacterial infections [9]. Lactic acid bacteria as probiotics improve gut function [10]. Camel milk effectively improves food allergies, cancer, cardiovascular diseases, autism, stomach and intestinal disorders, and viral Hepatitis [11]. The anti-cancerous potential of camel milk lactoferrin is through cell cycle regulation, apoptosis induction, inhibition of metastasis, and immunomodulation. Camel milk may be effective as a unique superfood in many human health issues. According to scientific research, this review represents camel milk as an adjunctive therapeutic supplement.

Camel milk and diabetes

About 3/4 of the world's population cannot use allopathic drugs for diseases. Therefore, they rely on natural products [4]. Type 1 diabetes is one of humans' most common metabolic disorders that causes

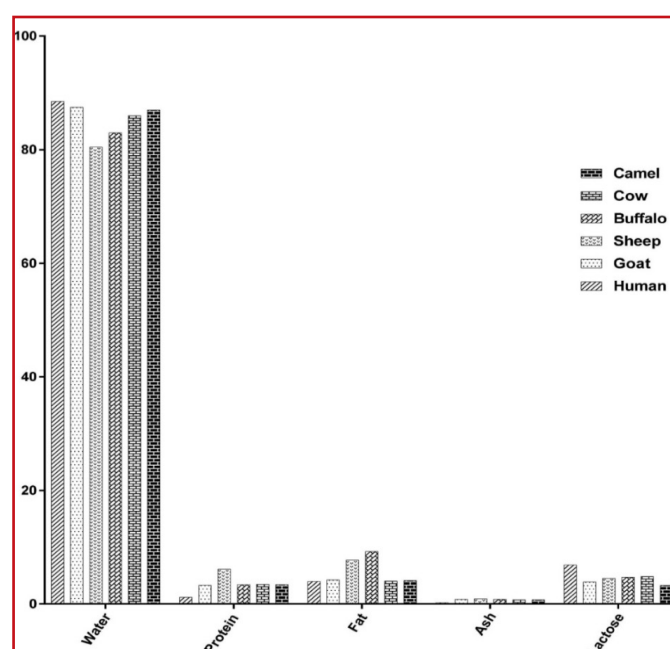


Figure 1: Comparison between camel milk composition with other milks, adapted from [3]

complications. Insulin-like proteins of camel milk do not degrade in the stomach, which may be a proper alternative for insulin [12]. The fat micelles protect insulin and transfer it to the blood in diabetic cases [13]. Agrawal et al. [14] have detected a high amount of insulin in camel milk (about 52 U/L), which causes reduced blood sugar and insulin requirements and decreased insulin resistance in diabetes patients [15]. Therefore, some bioactive components of raw camel milk have immune-modulatory effects on β -cells and insulin receptor function in the insulin-sensitive tissues. Thus, insulin secretion will be increased in type 1 patients [16, 17]. Using camel milk regularly may meet about 60 % of the insulin in patients [4].

Diabetes mellitus is linked with cardiovascular diseases and kidney and liver failures [18]. Camel milk improves inflammation, wounds, obesity, and oxidative stress as main diabetes complications [19]. The anti-oxidative activity of whey proteins in camel milk enhances immune cell proliferation and wound healing caused due to diabetes by increasing glutathione synthesis and improving the cellular antioxidant defense system [20, 3]. Camel milk whey protein alleviates the oxidative stress and promotes immune responses, which are essential to treating diabetes [21]. The beneficial immune-stimulating effects of camel's whey proteins as natural antioxidants have been reported to accelerate the healing process of diabetic wounds in laboratory animals; Therefore, milk-derived peptides at all ages affect the overall health and function of the immune system [3]. Hypoglycemia effects of camel milk may improve renal and liver disorders in diabetic cases [22], diabetic nephropathy, proteinuria, and cardiovascular challenge as main complications in type 1 and 2 diabetes [23]. Thus, camel milk controls long-term glycemic and reduces the required insulin doses in type 1 [3] and type 2 diabetes [4]. In one study in India, 500 mL of camel milk significantly reduced blood sugar in diabetic juveniles [14].

Camel milk and cardiovascular diseases

Probiotic bacteria and bioactive peptides in camel milk produced by their proteolytic activity have hypocholesterolemic effects. Probiotic bacteria deconjugate bile salts and inhibit cholesterol reabsorption, thus reducing cholesterol absorption in the intestine. Probiotic bacteria ferment indigestible carbohydrates and produce short-chain fatty acids in the gut, affecting hepatic cholesterol synthesis and cholesterol distribution from plasma to the liver [24]. Cholesterol-lowering peptides also reduce cholesterol by binding to cholesterol by electrostatic and hydrophobic reactions or by lowering the micellar solubility of cholesterol and inhibiting cholesterol absorption [25]. The decrease in cholesterol levels may also be due to the direct interaction of arginine and tyrosine with cholesterol and the formation of the apoprotein-cholesterol complex, which depends on the amount of arginine in the protein [26]. The concentration of L-carnitine in camel milk is high, positively affecting the lipid profile by reducing the absorption of exogenous cholesterol [27]. Thus, reducing the entry of long-chain fatty acids into the mitochondria for catabolism in β -oxidation indirectly increases blood lipid [28, 27]. According to other research, orotic acid obtained from nucleic acid metabolism in camel milk lowers cholesterol in rats and humans [29]. Using camel milk for 45 days significantly decreased triacylglycerol, total cholesterol, LDL, VLDL, and free fatty acids in plasma, heart, liver, and kidney and improved the HDL content. The administration of camel milk for five weeks reduced total cholesterol from 6.17 to 4.35 mmol/L [4]. Other researchers declared the hypocholesterolemic Effect of fermented camel milk or gariss [26]. Recently, Yahya et al. [30] reported that using non-cream camel milk (fermented by *Lactobacillus helveticus* and *Streptococcus thermophilus*) in adult male Wistar rats

significantly decreased serum cholesterol levels and atherogenic index LDL-cholesterol/HDL cholesterol. Cholesterol-lowering effects are related to the improvement of the oxidative state of the body, which has been shown by the reduction of catalase and peroxidase enzymes [31]. According to research, a 1 % reduction in serum cholesterol leads to a 2 to 3 % reduction in the risk of cardiovascular diseases. Recent studies have shown that non-hydrolyzed casein does not affect lowering cholesterol; However, compounds obtained by casein hydrolysis by Bb12 or trypsin and Bb12 reduced cholesterol levels by 24 to 87 %. Also, the cholesterol-lowering effects of camel milk proteins may be due to other factors, such as cysteine, insulin-like proteins in whey proteins, and small-size Igs [32]. The *Lactobacillus helveticus* releases the angiotensin-converting enzyme (ACE) inhibitory peptide from camel milk proteins the reduces blood pressure. ACE inhibitory activity was higher in cultured camel milk than in cow milk. This may be due to structural differences and higher proline in the initial structure of camel milk casein than cow milk [33].

Camel milk and gastrointestinal failures

Inflammatory bowel disease: Inflammatory bowel disease is an autoimmune disease and persistent inflammation of the large intestine that includes Crohn's disease and ulcerative colitis [34]. Camel milk has strong antibacterial properties and can recover the immune system. Therefore, it may help reduce inflammatory diseases affecting the human large intestine. It has been found that drinking unpasteurized camel milk is beneficial for people who have a variety of symptoms associated with gastrointestinal infections [35]. These agents may help reduce or treat these inflammatory diseases. Vitamins E and C act as exogenous antioxidant defenses that reduce reactive oxygen species. Camel milk stimulates immune responses [36]. It also contains high amounts of unsaturated fatty acids and linoleic acid [37]. Camel milk has antioxidants and is helpful for immunocompromised patients [38, 39]. In addition to antioxidant nutrients, camel milk contains higher concentrations of lactoferrin than cow's milk, an anti-inflammatory and antioxidant agent [40].

Lactose intolerance: Cardoso et al. [41] did a study on 25 lactose intolerance patients whose results showed camel milk is a suitable option for these patients. Lactose-intolerant cases digest camel milk quickly [42] due to the high amount of L-lactate compared to cow milk, which is high in D-Lactate [43]. Lactic acid bacteria isolated from camel milk benefit colon and gastrointestinal health. Antimicrobial peptides, glycomicropeptides, alpha-lactalbumin, casein, and lactoferrin macro peptides in camel milk stimulate the growth and proliferation of bifidobacteria and prevent gastrointestinal bacterial infections [44].

Diarrhea: Camel milk contains high concentrations of anti-inflammatory proteins that sound affects the stomach and intestinal issues [45, 33]. Regarding recent reports, camel milk has anti-diarrhea properties in kids [46]. Camel milk has high levels of anti-rotavirus antibodies and may cure rotavirus diarrhea in children [46]. Camel milk also improved complications of autism, such as diarrhea and bowel movements. Camel milk immunoglobulins may recover the immune system in Crohn's disease [29]. In addition, lactic acid-producing bacteria isolated from camel milk are important as vital probiotics for intestine health [47].

Camel milk and kidney diseases

Fermented camel milk (FCM) benefits oxidative damage in kidney diseases. In an animal study, renal dysfunction was prevented by significantly reducing oxidative stress in female mice pretreated with FCM. Also, uric acid, creatinine, lactate dehydrogenase, urea, plasma

electrolytes, and kidney disease biomarkers decreased. Hence, general camel milk consumption and FCM are considered antioxidant anti-stress agents that prevent kidney damage [48]. The immune function in the kidney against the availability of free iron in the urine is by recovering iron for use in metabolism, protecting body tissues against iron-induced lipid peroxidation (reducing iron power), and regulating cell growth and DNA and RNA binding [49]. Lactoferrin has also been proven to protect the kidney against non-microbial oxidative damage and inflammation, the primary defense against microbial and viral infections. Camel milk lactoferrin has more significant potential against *E. coli* than bovine and humans lactoferrin [50].

Camel milk for autistic cases

Autism spectrum disorder is an autoimmune disease characterized by defeats in communication and social interaction and can be realized at three years of age. Autism is linked with high gastrointestinal and mental issues [51]. Autistic cases have intestinal problems that cause diarrhea and affect appetite [52]. The increased production of reactive oxygen species and oxidative stress may cause brain cell injury, apoptosis, and autism [53]. Controlling reactive oxygen production is essential for cell function, and they should be removed by antioxidants, glutathione peroxidase, catalase, and superoxide dismutase [54]. Consumption of camel milk in autistic subjects improved motor skills, language, and communication [55]. Also, these children have better gut function by consuming camel milk [56]. Camel milk reduces oxidative stress by altering antioxidant enzymes and levels of non-enzymatic antioxidant molecules, thus improving autism behaviors and symptoms [55]. Also, camel's milk might improve the immune system due to immunoglobulins, and brain damage can be prevented early. Camel milk immunoglobulins are smaller in size and penetrate the tissues, and as a result, are more active against antigens and are effective in fighting autoimmune diseases [1]. The researchers reported use of camel milk in autism conditions significantly improves the situation and behavior of these cases as early as two weeks after camel milk consumption. Camel milk can enhance social cognition, communication, speech, and language ability in autistic children [57].

Regarding the studies, camel milk decreased the mortality rate in mice due to protective effects against convulsions. This effect may be attributed to antioxidant, glycinergic stimulatory, and GABAergic activities that can intensify antiepileptic properties [58]. One study investigated the effect of camel milk consumption on oxidative stress in ASD cases. Sixty subjects (2–12 years old) with ASD, especially those with known allergies, were divided into three groups. Groups received 500 mL/day of raw camel, boiled camel, and cow milk. Results showed glutathione peroxidase, superoxide dismutase, and myeloperoxidase significantly increased two weeks after camel milk consumption [57]. There was a significant elevation of myeloperoxidase in the raw and boiled camel milk groups but not in the cow milk group and control. Camel milk lowers oxidative stress after two weeks, improves behavioral and cognitive tests, and increased antioxidant activity [54, 59].

In another study on an autistic kid diagnosed at three years of age, camel milk was used at nine years old. At first, half a cup of frozen raw camel milk was consumed daily. The consumption of camel milk continued and improved autism symptoms for six consecutive years. Also, significant progress in behavior and motor skills was observed by drinking 4 oz of camel milk daily. By consuming camel milk to 8 oz, vocabulary, and pragmatic language were enhanced, and academic skills were above average. Therefore, this study showed that camel milk was important exclusively with no apparent loss of health [60].

The results of Shabo and Yagil [5] showed the effective use of camel milk against autism. Autism symptoms of a 4-year-old girl disappeared after 40 days of drinking camel milk. Also, an autistic 15-year-old boy was cured after 30-day camel milk consumption. Autistic cases (21 years) were quieter and less self-destructive after two weeks of taking camel milk. Al- Ayadhi and Elamin [54] assessed behavioral differences of 65 children with ASD two weeks before and two weeks after daily consumption of camel's milk (boiled and raw form). It is declared that camel milk is a scavenger of free radicals and has an antioxidant role that performs the innate immune response by regulating inflammatory pathways and apoptosis [61]. The effect of 500 mL pasteurized camel milk for eight weeks on eight autistic children was examined, and positive effects on behavioral and pathophysiological disorders were recorded [56]. It is reported that camel milk caused to reduce oxidative stress and improvement of the behavior of autistic children [54]. Also, the autistic children, after using camel milk, had better social conditions, reduced hyperactivity, and increased regular bowel movements [62]. Oxidative stress and subsequent damages occur when antioxidant defense mechanisms are unable to cope with endogenous or external sources of reactive oxygen species (ROS). Increased oxidative stress might contribute to behavior, sleep, and gastrointestinal disturbances in autistic children. Therefore, regulation of ROS production is essential for the cell physiological function [63]. Improving oxidative stress may contribute to behavioral, sleep, and gastrointestinal disorders in children with autism. Low levels of antioxidant enzymes and the presence of free radicals increase oxidative stress and play an essential role in the development of autism. In addition, increased oxidative stress in autism leads to decreased levels of antioxidants such as glutathione and vitamin C, which disrupt metabolic pathways and contribute to growth retardation in autism [54, 64]. The studies showed a significant increase in glutathione after camel milk consumption; due to the antioxidant nutrients of camel milk. Magnesium in camel milk increases vitamin E and C absorption and decreases oxidative stress [65].

In contrast, Klevay [66] reported that zinc enhances peroxidase, total glutathione, superoxide dismutase, and catalase level, and vitamin E increases glutathione. High Mg, Zn, and vitamin E levels in camel milk may increase glutathione and enzyme, decreasing oxidative stress in autistic subjects [65]. High minerals like sodium, potassium, iron, copper, zinc, magnesium, and vitamin C in camel milk are potent antioxidants against free radicals [5]. Studies reported a significant decrease in superoxide dismutase in autistic children due to the impairment of the defense mechanism against oxidative stress. Copper deficiency reduces superoxide dismutase [66], and zinc deficiency decreases superoxide dismutase, glutathione peroxidase, total glutathione, and vitamin E [67]. Superoxide dismutase was significantly increased by camel milk due to the high contents of zinc, copper, magnesium, and vitamin E [54]. Myeloperoxidase indicates oxidative stress and inflammation responsible for antimicrobial activity against many organisms [29]. Autistic cases with gastrointestinal problems have low myeloperoxidase content, directly associated with gastrointestinal pathology [68]. A significant increase in the plasma myeloperoxidase amount was reported after camel milk consumption. Myeloperoxidase and superoxide dismutase work synergistically to protect the cell contents against oxidizing activity by free radicals [68]. Studies showed that increasing glutathione, superoxide dismutase, and myeloperoxidase by raw camel milk consumption improved the behavior of autistic children after two weeks [54]. Another possibility is that camel milk can treat gastrointestinal problems, in ASD subjects, due to camel milk containing inflammation-inhibiting and hypoallergenic properties, and

its smaller size antibodies are similar to human antibodies [69, 70], and thus improve some autistic behaviors. Camel milk is casein and gluten-free; therefore, it improves autistic clinical symptoms and behavior [5], possibly by reducing the effects of excess central opioids [68]. Also, the potential enhancement of gastrointestinal issues is due to the lack of β -lactoglobulin and β -casein in camel milk compared to cow milk which causes food allergy and gastrointestinal disease in autistic cases [71, 29]. Presence of protective proteins and lack of allergic proteins in camel milk cause restoration of the immune system [7].

Short neuroactive peptides, such as β -casomorphins, are derived from the incomplete metabolism of casein in the intestine, and β -casomorphin has been considered a risk factor for autism [72]. Camel milk whey proteins reduce inflammation, free radicals, oxidative stress, and blood pressure; Therefore, oxidative stress is reduced by decreasing hepatic lipid peroxidation and increasing glutathione levels. The antioxidant activity of camel milk alpha-lactalbumin is higher than that of cow's milk due to higher antioxidant amino acids and differences in the structural properties of proteins [44]. Research has shown that their antioxidant activity increases after enzymatic hydrolysis of beta-casein and total camel milk casein with digestive enzymes. Of course, camel milk beta-casein also has a high antioxidant activity after hydrolysis with chymotrypsin. According to research, the antioxidant activity of camel milk cultured with *Lactobacillus rhamnosus* PTCC 1637 was higher than that of cow milk. Increasing proteolytic activity during the storage of both kinds of milk increases antioxidant activity [44]. However, compounds obtained from casein hydrolysis have a more significant role in reducing DPPH (2,2-diphenyl-1-picrylhydrazyl) free radicals than whey. Both peptides have protective effects and are good candidates for improving oxidative stress and associated diseases [44]. Therefore, camel milk consumption is vital in improving autistic behaviors by reducing oxidative stress so that patients become quieter and less destructive and show better emotional expression and communication. Still, more studies need to be done on the duration and amount of daily intake of camel milk on oxidative stress and the treatment of autism.

Antibacterial and antiviral effects of camel milk

Camel milk contains different enzymes and proteins with immunological and antimicrobial properties [73]. Lysozymes participate in the immune responses [74]. Immunoglobulins protect the body against infections; Lactoferrin enhances the primary immune system and prevents pathogenic bacteria growth in the gastrointestinal tract [75]. Lactoferrin of camel milk is much more than other milk, 95-250 mL/dL, prohibiting infectious microbes [76]. The lactoperoxidase of camel milk is about 2.23 ± 0.01 U/mL and is against gram-negative bacteria [7]. The highest amount of peptidoglycan recognition protein is found in camel milk and influences breast cancer by controlling metastasis and stimulating the immune response [75]. N-acetyl- β -D-glucosaminidase elevates antibacterial-antiviral activity [77]. Immunoglobulins (Igs), lactoferrin, and lysozyme are higher in camel milk whey proteins than in cow's milk [78]. Camel IgG only has heavy chains [75], and camel milk Ig is present during lactation, treating autoimmune diseases by boosting immune responses [79]. Immunoglobulins (Ig) of camel milk are against *Mycobacterium tuberculosis* and infections [7]. Whey camel milk proteins significantly improved rabbits' immune response to influenza, diphtheria, and tetanus vaccines. These proteins stimulate immune function and promote lymphocyte activation, proliferation and chemotaxis, cytokine secretion, antibody production, enhanced leukocyte proliferation, and phagocytic activity of granulocyte cells. Also increases the production of interleukins, IL-8, IL-6, IL-1 β , MIP-

1 α , MIP-1 β , and TNF- α , improves primary and secondary antibody responses of gastrointestinal and plays a vital therapeutic role in some immune system disorders in diabetes [44]. These proteins increase IL-2 and IL-8 and decrease IL-1 α , IL-1 β , IL-10, IL-6 [44]. Significant improvement in tuberculosis symptoms observed by consumption of camel milk in drug-resistant patients. Patients did not show cough, sputum, or chest pain with 1 liter of camel milk daily [62]. Clinical signs of tuberculosis patients showed no coughs, difficulty breathing, coughs with blood, sputum, and fever in patients supplemented with camel's milk; Therefore, camel milk can be used as a nutritional supplement in tuberculosis patients. Camel milk acts against foodborne pathogens such as *E. coli* O157:H7 and *Listeria monocytogenes*. Pasteurization of camel milk did not affect antimicrobial activity [80]. Lactoferrin has antiviral activity and inhibits *Schistosoma mansoni* [81]. Camel milk also prohibits the growth of *Klebsiella pneumoniae*, *E. coli*, *Helicobacter pylori*, *Clostridium* spp., *Candida albicans*, and *Staphylococcus aureus*. Also, it works on hepatitis B and C infections, the human immunodeficiency virus, herpes simplex virus-1, and cytomegalovirus [82]. Therefore, the most therapeutic effects of camel milk are due to lactoferrin and Igs [82].

Lactoferrin inhibits bacterial growth and binds iron, which is essential for bacterial growth and prevents the growth of *Salmonella typhimurium*. Lactoferrin has the highest antiviral activity among all the components in camel's milk whey protein. It has shown its antiviral, antibacterial, and antioxidant effects by binding to iron as a stimulant of immunity and anti-inflammatory activities [83]. The activity of camel milk lysozyme against *Salmonella typhimurium* is higher than that of other livestock milk. It destroys the bacterial cell wall and prevents bacteria growth [78, 64]. Alpha-lactalbumin is one of the most active components of whey proteins, which protects infants from infection with various pathogens. Camel lactoperoxidase activity is more efficient than cow's milk and human proteins. RNA and DNA lactoperoxidase inhibit viruses such as Echovirus type 2, HSV, respiratory syncytial virus, HIV, and viruses replicating within infected cells. Camel milk whey proteins maintain high concentrations of antioxidants and stimulate the immune system [83]. However, as natural antioxidants in the diet, camel milk whey proteins and compounds obtained from their hydrolysis reduce oxidative stress [74].

In most parts of the world, rotavirus is the most common non-bacterial cause of gastroenteritis in infants or calves. Purified immunoglobulins from camel's milk, including IgG and IgA, are effective against rotavirus isolated from cattle or humans. Camel milk inhibits *Salmonella typhimurium*, *Listeria monocytogenes*, *E. coli*, and *Staphylococcus aureus*. Camel milk prevents *Listeria monocytogenes*, *E. coli*, and *Staphylococcus aureus* due to lactoperoxidase, hydrogen peroxide, and lysozyme, but stopping the growth of *Salmonella typhimurium* with camel milk lactoferrin is by binding iron and not providing it for bacterial growth [78]. Camel milk lactoferrin is more effective than bovine and human milk lactoferrin in preventing HCV entry to human leukocyte cells. The antioxidant and anti-inflammatory properties of camel milk are effective in treating colitis. High levels of lactoferrin act as an immunostimulant and antioxidant, and camel milk IgG levels as a protective factor against infectious agents [81].

Lactoferrin binds Iron and reduces bacterial growth, prohibits bacterial adhesion, biofilm formation, and the expression of pathogenic bacteria's virulence factors, and influences immune cell activation (Fig. 2). Regarding the increasing antibiotic resistance, it is necessary to explore novel nutraceutical supplements such as lactoferrin for bacterial diseases [9].

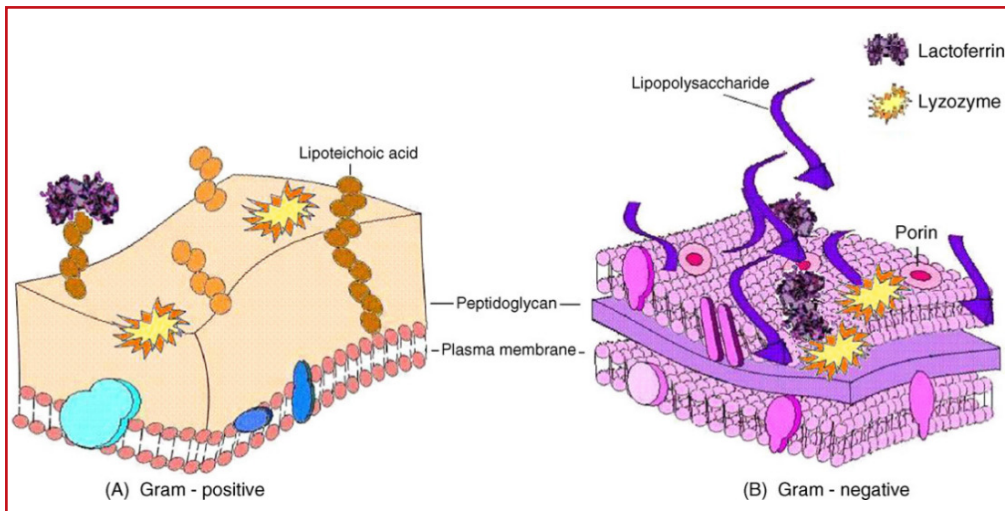


Figure 2: The inhibitory effect of lactoferrin against bacteria, adapted from [84]

According to Fig. 3, 4 lactoferrin is a defense agent against cell surface infections, stops the connection between heparan sulfate receptor viruses, prevents viral adhesion and entry into target cells, binds viral particles and/or host cells, and prevents nuclear localization [83,85]. The antiviral activity of lactoferrin is against DNA and RNA viruses, enveloped and naked viruses such as rotavirus, respiratory syncytial virus, herpes simplex viruses, and HIV. Lactoferrin provokes the immune system against bacterial infections and respiratory viruses such as SARS-CoV, an etiological agent of COVID-19 and very similar to SARS-CoV-2 [85, 86].

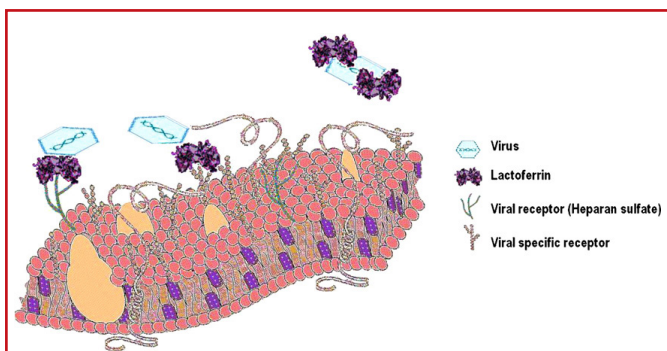


Figure 3: Lactoferrin effects on the viruses, adapted from [84]

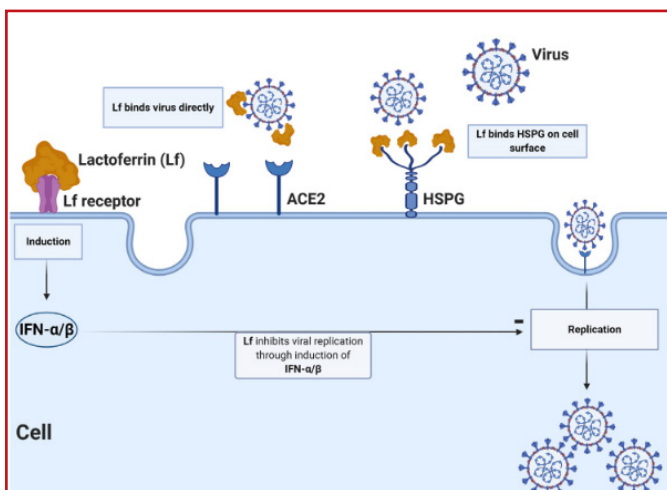


Figure 4: Mechanisms of lactoferrin on the viruses, adapted from [87]

Camel milk lactoferrin is a primary agent against HCV infection, inhibiting virus entry into target cells. Camel's milk was more effective than mare's in improving and normalizing chronic active Hepatitis. The antiviral activity of camel milk lactoferrin is more substantial than human and bovine milk lactoferrins [81].

Camel milk and food allergies

The incidence of milk allergies in infants and children is very high, and camel milk is a good alternative [88]. Immunoglobulin in camel milk is the same as in human milk, improving allergic reactions. IgE of cases suffering from allergies to cow's milk did not respond to camel milk [89]. The camel milk effect was studied on eight children with severe food allergies [5]. The children used camel milk for 14 days; after one day, they showed fewer allergy symptoms, and after four days, all the symptoms disappeared. In all cases, camel milk causes fast improvement in the digestion of other foods. Camel milk immunoglobulin effectively reduces allergic symptoms to cow milk in children. The lack of β -lactoglobulin and low β -casein in camel milk makes it ideal for children suffering from milk allergies and improves these children [90]. Thus, it is an alternative protein for kids with allergies to cow's milk [55]. Camel milk improved eighty percent (80%) of food allergy cases. These cases could safely consume camel milk. Children with severe food and cow milk allergies could improve after taking camel milk daily, even if they do not respond to any therapies [5]. In a study, 35 children aged 6 to 12 months with sensitivity to cow's milk were evaluated; Eighty percent (80%) of these children consumed camel milk without any adverse reaction [88]. In another study, 38 children were evaluated with fresh camel and goat milk. Hypersensitivity reactions to camel milk compared to goat milk showed that camel milk is a more suitable and safer alternative [88]. In another research, two patients (3 and half years, two years, and three months) tested positive for cow's milk and negative for camel's milk [91]. In a similar study, six patients (14 months to 13 years) tested positive for cow's milk and negative for camel's milk. Thus, camel milk may be an essential alternative to infant formula in milk allergy cases [92].

Camel milk and cancer

The antitumor effects of camel milk can directly impact cell cytotoxicity and the removal of tumor cells from the blood by antiangiogenic action or significant inhibition of the expression of coding genes, ultimately leading to the discovery of effective anti-cancer drugs. Most anti-cancer effects have been reported with bovine whey proteins. However,

the effect of camel milk lactoferrin on colon cancer cells has been investigated. Those high concentrations of lactoferrin in camel milk have reduced the growth of colon cancer cells. Camel milk lactoperoxidase also has antitumor activity. High levels of glutathione protect cells from induced apoptosis by anti-cancer drugs; Therefore, camel milk whey proteins effectively treat breast cancer [9, 93]. Studies have proven that camel milk noticeably inhibited cancer cell proliferation by 50 % by activating caspase-3 mRNA [94] and exerts DNA damage inhibitory activity [8]. Camel milk stops cancer cells by activating apoptotic pathways [7]. Camel milk can remove cancer cells in the colon, lung, hepatic, glioma, and leukemia [95]. The active antibodies may destroy tumor cells [96]. Additionally, camel milk inhibits fibrin formation, consequently inhibiting the tumor cells' growth [97]. Also, camel milk lactoferrin inhibits DNA damage, in vitro proliferation of colon cancer cells, and HCT-116 [8]. High amounts of Ig, lactoferrins, and iron-binding glycoprotein in camel milk have antitumor effects due to increasing RNA synthesis and the inhibition of protein kinases. Also, lactoperoxidase possesses antitumor activity. Peptidoglycan recognition protein in camel milk combats breast cancer by takeover metastasis [7]. Antigenotoxic and anticytotoxic properties of camel milk inhibit micronucleated polychromatic erythrocytes. Although camel milk lactoferrin reduced cancer by 56 %, further research is needed to prove the efficacy of camel milk lactoferrin on cancer [8]. The anticancer effects of camel milk can be attributed to a group of bioactive nutrients that synergistically stimulate the usual division of cells and suppress tumorigenesis. Peptidoglycan detection protein (PGRP) is the first peptidoglycan found in camel milk, with the highest concentration (115.3 mg/L) compared to other milk. Peptidoglycan detection protein is against breast cancer by stimulating an immune response and regulating metastasis [98]. Studies have shown that the anti-cancer activity of fermented milk is induced by the inhibition of the angiotensin-converting enzyme (ACE) [99]. Alpha-lactalbumin (α -LA) shows anti-cancer and pre-apoptotic activities against four cancer cell lines [100]. Lactoferrin has been studied for its ability to repair DNA damage and inhibit the proliferation of colorectal cancer cells in vitro due to its antioxidant properties [8]. The anti-metastatic activity of lactoferrin may cause apoptosis induction in deformed cells by activating the signaling pathway of Fas, suppressing cell proliferation, and transporting iron to the cells as a growth factor activator. Lactoferrin has the potential to cure tumors by preventing the proliferation of tumor cells [101].

Hepatoprotective effects of camel milk

According to research, the direct interaction between camel milk lactoferrin and hepatitis C virus prevents virus entry after seven days in a culture medium [81]. In addition to lactoferrin, camel milk IgG, compared with human IgG, can recognize peptides of HCV [102]. Furthermore, camel milk enhances cellular immune responses, inhibits viral DNA replication, and restores chronic hepatitis B [103]. Improvement in fatigue was observed in 50 % of these patients. Camel milk lactoferrin effectively stops entry and replication of HCV in infected HepG2 cells more than human, bovine, and sheep lactoferrin. Using camel milk normalizes liver enzymes, improves liver function, reduces serum triglycerides, hepatic malondialdehyde, and TNF- α and apoptosis, and enhances total antioxidant capacity and the antioxidant defense system [104]. Camel milk casein begins the apoptosis of HCV cells [105]. High vitamin C in camel milk enhances liver function [106]. Also, the camel milk antibodies selectively control viruses. Camel milk antibodies are tenth of human antibodies, caused to penetrate antigens [79]. Consuming camel milk for eight weeks restored liver function, reduced

hepatic fat and inflammatory infiltration, and increased glutathione and catalase activity [107]. Camel's milk was more effective than mare's in improving and normalizing chronic active Hepatitis [81].

Camel milk and skin health

Bioactive peptides [108, 109] and high vitamin C in camel milk have antioxidant activity on skin tissue against free radicals and heal skin issues, wrinkles, and wrinkles, and dryness. Vitamin C is vital in collagen synthesis, cells, and blood vessel growth and strengthens skin firmness [97]. Camel milk contains lanolin and other moisturizing agents that have soothing properties, heal acne, psoriasis, dermatitis, and eczema and keep the skin beautiful [55]. Camel milk contains α -hydroxyl acid as an anti-aging agent which sheds dead skin cells. Presence of α -hydroxyl acids is essential to eliminate wrinkles and spots and improve dryness [55]. In addition, liposomes of camel milk are beneficial for cosmetic ingredients. Using camel milk crème containing 40 % raw camel milk had excellent results on psoriasis. When 20 psoriasis patients were treated with 2 x camel milk crème for four weeks, itching, skin redness, and dryness were reduced [63].

Conclusions

Camel milk is vital in healing severe human diseases due to lactoferrin, immunoglobulins, lactoperoxidase, and vitamin C. Camel milk is a beneficiary for cancer, diabetes, food allergies, hepatitis, and autism and enhances immune responses. However, camel milk's medicinal effects still need more studies to prove its properties. Therefore, camel milk is recommended as a superfood for health complications.

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