

# Biological Activities of Fermented Camel Milk Peptides: a Review

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**Abstract.** Camel milk is widely used in arid desert areas, and it is of great importance from a health standpoint due to its chemical content and health benefits, which increase after fermentation as a result of the decomposition of its components by lactic acid bacteria. Among these components are the proteins that, when decomposed, produce bioactive peptides that help in the prevention and treatment of many diseases. Thus, it is considered a functional food for human nutrition and to treat health problems in these areas due to its high nutritional value and ease of digestion. It has been proven that camel milk has many beneficial health effects, such as anti-bacterial activities because it contains lactoferrin, lysozyme, immune globulin, and lactoperoxidase, in addition to its ability to adjust cholesterol and blood sugar, and its possession of antioxidant, angiotensin-converting enzyme inhibitor, and anti-cancer activities, and to treat digestive system problems. The effectiveness of these activities increases after fermenting camel milk with Lactic acid bacteria and probiotics are a result of the activity of these bacteria to break down the milk components of fats, proteins and carbohydrates into fatty acids, peptides and polysaccharides that are beneficial from a health standpoint and contribute to prolonging the shelf life of fermented products made from camel milk.

**Keywords.** Antimicrobial activity, angiotensin-converting enzyme, antioxidant activity, fermented camel milk, biological functional properties.

## 1. Introduction

The number of camels, according to the statistics of the Food and Agriculture Organization (FAO) for the year 1998, constitutes seventeen million camels, 12.2 million of which are in Africa and 4.8 million in Asia. Milk production varies according to the breed, duration of lactation, feeding conditions and other factors [1]. Camel milk is one of the sources of nutritional and therapeutic products in desert areas, It is an excellent source of high-quality protein, carbohydrates, fats, minerals and vitamins. It also serves as an important source of essential micronutrients, biologically active compounds and lactic acid bacteria [2]. It has a good protein content as it contains active peptides such as lactoferrin and globulin, It is also low in lactose and rich in medium-chain fatty acids, It is associated with anti-diabetes, anti-cancer, high blood pressure and many other health properties [3]. Camel milk is a good alternative to mother milk because they are similar in composition, contain a high percentage of casein and lack the lactoglobulin, in addition to containing a high percentage of vitamins, including vitamin C and minerals such as iron and calcium, and protective proteins that give

the body vital and functional properties [4]. Camel milk is famous for its anti-infective and anti-diabetic effectiveness, as it balances blood sugar levels, as well as its anti-cancer effectiveness, such as cancer of the digestive system, and by providing energy to carry out vital processes, and Helps in treating many diseases such as tuberculosis, hyperacidity, high blood pressure, and respiratory system diseases. It is distinguished by its white color due to its content of Unsaturated fats are small in size and have a natural smell and salty taste [5]. Camel milk contains water, protein, fat, ash and lactose in proportions of 88-86, 3.9-3.0, 5.4-2.9, 0.9-0.6 and 3.3%, which vary compared to cow's milk 87-85, 3.8-3.2, 4.4- 3.7 and 0.7-0.8. And 4.9-4.8% [6]. Pointed out [7] That Camel milk is superior in antimicrobial activity, vitamins, water, and minerals, and has lower levels of fats, proteins, and carbohydrates compared to cow's milk. It is a major source of vitamin C in desert areas, as well as being a rich source of minerals such as minerals, iron, and zinc. It contains monounsaturated fatty acids and Biologically active peptides that are beneficial to health. This review aims to highlight the nutritional importance and biological efficacy of fermented camel milk and the recent development regarding the processing and conversion of camel milk into functional dairy products.

## 2. Camel Milk Proteins

Proteins constitute an essential part of human nutrition and perform many vital functions important for human health. Arabian camel milk contains 3.9-3% protein and consists of caseins and whey proteins, which contain immune proteins and insulin [6]. Camel milk proteins contain caseins and whey proteins, and caseins in camel milk reach 76-72% of the total proteins, while the percentage of whey proteins reaches 22-28% [1]. Camel milk contains 87% of casein proteins of the type  $\alpha_1$ ,  $\alpha_2$ ,  $\beta$ , and  $\kappa$ , which decompose quickly, making camel milk better in terms of digestibility and less allergenicity compared to cow's milk. The percentage of whey proteins in camel milk is 20-25% [6]. Camel milk consists of various proteins, the most important of which are functional enzymes that give it immunity against diseases and have antibacterial activity and many other therapeutic properties. They are called protective proteins, including Lysozymes, Immunoglobulin, Lactoferrin, Lactoperoxidase, Peptidoglycon, and N-acetyl- $\beta$  glucosaminidase [5]. Camel milk is rich in the enzyme N-acetyl- $\beta$  glucosaminidase (NAGase), which is a test for mastitis in cows. It also gives camel milk antimicrobial and antiviral activity, which is similar to its percentage in mother milk [8]. Table No. [1] shows the whey proteins in camel milk and their health effects on humans. Compare [7] on the proportions of caseins and whey proteins between camel and human milk. He noted that camel milk was superior in the proportion of  $\alpha_1$ ,  $\beta$ , and  $\kappa$ , reaching 47, 67, and 58% compared to mother's milk, 33, 55, and 52%, respectively, which lacks  $\alpha_2$  casein, which reached a percentage in camel milk. 56%, while whey proteins in humans had the highest content of  $\alpha$ -lactalbumin, reaching 74%, compared to camel milk, 60%. Serum albumin and Lactoferrin were superior in camel milk, 81 and 75%, compared to mother milk, 76 and 70%, Both types are devoid of  $\beta$ -lactalbumin.

**Table 1.** Whey Proteins in Camel Milk and their Health Effects on Humans.

Whey Proteins	Its health effects	References
Peptidoglycan	Anti-breast cancer stimulates the immune response and is anti-microbial	[9]
Lactoferrin	It has antioxidant properties due to its ability to bind iron Prevents the growth of microorganisms and pathogens It has antimicrobial activity against Gram- negative microorganisms Promote growth	[10]
Lactoperoxidase	Antitumor activity	[9]
	It affects the thyroid hormone because it participates in adding iodine Stimulates the immune response	[8]
Lysozyme	It has antimicrobial activity against Gram-positive microorganisms	[7]
Immunoglobulins	Fighting infections: Its ability to penetrate tissues and cells of the	[3]

Whey Proteins	Its health effects	References
Peptidoglycan	Anti-breast cancer stimulates the immune response and is anti-microbial human body due to its small size Immune protection against infections	[9]
N-acetyl- $\beta$ glucosaminidase (NAGase)	Antimicrobial and antiviral activity	[8]

### 3. Fermentation of Camel Milk

For thousands of years, humans have resorted to fermenting all types of milk, including camel milk, to prolong its storage period, give it functional qualities, and improve the flavour by converting lactose sugar into lactic acid by adding lactic acid bacteria such as *Lactobacillus* [11]. Fermentation is one of the ancient common practices for manufacturing and preserving foods, improving their flavour and colour, and giving fermented products desirable qualities from a sensory, health, and physical standpoint. Camel milk contains all the nutrients that facilitate the work of lactic acid bacteria, which are spherical or bacillary bacteria that are gram-positive and resistant to acidity [12]. Yogurt can be obtained by fermenting milk from different types of dairy animals such as sheep, goats, cows, buffalo and camels, but the last one types are not considered for the production of fermented dairy products on a commercial level [13]. Pointed [7] that the predominant genus of lactic acid bacteria in camel milk is *Lactobacillus*, followed by *Enterococcus*, *Lactococcus*, *Weissella* *Pediococcus*, and *Streptococcus*, in addition to the probiotic *L. plantarum*, which has antimicrobial properties because it possesses proteolytic activity and improves sensory quality. It has also shown its ability to produce antioxidants and acids. Fatty, peptides and polysaccharides enhance the rheological properties of dairy products. Camel milk is fermented after pasteurization at 74°C for 15 seconds and is not preserved for more than 5 days. Camel milk is characterized by being more resistant to heat than cow's milk, as the alkaline phosphatase enzyme present in camel milk is not affected when the temperature rises to 72°C, and the Gamma-glutamyl transferase enzyme (GGT), which is an indicator of whether camel milk has been pasteurized or not, is destroyed after 10 and 20 minutes at 72 °C [5]. Fermented lactic acid bacteria ferment the lactose sugar and produce lactic acid, which raises the acidity of the milk, affects the physical properties of caseins, enhances the digestive process and eliminates harmful bacteria. It also works to increase the breakdown of proteins and the production of essential amino acids and peptides. There are different types of fermented camel milk products, including Gariss and Chal, Shubat, Dhanaan, Airag, Butsalgaa, Arkhi, Tsagaa, Shmen, and Yoghurt [12].

### 4. Fermented Camel Milk Peptides

Proteins, including caseins, are degraded through a series of processes to produce peptides, which in turn are degraded into small peptides and amino acids by the enzymes peptides and pepsin. Changes during proteolysis lead to the generation of an increase in biologically active peptides [14]. Recent studies have proven that camel milk is closer to mother milk compared to other types of milk in terms of composition and effectiveness, as it is easily digested by people with lactose intolerance. It is rich in vitamins, including B and C, and minerals such as iron, as well as containing proteins and peptides that give it antimicrobial, antioxidant, and anti-tumour activity. As well as enhancing the effectiveness of the immune system and resistance to diseases [8]. Fermentation of camel milk with lactic acid bacteria results in the degradation of its proteins by the enzymes secreted by these bacteria, thus producing peptides that give the milk functional properties, including:

#### 4.1. Reducing Blood Cholesterol

Fermented camel milk contains *Bifidobacterium lactis*, which has a lowering effect on total cholesterol in blood plasma, very low-density lipoprotein VLDL, and low-density lipoprotein LDL [15]. Lactic acid bacteria produce peptides that have a cholesterol-lowering effect, as they break down bile salts and prevent the reabsorption of cholesterol in the intestine or it's binding to cholesterol, or by reducing the solubility of cholesterol due to its interaction with arginine and tyrosine [16]. Confirmed [17] that consuming camel milk for 45 days resulted in a significant reduction in blood lipids. Total cholesterol,

triacylglycerols, free fatty acids, LDL, and VLDL in plasma, liver, heart, and kidneys toward normal levels.

#### 4.2. Antimicrobial Activity, Immunity, and Disease Resistance

Fermented camel milk has antimicrobial effects, as it has been proven to exhibit antimicrobial activity against *Staphylococcus aureus*, *Listeria monocytogenes*, *Escherichia coli*, and other pathogenic microorganisms that cause food spoilage [12]. Lactoperoxidase found in camel milk works against gram-positive and gram-negative strains [18]. Camel milk contains lactoferrin, lactoperoxidase, lysozyme, and protective antibacterial proteins. It also has anti-tuberculosis activity, which is attributed to the hydrolysis of caseins by proteolytic enzymes, thus producing peptides. With a lower molecular weight than proteins [6]. [8], stated that camel milk is more effective in eliminating viral diseases than mother's milk, in which the immune bodies are larger than in camel milk and therefore do not reach their goal of eliminating diseases easily, while the immunoglobulins present in camel milk are easily transferred to human blood when Eating it provides a tool to combat immune diseases. Camel milk reduces the risk of many diseases, such as tuberculosis, which is a chronic infectious disease resulting from bacillus bacteria, which reduces the body's immune defence mechanism, making the body resistant to drugs. Research results indicate that camel milk has benefits against this disease because it contains protective proteins that enhance immune defences, etc. [5].

#### 4.3. Antioxidant Activity

The oxidation process produces large amounts of free radicals and active oxygen species that damage cellular molecules and lead to cell death and tissue damage, which increases the risk of skin diseases, arthritis, diabetes, and cancer [14]. Peptides resulting from the hydrolysis or enzymatic degradation of camel milk proteins by lactic acid bacteria work to seize free radicals, bind metals, and inhibit the peroxides of fats and minerals. Antioxidant effectiveness depends on the arrangement of amino acids in the peptide chain, as antioxidant peptides consist of 5-11 amino acids, including Hydrophobic amino acids such as proline, histidine, tyrosine, and tryptophan [19]. Free radicals cause DNA damage and fat oxidation, which causes many diseases such as diabetes, arthritis, and atherosclerosis, Camel milk peptides play an important role in maintaining oxidative balance, as well as containing ascorbic acid and lactoferrin, which are anti-oxidative stress agents that work to scavenge free radicals [16].

#### 4.4. The Inhibitory Effect of the Angiotensin-Converting Enzyme

Camel milk is known as a distinct protein source, and after the degradation of its proteins, peptides are produced that have an inhibitory effect on the angiotensin-converting enzyme, which raises blood pressure, which is higher in fermented camel milk compared to other types of milk [20]. Angiotensin-converting enzymes stimulate the production of angiotensin II, which works to constrict blood vessels, and stimulates the release of the hormone aldosterone, which works to absorb sodium and thus regulate blood pressure [14]. Indicated [21] that the inhibitory activity of the angiotensin-converting enzyme is due to heat-resistant enzymes present in milk, or peptides formed by bacterial enzymes in raw milk, or due to heat treatments, and the percentage of these peptides increases after fermentation to increase the activity of proteolytic lactic acid bacteria. The arrangement of the angiotensin-converting enzyme inhibitory peptides is Ala-Ile-Pro-Pro-Lys-Lys-Asn-Gln-Asp, gives them a blood pressure-lowering effect. This is because camel milk is a rich source of proline, which when fermented with lactic acid bacteria produces these peptides [12]. The increase in proline production is attributed to the metabolic reactions of lactic acid bacteria that lead to the formation of C-terminal peptides with high activity [14].

#### 4.5. Anti-Diabetic Activity

Type 1 diabetes results from autoimmune destruction of insulin-producing cells in the pancreas or a defect in insulin receptors on the cell surface, which leads to an increase in the level of glucose in the blood and urine. It has been found that fermented camel milk works to repair damaged tissues [9]. Camel milk improves blood sugar control and reduces insulin resistance in diabetics [22]. Bioactive

peptides in fermented camel milk inhibit the enzymes  $\alpha$ -amylase and  $\alpha$ -glucosidase, which reduces the decomposition of carbohydrates and thus reduces their absorption in the intestine [23]. Camel milk contains insulin, which does not decompose in the digestive system because it is coated with nanoparticles that facilitate its absorption and passage into the bloodstream, in addition to containing immunoglobulin and lactoferrin, which are anti-diabetic [6]. [8], mentioned that camel milk is used to treat and prevent diabetes because it contains a high percentage of insulin-like proteins, which do not form a blood clotting substance in the acidic environment of the stomach and can be an effective alternative to insulin. Camel milk and some of its active substances affect the work of pancreatic beta cells and insulin receptors in insulin-sensitive tissues, and thus increases insulin secretion [24]. Therefore, camel milk can control diabetes, high cholesterol levels, liver and kidney diseases, and wound healing, as daily drinking of camel milk may fulfill about 60% of insulin in diabetics [25].

#### 4.6. Anti-Cancer Activity

Camel milk peptides fermented by lactic acid bacteria are characterized by cytotoxicity against cancer cells, which leads to programmed death of these cells due to the ability of these peptides to compete with cancer growth factors on cancer cell membrane receptors [23]. Lactoferrin in camel milk works to prevent the proliferation of cancer cells, repair DNA damage, cut off the blood supply to cancer cells, and bind active antibodies to tumours, leading to their elimination without harming healthy cells. Thus, it shows antioxidant activities [9]. High amounts of camel milk immunoglobulin, lactoferrin, iron-binding glycoprotein, and lactoperoxidase are antitumor substances due to increased RNA synthesis [18].

#### 4.7. Effectiveness Against Diarrhea and Digestive System Diseases

Camel milk is used to treat diarrhea resulting from viral infections due to its unique composition, which gives it therapeutic benefits against diarrhea and digestive system problems [12]. Camel milk contains protective proteins such as lactoperoxidase, lactoferrin, and lysozyme, which cause immunity against microbes and thus show an anti-diarrheal effect, in addition to being rich in antibodies to Rota virus, which causes diarrhea in children [6]. Camel milk works to reduce inflammatory bowel symptoms, including Crohn's disease, which causes abdominal pain, diarrhea, vomiting, and complications outside the digestive system, such as skin rash, arthritis, eye inflammation, fatigue, and lack of concentration, because it is rich in peptidoglycan protein and immunoglobulin, which activates the immune system [5].

#### 4.8. Anti-Aging Effectiveness

Camel milk is characterized by its anti-aging effect because it contains hydroxyl acids that penetrate the skin lines and also helps to get rid of the layer of dead cells on the skin by breaking down the sugars that bind the skin cells together and thus getting rid of wrinkles, spots and dryness [16]. The presence of a high percentage of vitamin C in camel milk as a powerful antioxidant has a protective activity on skin tissue against free radicals and cures skin problems, wrinkles and dryness, as vitamin C plays a major role in collagen synthesis, cell growth and blood vessels, and strengthens skin firmness [6]. Moreover, after the consumption of fermented camel milk, some bioactive peptides produced from the digestion of camel milk protein act as natural antioxidants [16].

#### 4.9. Anti-Allergic Activity

Camel milk lacks the protein  $\beta$ -lactoglobulin that causes allergies in humans, and therefore it works to improve children with or without allergies, in addition to the similarity of its composition to mother's milk. Therefore, it is a good alternative to the milk of cows, goats, and sheep, whose milk is rich in this protein [6]. He pointed out that the health properties of camel milk reduce milk allergies that it does not contain  $\beta$ -lactoglobulin and contains  $\beta$ -casein, in addition to the presence of immunoglobulins similar to mother milk globulins, which reduces allergic reactions in children [5]. [16], confirmed. 80% of children who suffer from food allergies improve by using camel milk, and children who suffer from severe food and milk allergies who have not responded to any treatment can improve after consuming camel milk daily.



#### 4.10. Autism

Autism spectrum disorder (ASD) is a severe neurodevelopmental disorder accompanied by failure in communication and social interactions. In addition, a high prevalence of gastrointestinal diseases and mental retardation occurs in cases of autism [26]. Autistic children who use camel milk have seen an amazing improvement in their behaviour, as camel milk reduces oxidative stress by changing antioxidant enzymes and non-enzymatic antioxidants, improves autistic behaviours, and improves motor skills, language, and social communication [27]. The immune system in children suffers from a defect that leads to the breakdown of milk caseinates not into amino acids, but into casmorphine, which is a stronger opiate than morphine, and its symptoms can be reduced by children consuming camel milk to reduce oxidative stress by changing the levels of antioxidant enzymes and non-enzymatic antioxidants [8]. Casmorphine causes brain damage and causes symptoms of autism, which is treated by reducing the amount of milk and its products given to children. Studies have indicated that consuming camel milk shows improvement in the disease because it does not contain casein and lactoglobulin, as well as containing immunoglobulins [5].

#### 4.11. Reducing Contamination with Heavy Metals

It was found that fermented camel milk prepared using certain strains of lactic acid protects against contamination with heavy metal elements such as lead and cadmium, which cause disease problems such as cancer and anemia. The results indicated that there is a protective effect of taking camel milk orally against anemia caused by cadmium. And oxidative stress in erythrocytes [28]. Fermentation of camel milk can reduce the availability of both lead and cadmium in the digestive system of consumers because lactic acid bacteria (LAB) can absorb this metal, which is then excreted in the feces [29]. Also, the use of camel milk for 30 days improved the toxic effects of aluminum through a high increase in total red blood cells and hemoglobin [30].

### Conclusion

This review showed the health-promoting benefits of fermented camel milk proteins and peptides resulting from the proteolysis of caseins by lactic acid bacteria after fermentation, which gives the product functional properties, including improving digestion, antimicrobial and antioxidant activity, as well as inhibitory activities of the angiotensin-converting enzyme, treating hypertension, cardiovascular diseases, diabetes and Digestive system problems. Further studies is required to improve the nutritional and sensory quality of camel dairy products to compete with their counterparts [ other animal species]. In addition, there is a need to develop new technologies and improve suitable processing methods to convert camel milk into different varieties of dairy products for special food or medical uses.

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