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# Bioactive Properties and Nutritional Value of Camel Milk: An Updated Overview

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Traditionally sipped in dry areas, camel milk has been of interest from all around the world because of its unusual nutritional makeup and possible therapeutic benefits. This paper provides an overview of the dietary components as well as the health advantages linked to consuming camel milk. Protein, vitamins (especially the B and C vitamins), minerals (calcium, potassium, and magnesium), and important fatty acids are all abundant in camel milk. Moreover, it has bioactive substances that support its antibacterial, anti-inflammatory, and immunomodulatory qualities, including lysozyme, lactoferrin, and immunoglobulin. Research indicates that camel milk might provide medical benefits for many illnesses, such as autism spectrum disorder, diabetes, heart disease, and gastrointestinal issues. Additionally, camel milk has been investigated as a potential replacement for milk from cows in cases of lactose intolerance or allergy to milk proteins. To completely evaluate its therapeutic potential and understand the processes underlying its health advantages, more research is necessary. All things considered, camel milk shows potential as a functional food with a variety of nutritional and therapeutic qualities, offering hope for both therapeutic and preventive uses in human health.
**Keywords:** Camel Milk, Nutritional Content, Biological Structure, Therapeutic Benefits.

## Introduction:

Pastoralists primarily raise camels within subsistence farming systems for their milk, as camels are renowned for maintaining milk production even during periods of drought. During dry seasons and severe droughts, when the milk supply from cattle, sheep, and goats becomes scarce, camels remain a particularly reliable source of milk [1]. According to the latest estimates from the Food and Agriculture Organization (FAO), there are approximately 29 million camels worldwide, with about 95% being dromedary (one-humped) camels [2].

The lactation period of a camel can range from 18 to 19 months. Several factors, including breed, health status, stage of lactation, and living conditions, affect the quantity of milk produced [3]. Although a camel milk supply is less consistent or lower than a cow's, it can be increased with improved diet, water, and veterinary care since camels' udder structures are similar to cows [4].

Millions of people consume milk daily due to its numerous nutritional benefits, including supporting the growth and development of young children's bones, as it is a rich source of calcium and vitamin D. Additionally, it has shown benefits for the elderly, particularly for menopausal women whose osteoporosis risk increases due to calcium shortage [5].

Camel milk is white and opaque, with a slightly saltier taste compared to cow's milk, and has a pH range of 6.5 to 7. It is considered a potential alternative to bovine milk due to its better digestibility and lower allergenicity [6]. In addition to this, camel milk is reported to contain a good balance of saturated and unsaturated fatty acids along with a higher content of long-chain (~92–99%) and unsaturated (35–50%) fatty acids and a very minor content of short-chain fatty acids [7]. According to [8], camel milk has a high digestibility, which presents possible problems for technological applications. Camel milk is rich in ascorbic acid, making it an essential dietary source in arid regions where green vegetables are scarce, containing three to five times the vitamin C levels found in cow's milk [9][10].

Camel milk exhibits antimicrobial properties to varying degrees due to its unique bioactive components, including lactoferrin, free fatty acids, immunoglobulins, and the lactoperoxidase/thiocyanate/hydrogen peroxide system.

In addition to providing nourishment, milk production helps the majority of people in developing nations with money and food security. Worldwide, milk production involves about 150 million homes [11]. Small-scale producers particularly benefit from camel milk due to its quick cash returns. In addition to providing essential nutrition, camel milk also offers therapeutic benefits [12].

Compared to the milk of other mammals, camel milk is unique, offering higher nutritional value and therapeutic properties [13]. Nomadic pastoralists have long used both fresh and fermented camel milk to treat various ailments [14]. The composition of camel milk is quite different from that of ruminant animals such as goats, sheep, and cows. These unique characteristics cause it to behave differently during processing and the development of new products.

## Nutritional Composition of Camel Milk:

### Macro-Nutrients:

#### Water:

The water content of camel milk ranges from 84% to 90% [15]. Research has shown that this variation is influenced by factors such as the animal's diet and the availability and consumption of water [16]. When camels receive unlimited access to water, milk has 86% water content; but, after water availability is controlled, milk has 91% water content. Thus, it appears that during dry periods, lactating camels lose water from their milk, producing smaller quantities on hot days when water is scarce [17]. Figure 1 shows the nutritional content of camel milk.

#### Total Solids:

Ash, proteins, lactose, and fat make up milk's dry matter. Season and lactation stage have significant effects on milk output every day. The average total solids composition of camel milk is 15.06%, of which protein (4.9%), fat from the milk (5.60%), lactose (5.85%), and mineral elements (0.99%) compose up [18][19]. Camel milk's estimated total solids content varied from 7.76 to 12.13% [20]. Determined that the total solids content of camel milk extracted from Sudan is 11.9 ± 1.5%. In contrast, [21] reported that camel milk from animals kept in Tsabong, southwest Botswana, had a total solids content of 12.2 ± 0.75%. The study also found a negative correlation between the amount of water consumed by camels and the total solids in their milk [22].

**Fats:**

The fat percentage in camel milk ranges from 2.9 percent to 5.4 percent. It claimed that the typical diameter and size of fatty globules in camel milk were 2.99 µm, although they were higher in goat milk (3.19 µm) and milk from buffaloes (8.7 µm). In comparison with small fat globules, an increased rate of milk fat dispersion is favorable for lipolytic enzyme access [23]. Camel milk contains smaller fat globules compared to cow milk [24]. While these small fat particles enhance digestibility [25], they also complicate butter production and result in lower butter yields [26].

Consequently, milk from goats and camels is easier for humans to digest [27]. Camel milk contains a high proportion of long-chain fatty acids, comprising 96.4% of its lipid fraction compared to 85.3% in cow milk, highlighting its distinctive lipid composition [28]. The high melting point of camel milk fat may be attributed to its substantial content of long-chain unsaturated fatty acids and low levels of short-chain fatty acids, along with elevated concentrations of high-molecular-weight triacylglycerols (TAGs, C48–C52). The temperature range of 8–12 °C, which is frequently employed for the churning of cow milk, is too high for camel milk fat to break down easily. As a result, more energy is needed to break the fat globule membrane in camel milk, causing the globules to remain more tightly bound together. The fatty acid composition and cholesterol content of camel milk differ from those of human and cow milk. Specifically, camel milk contains fewer short-chain fatty acids (C4–C8) compared to cow milk fat. Studies have shown that camel milk contains seven to eight times fewer short-chain fatty acids than the milk of cows, goats, sheep, and buffaloes [6]. Compared to cow, mare, and goat milk fat, camel milk fat has higher levels of long-chain monounsaturated fatty acids [29]. Milk from dromedary camels is high in monounsaturated fatty acids (MUFAs), which make up an average of 73 g/100 g of total fatty acids [30].

Camel milk fat contains more unsaturated fatty acids, less short-chain and concentrated saturated fatty acids, and less beta-carotene than fat from cows [31]. Compared to bovine milk, the fat from one-humped camel's milk has a higher concentration of long-chain fatty acids. The proportion of monounsaturated to saturated fatty acids in camel milk is also advantageous when compared to other dairy products [32]. It was reported that the unsaturated oils in camel milk were 0.4%–5% arachidonic acid, 7.3% palmitoleic acid, and 25% oleic acid, respectively.

However, relatively low levels of polyunsaturated fatty acids, including linoleic (4.1%–4.6%) and linolenic acid (0.6%–0.9%), are present. The primary saturated fatty acids in camel milk are palmitic acid, stearic acid, capric acid, and myristic acid [33].

Variations in the fatty acid composition of camel milk fat have been associated with genetic differences within the species [34]. The total quantity of omega-3 fatty acids in camel milk fat varied greatly depending on the breed of camel [35].

**Proteins:**

Camel milk's total protein concentration is typically 3.1 ± 0.5%, with a range of 2.15% to 4.90%. Whey and casein proteins are the two main components of the proteins. Numerous features change the protein composition of camel milk, breed or season being just two of them. According to August has the lowest concentration (2.48%) and December has the highest content (2.9%). Comparing camel milk to human and bovine milk, looking at the protein fractions and amino acid composition.

The primary portion (52%–87%) of total protein found in camel milk is casein, which ranges from 1.63% to 2.76% [36]. There are significant differences in the statistical breakdown of casein and whey proteins between camel milk and bovine milk proteins. While α-casein, which makes up roughly 13% of all caseins, is present in bovine milk, it only makes up 3.5% of the casein element in camel milk.

Unlike bovine milk, which contains 39% total casein, camel milk has a higher proportion of α-casein, making up 65% of its total casein. Specifically, camel milk contains 21% αs1-casein and 9.5% αs2-casein [37]. Camel milk does not coagulate easily, making it challenging to make dairy products that ferment like cheese and curd. The challenges faced in producing goods from camel milk can be attributed to the unique functional and structural characteristics of milk proteins, namely the low quantities of kappa casein that disrupt the casein network during cutting and lead to the loss of cheese's dry matter to whey [38].

When compared to the micellar size distribution, camel milk casein is different from cow milk casein since it contains more large particles than cow milk. Most casein particles from cow milk have a length ranging from 40 to 160 nm. The diameter of the casein particles in the camel milks varies from 20 to more than 300 nm. When compared to bovine milk, camel milk has a lower amount of k-casein due to its larger casein micelle size and less capacity for coagulation when acidic and enzyme-induced. When rennet/chymosin is digested in the stomach and during the manufacturing of cheese, it is believed that the structure and composition of micelles made of casein affect how enzymes destabilize and coagulate those [39]. In contrast to that of bovine milk (Phe105-Met106), the chymosin cleavage site of camel milk's k-casein (Phe97-Ile98) has two extra residues of proline at positions 95 and 105 [40]. Whey proteins contribute 20%–25% of camel milk proteins, which is the second-largest component. Whey proteins and total proteins in milk range from 0.63 to 0.80 g/100 g.

Major whey proteins in the camel milks comprise immunoglobulins, α-lactalbumin, lactophorin, lactoferrin, serum albumin, lactoperoxidase, lysozyme, and peptidoglycan recognition proteins. A contrasting evaluation of camel milk whey proteins in milk from cows, the content of whey proteins varied, with β-lactalbumin having the primary constituent in camel milk and β-lactoglobulin having the primary constituent in bovine milk. α-lactoglobulin, the main whey protein found in cow's milk, is present in camel milk. Yogurt prepared from camel milk has a thin texture and delicate gel structure because camel milk lacks α-lactoglobulin. The formation of firm yogurt gels in cow milk primarily depends on the denaturation of α-lactoglobulin and its interaction with ϰ-casein at around 80°C. Human milk has a comparable whey protein composition [41].

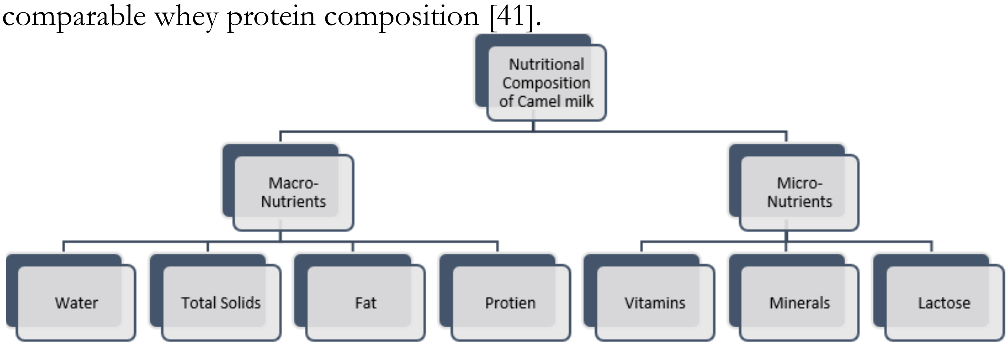



**Figure 1.** Nutritional Composition of Camel Milk

**Micro-Nutrients:**

**Lactose:**

The range of camel milk's amount of lactose is 4.8 to 5.8%, which is somewhat greater than that of cow milk. Camel milk appears to maintain a relatively stable lactose concentration throughout lactation. However, studies examining the impact of drought on its composition found that lactose levels can increase rapidly, rising from 2.8% at birth to 3.8% within a single day. With access to drinking water, lactose levels in camel milk can increase by an additional 5%. Conversely, dehydration in the animals can reduce lactose content to as low as 2.6%.

The type of feed that animals eat in dry areas may be the cause of significant variations in lactose content. To meet their dietary salt requirements, camels often consume plants such as Salsola, Atriplex, and Acacia [6]. As a result, the flavor of camel milk can range from salty to sweet, and occasionally even bitter.

Lactose-intolerant individuals often have difficulty digesting the lactose in raw cow milk. Although camel milk contains similar lactose levels, it can be consumed by those sensitive to lactose without adverse effects [42]. Additionally, camel milk is more easily digested than cow milk [43]. According to some theories, camel milk produces less casomorphins than cow's milk, which would improve lactase activity and diminish intestinal motility. This would account for the susceptibility of those who are lactose intolerant to camel milk [44].

**Minerals:**

Dromedary (one-humped) camels have an average total mineral content of 0.79 ± 0.07%, ranging from 0.60% to 0.90%, commonly referred to as total ash. Variations in mineral content can be influenced by several factors, with differences in breed playing a significant role in the mineral composition of dromedary camel milk [44]. Every 100 g of camel milk contains copper (Cu) 140 µg, manganese (Mn) 80 µg, zinc (Zn) 530–590 µg, iron (Fe) 230–290 µg, potassium (K) 144–156 mg, phosphorus (P) 87.4 mg, sodium (Na) 59 mg, magnesium (Mg) 10.5–12.3 mg, and calcium (Ca) 114–116 mg. According to, 100 g of camel milk contains 0.20–0.28 g of chloride, with an average of 0.26 g per 100 g. This indicates that camel milk has significantly higher levels of potassium (K), sodium (Na), copper (Cu), iron (Fe), and manganese (Mn) compared to cow milk. In a similar vein, found that camel milk contained much higher concentrations of K, Na, Cu, and Fe than did cow's milk. Additionally, they said that camel milk had a greater concentration of iron, zinc, or copper in comparison to goat, human milk, and cow milk.

Compared to bovine milk, camel milk contains six times more iron. A substantial portion of this iron is bound within lactoferrin, a ferrous-binding protein present in camel milk [45]. A component of blood is iron, and it's necessary for several storage proteins, DNA synthesis, oxygen transport, electron transport procedures, and gene regulation [46]. Cofactors magnesium, zinc, and manganese are essential for the activation of some metabolizing enzymes [47]. Manganese (Mn), zinc (Zn), and copper (Cu) protect body cells from damage caused by oxidative stress due to their strong antioxidant properties [47]. Due to their strong antioxidant abilities, Mn, Zn, and Cu protect body cells from cellular damage caused by oxidative stress. The interaction between insulin and its receptors and also the secretion of insulin from islets of ß-cells are both significantly affected by the greater zinc content found in camel milk [48]. Blood pressure and volume are regulated by the elements Na, K, Ca, and Mg present in camel milk [49].

**Vitamins:**

Vitamins that are soluble in water and fat, such as the B complex, C, D, A, and E, have been given to camel milk [50]. Vitamin E concentrations in camel and cow milk were similar (0.56 mg/L and 0.60 mg/L, respectively). The concentrations of other vitamins are, however, comparatively lower. For instance, compared to 1.56 mg/L of cow milk, the quantities of pantothenic acid, vitamin B12, vitamin A (0.10 milligrams per liter), and vitamin B2 (0.57 mg per liter) are lower [50]. Camel milk is high in vitamin C and low in niacin (vitamin B3) and vitamin D; the other vitamin concentrations are identical to those in milk from other animals [51]. It has been discovered that camel milk has eight times more vitamin D3 than cow milk.

Compared to cow's milk, camel milk contains higher levels of vitamin C [52]. Vitamin C acts as an antioxidant, aids in iron absorption, and contributes to wound healing.

Due to its great nutritional value, a single liter of camel milk may satisfy all of the body's needs for minerals and electrolytes [53]. A quarter of a liter (250 mL) of camel milk provides approximately 10.5% of the daily recommended intake of the antioxidant vitamins C, B1, and B6, as well as 8.25% of vitamin B2, 15.5% of vitamin B12, and 5.25% of vitamin A. Table 1 had showed compositional comparison of different milks.

**Table 1.** Compositional comparison between Camel and Cow milk

| Proximate composition(g/100g) | Camel | Cow | References |
|---|---|---|---|
| Water | 88.7-89.4 | 87.7-89.2 | [54], [24] |
| Protein | 2.4-4.2 | 3.1-3.3 | [54], [24] |
| Fat | 2.0-6.0 | 3.3-5.4 | [54], [24] |
| Lactose | 3.5-4.9 | 4.9-5.6 | [54], [24] |
| Total solids | 10.6-11.3 | 10.8-12.3 | [54], [24] |

**Therapeutic Properties of Camel Milk:**

Significant bioactive components discovered in milk produced by camels can be exploited for both curing and preventing disease. It has been speculated that camel's milk has medicinal properties and positive health aspects for an assortment of human maladies. Camel milk is frequently praised for its antidiabetic, antimicrobial, antihypertensive, anticarcinogenic, anticholesterolemic, and immune-stimulating abilities.

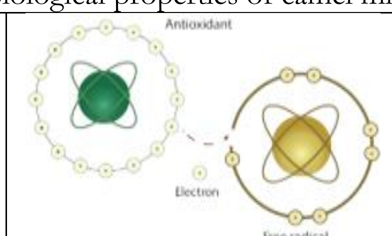
**Antioxidant Activity:**

Peptides obtained from camel milk have antioxidant qualities, making them useful for preventing illness. The vast majority of camel milk's medicinal benefits, including being able to combat cancer, protect the liver from damage, and treat autism, are caused by its antioxidant activity. Once a protein breaks down, milk-derived peptides that are inactive inside its basic proteins become dynamic and are liberated. These peptides, by chemical hydrolysis is responsible for their capacity to protect against lipid peroxidation, scavenge free radicals, and chelate metal ions [55].

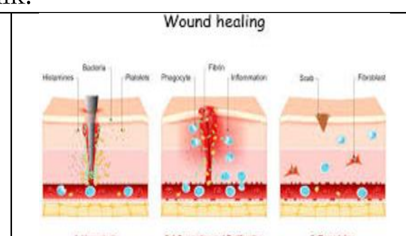
**Anticancer Activity:**

Additionally, camel milk has anticancer properties. Recent research indicates the potential of camel milk peptides (KQ-15 & NV-13) in the therapy of oxidative ailments linked to stress [56]. Camel milk has been shown to reduce the survival and proliferation of human blood vessel and malignant breast cancer cells by activating both extrinsic and intrinsic apoptotic pathways [57]. Camel milk lactoferrin inhibited around 50% of gastrointestinal cancer cells and, by inducing autophagy, was also able to drastically reduce DNA damage, proliferation, viability, and mobility of colorectal carcinoma HCT 116 and breast cancer MCF-7. [58]. Figure 2 shows the biological properties of camel milk.


Damage of Bacterial Cell Membrane, Bactericidal Effect, and Iron Availability




Free Radical Scavenging ROS Production




Pro-inflammatory Cytokines IL 6, 8TNF alpha & MP-1 alpha Free radicals of ROS Wound Healing Process

Glycogen Receptor in liver, Blood Glucose level, Pancreatic cells activity,


Iron Absorption from the intestine, Bone growth factor, Alkaline Phosphate (ALP)

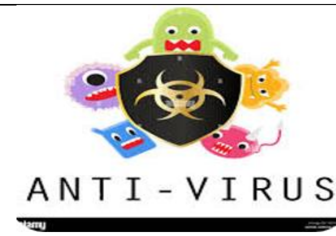
| | | |
|---|---|---|
| Insulin Receptor activity, Antithrombotic action& platelet aggregation | | |
|   |   |   |
| Cancer cells growth & metastasis Expression level of survivin gene Cleavage of caspases 8,9 &3 Expression level of cytokines TNF-alpha & IFN-alpha | Innate immune response, Adaptive immune system, Anti-inflammatory cytokines, Restoration of microscopic alteration | Antioxidant defence, iron availability, Cellular internalization of virus, Replication of Virus |

**Figure 2.** Diagram representation of the biological effects of camel milk and their bioactive elements for the improvement of health disorders.

**Hepatoprotective Effect:**

The hepatoprotective effects of camel milk are attributed to its antioxidant activity. Studies have reported that camel milk can protect against drug-induced hepatotoxicity thanks to its antioxidant properties. Although camel's milk has a high concentration of antioxidants, amino compounds, and chelating toxicants, it has greater antioxidant activity [59]. Furthermore, compared to liver tissues from non-camel milk-treated subjects, histopathological evaluation of the liver tissues also demonstrated the camel milk's protective properties in lowering alcohol-associated cellular damage [60]. Camel milk influences inflammatory agents and immunological disturbances to ameliorate mice's alcoholic liver injury [61]. In addition to preventing alcohol-induced lipid buildup and intestinal dysfunction, camel milk also protects mice against chronic alcoholic liver disease by controlling the generation of inflammatory cytokines and oxidative stress.

**Anti-inflammatory Effect:**

Camel milk possesses anti-inflammatory properties and can modulate gut microbiota in rats with dextran sodium sulfate–induced colitis, suggesting its potential to reduce colonic inflammation. Camel milk lessens the inflammatory response by decreasing the excessive production of inflammatory cytokines in the colon [62]. It improved the diversity of the gastrointestinal microbiota, increased the amount of bacteria that are very beneficial, and diminished the amount of pathogenic microbes in mice with colitis, effectively controlling the intestinal microbiota. Camel milk can help alleviate dextran sodium sulfate–induced colitis by modulating gut microbiota, supporting intestinal barrier function, and reducing proinflammatory cytokines.

During the fermentation of camel milk by the lactic acid bacterium Lactobacillus plantarum KGL3A, peptides with antioxidant and anti-inflammatory properties are produced. These low-molecular-weight peptides inhibited the release of proinflammatory cytokines from lipopolysaccharide-treated mouse macrophages [63].

**Antimicrobial Activity:**

Compared to milk from other mammals, camel milk has been observed to stay stable at normal temperature for a longer period of time. At 30°C, cow milk required three hours to reach an acidic pH of 5.7, whereas camel milk took eight hours to reach the same pH [64]. The higher concentrations of antimicrobial molecules in camel milk are responsible for its extended shelf life and antibacterial properties, especially bacteriocins, immunoglobulin, lactoperoxidase, lysozyme, and lactoferrin. Anti-microbial and antiviral properties of camel milk are demonstrated against pathogenic pathological agents such as Salmonella, Bacillus, Staphylococcus, Listeria monocytogenes, and rotavirus [65]. The antimicrobial properties of camel milk contribute to the management of bacterially-induced complications like Crohn's disease and tuberculosis. Patients suffering from several drug-resistant tuberculosis cases showed faster therapeutic and radiological improvements when they regularly consumed camel milk. The justification that camel milk has antibacterial and antiviral qualities is that it has more lactoferrin than cow milk does [66]. The one-humped camel's raw milk was found to have a mean lactoferrin concentration of 0.209 ± 0.131 mg/mL and 0.220 mg/mL. Conversely, the literature reports that the lactoferrin level of cow milk varies between 0.0767 ± 0.022 mg/mL and 0.140 mg/mL [67]. Individuals with hepatitis C who consumed camel milk showed improvements in blood parameters and liver function [68]. As opposed to human, sheep, and cow lactoferrin, camel lactoferrin has a stronger antiviral effect against the viral infection hepatitis C and reduces its activity. Camel milk has also been shown to enhance immune cell activity and support the recovery of patients with chronic hepatitis B by inhibiting viral DNA replication.

**Anti-Allergenic Effect:**

When babies consume mammalian milk, especially cow's milk, they experience a significant immunological attack because they are allergic to the proteins in the milk [69]. Cow's milk is often used as a supplement or substitute for human milk in children. However, it is a major cause of food allergies, particularly in infants, due to hypersensitivity to cow's milk proteins. Most children allergic to cow's milk proteins produce antibodies primarily against α-casein (αs1-CN) and β-lactoglobulin (β-LG). Although camel milk is hypoallergenic, it poses a possible alternative for children allergic to cow's milk [70]. The variations in the amino acid composition of human and cow's milk are thought to be the cause of issues with feeding infant formula made from cow's milk. The casein profile of human milk is dominated by β-casein, with only trace amounts of αs1-casein. Similarly, camel milk has high β-casein, reduced αs1-casein, and lacks β-lactoglobulin, indicating a closer resemblance to human milk.

**Autism Treatment:**

Additionally, there have been reports that camel milk may have therapeutic benefits for autistic patients. According to [71] autism is a severe brain illness marked by impairment in creativity, both spoken and unspoken interaction media interaction that is mutual, and delays in growth within the first three years of life. As of acceptable accessible, there is no recognized, evidence-based autism intervention strategy. According to other studies, camel milk helps autistic youngsters with their behavior and may be a promising treatment option for autism spectrum disorder [72]. The use of camel milk has been associated with significant improvements in the behavior of children with autism [73]. Initially, consumption of camel milk reduced their symptoms and led to enhancements in motor skills, language, cognition, joint function, and skin health [74].

**Antidiabetic Effect:**

In Asia and the Middle East, camel milk has long been used to manage and treat diabetes. Nomadic Bedouins have traditionally relied on camel milk as a remedy for diabetes mellitus. In India, the incidence of diabetes is reported to be zero among camel milk consumers, compared to a five percent prevalence in those who do not drink camel milk [48]. Moreover, diabetic individuals' typical insulin levels drop from thirty to thirty-five percent when they consume milk, which lowers blood sugar levels [75]. Similarly, camel milk contains immunoglobulin, insulin, and small amounts of elements that have medicinal properties [76]. Camel milk differs from human and other animal milk because its micelles protect insulin from degradation in the digestive tract, enabling faster absorption and facilitating passage across the blood-brain barrier [77].

Camel milk contains antioxidants that may help alleviate symptoms of metabolic syndrome, such as high blood sugar and cholesterol levels. Additionally, because it has lower lactose content than cow's milk, it is a suitable option for individuals who are lactose intolerant [78][79].

**Hypocholesterolemia Effect:**

Obesity and high cholesterol are two serious issues that are becoming more and more prevalent. They are linked to some potentially fatal illnesses, including cancer, hypertension, and cardiovascular diseases. It has been found that bioactive peptides from cultured camel milk can effectively decrease plasma cholesterol levels. Orotic acid is believed to lower cholesterol levels in humans; hence, its presence in camel milk may contribute to its hypocholesterolemia impact [80].

**Effect on Autoimmune Disorders:**

As an alternative medicine, camel milk can be utilized to manage autoimmune illnesses that affect the gut and brain tissues. The immunoglobulins IgD, IgA, IgG, and IgM that exist in camel milk also provide the foundation for this function of camel milk. The immunoglobulins found in camel milk are one-tenth of the number of human antibodies, and they are substantially smaller. The development of immune therapy has been hindered by the size of antibodies, as larger antibodies are more difficult to reach their target locations. Thus, these tiny camelid immunoglobulins create natural nanobodies, offering a novel drug delivery method for the management of autoimmunity or neurodegenerative illness [81]. Camel milk antigens are able to easily access the active region, navigate through dense cells, and interact with the target antigen because of their modest size, uncomplicated structure, and strong affinity for certain antigens. According to Camel, IgG is recognized as a superior enzyme inhibitor protein and has complete neutralizing activity against tetanus toxin.

**Conclusion:**

To sum up, the investigation of the writing to date highlighted the wealth of wholesome cosmetics of camel drain, which is famous for its unmistakable proportion of proteins, lipids, vitamins, and minerals. Its antiviral, anti-inflammatory, and immunomodulatory actions, among other possible therapeutic attributes, point to promising directions for its application in the management of a range of medical diseases. To completely grasp the mechanisms of action and define the degree of camel milk's medicinal perks, more study is necessary, especially well-designed clinical studies. Notwithstanding the encouraging results, it's important to take into account variables like compositional diversity brought on by geographic and agricultural factors, in addition to possible allergic reactions in certain people. All things considered, camel milk seems like an intriguing topic for further research, one that could lead to unique therapeutic methods and a wider variety of dietary choices.

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