

Camel Milk and its Therapeutic Effects: A Review

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Abstract: Camel is a vital animal to daily life of people in desert areas as a source of food, means of transportation and its milk uses as medicine for several diseases. In the harsh environment it can produce more milk for longer period than any other livestock species. The aim of this manuscript was to review currently available articles on the camel milk focusing on its composition and medicinal values by systemic overview of literatures. Camel milk is more similar to human milk as it contains low cholesterol and sugar, high minerals and vitamin C and higher protective proteins like lactoferrin, lactoperoxidase, immunoglobulins and lysozyme. It is unique in terms of antioxidative factors, anti-microbial activities, anti-ulcer, anti-cancer and anti-arthritis properties, autoimmune diseases treatment, cosmetic and detergent values. Additionally, insulin in camel milk is safe and efficacious in improving long-term glycemic control in diabetic patient. Moreover, camel milk reduces autism symptoms in children. High level α -hydroxyl acid in camel milk smoothies the skin and is effective for treatment of skin disorders such as dermatitis, acne, psoriasis and eczema. Additionally, camel's milk can be used as an option for the individuals intolerant to cow's milk and is useful water source for dehydrated calves and the humans. Although camel milk has a lot of health benefits; its consumption is restricted to the pastoral areas. Hence, camel is scientifically abandoned animal documentations on camel milk composition and its medicinal importance is limited which created information gap in this area. So, further studies should be conducted on the chemical compositions and medicinal values of camel milk.

Key words: Camel Milk • Chemical Composition • Medicinal Value • Protective Protein

INTRODUCTION

The total population of camel in the world is believed to be 25.89 million, of which 89% are one-humped dromedary camels (*Camelus dromedarius*) and the remaining 11% are the two-humped (*Camelus bactrianus*) that generally found in the cold deserts of Asia while more than 60% of the dromedary camel population is concentrated in the arid areas of North East African countries like Somalia, Sudan, Ethiopia and Kenya. Ethiopia ranks third in the world by the number of camel herd after Somalia and Sudan [1, 2].

For desert people in Asia and Africa, camel is vital to daily life as a source of food and a means of transportation and just as importantly, its milk has been used as medicines for diverse ailments since ancient times[3]. Camel can produce more milk for a longer period of time in arid zones and harsh environment than any other domestic livestock species [4]. The daily yield of

camel milk ranges from 3 to 10 kg in a lactation period of 12 to 18 months [5]. Ethiopia which possesses about 2.4 million heads camels ranks second in camel milk production in the world next to Somalia. The annual camel milk production in Ethiopia is estimated as 75,000 tones [6].

Camel milk so called white gold of the desert is more similar to human milk than any other milk and differs from other ruminant milk because it contains low cholesterol, low sugar, high minerals (sodium, potassium, iron, copper, zinc and magnesium), high vitamin C, protective proteins like as lactoferrin, lactoperoxidase, immunoglobulins, lysozyme [7]. Camel milk has been acknowledged for a long time to provide a potential treatment for a series of diseases such as dropsy, jaundice, anti-hypertensive, asthma and leishmaniasis or kala-azar [6, 7].

It has been reported that camel milk contains low quantity of β -casein and it lacks β -lactoglobulin because allergic reaction in lactose intolerant person [8].

Nevertheless, it contains insulin-like and protective protein used for the treatment of many ailments like diabetes, autism and diarrhea and possesses anti-tumors properties [9]. Moreover, camel milk is endowed with very strong immune system [3] and remedy for peptic ulcers, anti-malignant [10], anti-platelet and anti-thrombotic properties [11]. More recently, studies confirmed that camel's milk is unique in terms of antioxidative factors, antibacterial, antiviral, antifungal and anti-hepatitis, treatment for paratuberculosis, hypoglycaemic activity, anticancer, preventives of aging, remedy for autoimmune diseases, cosmetic and detergents [2, 12 & 13]. Numerous reviews have been carried out in different milking animals in the world but since a camel is scientifically abandoned animal the importance and use of camel milk was not reviewed well which created information gap in the area

Therefore in the line with the above, the objectives of this paper were:

- ▶ To review available information on medicinal values of camel milk.
- ▶ To recommend further investigation concerning medicinal values of camel milk based on the information from this review.

Composition of Camel Milk: Camel's milk is generally an opaque white color and has a faint sweetish odor and sharp taste; sometimes it can be salty [14]. Its opaque white color because of the fats are finely homogenized throughout the milk whereas, the changes in taste are caused by the type of fodder and availability of drinking water [7]. Its density-ranges from 1.026-1.035 g/cm³ and the pH from 6.2-6.5, both are lower than those of the cow's milk and maximum buffering capacity of skim milk is at pH 4.95 [9].

According to most authors the composition of camel milk varies due to difference of geographical origin and year of publication of the published data but other factors such as the physiological stage, feeding conditions, seasonal or physiological variations, genetic or health status of camel has also a paramount importance [8]. In general the average amount of components of camel milk is protein 3.4%; fat 3.5%; lactose 4.4%; ash 0.79%, while water covers 87% [15].

Water: Water is the most important factor in camel milk. Unlike other animals the water content of camel milk increases during dehydration. With water freely accessible the water content of the milk is 86 percent, but

Table 1: Chemical composition of milk of different species

Proximate	Water (%)	Protein (%)	Fat (%)	Ash (%)	Lactose (%)
Camel	86-88	3.0-3.9	2.9-5.4	0.6-0.9	3.3
Cow	85-87	3.2-3.8	3.7-4.4	0.7-0.8	4.8-4.9
Buffalo	82-84	3.3-3.6	7.0-11.5	0.8-0.9	4.5-5.0
Sheep	79-82	5.6-6.7	6.9-8.6	0.9-0.1	4.3-4.8
Goat	87-88	2.9-3.7	4.0-4.5	0.8-0.9	3.6-4.2
Human	88-89	1.1-1.3	3.3-4.7	0.2-0.3	6.8-7.0

Source: [15].

when water is restricted the water content of milk rises to 91 percent. This is useful as water source for dehydrated calf and the humans in area where water is scarce [16]. The reasons for increment of water content of milk of dehydrated camel are ADH secretion is elevated in the dehydrated camel, a decrease in the fat content and type of forage eaten [1].

Proteins: Milk proteins are heterogeneous group of compounds that differ in composition and properties [5]. Dromedary camel milk contains 3 to 3.90 percent of protein (Table 1). It contains two main groups (Caseins and Whey proteins and relatively higher amount immune proteins (*Peptidoglycan Recognition Protein*, *Lactoferrin Lysozyme* and *Lactoperoxidase*) and insulin [9, 14]. Casein is the most important and higher in proportion, while the proportion of whey proteins is relatively low [17]. Camel milk contains higher protein (especially casein) and lower in whey milk than human milk [18].

Casein is a major part of protein in camel milk. Dromedary camel milk has 1.63 to 2.76 percent of casein protein that constitutes 52 to 87 percent of total milk protein [19], there are 4 main casein fractions casein: α s1-, α s2-, β - and κ their proportions are diverse and polymorphism of these proteins was demonstrated in most of the animal species [20]. The human casein does not contain the α s1-fraction, which is the predominant factor causing milk protein allergy. However; it is rich in the β -fraction. But casein in cow and buffalo milk is very abundant (38.4 and 30.2% of total casein, respectively) in the α s1-fraction [21]. Milk protein allergy (MPA) is an allergic reaction to proteins commonly found in cow milk. In whole casein portion, β -CN is 65 percent and α s1-CN is 21 percent. Camel milk has more digestibility and less allergic reactions in infants as α s-CN slowly hydrolyze than β -CN [22].

Whey protein is the second biggest fraction of protein of camel milk which covers 20 to 25 percent of camel milk protein. The milk of dromedary camel has a whey protein in range of 0.63 and 0.80 percent [23]. B-lactoglobulin is found in trace, while α -lactalbumin

comprises the major camel milk portion. In the milk of bovines, α -lactalbumin constitutes only 25 percent, while β -lactoglobulin made 50 percent of the total whey protein that makes it the major whey protein of bovine milk [14]. Whey protein of camel milk consists of some other main components such as peptidoglycan, recognition protein, immunoglobulins, lactoferrin and serum albumin [24].

Peptidoglycan Recognition Protein (PGRP); its highest concentration was first discovered in camel milk and it has apparent effect on breast cancer by controlling metastasis and stimulates the host's immune response [5]. It stimulates the host's immune response and has potent antimicrobial activity. It even appears to have an effect on breast cancer in studies [9].

Lactoferrin is a glycoprotein which has an ability to bind two metal cations (preferably Fe³⁺) to the binding sites that are structurally closely related. The majority of lactoferrin is needed for transportation or storage of iron and possesses antioxidant properties. Lactoferrin contents of camel milk (0.22 mg.mL⁻¹) were significantly higher than goat, sheep, buffalo and cow milk [14]. The highest level of lactoferrin (2.3 gL⁻¹) was noticed after 2 days of parturition [25]. *Lactoferrin* is among the protective proteins in camel milk with higher concentration and thus prevents microbial overgrowth and invading pathogens [26].

Lactoperoxidase is resistant to acidic and proteolytic digestion contributes to the non-immune host defense system, exerting bactericidal activity, growth promotion activity, anti-tumor activity and it has a close relation (71%) to human thyroid peroxidase, which is involved in iodination and coupling in the formation of the thyroid hormones [27]. *Lactoperoxidase* has bactericidal activity mainly on Gram-negative bacteria like *Escherichia coli*, *Salmonella* and *Pseudomonas* [9, 14]. *Lysozyme* is a protective protein highest in camel milk than milk of cow and human. It has antibacterial activity against gram-positive bacteria like N-acetyl-beta-D-glucosaminidase (NAGase) found in similar quantities in human milk [9].

The immunoglobulins (Igs) in camel milk contribute to camel milk's incredible infection fighting and eradication capacity. Camel Igs are able to penetrate into tissues and cells that human Igs were unable to do. Because of its reduced size (one-tenth the size of human antibodies) it can readily pass to the milk of the lactating camel, can pass the blood brain barrier and is readily absorbed from the gut into the general circulation [3]. Additionally, the level of immunoglobulin G in camel milk is highest among goat, cow, sheep, buffalo and human milk [22].

Fats: The level of dromedary camel milk fat is believed to be 2.9 to 5.4 percent (Table 1) and can be reduced from 4.3 to 1.1 percent in the milk of thirsty camels [8, 28]. But, a recent study reported that camel milk contains only 2% fat which are mainly composed of polyunsaturated fatty acids and omega fats [9]. It is claimed that fat globules with the biggest average diameter found in buffalo milk (8.7 μ m), the smallest in camel (2.99 μ m) and goat milk (3.19 μ m) [29]. A high state of dispersion of milk fat has a positive influence on the access that lipolytic enzymes have to small fat globules (SFGs). Therefore, milk from goats or camels is more digestible for humans [30]. The lipid fraction in camel milk is characterized by a high proportion of long chain fatty acids, which accounts for 96.4 percent compared to 85.3 percent in bovine milk [14].

It is reported that the cholesterol level of fat of camel milk (34.5 mg.100 g⁻¹) is higher as compared to cholesterol level (25.63 mg.100 g⁻¹) of bovine milk fat [19]. Milk fat of dromedary camels carries a lower level of carotene and lesser concentrations of short chain fatty acids as compared to milk of bovine [14].

Cholesterol is present in the milk fat globule membrane (MFGM) and it accounts for 95% of the sterols of milk fat. SFGs are characterized by a larger surface area of MFGM per fat unit. Therefore, a bigger share of SFGs is connected with a relatively higher concentration of cholesterol in milk. Camel milk is also unique concerning its fatty acid profile containing 6 to 8 times less of the short chain fatty acids compared to milk from cows, goats, sheep and buffalo [5]. Various fatty acids such as butyric, caproic, caprylic, capric, lauric, myristic, myristoleic, palmitic, palmitoleic, stearic, oleic, linoleic and arachidic acids are present in camel milk [31].

Carbohydrate: The major carbohydrate fraction in camel milk is lactose sugar with range between 3.3 to 5.80 percent (table 1). The nature of vegetation eaten by the camels in desert areas could be a significant factor for extensive variation in lactose contents. Camels generally like to take halophilic plants like *Salosa*, *Acacia* and *Artiplex* to fulfill their physiological necessities of salts. However, in some dromedary varieties of the world lactose contents found to be changed slightly over a period of time [14]. Lactose (milk sugar) is readily digested by human lactase with no signs of "lactose intolerance".

Minerals: The total amount of mineral of dromedary camel milk is between 0.60 to 1.0 percent [8]. There are significant fluctuations in minerals level due to the differences in feeding, breed and water intake [28]. Camel

milk is a rich source of various minerals like Na, K, Ca, P, Mg Fe, Zn and Cu [32]. The mean values for zinc, manganese, magnesium, iron, sodium, potassium and calcium in mineral contents of dromedary camel milk (100g-1) are 0.53, 0.05, 10.5, 0.29, 59, 156 and 114 mg respectively [14].

Vitamins and Electrolytes: Numerous vitamins such as D, E, A, C and vitamins of B group are found in dromedary camel milk [14, 28]. It was revealed that camel milk contained three to five times more vitamin C as compare to bovine milk. The mean value of vitamin C concentration present in camel milk is 34.16 mg.L-1. It's also reported that camel milk contained higher concentration of niacin (B3) as compared to bovine milk. Camel milk (250 mL) of dromedary camel nourishes a normal adult by means of 10.5 percent of ascorbic acid (C), 5.25 percent of vitamin A, 8.25 percent of riboflavin (B2), 15.5 percent of cobalamin and pyridoxine and thiamin of the Recommended Daily Intake (RDI). In comparison, bovine milk (250mL) nourishes a normal adult by means of 9 percent of vitamin A, 3.5 percent of ascorbic acid (C), 11.5 percent of pyridoxine (B6), 36 percent of riboflavin (B2) and 43.5% of cobalamin (B12) [33]. The low pH of camel milk is due to higher concentration of vitamin C. This acidity stabilizes the milk and therefore it can be kept for relatively longer periods without cream layer formation. In addition, higher amount of vitamin C in camel milk has significant role from the nutritional point of view as it exerts powerful anti-oxidant activity [34]. Moreover, vitamin C and iron are needed for calcium absorption in cases of osteoporosis increasing the amount of calcium absorbed and deposited in the bones [35].

Therapeutic Values of Camel Milk: Health benefit potentials of camel milk are obtained through a number of bioactive components in camel milk [36]. Study conducted between July, 2005 and January, 2006 in Babilie and Kebribeyah woredas, Jijiga Zone of the Somali Regional State reported that respondents (97.5 and 85% for Babilie and Kebribeyah, respectively) recognized the medicinal value of camel milk. This research indicated the medicinal value of camel milk for treatment of gastritis, asthmatics, stomach discomfort, HIV, *hamot (kar)*, tuberculosis, fever, urinary problems and hepatitis [6]. Interviewed pastoralists claimed that camel milk is used to treat a number of illnesses in human beings such as Jaundice, Malaria, Constipation, to clear the stomach, post-partum care of women, to detoxify snake venom and flatulence, jaundice, malaria and constipation for reason that camels browse on various plant species and active agents with

therapeutic properties from these plant species are secreted into the Milk [37].

Camel milk have been acknowledged for a long time in different parts of the world to provide a potential treatment for a series of diseases such as dropsy, jaundice, tuberculosis, asthma and leishmaniasis or kala-azar [6]. It's also revealed that several studies have shown that milk is an important nutritional and functional source of food and provide particular health benefits due to the presence of bioactive substances in it. In the same way, in all camel rearing countries, the breeders are convinced that camel milk has special medicinal properties, especially for dropsy, jaundice and conditions affecting the lungs and spleen [13, 38].

Camel milk is enriched with various protective proteins like lysozyme, lactoferrin, lactoperoxidase, NAGase, PGRP, IgG and IgA which exert antibacterial, antiviral, antifungal and antiparasitic activity, immunological properties, growth promotion activity and anti-tumor activity [39], protective proteins and their immunological action in camel milk have therapeutic effects [40]. As LZ participates in primary immune system based on targeting the structures common to invading pathogens where as Immunoglobulins give the immune protection to the body against infections. Another protective protein in camel milk Lactoferrin prevents microbial growth in gut.

Camel milk contains peptides and proteins that exhibit its biological activities that have beneficial effect on many bioprocesses as digestion, absorption, growth and immunity [41]. Furthermore; camel's milk can be stored at room temperature longer period than milk from other animals [42].

Currently, the value of camel milk has increased worldwide due to its high therapeutic value for human health. Studies confirmed that the composition of camel milk is unique in terms of anti-oxidative factors, anti-bacterial, anti-viral, antifungal and anti-tumor activity, hypoglycaemic, anticancer, to prevent aging and for autoimmune diseases effect [12, 13].

Anti-diabetic Properties of Camel Milk: Diabetes mellitus is characterized by abnormally high blood glucose levels, resulting from low insulin secretion and/or increased insulin resistance [3]. Diabetes mellitus type 1 is caused by autoimmune destruction of insulin-producing beta cells of the pancreas or malfunction of the receptors for insulin on the cell surface. The subsequent lack of insulin leads to increased blood and urine glucose. But as camel milk contains tissue repairing proteins, the problem is cured [9].

In India a comparison between conventionally treated juveniles diabetes with those also drinking camel milk showed that the group drinking the camel milk had significantly reduced blood sugar and reduced HbA1C levels [43]. Insulin of camel milk has unique properties thus act with regulatory and Immuno modulatory function on cells [44]. Camel milk contains large concentration of insulin 150 U/ml [5]. Additionally, Camel milk insulin does not form coagulum in the acid environment of the stomach like insulin of other mammals [27]. Furthermore, the insulin of camel is contained within micelles and protected from proteolysis in the upper gastrointestinal tract; it is encapsulated in nanoparticles that facilitate its absorption and easy passing to the blood stream; it is again plausible that the antioxidant action of camel milk prevents metabolic syndrome, including hyperglycaemia, hyperlipidaemia and insulin resistance [3].

Study demonstrated that insulin concentration in camel milk is higher as compared to cow milk and it can be used as an adjunct to insulin therapy as it appears to be safe and efficacious in improving long-term glycemic control and also helps in the reduction of insulin requirement in type 1 diabetic patient [44]. In the same way, a recent study proved that camel milk is rich source of insulin [45]. Biochemical studies also revealed that the components of camel milk insulin like protein, lactoferrin and immunoglobulins are responsible for camel milk as anti-diabetic. In parallel, epidemiological surveys are also state low prevalence of diabetes in communities consuming camel milk [46].

Long-term study was undertaken to assess the efficacy, safety and acceptability of camel milk as an adjunct to insulin therapy in type1 diabetics, type 1 diabetic patients were grouped into two groups. Group I received usual care:diet, exercise and insulin and Group II received camel milk in addition to the usual care.. The results showed that, in camel milk receiving group, there was decrease in mean blood glucose, hemoglobins and insulin doses. From group receiving camel milk, insulin requirement reduced to zero. There was non-significant change in plasma insulin and anti-insulin antibodies in both groups. It may be stated that camel milk is safe and efficacious in improving long-term glycemic control in type 1 diabetic patients [47].

Anti-bacterial and Antiviral Properties: Camel milk contains antimicrobial enzymes (lactoferrin and Lactoperoxidase), protective protein like caseins, stronger immune system and smaller immunoglobulins than other runinants.

Camel milk has higher concentrations of lactoferrin and lysozyme than bovine milk [48]. Literature has shown that lactoferrin can act as either a bacteriostatic and/or bactericidal agent [49]. This difference in the activity may, in part, explain the wide range of MIC values for lactoferrin activity. As several studies revealed that lactoferrin has inhibitory activity on both Gram- positive and Gram-negative bacteria *in vitro* [50].

Report from study on antimicrobial effects of camel milk against *E. coli* and *L. monocytogenes* confirmed that camel milk has a bacteriostatic effect against both pathogens tested, while the colostrum is bactericidal to *E. coli* and bacteriostatic to *L. monocytogenes*. This study also compared antimicrobial effect of raw camel milk and heated milk and it was suggested that the raw milk is more effective. This justified the clue that heat treatment process may have destroyed, at least partially, some of the inhibitory systems present in the milk. The lysozyme is sensitive to heat and the LPS was shown to be completely inactivated when heated at 80°C for 40 s or at 76°C for 1 min [51].

The Study conducted on effect of protective proteins of camel milk against gram- negative and gram-positive bacteria and rotavirus by extracting Lysozyme, lactoferrin, lactoperoxidase, immunoglobulin G and secretory immunoglobulin A from camel milk and the activity of these protective proteins was assayed against *Lactococcus lactis subsp. cremoris*, *Escherichia coli*, *Staphylococcus aureus*, *Salmonella typhimurium* and *rotavirus*. The result concluded that camel milk LP was bacteriostatic against the Gram-positive strains and bactericidal against Gram-negative cultures and immunoglobulins have little effect against bacteria but high titres of antibodies against rotavirus is found in camel milk [49].

Camel milk has been noted to have medicinal properties treating tuberculosis. Study conducted on the effect of camel milk on multiple drug resistance patients with tuberculosis concluded that camel milk can act as an adjuvant nutritional supplement in MDR patients [52].

Protective proteins like lactoferrin, lactoperoxidase, NAGase and PGRP that exert immunologic, bactericidal and virucidal properties. Among them camel milk lysozyme, lactoferrin, LP and PRP have anti-diarrheal/antibacterial action as well as high titers of antibodies against rotavirus and their impact on the immune system [53]. Rotavirus is the most common cause of diarrhea in children under 5 years old [54]. Since camel milk is rich in anti-rotavirus antibodies the diarrhea subsides.

Recent study done to test antimicrobial activity of camel caseins proved that it has bactericidal activity. Caseins were hydrolyzed successively by pepsin and pancreatin mainly into fragments with a molecular weight below 1 kDa. The antibacterial activity of camel milk of hydrolyzed caseins was increased when compared with that of native casein after successive hydrolysis by proteolytic enzymes. This suggests that antibacterial fragments derived from camel caseins were released [55].

Immune system of camel is stronger than that of human and the small immunoglobulins pass from the camel milk into the human blood. As immunoglobulins are found in camel milk throughout lactation, drinking milk will provide a 'tool' for combatting autoimmune diseases by rehabilitating the immune system rather than is depression [54]. In addition, another study also clarified that camel milk has antibacterial effect against pathogenicity induced by *E. coli* and *S. aureus* in doing trial on rats [52]. Moreover, camel milk has synergistic action with antibiotics which may be used to reduce the dose of antibiotics and decrease bacterial antibiotic resistance. Camel milk supplementation decreased the oxidative stress and normalized antioxidants biomarkers that were ameliorated by *E. coli* and *S. aureus* injection [42].

Camel Milk for Treatment of Crohn's Disease: Crohn's disease is a condition that causes inflammation of the digestive system or guts that boosts with autoimmune disease. It has been approved that infection by *Mycobacterium avium* – subspecies: paratuberculosis (MAP) lead to a secondary autoimmune response, paving the way for Crohn's disease but Camel milk has been identified as effective in recovering autoimmune diseases due to powerful bactericidal properties of camel milk combined with PGRP have a quick and positive effect on the healing process [56].

Camel milk has powerful bactericidal properties and can rehabilitate the immune system. It was observed that drinking non-pasteurized camel milk is beneficial to people with all the variety of symptoms associated with an infection of the alimentary canal [57]. Camel milk has shown good effect for treating Crohn's diseases [58]. As the bacteria belongs to the family of tuberculosis and as camel milk has been used to treat tuberculosis it becomes apparent that the powerful bactericide properties of camel milk combined with PGRP have a quick and positive effect on the healing process. In addition, immunoglobulin's restore the immune system [7].

Camel Milk for Treatment of Autism: Autism disease is general terms for a group of complex disorders of brain development. The etiology of many autistic cases is based primary on autoimmune disease, affecting an intestinal enzyme responsible for the formation of amino acids from the milk protein casein. Sometimes casein breaks down to powerful opioid, casomorphin instead of primarily beta-casein and beta-lactoglobulin. This opioid leads to typical cognitive and behavior symptoms due to brain damage [12].

The most prominent cerebral symptoms are caused by a malfunction in the formation of amino acids from two caseins in cow milk, beta-casein and beta-lactoglobulin. Instead, a powerful opioid, casomorphin, is formed [54]. This opioid elicits the cerebral symptoms of the autism syndrome.

But Camel milk does not contain the two caseins that form casomorphin from cow milk, so symptoms do not develop [59]. In addition; camel milk contains Igs necessary for initiating the immune system and nutritional advantages for brain development [12]. Furthermore, camel milk has emerged to have potential therapeutic effects in autism [13].

The consumption of camel milk in children suffering from autism showed reduction in autism symptoms and improved motor skills, language, cognition, amazing improvements in their behavior and diets, joint coordination and skin health. The previous study evaluated the effect of camel milk consumption on oxidative stress biomarkers in autistic children, by measuring the plasma levels of glutathione, superoxide dismutase and myeloperoxidase before and 2 weeks after camel milk consumption using the ELISA technique. All measured parameters are exhibited significant increase after camel milk consumption. These findings suggests that camel milk could play an important role in decreasing oxidative stress by altering anti-oxidant enzymes and non enzymatic anti-oxidant molecules level, as well as improving of an autistic behaviour by childhood autism rating scale [5].

Treatment for Allergies: The milk protein called β -lactoglobulin present in cow and mare milk is responsible for allergies in humans. However, camel milk lacks this protein and thus does not cause problem of allergies in sensitive individual. β -casein present in cow milk also causes hypersensitivity into humans. Beside, camel milk contains β -casein, but its structure is very different from the cow milk protein. Phylogenetic differences could be responsible for the failed recognition of camels' proteins

by circulating IgEs and monoclonal antibodies. Children with severe food allergies improved rapidly with camel milk. It appears that camel milk has a positive effect in children with severe food allergies [5]. Absence of immunological similarity between camel and cow milk proteins may be taken an important criterion from clinical point of view [22] Therefore; camel milk may be suggested as a new protein source for nutrition for children allergic to cow's milk.

A person allergic to cow milk will develop an allergic reaction after ingesting buffalo, goat, sheep and horse milk proteins due to the presence of positive immunological cross-reaction with their counterparts in cow milk but researchers confirmed that camel milk does not contain the allergens which are present in ruminant milk [22]. So, camel milk is recognized as a good substitute for human milk as it does not contain β -lactoglobulin, a typical milk protein characteristic of ruminant milk [57].

Another fact is that the components of camel milk include immunoglobulins similar to those in mothers' milk, which reduce children's allergic reactions and strengthen their future response to foods. It appears that camel milk has a positive effect in children with severe food allergies. The reactions are rapid and long lasting [57].

Camel's milk can be used as an option for the individuals intolerant to lactose of cow's milk [60]. Camel milk contained low lactose of small molecules and is easily digested and metabolized by the human body [61]. Individuals intolerant to lactose are able to accept camel milk without adverse symptoms [62].

Therapeutic Effects of Camel Milk on Cancer, Tumor and Ulcer: It has been confirmed that lactoferrin has ability to inhibit the proliferation of cancer cell *in vitro* and repair of DNA damage [26], the main iron binding protein of camel milk, lactoferrin is potent for 56% reduction of cancer growth [63]. Investigation of molecular mechanisms that govern the effect of camel milk on human cancer cells demonstrated that camel milk induces apoptosis in HepG2 and MCF7 through apoptotic and oxidative-stress-mediated mechanisms [10]. Other scholars also added that camel milk has antigenotoxic and anti-cytotoxic effects through inhibition of Micro Nucleated Polychromatic Erythrocytes it improves the mitotic index of bone marrow cells [64]. More recent literature claimed that in a series of *in vitro* experiments, camel milk stopped the growth of tumour cells and malignant cells such as hepatocellular carcinoma, colon carcinoma, human glioma cells, lung cancer cells and leukaemic cells and its also suggested that this anti-

cancer action could be both a direct cell cytotoxicity and anti-angiogenic action (cutting blood supply to tumor cell) of camel milk lactoferrin [3].

Tumors can be cured with camel milk; very active antibodies bind onto the tumors, killing the tumor cells without damaging healthy tissue while human antibodies are too big to do this [35]. It is also revealed that anti-tumor properties of camel milk are due to strong antimicrobial and anti-oxidative activities that help in reduction of liver inflammation and camel milk is rich with nutrients that are required for healthy liver function. Conversely, camel milk has also shown to have potential thrombolytic action, as it causes inhibition of coagulation and fibrin formation which in turn hinders the spread and growth of metastatic tumour cells [11].

Camel milk has been proved to have pronounced antiulcer properties. Nonetheless, it contains high levels of vitamins C, A, B2 and E (acidic pH) and is very rich in magnesium and zinc [65]. These vitamins are useful in reducing the oxidative stress caused by toxic agent and Magnesium is very essential for absorption and metabolism of vitamins, B, C and E [66]. Additionally, magnesium is essential for biosynthesis of glutathione; prevents damage to cellular components caused by free radicals, peroxides, heavy metals. More recently, magnesium significantly enhances the antioxidant defence [67].

A protective effect of zinc has been reported against the cellular toxicity due to palliative effect on oxidative stress and apoptosis, activation of the antioxidant system to decrease lipid peroxides. Moreover, camel milk can generate *nitric oxide* which stimulates mucus production, inhibits the adherence of neutrophils to the endothelial cells and, especially, increases the blood flow to the gastric mucous membrane [65].

Camel Milk Effect as Anti-Aging: Studies done on the effect of camel milk as anti-aging suggested that when camel milk is consumed and digested the produced peptides start to act as natural antioxidants and ACE-inhibitors. Camel milk is good for anti-ageing as the high levels of vitamin C protect collagen. Vitamin C in camel milk has antioxidant and tissue repair protection activities. Vitamin C is an essential water soluble vitamin that helps protect the immune system [68]. According to Natural Standard Research, Vitamin C is necessary in the body for the production of collagen, a protein that aids in the growth of cells and blood vessels and gives skin its firmness and strength. Vitamin C strengthens the structural support and resiliency of skin so helps repair.

Vitamin C is an antioxidant that slows the rate of free-radical damage which causes skin dryness and wrinkles [69]. Furthermore, camel milk has high amount of iron chelating protein known as lactoferrin. This protein removes free iron from joints of arthritic patients thereby improves arthritis [31].

Therapeutic Effect of Camel Milk on Hepatitis: Scientific publications have shown that camel milk cures both hepatitis B and hepatitis C. The special fat in camel milk soothes the liver and has beneficial action on chronic liver patients [70]. There is also a possibility that the relatively high concentrations of ascorbic acid in camel milk helps in improving liver function [9]. But Subsequent studies have shown that camel lactoferrin markedly inhibits hepatitis C virus genotype 4 infection through preventing the entry of the virus into the cells[3] Additionally, camel lactoferrin is more potent anti-viral agent than bovine and human lactoferrin, even its anti-parasitic action can clear *Schistosoma Mansoni* [71, 72].

Skin Disease Treatment and Cosmetic Values of Camel Milk: Camel milk has cosmetic effect due to presence of α -hydroxyl acids which are known to plump the skin and smooths fine lines. Alpha- hydroxyl acids help to shed the outer horny layer of dead cells on the skin (epidermis) by helping to break down sugars, which are used to hold skin cells together. This helps in revealing new cells, which are more elastic and clear. Alpha-hydroxyl acids helps to eliminate wrinkles and age spots and relieve dryness as they make the outer layer of the skin thinner and support the lower layer of the dermis by making it thick. In addition, liposome occurring in camel milk is applicable for a potential cosmetic ingredient to improve anti-aging effect [73].

Vitamin B, C, carotin and iron are crucial for skin. The milk contains lanolin and other moisturizing properties providing a calming and soothing effect on the skin. In addition to keeping the skin beautiful used to treat skin disorders such as dermatitis, Acne, Psoriasis and Eczema. Moreover, camel milk is natural source of *alpha-hydroxy* acids for softening the skin, keeping it supple, smooth and preventing wrinkles [74].

CONCLUSIONS

Camel is a vital animal to daily life of desert dwellers as a source of food and a means of transportation and just as importantly, its milk uses as medicines for diverse ailments. Camels produce more milk and for longer period

of time than any other milk animal held under the same harsh condition. Camel milk so called white gold of the desert is more similar to human milk than any other milk. Camel milk is unique containing various protective proteins like lysozyme, lactoferrin, lactoperoxidase, immunoglobulins which exert antioxidative, antibacterial, antiviral, antifungal, hypoglycaemic and antiparasitic agents, growth promotion, aging prevention, autoimmune diseases and anti-tumor activity.

Camel milk contains high levels of insulin or insulin like protein which passes through the stomach without being destroyed. Camel's milk cures severe food allergies, skin diseases and hepatitis. Although camel milk has such values, it's less appreciated thus its consumption is restricted to pastoral area.

Based on the above outline the following recommendations are forwarded:

- ▶ Biochemical analysis should be conducted on the chemical composition and medicinal values of camel milk.
- ▶ Camel milk should be given to the people with lactose intolerance, malnutrition and to diabetic patients as adjunctive with insulin therapy.
- ▶ Camel should be incorporated in to dairy sector
- ▶ Training on camel in general and the chemical composition and medicinal value of camel milk in particular should be integrated in the livestock extension program
- ▶ Ethiopia which has the highest potential of camel population should give priority to further investigate the nutritional and medicinal value of the animal.

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