Review on Medicinal and Nutritional Values of Camel Milk

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Abstract: Of 19 million camels in the world, 15 million are found in Africa and 4 million in Asia. The camels produce more milk and for longer period of time than any other milk animal held under the same harsh conditions. It is a multi-purpose animal with huge productive potential and has been utilized by humans for transport, milk, meat and skin. Camel milk is one of the main components of the pastoral community's basic diet, which contributes up to 30% of the annual caloric intake. The main component of milk which has a major impact on its nutritional value and technological suitability is protein. Milk proteins are a heterogeneous group of compounds that differ in composition and properties. Camel milk is a good substitute for human milk as it does not contain *β*-lacto globulin. Many research findings proved that Camel milk is easily digested by lactose-intolerant individuals. It is rich in healthy vitamins and minerals, especially B vitamins, vitamin C and iron. The lactoferrin in camel milk has also medicinal values: antibacterial, antiviral and anti-tumor properties. It contains disease-fighting immunoglobulin's which are small in size, allowing penetration of antigens and boosting the effectiveness of the immune system. It is a rich source of insulin and also it containing approximately 52 units of insulin in each liter of camel milk, making it a great treatment option for Type 1 or Type 2 diabetics as well as Gestational Diabetes.
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1. Background

Camels are the most numerous species of animal in the arid areas of Asia and Africa, particularly in east African counties (Sudan, Ethiopia, Somalia and Kenya, Djibouti). One humped camel (*Camelus dromedary*), is an important livestock species uniquely adapted to hot and arid environment more than any other domestic animals (Schwartz and Dioli, 1992). Among 19 million camels in the World, of which 15 million are found in Africa and 4 million in Asia (FAO, 2004). Among this estimated world population, 17 million are believed to be one-humped dromedary camels (*Camelus dromedarius*) and 2 million two-humped (*Camelus bactrianus*). More than 60% of the dromedary camel population is concentrated in the four North East African countries Somalia, Sudan, Kenya and Ethiopia. Somalia with over 6 million heads has the largest herd in the world (Farah and Fischer, 2004).

This animal is a multi-purpose animal with huge productive potential. It has been utilized by humans for transport, milk, meat and skin. The camels produce more milk and for longer period of time than any other milk animal held under the same harsh conditions. Daily yields between 3 to 10 kg in a lactation period of 12 to 18 months are common. Camel milk is one of the main components of the pastoral community's basic diet, which contributes up to 30% of the annual caloric intake, at the same time it is an important source of essential components and vitamin C (Farah *et al*., 1992). The milk has many properties that make it very useful choice as camel's milk is used in some parts of the world to cure certain diseases (Attia *et al*., 2001).There is reports that camel milk has medicinal properties (Yagil, 1982) suggesting that this milk contains protective proteins which may have possible role for enhancing immune defense mechanism. Camel milk also contains higher amount of zinc. The rapidly dividing cells of the immune system are sensitive to zinc deficiency. The role of Zn in the development and maintenance of a normally functioning immune system has been well established (Hansen *et al*., 1982). Antibacterial and antiviral activities of these proteins of camel milk were studied (El-Agamy *et al*., 1992).

Camel milk has insulin like activity, regulatory and immunomodulatory functions on β cells. Camel milk exhibits hypoglycemic effect when given as an adjunctive therapy, which might be due to presence of insulin/insulin like protein in it and possesses beneficial effect in the treatment of diabetic patients. Camel milk has been used for the treatment of food allergies, crohn's disease and autism (Shabo and Yagil, 2005).

Even if a numerous review has been carried out in different milking animals in the world, the importance and use of camel milk and its products was not reviewed which created paucity of information in the area. Therefore in the line with the above the objective of this paper is aimed to review available information on the nutritional and medicinal value of camel milk and recommend further investigation concerning nutritional and medicinal value of camel milk based on the information from this literature review

2.1. Nutritional Value

2.1.1 *Milk protein*

The main component of milk, which has a major impact on its nutritional value and technological suitability, is protein. Milk proteins are a heterogeneous group of compounds that differ in composition and properties. They are divided into casein complexes and whey protein fractions. Casein is the most important protein in milk, while the proportion of whey proteins is relatively low (Guo and others, 2007). Currently there are 4 main casein fractions distinguished: αs1-, αs2-, β-, and κ. their proportion is diverse and polymorphism of these proteins was demonstrated in most of the animal species (Barłowska, 2007).

The human casein does not contain the αs1-fraction which is the predominant factor causing milk protein allergies. However; it is rich in the β-fraction. Conversely, casein in cow and buffalo milk is very abundant (38.4% and 30.2% of total casein, respectively) in the αs1-fraction (Zicarelli, 2004). Milk protein allergy (MPA) is an allergic reaction to proteins commonly found in cow milk. It is caused by the immune system reacting to the milk proteins as they would present a threat to the body. An activated immune system reacts just as it would to a foreign virus or a toxin. Several studies have demonstrated that the majority of children with cow milk protein allergy (CMPA) synthesize antibodies predominantly against α-casein and β-lacto globulin (Lara *et al.*, 2005).

Some infants and children allergic to cow milk will have 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 (El-Agamy *et al.*, 2009).

Camel milk is a good substitute for human milk as it does not contain β-lactoglobulin, a typical milk protein characteristic of ruminant milk. Another crucial anti-allergenic factor is that the functional components of camel milk include immunoglobulin similar to those in human milk, which are known to reduce children's allergic reactions and strengthen their future response to foods (Shabo *et al*., 2005). El-Hatmi *et al*. (2007) reported that camel milk contains higher amounts of antibacterial substances (for example, lysozyme, lactoferrin, and immunoglobulin) as compared to cow and buffalo milk.

2.1.2 Milk Lipids

Fat is the major substance defining milk's energetic value and makes a major contribution to the nutritional properties of milk, as well as to its technological suitability. Milk fat globules have an average diameter of less than 0.1 μm to approximately 18 μm (El-Zeini, 2006) and consist of a triglyceride core surrounded by a natural biological membrane. The milk fat globules membrane (MFGM) contains the typical components of any biological membrane such as cholesterol, enzymes, glycoproteins, and glycolipids (Fauquant *et al.*, 2007). Mansson (2008) claims that lipids build 30% of the membrane and can be further broken down into the following groups: phospholipids (25%), cerebrosides (3%), and cholesterol (2%). The remaining 70% of the membrane consists of proteins. Fat globules with the biggest average diameter are found in buffalo milk (8.7 μm), the smallest in camel (2.99 μm) and goat milk (3.19 μm). 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 (D'Urso *et al.*, 2008).

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, which has the highest state of dispersion of milk fat, contains the most (of the studied animals species) cholesterol (31.3 to 37.1 mg/100 g milk). Camel milk is also unique concerning its fatty acid profile. It contains 6 to 8 times less of the short chain fatty acids compared to milk from cows, goats, sheep, and buffalo (Ceballos *et al.*, 2009).

One of the specific features of camel milk is the presence of the fore mentioned CLA, which has numerous functional properties. The most biologically active is the diene of configuration *cis*-9, *trans*-11 (octadecadienoic); it is claimed to inhibit the occurrence and development of cancer of the skin, breast, colon, and stomach, while its isomer *trans*-10, *cis*-12 is thought to prevent obesity (Wang and Jones, 2004).

Additionally, CLA reduces the levels of triglycerides, total cholesterol, including LDL, and thus improves the ratio of LDL/HDL in plasma, which is a crucial factor in the prevention of coronary heart disease and arteriosclerosis. CLA also is said to inhibit the development of osteoporosis, to improve the metabolism of lipids, to reduce the blood glucose level, and to stimulate the immune system (O'Shea *et al.*, 2004).

2.1.3 Milk Mineral Components

Milk is an important source of mineral substances, especially calcium, phosphorus, sodium, potassium, chloride, iodine, magnesium, and small amounts of iron. The main mineral compounds of milk are calcium and phosphorus, which are substantial for bone growth and the proper development of newborns. The high bioavailability of these minerals influences the unique nutritional value of milk. Camel milk is the richest in these minerals (Al-Wabel, 2008).

Average values of Na (29.70 $mEqL^{-1}$), K (50.74$mEqL^{-1)}$, Ca (94.06 mg %), P (41.68 mg %) and Mg (11.82 mg %) present in milk of early lactating camels. In late lactation period, the corresponding levels were 35.49±0.89 mEqL-1, 71.86±1.43 mEqL-1, 97.32±0.51 mg%, 47.14±0.52 mg% and 13.58±0.31 mg %, respectively (Mal *et al*., 2007). The differences in macro-minerals levels reported by various research groups might be due to breed differences or as a result of environmental conditions such as feed and soil. Different breeds of camels have different capacities to deposit minerals in their milk (Wangoh *et al*., 1998). The concentration of Fe, Zn and Cu were 1.00012, 2.00002, 0.44004 mg/dl, respectively. The values of trace minerals viz. Fe, Zn, and Cu were significantly higher in camel milk as compared to bovine milk (Singh *et al*., 2006).

2.1.4 Milk Vitamins

Milk is a valuable source of vitamins, both water-soluble and fat-soluble ones. Camel milk is a kind of exception because of its high concentration of vitamin C. Camel milk contains 30 times more vitamin C than cow milk does, and 6 times more than human milk. This is highly important in desert areas, where fruits and vegetables are scarce. Therefore, camel milk is often the only source of vitamin C in the diet of inhabitants of those regions (Haddadin *et al.*, 2008).

The levels of vitamin A, E and B1 were reported to be low in camel milk compared to the cow milk. Cow milk contains 99.6±62.0 µg% β-carotene and it is not detected in camel milk. The concentration of vitamin C in camel milk in early and late lactation has been reported 5.26±0.47 and 4.84±0.20 mg%, respectively. The vitamin C content in camel milk is two to three folds higher in camel milk compared to cow milk. The levels of vitamin A, E and B1 were higher in camel colostrum than mature camel milk. However, the vitamin C content remains higher in mature camel milk. The higher vitamin C content may be attributed to the more synthetic activity in the mammary tissues during early phase of lactation that declined as lactation advanced (Stahl *et al*., 2006).

The low pH due to the vitamin C content stabilizes the milk and can be kept for relatively longer periods. The availability of a relatively higher amount of vitamin C in raw camel milk is of significant relevance from the nutritional point as vitamin C has a powerful anti-oxidant action. Camel milk can be an alternative source of vitamin C under harsh environmental conditions in the arid and semi-arid areas (Mal *et al.,* 2007).

2.2. Medicinal properties of camel milk

2.2.1 Anti-diabetic property

There is a traditional belief in the Middle East that regular consumption of camel milk helps in the prevention and control of diabetes. Recently, it has been reported that camel milk can have such properties. Literature review suggests the following possibilities: i) insulin in camel milk possesses special properties that makes absorption into circulation easier than insulin from other sources or cause resistance to proteolysis; ii) camel insulin is encapsulated in nanoparticles (lipid vesicles) that make possible its passage through the stomach and entry into the circulation; iii) some other elements of camel milk make it anti-diabetic. Sequence of camel insulin and its predicted digestion pattern do not suggest differentiability to overcome the mucosal barriers before been degraded and reaching the blood stream. However, we cannot exclude the possibility that insulin in camel milk is present in nanoparticles capable of transporting this hormone into the bloodstream. Although, much more probable is that camel milk contains 'insulin-like' small molecule substances that mimic insulin interaction with its receptor (Ajamaluddin *et al.,* 2012).

The long-term study was undertaken previously to assess the efficacy, safety and acceptability of camel milk as an adjunct to insulin therapy in type 1 diabetics. In randomized clinical, parallel design study, type 1 diabetic patients were enrolled and divided into two groups. Group I received usual care, that is, diet, exercise and insulin and Group II received camel milk in addition to the usual care. Insulin requirement was titrated weekly by blood glucose estimation. The results showed that, in camel milk group, there was decrease in mean blood glucose, hemoglobins and insulin doses. Out of subjects receiving camel milk, insulin requirement reduced to zero.There was non-significant change in plasma insulin and anti-insulin antibodies in both the groups. It may be stated that camel milk is safe and efficacious in improving long-term glycemic control, with a significant reduction in the doses of insulin in type 1 diabetic patients(Amjad *et al.*,2013). In India, a comparison between conventionally treated juvenile diabetes with those also drinking camel milk showed that the group drinking the milk had significantly reduced blood sugar and reduced Hb levels (Agrawel *et al.*, 2002). The amounts of injected insulin were also significantly reduced. Insulin in milk is proved by the following many research outcomes: (a) Camel milk contains large concentrations of insulin 150 U/ml. (b) Fasted and dehydrated rats and rabbits had a decline in blood sugar after receiving camel milk. As fasting nullifies insulin secretion, the drop in blood sugar indicates insulin activity. It must be noted that fasted rabbits used to be the bioassay for insulin – the concentration of insulin given as rabbit units. (c) Streptozotocin induced diabetes in rats was controlled and cured with camel milk. (d) Although human, cow and goat milk contain insulin, it is degraded in the acid environment of the stomach. This does not occur with camel milk which does not react to acid and no coagulum is formed. Personal observation in a calf which died 2 hours after suckling: no coagulum was present in stomach although it was filled with milk (Zagorski *et al* .,1998).

2.2.2 Anti-bacterial and Immunological properties

Camel immune system: IgM, IgG, IgA and even IgD have been detected in camel sera on the basis of cross-reactivity with human immunoglobulins (Abu-lehiya, 1997). Hamers-Casterman *et al.* (1993) described the amazing camel immune system, different from all other mammalians. Subclasses IgG2 and IgG3 (natural for camels) consist of only two heavy chains. Light chains (VL) are not present. There is a single V domain (VHH). Camel VHH have a long complementary determining region (CDR3) loop, compensating for absence of the VLConventional antibodies rarely show a complete neutralizing activity against enzyme antigens (Hamers, 1998).

Camel IgG has a full neutralizing activity against tetanus toxin as it enters the ezymes structure. Camel hypervariable regions have increased repertoire of antigen binding sites. Camel VHH domains are better suited to enzyme inhibitors than human antibody fragments, thus offering a potential for viral enzymatic neutralization (Reichmann and Muylderman,1999). Amajor flaw in the development of humanimmunotherapy is the size of the antibodies. The comparative simplicity, high affinity and specificity of camel Igs, and the potential to reach and interact with active sites allow for penetration of dense tissues to reach the antigen. Camels' immune system is stronger than that of humans. 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 (Muylderman *et al*., 2001).

2.2.3 Antibacterial activity

Camel milk contains various protective proteins mainly enzymes which exert antibacterial and immunological properties.The presence of these proteins help explain some of the natural healing properties of the milk (Farah, 1993). According to Conesa *et al*., 2008; Ueda *et al*., 1997 and Kiselev, 1998, the known protective proteins, and their immunological action, in camel milk are: *Lysozymes*; participates in primary immune system, which is based on targeting of structures common to invading pathogens. *Immunoglobulins*; These give the immune protection to the body against infections; *Lactoferrin*: Iron-saturated lactoferrin (from second week lactation) prevents microbial growth in gut, participates in primary immune system, which is based on targeting of structures common to invading pathogens. Camel milk apparently contains much more lactoferrin than in ruminant (cow, sheep and goat) milk; *Lactoperoxidase:* is found in milk, tears and saliva. It contributes to the non-immune host defense system, exerting bactericidal activity(mainly on gramnegative bacteria), has growth promotion activity, has anti-tumor activity, has a close relation (71%) to human thyroid peroxidase, which is involved in iodination and coupling in the formation of the thyroid hormones; *Peptidoglycan recognition protein (PGRP):* the highest concentrations of this enzyme is in camel milk,was first discovered in camel milk, has apparent effect on breast cancer by controlling metastasis, stimulates the host‘s immune response.

Broad antimicrobial activity *N-acetyl-§-glucosaminidase (NAGase)*: The milk enzyme NAGase has an antibacterial activity and so strengthens the antibacterial-antiviral activity of the milk. It is noteworthy that the NAGase activity is similar to that in women's milk, confirming the nutritional advantages of camel milk over cow milk (Hoelzer *et al*.,1998).

2.2.5 Treatment of Crohn's disease

Crohn‘s disease is becoming an epidemic in many countries. Lately increasing evidence points to a primary bacterial infection by Mycobacterium avium - subspecies: paratuberculosis (MAP). This mycobacterium could spread via cow milk as it is unaffected by pasteurization. Apparently MAP enters the mucosa as saprophytes and only become active when the person is in severe stress, leading to a secondary autoimmune response. 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, immunoglobulins attack the anti-DNA and restore the immune system(Urazakov and Bainazarov, 1991).

2.2.4 Therapeutic effect of camel milk for Autism

As a malfunction of the immune system causes an alimentary enzyme inhibition, causing the breakdown of casein, not to aminoacids, but to casomorphine. The casomorphine is a powerful opioid, much more potent than morphine itself. Autistic children drinking camel milk have had amazing improvements in their behavior and diets. Extensive studies have demonstrated that oxidative stress plays a vital role in the pathology of several neurological diseases, including autism spectrum disorder (ASD); those studies proposed that GSH and antioxidant enzymes have a pathophysiological role in autism. Furthermore, camel milk has emerged to have potential therapeutic effects in autism. 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 exhibited significant increase after camel milk consumption. These findings suggest that camel milk could play an important role in decreasing oxidative stress by alteration of antioxidant enzymes and nonenzymatic antioxidant molecules levels, as well as the improvement of autistic behaviour as demonstrated by the improved Childhood Autism Rating Scale (CARS) (Laila and Nadra, 2013).

2.2.5 Treatment for allergies

The fact that camel milk lacks β–lactoglobulin and a "new" β—casein (Makinen-kijunen and Palosne, 1992) ,two powerful allergens in cow milk, makes the milk attractive for children suffering from milk allergies. 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. The reactions are rapid and long lasting. Much research still needs to be done on the healing effects of the milk (Restani *et al.*,1999).

Conclusions

Camel is a multi-purpose animal with huge productive potential and has been utilized by humans for transport, milk, meat and skin. The camels produce more milk and for longer period of time than any other milk animal held under the same harsh conditions. Camel milk has valuable nutritional properties as it contains a high proportion of antibacterial substances and 30 times higher concentration of vitamin C in comparison with cow milk. The camel milk contains high levels of insulin or insulin like protein which pass through the stomach without being destroyed. Immunoglobulin is the substance in the camel milk that contributes to immunity against infection. Camel´s milk cures severe food allergies and rehabilitates the immune system in children. We can affirm that the use of camel's milk could be an option for patients intolerant to lactose and who, therefore, cannot take cow's milk. Although camel milk has such values, its consumption is restricted to pastoral area and camel is abandoned animal. Thus, training on the nutritional and medicinal value of camel milk in particular should be integrated in the livestock extension program. Further studies should be conducted on the nutritional and medicinal value of camel milk.

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