Modern health concept of non-bovine milk: A review

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Received: 03.01.2023; Accepted: 07.03.2023

ABSTRACT

Milk is considered as the most complete single food available and is a fundamental part of the human diet in which major contribution comes from bovine than that of Non-Bovine Animals (NBA). Among NBAs, goat, camel, and donkey are important components of livestock industry which play vital role in the socio-economic structure in rural areas. The gross composition of the Non-Bovine Milk (NBM) is almost like that of bovine milk, except donkey milk due to its lower fat and protein and higher lactose content. NBM has several health benefits as it is rich source of essential fatty acids, some essential amino acids, micro-nutrients, and several bioactive compounds. Goat and camel milk have smaller fat globules hence known as naturally homogenized milk and have better digestibility and protein utilization. Camel and donkey milk are rich source of vitamin C as compared to bovine milk. Furthermore, the protein composition of NBM is one of the attractive points as compared to bovine milk due to its lower allergenic effects in consumers. NBM is also a very rich source of healthy unsaturated fatty acids. Multiple medicinal and therapeutic anti-allergic, anti-microbial, anti-inflammatory, anti-oxidative and anti-cancerous properties help to promote them as "functional foods" to attract consumers. Goat, camel and donkey milk are well known for their bifidogenic, anti-diabetic and antioxidant effects, respectively. NBM has potential for human well-being though, less awareness, information about the microbiota and its significance for milk quality and safety are challenging fields for further exploration.

Key words: Milk, Non-Bovine, Goat, Camel, Donkey, Health

Milk and dairy products have always been accredited as a vital part of anthropological diet both in developing as well as developed nations of the world. All mammals produce milk but only some of them are domesticated based on, regularity, production, cost effectively, human nutritional needs, convenience, stability and suitability to form value added. The major contribution in dairy sector comes from bovine, while non-bovine animals (NBAs) are more connected to rural areas as they are part of their daily practices⁶¹. Furthermore, NBAs are proving income to people in many ways. Human milk is considered as nature’s best infant food from nutritional, immunological and food safety point of view. Due to the time constraints, health conditions and urbanization, mother may cause the early termination of breast feeding. Normally, cow milk represents the most important part during the infant weaning and early termination, but it is also the first allergen in life. Donkey, camel, and goat milk are considered a good substitute of human milk. Considering the possible use of alternative milk sources for human in cases of cow milk allergy, the usage of other mammals should be pursued.

Camels play a major role in the lifestyle of many communities; particularly those in dry zones as well as they have ability to sustain in harsh climatic conditions. Camels also contributing to raising the economy and food security for humans as they are used in transport, sport, source of meat and milk. Camel milk is well known for its anti-diabetic, anti-carcinogenic,
immunomodulatory, and anti-microbial effect\textsuperscript{65}. Donkey milk is gaining attention as a natural nutritional and medicinal product, mainly because its composition is parallel to that of human milk and it has some potential biological properties, such as antioxidant, anti-inflammatory, anti-aging, antimicrobial, and anti-allergic\textsuperscript{38}.

Goat’s milk is becoming more and more widespread due to its better digestibility as well as other unique features like, bifidogenic, anti-inflammatory, anti-microbial, anti-atherogenic effects etc\textsuperscript{57}. The higher acceptance is mainly due to similar chemical composition of goat’s milk to that of cow’s milk. In this regard the objective of this review is to study the compositional value of milk of different species and to discuss their nutritional value. It is very much essential that all should have the knowledge regarding nutritional and medicinal values of milk from different species which will be helpful for their choice or their requirement.

**Gross Milk Composition of Non-Bovine Milk (NBM)**

The overall average composition of milk of different mammals is presented in Table 1. Chemically donkey milk is very similar to human milk while goat milk is like cow milk. The higher fat content is observed in camel milk while lowest in donkey milk hence the donkey milk has reduced energetic level as compared to other milk sources. Author\textsuperscript{59} reported that adding 1.6 g of sunflower oil to 100 mL of donkey milk (16 mL.L\textsuperscript{-1}) compensates for the low fat and caloric values found in donkey milk and constitutes a formula that is very close to human milk. Agglutinin is responsible for fat agglomeration in milk which is absent in goat. Goat and camel milk are known as naturally homogenized milk due to smaller fat globules.

Milk proteins are a heterogeneous group of compounds that differ in composition and properties. The milk protein profile in non-bovine animals is mentioned in Table 2. Caseins and whey proteins are the major milk protein fraction, among which caseins contributing 80% of total milk protein content. The other small fractions of milk protein are protease, peptones, and non-protein nitrogen substances. Caseins are of three types; alpha, beta and kappa while whey protein includes α Lactalbumin, β lactoglobulin immunoglobulins, lactoferrin, transferrin etc. Casein is the major protein fraction present in both goat\textsuperscript{35} and camel milk\textsuperscript{1}. The amount of small-sized casein micelles is relatively higher in goat’s milk than cow’s milk that explains the better digestibility of goat’s milk\textsuperscript{24}. The β-casein is the principal component of goat and donkey milk casein; in contrast, α-S1 is the major component of cow milk casein (Table 2). The lower level of α S1 casein in non- bovine milk make it preferable in case of cow milk protein allergic condition\textsuperscript{36}. Moreover, better utilization of protein has been also studied in rats receiving goat milk as compared to rats receiving cow milk\textsuperscript{40}.

### Table 1: Gross composition of milk in different mammals (%)

<table>
<thead>
<tr>
<th>Proximate</th>
<th>Water content</th>
<th>Total Solids</th>
<th>SNF</th>
<th>Fat</th>
<th>Protein</th>
<th>Lactose</th>
<th>Ash</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cow</td>
<td>87.80</td>
<td>12.20</td>
<td>8.60</td>
<td>3.60</td>
<td>3.20</td>
<td>4.70</td>
<td>0.70</td>
</tr>
<tr>
<td>Human</td>
<td>87.90</td>
<td>12.10</td>
<td>8.30</td>
<td>3.80</td>
<td>1.80</td>
<td>6.20</td>
<td>0.30</td>
</tr>
<tr>
<td>Goat</td>
<td>87.80</td>
<td>12.20</td>
<td>8.40</td>
<td>3.80</td>
<td>3.50</td>
<td>4.10</td>
<td>0.80</td>
</tr>
<tr>
<td>Camel</td>
<td>87.08</td>
<td>12.92</td>
<td>7.80</td>
<td>4.39</td>
<td>2.93</td>
<td>4.15</td>
<td>0.72</td>
</tr>
<tr>
<td>Donkey</td>
<td>90.63</td>
<td>9.37</td>
<td>8.61</td>
<td>0.76</td>
<td>1.91</td>
<td>6.30</td>
<td>0.40</td>
</tr>
</tbody>
</table>

References: \textsuperscript{34, 47, 59}
Whey protein is the second biggest fraction of protein which is mainly present in higher concentration in donkey milk. The lower protein content in donkey and human milk may avoid an excessive renal load of solute. The higher concentration of peptidoglycan recognition protein was also discovered in camel milk which has apparent effect on breast cancer by controlling metastasis and stimulates the host’s immune response. Furthermore, Camel milk is being more attractive due to presence of immune proteins (mainly immunoglobulin) and absence of β lactoglobulin as compared to bovine milk. Lactoferrin, lactoperoxidase, lysosomes and immunoglobulins are another protein components which are responsible for unique features of non-bovine milk. Lactoferrin is a glycoprotein which has an ability to bind two metal cations (preferably Fe$^{3+}$) to the binding sites that are structurally closely related. The majority of lactoferrin is needed for transportation or storage of iron and possess antioxidant properties. Lactoferrin is among the protective proteins in milk of non-bovine animals with higher concentration and thus prevents microbial overgrowth and invading pathogens.

Lactose is the major milk carbohydrate present in all non-bovine milk. However, goat milk is having additionally higher oligosaccharides (0.25-0.30 g/L). Donkey milk is having highest content of lactose which may facilitate better intestinal absorption of calcium and phosphorus. Higher lactose is the good source of good growth medium for potentially probiotic strains of Lactobacillus rhamnosus and wields a good influence on gut health. The lactose content in milk may depend on the nature of vegetation eaten by the animals.

The lipid profile of milk from different animals is presented in Table 3. The goat milk is very rich source of Medium Chain Fatty Acids (MCFAs), furthermore 97% of the milk lipid fraction is made up of triglyceride including large number of esterified fatty acids. The higher unsaturated fatty acids are seen in camel and donkey milk. The higher cholesterol content is observed in camel milk as compared to other animals. Cholesterol is present in the milk fat globule membrane (MFGM) and it accounts for 95% of the sterols of milk fat. Small Fat Globules (SFGs) are characterized by a larger surface area of MFGM per fat unit. Therefore, a bigger share of SFGs relates to a relatively higher concentration of cholesterol in milk. The higher PUFA content seen in donkey milk can be also beneficial in lipid accumulation via mild augmentation of mitochondrial uncoupling pathway, associated with chemo protective and anti-inflammatory effects.

The micro-nutrient profile of NBM is varying within different species. Goat is a rich source of Ca, P, K, Mg and Cl while less Na and

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Table 2: Protein profiles of milk from different mammals (g/L)

<table>
<thead>
<tr>
<th>Variables</th>
<th>Goat</th>
<th>Camel</th>
<th>Donkey</th>
<th>Cow</th>
<th>Human</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total casein</td>
<td>25</td>
<td>26.4</td>
<td>6.6</td>
<td>27.2</td>
<td>5.6</td>
</tr>
<tr>
<td>αs1-CN</td>
<td>0-7</td>
<td>5</td>
<td>0.2-1</td>
<td>10-15</td>
<td>0.3-0.8</td>
</tr>
<tr>
<td>αs2-CN</td>
<td>4.2</td>
<td>2.2</td>
<td>0.2</td>
<td>3-4</td>
<td>-</td>
</tr>
<tr>
<td>Total Whey Protein</td>
<td>6</td>
<td>6.6</td>
<td>7.5</td>
<td>4.5</td>
<td>8</td>
</tr>
<tr>
<td>β-Lactoglobulin</td>
<td>2.1</td>
<td>1.45</td>
<td>3.2-3.7</td>
<td>3.3-4</td>
<td>-</td>
</tr>
<tr>
<td>Lactoferrin</td>
<td>0.02-0.03</td>
<td>0.2-0.9</td>
<td>0.3</td>
<td>0.02–0.5</td>
<td>0.70-1.70</td>
</tr>
<tr>
<td>Immunoglobulins</td>
<td>1</td>
<td>1.54</td>
<td>-</td>
<td>1</td>
<td>1.1</td>
</tr>
</tbody>
</table>

Reference
Non-bovine milk

S contents. It is also rich source of vit A, B1, B2 and B3 while poor source of folate, pyridoxin, B12, vit. C (1.04mg%) and D. However, donkey milk is having higher content of niacin, B12 and vitamin E (5.2 mg%) while Lower content of vitamins A, Folic acid and other water-soluble vitamins. Calcium in cow milk is reported to interfere with the absorption of dietary Fe but goat milk consumption may positively affect the digestive and metabolic utilization of Ca and Fe. However, author36 showed that rats in the goat milk group had higher Fe content in the reserve organs and higher Ca content of femur, sternum, and Longissimus dorsi muscle. Vit C is found in both Camel (6.92 mg%) and Donkey milk (5.7 mg%) in good amount which is responsible for anti-aging as well as anti-oxidant properties.62 Similarly, camel milk is a good source of vitamin A (82.29 µg/100ml) and niacin with higher level of various minerals like, Na, K, Ca, P Mg Fe, Zn, Cu7, 47.

### Health aspects of Non-Bovine Milk

**Goat Milk:**

Goat milk is very well known for its lower allergic property as it, contains low levels (89% less than cow’s milk) of alpha S1 casein and high levels of alpha S2 casein, which is non-allergic.36 Along with that Goat’s milk does not produce mucus due to the smaller size of fat globules; hence it does not stimulate a defence response from the human immune system34. Polyamines play an important role in maturation of the GIT enzymes, cell function and reduce the incidence of food allergy in infants. The concentration of polyamines in goat milk is highest in goat milk compared to cow and human milk. Author49 found higher tolerance level of goat milk in patients as compared to cow milk by 40-100%. The Cytokine levels (pg/ml) in cultured supernatants of lymphocytes of children stimulated against protein fractions of cow’s and goat’s milk has been also studied4. Ten patients with cow’s milk protein allergy and ten non-allergic control subjects were consecutively involved in the study. The production of tumor necrosis factor-α after exposure to goat milk casein and β-lactoglobulin was lower than after exposure to the same fractions from cow milk. Goat milk induced higher levels of regulatory interleukin-10 by peripheral blood mononuclear cells than cow milk.

An anti-microbial effect of a goat milk is also well known due to its medium chain triglycerides composition as well as lactoperoxidase (LPO) and lactoferrin content. Goat milk is rich in caproic (90 mg/100g of milk), caprylic (100 mg/100g of milk) and capric fatty acids (260 mg/100g of milk)31. The anti-bacterial action of some of medium chain fatty acids by agar well diffusion method has been also studied9. The zone of inhibitions was found against all four pathogens (Staphylococcus aureus, Bacillus cereus, Listeria monocytogenes and Staphylococcus epidermis) by medium chain fatty acids. Goat milk is three times higher in LPO (260 mg/100g of milk) as compared to cow milk (1.4 units/ml)30. LPO is one of the crucial enzymes in milk with oxidoreductase activity. The impact of

### Table 3: Lipid Profiles of Milk from Different Mammals

<table>
<thead>
<tr>
<th>Variables</th>
<th>Goat (mg/100ml)</th>
<th>Camel</th>
<th>Donkey</th>
<th>Cow (mg/100ml)</th>
<th>Human (mg/100ml)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cholesterol</td>
<td>10-22</td>
<td>27-37</td>
<td>8.6-11</td>
<td>12-31</td>
<td>14-20</td>
</tr>
<tr>
<td>Saturated Fatty Acids (%)</td>
<td>57-78</td>
<td>24-57</td>
<td>44-68</td>
<td>52-76</td>
<td>35-57</td>
</tr>
<tr>
<td>Poly Unsaturated Fatty Acids (PUFA) (%)</td>
<td>0.5-80</td>
<td>2-6</td>
<td>11-20</td>
<td>2-6</td>
<td>10-31</td>
</tr>
<tr>
<td>CLA (%)</td>
<td>0.15-1.20</td>
<td>0.40</td>
<td>-</td>
<td>0.3-1.6</td>
<td>0.1-0.6</td>
</tr>
</tbody>
</table>

References61
LPO on bacteria results from the oxidation of sulfhydryl. The oxidation of the -SH groups make the bacterial cytoplasmic membrane lose its ability to transport glucose, potassium ions, amino acids, and peptides. The antimicrobial effect of lactoferrin is presumably the result of the ability of the protein to deprive bacteria of the iron essential for growth. The most common mechanism of action is through membrane permeabilization. Peptides derived from digestion of bioactive components are also proved to be precursors for anti-microbial peptides in goat milk\textsuperscript{18, 56}.

Author\textsuperscript{15} has also evaluated the antimicrobial activity of peptides derived from enzymatic hydrolysis of goat milk caseins against \textit{Escherichia coli} and \textit{Bacillus cereus} which are major human pathogenic bacteria.

Goat milk is also well accepted for its anti-atherogenic effect due to higher amount of Angiotensin Converting Enzyme (ACE) inhibitory peptides. Author\textsuperscript{27} has found significant inhibition of ACE by proteins which are separated from caseins and whey proteins of goat milk. Furthermore, one \textit{in vitro} study has shown that cells isolated from humans who had been drinking goat milk from different breeds were triggered by components in the milk to release nitric oxide (NO)\textsuperscript{50}. This NO is having property of vasodilation. Author\textsuperscript{33} has also examined the effect of the fermented probiotic goats’ milk on oxidative stress markers (including markers for atherosclerosis) in human blood. The lower (p<0.05) concentration of oxidized low-density lipoproteins was found in the group which have consumed the fermented goat’s milk.

Goat milk is also well accepted due to its bifidogenic and anti-infectious effect. Goat milk is a rich source of oligosaccharides (250-300 mg/L) with higher number of it\textsuperscript{58}. The bifidogenic effect of oligosaccharides is due to their use in the colon as an energy substrate for the proliferation of anaerobic bacteria, especially bifidobacteria, which can inhibit the growth of the putrefactive and the pathogenic bacteria present in the cecum and colon\textsuperscript{51}.

Goat milk can be also used for treating dengue fever as it directly modulates the human immune system. Goat milk is rich in Se content (13.3 mg/L) as compared to cow milk (0.009 mg/L)\textsuperscript{8}. This Se has vital role as an antioxidant agent as well as in clotting function\textsuperscript{5}. Se has also beneficial effect on replication of virus with interaction of T cells and interleukins (IL)\textsuperscript{50}. Due to this property goat milk can be useful in dengue fever too. Dengue fever may lead to many other secondary complications, among which hepatitis is major one. The beneficial effect of goat milk on hepatotoxicity has been also studied\textsuperscript{45}. Though, its acceptance is controversial.

Oligosaccharides present in the goat milk are act as an anti-inflammatory agent by increasing production of butyrate and reducing pro-inflammatory bacterial species through inhibiting their adhesion to the epithelial membrane and bacterial translocation. Butyrate inhibits nuclear factor κB which is the main regulators of cellular genes involved in early immune inflammatory responses, including cyclooxygenase -2, IL-1b, IL-2, IL-6, IL-12 etc\textsuperscript{25}. The anti-Inflammatory effect of goat milk oligosaccharides has been also studied in Wistar Rats\textsuperscript{12}.

\textbf{Camel milk:}

Camel milk is well accepted for its hypoglycemic effect. The camel milk is containing insulin like proteins (52 micro units/ml) with unique features which is all most three times higher than cow milk\textsuperscript{55}. These proteins are believed to be mimics the insulin interaction with its receptor. Furthermore, they can resist proteolytic digestion as they are protected by nanoparticles (lipid vesicles) which makes its absorption into circulation faster than insulin-like protein from other milk sources\textsuperscript{55}. The effect of camel milk on insulin requirement and blood glucose level has been studied in type 1 diabetic patients\textsuperscript{2} in which 44 and 20% decline was seen for insulin dose requirement and blood glucose level respectively. Similarly, significant lower
blood glucose and cholesterol were found by 44 and 38% respectively in diabetic dogs as compared to control group. A significant reduction was also seen in blood glucose level of rats receiving kacchi camel milk (2 ml P.O. twice a day) as compared to goat milk, anti-diabetic drugs and control group.

Camel milk contains various protective proteins [lactoferrin, lactoperoxidase, Immunoglobulins, lysozyme etc.] which exert anti-microbial and other medicinal properties. Lysozyme (288 mg/100 mL) is an enzyme that is part of the innate immune system that targets gram-positive bacteria. Camel milk is rich in lactoferrin (220mg/l) with potent antimicrobial and anti-inflammatory properties, including, antibacterial inhibition, antiviral and antifungal effects. This lactoferrin exhibits its effect through different ways like, membrane permeabilization, disaggregation of biofilms, decrease in toxins, decrease adhesion, apoptosis of cell, etc. The antimicrobial activity of water-soluble extract (WSE) containing bioactive peptides isolated from fermented and unfermented camel milk against some pathogens has been studied through antibiotic sensitivity test. Authors carried out one cross sectional study among the camel breeders (consumption since birth) of the four districts of Rajasthan (Jodhpur, Jaisalmer, Bikaner, Badmer) for find out the prevalence of the tuberculosis in which only 1.14% of the tuberculosis has been found in camel milk consumers, while 14% in non-camel milk consumers.

Camel milk has also anti-allergic effect as it lacks β-lactoglobulin. Though camel milk contains β - casein, but its structure is very different from the cow milk protein. Furthermore, 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. Camel milk contained low lactose with small molecules which can easily digest and metabolized by the human body. Author examined the anti-allergic effect of camel milk on eight children, who were having allergic symptoms.

Camel milk has also an immune modulatory effect due to unique property of immunoglobulins. These antibodies can readily pass to the milk of the lactating camel, can pass the blood brain barrier, and are readily absorbed from the gut into the general circulation of consumers of camel milk.

Camel milk has antioxidant potential and may regulate the genes that prevent/decrease the growth of cancer cells or downregulate those that promote their growth. The antibodies of camel milk are very active and able to bind to tumor cells and kill them with keeping healthy cells undamaged. Camel milk lactoferrin prevents the proliferation of colorectal cancer cells and exerts antioxidant and DNA damage-inhibitory properties in cancerous cells. Furthermore, camel milk may also regulate the apoptotic pathways, thereby stopping the cancer cells’ proliferation. The anti-cancerous activity of camel milk has been studied via induction of autophagic death in human colorectal (HCT 116) and breast cancer (MCF-7) cells. The anti-oxidant effect of camel milk is also associated with anti-autism effect which is also proven.

Camel milk is a rich source of Vit. C. Presence of vitamin C in the milk imparts antioxidant skin tissue protective activities. Vitamin C is also necessary to produce collagen protein as it helps the growth of cells and blood vessels and consequently imparts strength and firmness to the skin. Vitamin C also protects the skin from free radicals which causes some skin problems such wrinkles and dryness. Camel milk has anti-aging effect due to presence of α-hydroxyl acids which are known to plump the skin and smoothies 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. Author studied the effect of application of camel milk crème in twenty patients of mild to moderate psoriasis ranging from 6 to
72 years old. The patients were treated with camel milk crème for 4 weeks. The significant reduction in the psoriasis symptoms (redness, dryness, itching etc.) were found in treated patients.

**Donkey milk:**

Donkey milk is well known for its antioxidant and anti-inflammatory effects which are governed by bioactive substances present in it like; bioactive peptides, Vitamin C, Lactoperoxidase, Lactoferrin, Lysozyme, Omega 3 fatty acids etc.\(^\text{44}\). The antioxidant effect of donkey milk powder has been also studied in 24 diabetic wistar rats\(^\text{37}\). While author\(^\text{28}\), studied beneficial anti-inflammatory effect of donkey milk lysozymes in 60 mices.

The low allergenicity of donkey's milk is related to its protein fraction. Donkey milk contains a low level of casein and a low casein/whey protein ratio (on average 1.3) with values ranging from 0.66 to 1.33 in individual milk along the lactation\(^\text{60}\). This ratio is believed to play a crucial role in the sensitization to cow milk protein fraction, reducing the allergenic capacity. Moreover, the low amount of a s2- casein and kappa-casein in donkey milk could also contribute to its lower hypoallergenicity. Donkey milk is a rich source of lactose as compared to other Species and this lactose content represents a substrate for the development of intestinal microbiota with health-promoting properties\(^\text{11}\). Author\(^\text{46}\) have documented that the tolerability of donkey milk was 82.6% in their selected cohort of children (96) with cow milk protein allergy (CMPA), without other alternative to the use of common cow milk protein substitutes.

The antimicrobial activity of Donkey milk is mainly attributed antimicrobial substances present in it. Lysozyme (Lyz) (4000mg/L) and lactoferrin are the major contributors to antimicrobial property. Lysozymes split the bond between N-acetylglucosamine and N-acetylmuramic acid of the peptidoglycan leading to fragments with high and low molecular weight\(^\text{10}\). Approximately 75% of donkey's milk lysozyme remains intact after digestion by human gastrointestinal enzymes; this is particularly important since the presence of intact lysozyme in the stool of infants is believed to confer antimicrobial activity and modulation of microbiota in the gut of infants receiving breast milk\(^\text{10}\). The preservative effect of antimicrobial proteins derived from donkey milk has been studied in kashar cheese\(^\text{48}\). Results of this study highlight lysozyme and lactoferrin from donkey milk for potential usage as natural antimicrobial agents to prolong the shelf-life of products, provide consumer safety and health and obtain better quality characteristics.

Donkey milk is also well accepted for its anti-aging effect which is mainly governed by its milk proteins, minerals, essential fats, bioactive enzymes and various growth factors like riboflavin, vitamin D etc. that provides natural nourishment to skin and toned it. The donkey milk naturally contains antibacterial compound such as lysozyme and lactoferrin inhibit the growth of pathogenic bacteria on skin and reduce the rate of skin infection\(^\text{42}\).

Donkey milk has a vital role in glucose metabolism. Furthermore, in comparison to ordinary milk, donkey milk has a higher content of whey protein, which might aid the prevention and treatment of diabetes\(^\text{26}\). Additionally, Donkey milk inhibits gluconeogenesis by regulating the expression levels of phosphoenolpyruvate carboxykinase 1 and glucose-6 phosphatase. Donkey milk enhances the antioxidant defense mechanisms by which it protects the development of insulin resistance\(^\text{38}\). Lactose, whey protein and bioactive peptides in DM have been shown to be involved in insulin response to glucose. In particular, lysozyme and lactoferrin from donkey milk may have a role in the prevention and treatment of diabetes. The curative effect of donkey milk powder has been studied in diabetic wistar rats. The rats were subjected in three groups; diabetic, donkey milk powder (3g/kg/day) and metformin (110mg/kg/day). The significant (p<0.01) reduction has been observed in rats which have
received donkey milk powder by 35% as compared to diabetic group.

CONCLUSION
Milk is considered as the most complete single food available and is a fundamental part of the human diet in which bovine milk remains the most abundant and most accepted type of milk at the global level. On the other hand, Non-Bovine Milk is still in the growing phase which brings new challenges and required acceptance in the society even though with higher health beneficial effects. Among non-bovine animals, Goat, Camel and Donkey are important components of livestock industry which play vital role in the socio-economic structure in rural areas. All three species produce milk with different health benefits including antimicrobial, antitumor, antioxidative, growth promoting, aging preventing, bifidogenic, antiatherogenic, anti-inflammatory etc. However, information about the microbiota and its significance for non-bovine milk quality and safety is a challenging field for further exploration.

REFERENCES


Non-bovine milk


