International Journal of Nutrition Research and Health
2024 Volume 3, Issue 1
DOI: 10.59657/2871-6021.brs.24.033

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Review Article

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# Emerging Role of Non-Bovine Milk from Human Health Perspective

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**Abstract**

Milk obtained from the healthy mammary glands of various types of domesticated dairy animals is used by the people throughout the world. Cow milk is more commonly consumed globally. However, in recent years people have become more conscious about their health, and therefore, many persons prefer to know the composition and nutritional value of the milk they are going to consume. The milk produced by non-bovine sources like goats, camels, and yaks offer distinctive nutritional and health benefits compared to bovine milk. Rich in bioactive compounds, these milks provide unique advantages such as improved digestibility, cardiovascular health, and hypoallergenic properties. Camel milk is known for its antimicrobial effects, while goat milk supports cardiovascular health. Sheep milk aids bone health, and donkey milk is suitable for infants with allergies. Yak milk shows promise for various medical conditions. This review highlights the expanding role of non-bovine milks in human nutrition and their therapeutic potential.

**Keywords:** human health; non-bovine milk; nutritional benefits; therapeutic properties

## Introduction

Although cow's milk is widely consumed globally by people of all ages and in all seasons, milk from other animals, such as buffalo, goat, camel, donkey, yak, bison, sheep, Mithun, and reindeer is also produced in various regions [1,2,3]. Often referred to as nature's most perfect food, milk is balanced in nutrients and typically has a high caloric value [4]. It is considered a complete food due to its richness in proteins, fats, minerals, and vitamins essential for human nutrition [5]. Non-bovine milk is rich in various nutrients and health-promoting ingredients, including oligosaccharides, lipids, bioactive peptides, high-quality proteins, minerals, and vitamins. The proteins in non-bovine milk have diverse structures and amino acid compositions, making them highly varied. Additionally, bioactive peptides from non-bovine milk hold significant potential for developing functional foods and other health-related products [6]. Of the 2,000 mammal species that produce milk, only 10 are regularly or occasionally consumed by humans. Besides cows, which account for 85% of global milk production [7], the main dairy animals include buffalo (10.7%), goats (2.4%), sheep (1.4%), and camels (0.4%). Although donkey, deer, and mare milk are not widely consumed or traded, they hold considerable cultural value in some areas [8]. Non-bovine milk, which is less allergenic than cow's milk and may offer health benefits, is increasingly being researched as a promising alternative for infant formula [9,10]. Bovine milk differs from non-bovine milk in its protein composition, specifically the ratios and types of casein and whey proteins. In cow, goat, sheep, and buffalo milk, the casein-to-whey protein ratio is 80:20, while in horse milk, it is 50:50 [11]. The predominant casein in camel, goat, and human milk is β-casein; in horse milk, both αs1 and β-caseins are dominant; and in cow milk, it is αs1-casein. Among whey proteins, β-lactoglobulin is the main protein in cow, buffalo, goat, and sheep milk but is absent in camel milk [12]. Although milk from many non-bovine species, including goats, sheep, camels, mares, and reindeer, has many medicinal qualities that are good for human health, these species have not gotten much attention. Functionally active lipids, lactose, immunological proteins, peptides, nucleotides, oligosaccharides, and metabolites are abundant in their milk. Furthermore, the special chemical and microbiological qualities of non-bovine milk can be used to improve human health [13]. Notwithstanding its potential, little is known about the importance of non-bovine milk for human nutrition and health advantages. This paper aims to address this gap by compiling information on the growing importance of non-bovine milk in promoting human health.

### Chemical Composition of Non- Bovine Milk

The composition of milk significantly influences its nutritive value and suitability for conversion into

 

processed and value-added products. This composition varies based on factors such as animal species, breed, lactation order, health, and feeding regime. While the nutritional composition of milk from non-bovine species is similar to that of cow milk, non-bovine milk possesses unique chemical, biochemical, and physical properties that impart distinct nutritional and therapeutic values. Bovine milk differs from non-bovine milk in its protein composition, particularly the ratio of casein to whey proteins. In cow, goat, sheep, and buffalo milk, this ratio is 80:20, whereas in horse milk, it is 50:50 [ 11]. The dominant casein type also varies: β-casein is predominant in camel, goat, and human milk; αs1 and β-caseins are found in horse milk; and αs1 is the main casein in cow milk. Among whey proteins, β-lactoglobulin is the main protein in cow, buffalo, goat, and sheep milk, but it is absent in camel milk [12]. Milk fat digestibility is influenced by the size of the fat globules. Buffalo milk has the largest fat globules, while camel, sheep, and goat milk have the smallest. Smaller fat globules create a more homogeneous mixture with a larger surface area for the lipase enzyme to act on, enhancing fat digestibility. Goat and camel milk have poor creaming abilities due to their deficiency in agglutinins, which facilitate the clustering of fat globules. Consequently, the digestibility of naturally homogenized goat milk is superior to that of mechanically homogenized bovine milk [ 14]. The fatty acid profile of goat and sheep milk features significantly higher levels of short-chain (C4:0–C8:0) and medium-chain fatty acids (C10:0–C14:0) compared to cow milk. The lipase enzyme more effectively acts on the ester linkages of these short- and medium-chain fatty acids, leading to easier digestion of goat and sheep milk. The distinctive "goaty" flavor of goat and sheep milk is attributed to the higher content of caproic, caprylic, and capric acids [14]. Lactose, the most consistent component of milk, is found in higher concentrations in the milk of horses, donkeys, and humans. Vitamin C levels are significantly higher in horse and camel milk compared to that of cows, buffalo, sheep, goats, and asses. Goat milk contains more vitamin A than cow milk, as β-carotene is converted into vitamin A in goat milk. Sheep milk is richer in most vitamins overall. Camel milk has higher levels of immunoglobulins (IgG), lysozyme, and lactoferrin compared to the milk of cows, buffalo, sheep, and goats [15].

## Health Benefits of Non- Bovine milk

Non-bovine milk from various animal sources is rich in several nutrients, including oligosaccharides, lipids, bioactive peptides, high-quality proteins, minerals, and vitamins, all offering nutritional and health benefits. The types, concentrations, and compositions of these nutrients can vary due to factors such as breed, animal age, season, feed type and quantity, and environmental conditions [16]. Camel milk, for instance, contains small-sized fat globules, high levels of cadherin-like proteins, essential fatty acids, unsaturated fatty acids, phospholipids, and low amounts of cholesterol and saturated fatty acids. This composition contributes to camel milk's high digestibility, nutritional value, and health benefits, which include anti-bacterial, anti-inflammatory, and anti-hyperlipidemia activities [17]. Consumption of sheep milk has been found to increase levels of calcium, phosphorus, and strontium in the bones of rats fed a diet low in these minerals, indicating its potential to maintain bone health in diets deficient in calcium and phosphorus [18]. Human milk oligosaccharides (HMOs) are vital components of human breast milk, playing crucial roles in immune system support, brain development, gut microbiota modulation, and antimicrobial protection against pathogens in newborns. Diallylated milk oligosaccharides (SMOs) are the most important HMOs and are present in the milk of various animals, including bovine, caprine, porcine, elephantine, equine, and donkey, each varying in their functional properties. Notably, elephant and goat milk contain high levels of soluble SMOs, making them potential candidates for use in the development of infant formulas [19].

## Bio functionalities of non-bovine milks

Non-bovine milk serves as an excellent alternative to human milk, particularly for individuals allergic to cow's milk, prompting increased research into alternative mammalian sources. Many societies, especially in desert regions, depend heavily on camels for their resilience to harsh climates and their roles in transportation, sports, and the production of milk and meat, all contributing to human livelihoods and food security. Camel milk is widely recognized for its antimicrobial, immunomodulatory, anti-diabetic, and anti-carcinogenic properties [20]. Donkey milk has gained popularity as a natural nutritional and medical supplement due to its compositional similarity to human milk and potential biological benefits, such as anti-inflammatory, anti-aging, antibacterial, and anti-allergic effects [21]. Goat milk is also becoming

increasingly popular due to its superior digestibility and unique properties, including anti-inflammatory, antibacterial, bifidogenic, and anti-atherogenic effects [22].

### Nutritional and therapeutic values of Non-Bovine Milk

Goat milk surpasses cow milk in several nutritional aspects, including higher levels of vitamins A, B1, B2, B5, calcium, phosphorus, zinc, potassium, and selenium [23]. It also contains a greater proportion of medium-chain triglycerides (36% in goat milk compared to 21% in cow milk), such as caproic (C6:0), caprylic (C8:0), and capric (C10:0) acids. These triglycerides contribute to its distinctive "goaty" odor and add to its medicinal value. Additionally, goat milk is richer in monounsaturated fatty acids (MUFA), polyunsaturated fatty acids (PUFA), and medium-chain triglycerides, which are particularly beneficial for individuals with cardiovascular diseases [24]. Goat colostrum and milk are notably high in polyamines, which play a crucial role in growth, gastrointestinal tract function, and the maturation of digestive enzymes, while also potentially reducing food allergies in infants [25]. Sheep (ewes) are raised for their wool, meat, and milk, with India producing about 0.2 million tons of sheep milk annually. Globally, sheep contribute approximately 1.3% of total milk production, though this figure rises to 6.6% in Africa. Sheep milk is characterized by higher specific gravity, viscosity, titratable acidity, and refractive index compared to cow milk, as well as a lower freezing point [26]. It is increasingly used to produce dairy products such as cheese, yogurt, and ice cream, contributing significantly to the economies of regions like the Mediterranean, sub-Saharan Africa, the Middle East, and East and Southeast Asia [27]. Sheep milk contains higher levels of medium-chain triglycerides (MCT) and polyunsaturated fatty acids (PUFA) than cow milk, and it surpasses cow milk in all 10 essential amino acids. Its sweet, soft flavor, creamy texture, and small fat globules contribute to its easy digestibility and distinctive taste, which is also noted in sheep milk butter and cheese [28, 29]. Camel milk exhibits diverse health benefits, including anti-aging, anti-inflammatory, and immunomodulatory effects. Its unique chemical composition, including high levels of vitamin C, essential minerals, and protective proteins like lactoferrin, lactoperoxidase, immunoglobulins, and lysozyme, makes it a potential alternative to bovine milk. Camel milk lacks βlactoglobulin, which causes allergies to cow milk proteins. Notably, camel milk's role in managing conditions such as diabetes, allergies, autism, cancer, tuberculosis, hepatitis, and arthritis. Moreover, its hypoallergenic nature and antimicrobial properties make it a promising functional food. Insulin like proteins, which imitate insulin's role in controlling blood sugar levels and hence improve glucose uptake, contribute to its efficacy. Camel milk has cosmetic effects due to the presence of α-hydroxy acids, which help to plump the skin and smooth fine lines [5]. Donkey milk is widely used as a substitute for human milk in various countries. Compared to bovine milk, donkey milk has lower levels of fat, protein, and inorganic salts but higher lactose content, making its composition closer to that of human milk. This higher lactose content provides readily available energy, making the milk sweet and palatable, particularly for children. The pH of donkey milk is neutral or slightly alkaline, similar to human milk, likely due to its lower casein and phosphate content [30]. Additionally, donkey milk is considered a natural hypoallergenic alternative, being well-tolerated by approximately 90% of infants with different food allergies, including breast milk protein allergy, which affects around 3% of children during their first three years [31]. Yak milk has a particular nutritional profile and composition that make it possibly helpful for several medical ailments. It contributes to general health and well-being as a valuable supply of vitamins, minerals, vital fatty acids, and proteins [32]. Many bioactive characteristics of yak milk and its derivatives have been highlighted by recent studies. These characteristics include lowering blood pressure, antioxidant activity, anticancer effects, antimicrobial qualities, and relief from constipation and weariness. These characteristics make it possible to use yak milk in high-value applications [33].

## Conclusion and Recommendations

Non-bovine milk, including those from camels, goats, sheep, donkeys, and yaks, offers distinct nutritional and therapeutic benefits beyond traditional bovine milk. Camel milk is valued for its anti-inflammatory and antimicrobial properties, while goat milk is noted for its digestibility and cardiovascular benefits. Sheep milk supports bone health and has unique sensory qualities, and donkey milk is hypoallergenic, making it ideal for infants with allergies. Yak milk shows potential for managing various health conditions.

 

These diverse milks present promising alternatives or supplements to bovine milk, especially for individuals with specific dietary needs or health conditions, though further research is needed to explore their long-term effects and optimize their use in functional foods and medical applications.

## Recommendations

Conduct comprehensive studies to further elucidate the health benefits, bioactive properties, and potential therapeutic uses of non-bovine milks.

Innovate and create new dairy products and functional foods using non-bovine milks. Consider developing specialized products for specific health needs, including infant formulas and dietary supplements.

Establish and enforce quality control and standardization measures for non-bovine milk production and processing.

Provide support and incentives for local producers of non-bovine milks, especially in regions where these animals are economically significant.

## Declarations

### Acknowledgements

We wish to thanks Prof. Dr. R.K. Narayan for his suggestions during the preparation of the manuscript. Computer help of Yashvardhan is also appreciated. This paper is dedicated to the scientists who did commendable work in milk and milk technology.

### Contribution of authors

All authors contributed during the preparation of the manuscript.

### Conflict of interest

There was no conflict of interest.

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**Cite this article:** P. Mahendra, R. Tesfaye. (2024). Emerging Role of Non-Bovine Milk from Human Health Perspective. International Journal of Nutrition Research and Health, BioRes Scientia Publishers. 3(1):1-5. DOI: 10.59657/2871-6021.brs.24.033



**Article History:** **Received:** August 13, 2024 | **Accepted:** August 26, 2024 | **Published:** September14, 2024