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Donkey Milk: The "White Gold" of the Animal Kingdom

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Abstract:

Donkey milk is valued for its unique nutritional composition, resembling human milk with high lactose, low fat and protein and beneficial whey proteins. It contains bioactive proteins that may provide antimicrobial, antioxidant, and immune benefits. Its high digestibility makes it a potential alternative for people intolerant to cow's milk. Research is ongoing into its effects on bone health, lipid metabolism, inflammation, and skin health, as well as its use in functional foods and cosmetics. However, more clinical studies are needed to confirm these benefits, and concerns about raw milk safety and low milk yield remain.

Keywords: Donkey milk; Nutritional composition; Bioactive proteins; Antioxidant activity; Hypoallergenic potential; Functional food.

Introduction:

For centuries, donkeys have played an important role in rural India as reliable working animals, particularly in areas where mechanized transport is difficult or economically unfeasible. They have traditionally been used for carrying agricultural produce, construction materials, bricks, water, and other loads, especially by small and marginal farmers and rural communities. However, rapid mechanization, changing agricultural practices, urbanization, and the availability of motorized transport have reduced the traditional use and economic importance of donkeys in many parts of the country.

India is home to several indigenous donkey populations that are well adapted to diverse climatic and agro-ecological conditions. Important recognized types include the Halari, Kachchhi, Spiti, and Ladakhi donkeys, which possess valuable characteristics such as adaptability, endurance, disease tolerance, and ability to survive under relatively harsh and resource-limited conditions.

Recent research has also explored the possible role of donkey milk in supporting bone health, lipid metabolism, inflammatory balance, gastrointestinal health, and skin health. The milk is increasingly being investigated as a raw material for fermented products, functional beverages, nutraceuticals, and cosmetic

formulations. However, many proposed health benefits are based on laboratory, animal, or small-scale human studies, and therefore should not yet be considered established therapeutic effects.

Why Donkey Milk Is Different?

Donkey milk possesses a distinctive combination of nutritional, functional, and bioactive properties that sets it apart from conventional dairy milks. The following sections highlight its potential.

A. Health Applications:

Donkey milk is very different from the milk of the major dairying animals (sheep, cow, buffalo, goat, and camel). Donkey milk has long been used in traditional diets and is now being recognized as a promising functional food in human nutrition. Scientific and consumer interest is growing due to its unique composition, which differs nutritionally from conventional dairy milk. Notably, donkey milk has several similarities to human milk, including higher lactose content, lower fat and protein levels, and a favourable whey protein profile. Because of these similarities, it is an appealing option for study and possible dietary uses, especially for those who are intolerant of cow's milk (Deepa *et. al* 2023, Bhardwaj *et. al* 2020). According to Tanaka (2007) immunoglobulins, lactoferrin, lactoperoxidase, and lysozyme are the main antimicrobial proteins found in milk of donkey.

Furthermore, growth factors, immunoglobulins, and antimicrobial peptides—all of which have anti-inflammatory, antioxidant, antibacterial, asthma, and joint discomfort and anti-allergenic qualities—are among the specialized bioactive components found in donkey milk. (Akbari-Adergani, 2019; Martini *et al.* 2018 and Ragona *et al.* 2016).

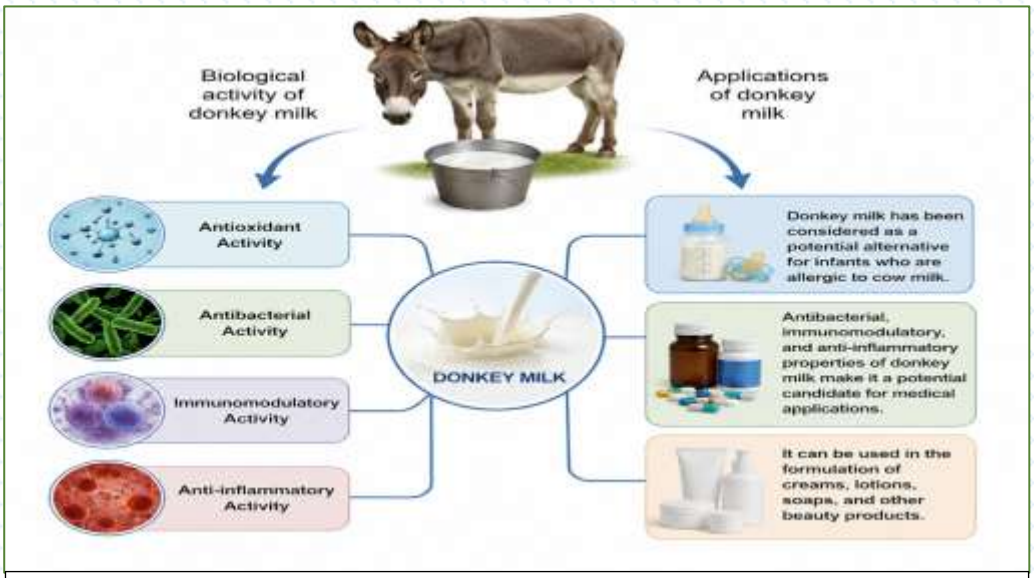

Figure 1- Biological Properties and Potential Applications of Donkey

Caseins, Omega-3 fatty acids, lactoferrin, lysozyme, α-lactalbumin, and β-lactoglobulin are among the many beneficial elements found in donkey milk that may have medicinal uses. As long-chain omega-3 polyunsaturated fatty acids (PUFAs) have been shown to be effective in preventing a number of carcinomas. The risk of depression, cancer, dementia, and inflammatory diseases like rheumatoid arthritis and dermatitis is decreased by omega-3 fatty acids (Madhusudan *et al.* 2017). In addition, the iron-binding protein lactoferrin is involved in controlling iron homeostasis, cellular growth, warding off infections, and preventing the spread of cancer in addition to providing protection against cancer development and

metastasis (Chandran *et al*. 2020 and Martini *et al*. 2021).

Also, donkey milk's high omega-3 fatty acid content can significantly impact a baby's brain, eye, and body development (Baloš *et al*. 2023). Donkey milk contains many development factors and hormones, including human-like leptin, ghrelin, triiodothyronine, and insulin-like growth factor 1. These substances have a direct impact on satiety regulation, body composition, and metabolism (Bhardwaj *et al*. 2020 and Cimmino *et al*. 2023).

B. Commercial Utilization:

- **Fermented Milk:**

  Since fermented milk is the most marketable dairy product because of its appropriate nutritional content, the dairy industry creates a variety of fermented milk varieties with unique physicochemical characteristics (Miao *et al*. 2020). Fermentation can improve the nutritional and functional properties of donkey milk, making it a promising food product. Fermentation also improved the fatty-acid profile by reducing saturated and increasing unsaturated fatty acids.

- **Yoghurt:**

  Donkey milk can be used to prepare yogurt, but its low protein, fat and total solids make it difficult to achieve the desired thickness. Dietary fibres can help improve the viscosity, texture and body of donkey-milk yogurt. Salgado *et al*. (2021) reported that donkey-milk yogurt supported higher lactic acid bacteria counts than cow-milk yogurt.

- **Kefir:**

  Donkey milk can be used to produce kefir, a fermented beverage containing lactic acid bacteria, yeasts and other microorganisms. Aroua *et al*. (2023) reported changes in pH, acidity and lactose during fermentation and storage. Donkey-milk kefir also showed antioxidant activity and favourable microbiological properties.

- **Cheese:**

  Donkey milk cheese production is challenging because its low casein, especially κ-casein, content results in weak curd formation and low cheese yield. However, studies have successfully produced fresh cheese using rennet, calcium chloride and starter cultures to improve coagulation. Faccia *et al*. (2018, 2019) reported that donkey-milk cheese has a distinctive aroma, sweet flavour and crumbly, easily soluble texture, similar to fresh feta-type cheese.

- **Ice-cream:**

  Ice cream represents another interesting route for utilizing donkey milk in a value-added food product. Tidona *et al*. (2017) developed a strawberry-flavored ice cream using donkey milk and two lactic acid bacteria with probiotic characteristics, *Bifidobacterium adolescentis* and *Lactobacillus plantarum*. The resulting product had a low-fat content of approx. 1.2% and an overrun of about 24.7%.

Overall Food Potential:

Donkey milk can be utilized in several food forms, including fermented milk, yogurt, kefir, cheese and ice cream. Among these products, fermented beverages appear comparatively easier to develop, whereas cheese production remains technically difficult because of the low casein content and poor coagulation properties of donkey milk. Yogurt requires attention to viscosity and texture, while kefir offers an interesting fermented-beverage opportunity. Ice cream provides an additional route for incorporating donkey milk into a familiar consumer product. Collectively, these applications demonstrate considerable potential for value addition, product diversification and commercialization of donkey milk.

Physio-Chemical Composition of Donkey Milk:

Donkey milk resembles water in appearance, flavour, and scent. Milk doesn't contain a lot of somatic cells or bacteria overall. (Massouras *et al*. 2020). Donkey milk is generally described as a white milk with a pleasant aroma, mildly sweet taste and relatively low viscosity. These characteristics contribute to its nutritional uniqueness as well as its specific processing behaviour (Aspri *et al*. 2017, Baloš *et al*. 2023).

Lactose Content:

Compared to cow or human milk, donkey milk has a higher lactose content (between 5.8 and 7.4%). The high quantity is advantageous because it increases the attractiveness of breast milk to babies and facilitates their absorption of calcium, which is necessary for the development of strong bones (Bhardwaj *et al*. 2020).

Nutrient	Donkey Milk	Camel Milk	Cow Milk	Goat Milk	Sheep Milk	Human Milk
Fat (g/100mL)	0.3–1.8	4–5	3–5	3–5	6.1	3–4
Protein (g/100mL)	1.3–1.8	3–5	3–4	3–3	6.21	1.1
Lactose (g/100mL)	5.8–7.4	4–4	4–5	4.1	4.8	6.5
Minerals (g/100mL)	0.3–0.5	0.7	0.7	0.86	5.5	0.21
Solids-not-fat (g/100mL)	9.018	8.6	9.1	8.75	10.33	8.9
Total solids (g/100mL)	8.8–11.7	16.89	13.12	13.2	18.75	12.75
Cholesterol (mg/100g)	8.6	34.5	5	11	27	14
Calcium (g/100mL)	6.89	1.43	1.20	1.34	2.00	3.20
Phosphorus (g/100mL)	1.596	1.16	1.3	1.08	0.15	0.13
Saturated fatty acids (g/100mL)	67.6	51.9	67.73	70.42	65.17	46.60
Monounsaturated fatty acids (g/100mL)	15.80	39.60	27.3	25.67	24.29	43.55
Polyunsaturated fatty acids (g/100mL)	16.60	8.46	5.25	4.08	2.45	9.85
Water (%)	92.5	87–90	87	82.46–89.05	80.62	87.5

Table no. 1: (Source- Madhusudan *et al*. 2017, Bhardwaj *et al*. 2020, Gadhwal *et al*. 2022, and Baloš *et al*. 2023)

Milk Proteins:

Numerous proteins are potentially found in milk, such as caseins, whey proteins, milk fat, globule proteins, enzymes, and more (Brumini *et al*. 2016, Saleena *et al*. 2022a and Saleena *et al*. 2022b). The protein content of donkey milk is significantly lower than that of cow milk (1.5–1.8 g/100g) and more akin to that of human and mare milk (Vincenzetti *et al*. 2017; Vincenzetti *et al*. 2021). Due to its palatability, nutritional sufficiency, clinical tolerability and physiological functions like digestive activity molecules, antibacterial substances, growth factors, and hormones, donkey milk is the best substitute for human milk for kids with cow milk protein allergies (Deepa *et al*. 2023, Bhardwaj *et al*. 2020 and Garhwal *et al*. 2022). Also, Donkey milk may be a novel dietetic meal and breast milk alternative because it is similar to human milk but has a lower percentage of Cys and a higher concentration of amino acids like Ser, Glu, Arg, and Val (Martini *et al*. 2021 and Garhwal *et al*. 2022).

Fat:

Donkey milk is a good choice for use in diet treatment to lower the incidence of cardiovascular disease, autoimmune disease and inflammatory diseases because its fat content is lower than that of human milk, ranging from 0.03 to 1.18 kg/kg in a nonlinear fashion from partum to the end of lactation **(**Bhardwaj *et al*. 2020). Given the high danger of fatty acid deficit, particularly in PUFA omega-3 fatty acids, which are essential for healthy growth, cognitive development, and cardiovascular function, donkey milk is a welcome addition to the human diet (Ragona *et al*. 2016).

Minerals:

According to Vincenzetti *et al*. (2021), the normal content of donkey milk varies from 0.3 to 0.9 g/100 g, depending on the breed and lactation stage.

Vitamins:

Studies on the nutritional content of donkey milk are just getting begun; however, it is well known that mare milk has far more vitamin C than cow milk. Donkey milk contains higher concentrations of cyanocobalamin, thiamine, riboflavin, and vitamin C, while human milk contains larger amounts of niacin (Papademas *et al*. 2022 and Deepa *et al*. 2023).

Future Prospects:

Future progress in donkey-milk production will require improved husbandry, nutrition and breeding management to address its naturally low milk yield. Better knowledge of breed, season, lactation stage and feeding effects is needed to improve consistency in milk composition. Standardized methods for collection, pasteurization, storage and microbiological quality control should be developed. Research can further optimize fermentation, yogurt, kefir, ice-cream and cheese-making processes for donkey milk. Because of its low casein content, new coagulation approaches are particularly important for improving cheese yield.

Donkey milk may have potential in specialty foods and selected nutritional applications, including products for people with cow-milk protein allergy under medical guidance. However, any health-related claims require confirmation through larger, well-designed human clinical studies. Clear food-safety regulations, product standards and traceability systems will be essential for commercial growth. Sustainable small-scale production models and consumer awareness may help expand this niche dairy sector.

Conclusion:

A promising non-bovine milk with unique nutritional and functional qualities is donkey milk. It has modest quantities of fat and casein but very high levels of lactose. Its whey proteins and bioactive substances, such as lactoferrin and lysozyme, give nutritional value. Specialty goods like yogurt, kefir, cheese, and ice cream could be made from donkey milk. It is still a specialty dairy product with little commercial distribution, though.

Large-scale production is limited by low milk yield, seasonal fluctuations, and expensive production costs. Processing issues are still significant, particularly in the production of cheese. Regulations, production methods, and quality standards all require improvement.

Although not yet proven, its antibacterial, antioxidant, and hypoallergenic properties are encouraging from a scientific standpoint. To verify its health importance, more carefully planned human clinical investigations are required.

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