



The Nutraceutical Characteristics of Donkey Milk: A New Insight for its Potential Probiotics

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Abstract

Toddlers, elder persons and immunocompromised persons the most frequent engender of hypersensitivity are some milk components. Several results of experimentations on milk hypersensitive toddler's serum shown that the caseins proteins manifest the allergic reaction and act as potent allergen. In few cases, α -lactalbumins & β -lactoglobulins also impart the potent role in the hyper allergic situation. And in such cases when human milk is not available for infants or not to be given then other alternatives are looked after like the donkey milk composition is close to the human milk and many clinical studies confirmed it as the best substitute of breast feeding for infants with severe Ig-E mediated milk hypersensitivity. Not only major components of the donkey milk but the potential probiotics exert beneficial effect in gut and prevent intestinal infection by boosting up the immune system. Fermented donkey milk enriched with probiotics can use as the potential beverage with manifested health benefits and delivers probiotics more efficiently. The previous studies reported that in donkey milk probiotic strains *Lactobacillus paracasei*, *Lactococcus lactis* and *Carnobacterium maltaromaticum* are more abundant and exhibit antimicrobial, antioxidant & other beneficiary effects *in vivo*. Although probiotics strains of donkey milk are less explored as compare to other non-bovine milk but now a day international market demand especially in European countries donkey milk and its probiotics rich products are used and production has been increased at large scale. So, this review highlights the Donkey Milk (DM) benefits, its comparative composition with other non-ruminants, bovine & human milk and the insights of probiotic profile of DM.

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Introduction

This scientific era is pushing human race to find out the healthy and nutritious drink for daily consumption. In order to compensate this demand many countries are exploiting non-ruminant milk as a good alternative of ruminant milk which is not only healthy but also vast source of probiotics and possesses diverse nutritional qualities. The non ruminant animal species as camel, donkey, yak, reindeer etc. are more widely explored as milk source and made a good economic impact in many countries. In addition, non ruminant milk is good and cheap source for isolating novel potential probiotics. As the Figure 1 shows the different isolated probiotic strains of non-ruminant milk:

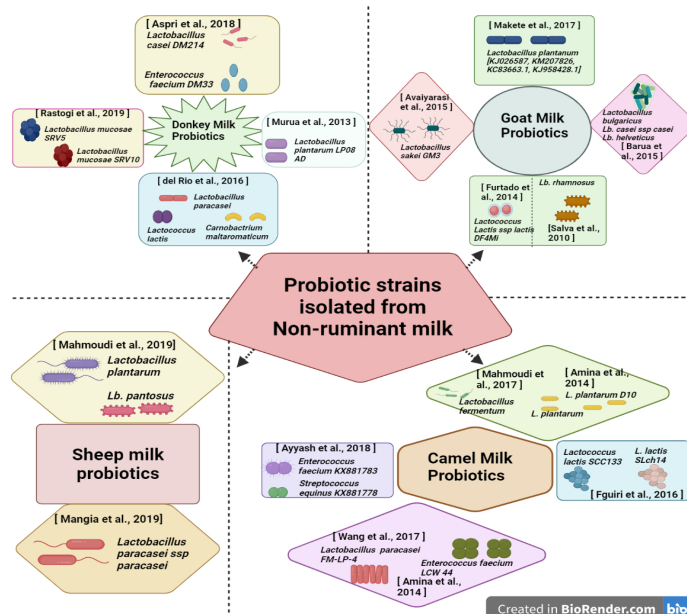


Figure 1: Potential probiotic strains isolated from different non-ruminants milk.

Despite of less exploration of nutritional values and potential in health consumers are interesting in more and more donkey milk consumption and gaining worldwide acceptance. The donkey milk is used as the alternative nutritional product for infants and children who suffer from cow's milk protein intolerance. Because donkey milk profile is closet to the human breast milk [1].

Female Donkey is also known as jenny and belongs to the family Equidae which also include horses and zebras. The modern domesticated donkey species *Equus asinus* are to evolved from the ancestor African wild ass, *E. africanus* and since ancient times the donkeys are domesticated all around the world but due to small udder size milk production is very less and hence difficult to commercialize it [2]. This makes the donkey milk slightly more expensive than cow milk. One liter of this nector is cost around \$50. In Italy donkey milk is key component

in some infant and medical nutraceuticals [3]. Thus we can say donkey milk is tasty and healthy really be an absolute amalgamation for more responsible and gratifying living way of life [4].



Figure 2: Donkey in rural area of state Haryana as pack animal.

In India, most of the breeds of donkeys are reared by only marginal people of rural areas and they don't know the importance of donkey milk. Here donkey is basically used only as draught or pack animal as shown in Figure 2. So this is necessary to awaken these local people about the health benefits of the donkey milk and also to promote indigenous breed quality. Moreover the probiotics of the Indian donkey breeds is less explored. Thus, the article emphasizes the benefits and downsides of donkey milk.

Nutritional qualities & uses of donkey milk

With reference to the nutritional qualities like lactose content, pH and protein content of donkey milk is comparable to the human milk. The gross composition of milk is affected by genetic and environmental factors, including the breed, individuality of animals, stage of lactation, frequency and completeness of milking, maternal age, health and type of feed [5]. Thus alike composition of donkey milk along with different minerals and vitamins promote the growth of healthy microbes in gut by increases delectability and enhancing the mineral absorption in intestinal lumen. Donkey milk not only provides nutrition but also selectively eliminate the baleful microbes of gut by high lysozymal concentration which causes lysis activity. Moreover, some unique nutritional qualities as rich source of whey proteins approx. 35-50% of the nitrogen content [6], high lysozyme concentration in comparison to goat, ewes, cow and other equines [7] and low concentration of fat approx. 0.28% to 1.82% (Carroccio et al. [8]) are also reported in donkey milk. And due to these constituents i.e. lactoferrin and α -lactalbumin wield antimicrobial, antioxidative, antifungal, anti-aging, anti-tumour activities [9]. Composition of different milk components in different species are given in Table 1:

Table 1: The comparative account of different nutritional components of human milk, donkey milk, Goat milk, Sheep milk and bovine milk which clearly indicates the close similitude of donkey and human milk.

Milk components	Human	Donkey	Goat	Sheep	Bovine	References
Lactose	7 %	7.5%	4.1%	4.8%	4.6%	Ballard et al., [30], Martini et al., [31] & Keszycka et al., [32] and Balthazar et al., [33]
Lysozyme	0.420 g/L	1.5 g/L	0.250mg/L	0.1µg/mL	0.0013 g/L	Hameed et al., [34], Cooper et al., [35], Shakir et al., [36] & Caroli et al., [37]
Lactoferrin	1.65 g/L	0.37 g/L	17.5mg/L	16mg/l	0.10 g/L	Uniacke-Lowe et al., [38], Cooper et al., [35] & Guo et al., [39]
Dry matter	11.7 g/100ml	9.5 g/100ml	--	--	12.5 g/ml	Salimei et al., [40] & Martini et al., [31]

Lipids	3.1%	0.50-1.7%,	4.3%	6.1%	3.7%,	Martini et al., [31], Guo et al., [39] & Keszycka et al., [32] and Balthazar et al., [33]
Ash	0.2-0.3	0.3-0.5	0.8	0.9	0.7-0.8	Guo et al., [39] & Keszycka et al., [32] and Balthazar et al., [33].
Proteins	0.9-1.7	1.5-1.8	3.7	5.5	3.1-3.8	Guo et al., [39] & Keszycka et al., [32] and Balthazar et al., [33].
Vitamin C	5600 µg/100 ml	5700 µg/100 ml	1300 µg/100 ml	4600 µg/100 ml	1500 µg/100 ml	Vincenzetti et al., [7], Moltó-Puigmartí et al., [41] & Keszycka et al., [32] and Balthazar et al., [33]
pH	7.0-7.5	7.0-7.2	6.6	6.6	6.6-6.8	Guo et al., [39] & Koutb et al., [42]

Along with these nutritional components DM, also possess a good microbial profile which has a great favourable effect as studied *in vitro* as well as *in vivo*. Like a study on DM peptide profile done by mass spectrometrically shown the bioactive properties of fermented milk boosted *in vitro* digestion under gastrointestinal conditions and bioactive peptides also exert immunomodulatory effects [10]. Another one isolated *Enterococcus spp.*, *Lactobacillus lactis*, and *Lb. Brevis* probiotic species as predominant species from DM and which exhibit antimicrobial, antioxidant & other beneficiary effects *in vivo* in animal models [11]. Many clinical trials on evaluating the efficacy of Donkey Milk (DM) for CMPA (cow milk protein allergy) and atopic dermatitis patients has proved that, DM is easily digestible & elicit the notable improvement in atopic dermatitis [12,13]. As per American Academy of Pediatrics definition DM is contemplated as 'Hypoallergenic' [14] and moreover the CMPA cured toddlers didn't show any allergy against DM and digested easily along with enhanced activity of immune system in older persons [15,16].

Thus donkey milk is capturing international attention & acceptance for consumption and use as potentially good healthy food.

Insights of donkey milk probiotics

The Donkey milk profile presents greater lactose sugar concentration and low fractions of fats & casein. The distinctiveness of this milk is the presence of high level of lactoferrin lysozyme approx. 1.5-3.7 g/l in different breeds which exert antibacterial activity and play a role in the preservation of milk's hygienic quality [6,17-19]. In spite of the higher concentration lysozyme, the copious level of lactose promote the growth & viability of some well adapted probiotic i.e. lactobacilli bacteria and strengthen the antimicrobial activity against the pathogenic bacteria of gastrointestinal tract [6,17,20]. More than 120 LAB species of raw & cultured donkey milk are reported by Cariminati et al. and also revealed their potential probiotic properties. These probiotic species produces bacteriocins in their exponential phase which suppress the activity of pathogenic bacteria. Like, *Lact. plantarum* LP08AD isolated from DM can resist low pH and produce high concentration of bacteriocin against pathogenic strains *Listeria monocytogenes* & *Enterococcus faecium*. Thus this isolated species *Lact. plantarum* LP08AD might be useful to design novel functional food with potential probiotic properties [21].

Likewise, the previous studies Russo et al. [22] explored the microbial populations from fresh and cold stored donkey milk by high-throughput sequencing which provides an indication for a correct management of this high-value product. The potential probiotic bacteria present in donkey milk can be further categorized in more and less potent species e.g. *Lactobacillus paracasei*, *Lactococcus lactis* and *Carnobacterium maltaromaticum* are more abundant while the genera *Leuconostoc*, *Enterococcus* and *Streptococcus* are least [19]. Many Studies have proven the differential microbial diversity distribution in raw donkey milk

and fermented milk [23]. The isolated probiotic strains from donkey milk can be used to study their functional properties like ACE-inhibitory, antimicrobial and antioxidant activities of fermented donkey milk. The probiotic strain *Enterococcus faecium* DM33 from fermented milk exhibit the strongest antioxidant and the highest antimicrobial activities. This strain exhibit highest ACE-inhibitory activity in milk fermented with *Lactobacillus casei* DM214 [10].

These findings will contribute to the development of a new functional dairy drink with anti-hypertensive, antimicrobial and/or antioxidant activities. Another bacterial strain *Enterococcus spp.* isolated from donkey milk has shown a very good safety profile and interesting technological and potential probiotic properties. Many evidences proven that this strain can be potentially utilized further by the food industry in the fields of food microbiology (i.e. biosafety/bio-preservation) or in dairy technology (i.e. fermented dairy products) [24]. The two new probiotic strains, have been isolated from donkey milk and reported their efficacy, safety and functional properties i.e. *Lactobacillus mucosae* strains, *L. mucosae* SRV5 and *L. mucosae* SRV10 [25].

Perna et al., [26] revealed that donkey milk is suitable for the production of a fermented probiotic beverage which effectively delivers probiotics in human body. This probiotic beverage gives an insight to industry for development of nutraceutical foods with lower lactose content and higher antioxidant activity. Milk microbiota concentration affects the chemical composition of milk as these microbes secrete metabolites which change the milk properties.

Papademas et al., [27] studied the probiotic, antioxidant, antimicrobial and the sensory properties of fermented donkey milk with *Lactobacillus fermentum* ME-3 and *Lactobacillus acidophilus* (ATCC4356) [43-47]. Along with good protein profile milk also contains higher calcium, saturated fatty acids which help in improving human gut microbiota composition [28]. Similarly, fermented milk also seems to be very beneficial, a fermented beverage of DM is prepared by employing co-culture of probiotic species *Lactobacillus plantarum* and *Streptococcus thermophilus*. The selected species *L. plantarum* stimulate the growth of *S.thermophilus* in that environment and also enhance the growth rate to of bacteria to attain that provided pH in limited time. This interesting growth activity was not predicted in monocultures [29].

Thus donkey milk possesses unique nutritional values & rich source of probiotics which gives an insight for its use in therapeutics.

Conclusion

Since ancient times, all domesticated animals play a crucial role in community establishment and development, likewise donkey had notable role in the economy in different ways. As, the donkeys are chiefly fostered; a) as pack animal or for work b) for milk c) variety or breed & d) for flesh. But now a day the

many researches highlighted the closeness of human and donkey milk profile which has increased its multifaceted demand in different fields as in health, cosmetics, pharmaceutical and for immunocompromised infants. DM contains variety of proteins as lysozyme, lactoferrin and α -lactalbumin which not only maintains milk preservative properties but also wield antimicrobial, antioxidative, antifungal, anti-aging, anti-tumour, nutritive growth promoting properties. So, it can be the best substitute of mother milk if mother is ill or for orphaned child. Although donkey milk has such values, it is less appreciated thus its consumption is restricted because of lack of awareness and myths.

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