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CAMEL MILK: A NUTRITIONAL TREASURE AND AN EMERGING OPPORTUNITY FOR THE DAIRY INDUSTRY

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SHREYA MISHRA[1], DHARMESH GOSWAMI[2]

[1]Livestock Products Technology,[2]Division of Biochemistry,

ICAR-Indian Veterinary Research Institute, Izatnagar, Bareilly, India-243122

Corresponding author e-mail: dharmeshgoswamijoura@gmail.com

Abstract

Camel milk, often referred to as the "white gold of the desert," is gaining attention as a valuable nutritional resource and an emerging opportunity for the dairy industry. It contains high-quality proteins, essential fatty acids, vitamins, minerals and bioactive components, including lactoferrin, lysozyme, lactoperoxidase and immunoglobulins. These components have attracted scientific interest in relation to antioxidant, antimicrobial and other potential biological activities. Research has also explored its possible role in diabetes management and its suitability for selected individuals with cow's-milk protein allergy, although further clinical evidence is required to establish these benefits. Beyond its nutritional value, camel milk offers considerable potential for value addition through the development of pasteurised milk, fermented beverages, yoghurt, ice cream, cheese, milk powder and speciality food products. In India, particularly in Rajasthan and Gujarat, camel dairying can support pastoral livelihoods and diversify dairy production. However, challenges related to milk collection, cold-chain infrastructure, processing technologies, product

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standardisation and consumer awareness must be addressed to ensure sustainable growth. Scientific innovation, appropriate quality-control measures and responsible health communication can help strengthen the camel milk value chain. Thus, camel milk represents a promising resource for dairy diversification, rural livelihood development and the production of innovative dairy foods.

Keywords: Camel milk, nutritional composition, bioactive components, health benefits, value addition, dairy processing, functional foods, India.

Introduction

In India's desert regions, the camel has long been more than a means of transport—it is a source of food, livelihood and resilience. Traditionally consumed by pastoral communities in arid and semi-arid regions, camel milk is now attracting growing interest from nutrition researchers, food technologists and dairy entrepreneurs. Often described as the *"white gold of the desert,"* it offers a distinctive nutritional profile and opportunities for developing innovative dairy products.

Camels are well adapted to harsh environmental conditions and can support livestock-based livelihoods where conventional dairy farming faces challenges. Their milk has traditionally been valued for its nutritional properties and is increasingly being investigated for its bioactive components and potential functional applications. With growing interest in diversified dairy products, camel milk offers opportunities to connect traditional livestock resources with modern dairy processing (Konuspayeva et al., 2009; Khaliq et al., 2024).

However, the future of camel milk depends not only on its nutritional appeal but also on scientific validation, appropriate processing technologies, food safety and the development of reliable marketing systems.

Nutritional Composition: What Makes Camel Milk Different?

Camel milk is generally opaque white, with a faintly sweet odour and a characteristic taste that may sometimes be salty. Its composition varies according to breed, geographical location, feed, water availability, season and stage of lactation. Consequently, its nutritional characteristics may differ considerably between production systems.

Camel milk contains high-quality protein, milk fat, lactose, vitamins and minerals. Its proteins include caseins, whey proteins and bioactive components such as lactoferrin, lysozyme, lactoperoxidase and immunoglobulins. An important compositional difference is the absence of β-lactoglobulin, a major whey protein found in cow's milk. This characteristic has stimulated research into camel milk as a potential

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alternative for some individuals with cow's-milk protein allergy; however, camel milk is not completely hypoallergenic (El-Agamy et al., 2009).

Table 1. Approximate composition of milk from different species (%)

Component	Camel	Cow	Buffalo
Water	86–88	85–87	82–84
Protein	3.0–3.9	3.2–3.8	3.3–3.6
Fat	2.9–5.4	3.7–4.4	7.0–11.5
Lactose	3.3–4.4	4.8–4.9	4.5–5.0
Ash (minerals)	0.6–0.9	0.7–0.8	0.8–0.9

Source: *Adapted from Konuspayeva et al. (2009) and Al haj and Al Kanhal (2010). Values are approximate literature ranges and may vary with breed, feeding, lactation stage and analytical method.*

Camel milk contains saturated and unsaturated fatty acids, including polyunsaturated fatty acids that contribute to its nutritional value. It also supplies vitamins such as A, C, D and E, along with B-group vitamins, and minerals including calcium, phosphorus, potassium, magnesium, zinc and iron. The concentrations of these nutrients depend on animal nutrition and other production conditions. Therefore, camel milk should be appreciated for its overall nutritional composition rather than assumed to be superior to all other milk types in every respect.

Bioactive Components and Potential Health Benefits

Interest in camel milk extends beyond its basic nutritional value. Researchers have investigated its protective proteins, antioxidant components and peptides that may be released during digestion or fermentation. These components have demonstrated various biological activities in laboratory and experimental studies, making camel milk a promising subject for functional food research (Khaliq et al., 2024).

Antioxidant and antimicrobial properties: Camel milk contains vitamin C and bioactive proteins that may contribute to antioxidant and protective activities. Lactoferrin binds iron and can inhibit the growth of certain microorganisms under suitable conditions, while lysozyme and lactoperoxidase participate in antimicrobial defence. These properties are relevant to research on functional foods and natural protective systems. Nevertheless, the presence of these components does not mean that consuming camel milk prevents or cures infections.

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Potential role in diabetes management: Camel milk has received particular attention for its possible influence on blood glucose regulation. Researchers have investigated insulin-like activity and the potential effects of its proteins and peptides on glucose metabolism. Agrawal et al. (2011) conducted a two-year randomised controlled study examining camel milk consumption alongside conventional care in patients with type 1 diabetes. Although the findings contributed to interest in this area, further well-designed clinical studies are needed to establish the extent and consistency of any benefits.

Camel milk should therefore be considered a subject of nutritional research, not a cure for diabetes or a substitute for prescribed insulin, medication or medical supervision.

Cow's-milk protein allergy: The absence of β-lactoglobulin distinguishes camel milk from cow's milk. Some research has explored its suitability for individuals with cow's-milk protein allergy. However, other proteins in camel milk can also trigger allergic reactions. It should not be recommended as a universal hypoallergenic alternative, particularly for children, without appropriate medical guidance.

Other experimental studies have examined possible anti-inflammatory, immunomodulatory and antitumour activities of camel milk components. Research has also explored potential applications in gastrointestinal disorders and autism spectrum disorder. These findings should be interpreted cautiously because laboratory observations do not necessarily translate into proven benefits in humans.

Overall, camel milk is best regarded as a nutritious food with promising functional properties, while its proposed therapeutic applications require further scientific validation.

Camel Milk as an Opportunity for Dairy Processing and Value Addition

One of the most promising aspects of camel milk is its potential for product diversification. Converting fresh milk into value-added products can improve convenience, expand market reach and create additional income opportunities for camel-rearing communities.

Several products can be developed from camel milk:

- Pasteurised and packaged milk: Hygienic collection, pasteurisation, rapid cooling and suitable packaging can improve safety and facilitate distribution beyond traditional production areas.
- Fermented milk and yoghurt: Fermentation offers opportunities to develop products with distinctive sensory properties. Starter culture selection, fermentation conditions and texture development require optimisation.

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- Ice cream and frozen desserts: Camel milk can be used in innovative frozen dairy formulations, with appropriate adjustments to improve texture, flavour and stability.
- Cheese and other dairy products: Camel milk presents challenges in coagulation because its protein composition differs from that of cow's milk. Research into suitable coagulants and processing conditions can help improve curd formation and product quality.
- Milk powder and speciality ingredients: Drying technologies can support storage, transportation and the development of ingredients for food formulations.
- Confectionery and speciality foods: Camel milk can be explored in products such as chocolate and sweets, depending on formulation and processing requirements.

Although these applications offer considerable potential, camel milk is not always processed in the same way as cow or buffalo milk. Differences in its physicochemical characteristics can influence fermentation, coagulation, drying performance and final product texture. Research into species-specific processing methods is therefore essential for improving product quality and commercial feasibility (Al haj and Al Kanhal, 2010; Konuspayeva et al., 2021).

Product development must also include sensory evaluation, microbial safety testing, shelf-life assessment and suitable packaging. These steps are essential to ensure that camel milk products are safe, consistent and acceptable to consumers.

Camel Milk in India: From Desert Livelihood to Modern Dairy Enterprise

India has a long tradition of camel rearing, particularly in Rajasthan and Gujarat. Camel milk can contribute to food security and diversify the income of pastoral communities, especially in regions where climatic conditions make conventional dairy production challenging.

According to the Government of India's 20th Livestock Census, the country's camel population was 2,51,799. The government has also included camel-related activities under the National Livestock Mission from 2024, with provisions for entrepreneurship development and genetic improvement (Government of India, 2025).

Commercial interest in camel milk has encouraged the marketing of packaged milk and value-added products. Dairy cooperatives and specialised producers can help connect camel-rearing communities with urban consumers. However, the sector faces several constraints, including a geographically dispersed supply base, limited collection and chilling facilities, transportation costs, seasonal variation in milk production and the need for greater consumer awareness.

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The following measures could help strengthen camel dairying in India:

1. Improved collection and cold-chain facilities: Local milk collection centres, hygienic milking practices and rapid cooling can improve milk quality and reduce spoilage.
2. Scientific processing and product innovation: Research institutions and dairy processors can develop suitable methods for fermentation, cheese manufacture, powder production and other value-added applications.
3. Quality assurance and standardisation: Regular compositional testing, microbiological examination, appropriate packaging and compliance with applicable food-safety standards can improve consumer confidence.
4. Producer support and market development: Training, cooperative marketing and better links between camel rearers, processors and retailers can improve market access and economic returns.

These measures can help transform camel milk from a regionally important resource into a specialised dairy commodity while supporting sustainable camel-based livelihoods.

Food Safety and Responsible Consumer Awareness

The commercial development of camel milk must be accompanied by strong food-safety practices. Like other types of milk, it can transmit harmful microorganisms if collected, handled or stored improperly. Consumption of raw or unpasteurised milk carries avoidable food-safety risks.

Pasteurisation, hygienic milking, rapid cooling, appropriate storage and microbiological testing should therefore be central to camel milk production and marketing. Producers and processors must comply with applicable food-safety and compositional standards.

Responsible communication is equally important. Claims that camel milk cures diabetes, cancer, autism or other diseases can mislead consumers and encourage them to delay effective treatment. Promoting its nutritional properties and potential functional applications, while clearly acknowledging the limitations of current research, will support public confidence in camel milk products.

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Conclusion

Camel milk is a valuable nutritional resource with distinctive protein characteristics, protective bioactive components and promising potential for dairy product innovation. Its use in packaged milk, fermented beverages, yoghurt, frozen desserts, cheese, milk powder and speciality foods offers opportunities to diversify the dairy industry.

In India, improved infrastructure, scientific processing, quality assurance and sustainable camel husbandry can help strengthen the camel milk value chain and support rural livelihoods. Future research should focus on processing efficiency, product quality, consumer acceptance, food safety and rigorous evaluation of proposed health benefits.

With appropriate scientific support and responsible marketing, camel milk can contribute to dairy diversification and the development of innovative functional foods. Its greatest promise lies not in exaggerated medicinal claims, but in combining traditional knowledge with modern dairy science to produce safe, nutritious and commercially valuable dairy products.

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