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Nutritional composition, bioactive compounds, functional properties, and processing technologies of camel milk and its value-added products: A review

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Abstract

Camel milk has gained increasing scientific and industrial interest due to its distinctive nutritional composition, functional properties, and potential therapeutic benefits. This review synthesizes peer-reviewed literature from 2010 to 2025 to critically examine the interconnections between camel milk composition, bioactive functionality, processing technologies, and the development of value-added products. It contains high-quality proteins, unsaturated fatty acids, essential vitamins and minerals, and bioactive components such as lactoferrin, lysozyme, and immunoglobulins, which contribute antimicrobial, antioxidant, and anti-inflammatory activities. These attributes support reported benefits in metabolic regulation, immune function, and gastrointestinal health. Compared with cow milk, camel milk is more digestible, less allergenic, and better suited for individuals with lactose intolerance, though its unique composition requires specialised processing. Recent advancements in pasteurisation, fermentation systems, drying technologies, and non-thermal preservation methods have improved nutrient stability and expanded the range of value-added products, including yogurt, fermented beverages, milk powder, and functional formulations. These developments enhance diversification of the nutrition supply and create new economic opportunities in camel-rearing regions. In addition, camel milk supports pastoral livelihoods and strengthens food system resilience in arid environments. Future research should focus on optimising processing methods that accommodate camel milk's physicochemical characteristics, improving fermentation through targeted culture selection, and addressing coagulation challenges that limit cheese production. Further priorities include evaluating the effects of processing on bioactive integrity, undertaking detailed characterisation of bioactive constituents, and validating health claims through well-designed clinical studies. Continued innovation in packaging, preservation, and product development will support broader market integration and the expansion of camel milk into high-value dairy sectors.

Keywords: Bioactive compounds, camel milk, functional properties, processing technology, value-added products