DOI: 10.54083/BRT/08.02.26/25-27

Bio. Res. Today 2026, 8(2):25-27

Biotica Research Today

e-ISSN: 2582-6654

February, 2026

Article ID: RT1868 **Popular Article**

From Oats to Almonds: The New Face of Plant-based Milk in India and Beyond: Uprise, Significance, Challenges and Opportunities

Sakshi Kaith*, Aadya Gautam and Danish Chauhan

ICAR-Indian Institute of Agricultural Biotechnology (IIAB), Ranchi, Jharkhand (834 003), India

Open Access

Corresponding Author

Sakshi Kaith

✉: kaithsakshi@gmail.com

Conflict of interests: The author has declared that no conflict of interest exists.

How to cite this article?

Kaith, S., Gautam, A., Chauhan, D., 2026. From Oats to Almonds: The New Face of Plant-based Milk in India and Beyond: Uprise, Significance, Challenges and Opportunities. *Biotica Research Today* 8(2), 25-27. DOI: 10.54083/BRT/08.02.26/25-27.

Abstract

Milk consumption patterns are changing worldwide, with plant-based milks derived from cereals, legumes, nuts and seeds increasingly gaining popularity. This shift can be attributed to several factors such as the high prevalence of lactose intolerance which affects half the global population and milk allergies. Furthermore, rising awareness in consumers regarding animal welfare, also the proliferation of veganism and concerns related to environment sustainability are fuelling this revolution. Studies have shown that plant-based milk such as oat milk, soy milk and almond milk require less water and produce fewer greenhouse gas emissions compared to cow's milk. However, these alternatives lack adequate protein content, bioactive peptides making fortification and processing technologies essential for improving their nutritional values. In India, coconut milk and almond milk have deep roots in ancient culture. But the high market price of plant-based milk is another challenge for low-income consumers. Therefore, the future of plant-based milk will depend on addressing the nutritional gaps and also making them affordable for all consumers.

Keywords: Dairy milk, Lactose intolerance, Milk allergy, Veganism

Introduction

Plant-based milk is an aqueous liquid obtained from different plant materials such as legumes, cereals, seeds, nuts and pseudocereals and has been developed as an alternative to animal milk. Researchers are working to create substitute products for animal milk due to the rise in lactose intolerance and animal milk allergies, new lifestyle choices, such as vegetarianism and veganism and environmental issues, such as water pollution and greenhouse gas emissions. Although these plant-based milks provide health-promoting functional factors, they often lack the complete nutrient profile of bovine milk, particularly in terms of protein content and bioactive peptides, requiring processing innovations such as fortification and novel fermentation techniques to improve their quality, flavor, texture and nutritional value (Maras, 2023). Oat and almond plant-based milks are considered more ecologically sustainable beverage choices than conventional dairy milk, due to lower greenhouse gas emissions and water requirements for production (Riofrio and Baykara, 2022). This recent upsurge in demand for plant-based milks has created a rapidly expanding marketplace for functional beverages; thus, plant-based milks are viewed as low-cost, ecologically-friendly and functional beverage options, particularly in regions where the availability of conventional cow's milk is low (*e.g.*, due to cows not being raised in that region) or for consumers who have food allergies or intolerances or who do not consume animal-based foods (Sethi *et al.*, 2016).

Factors Driving the Transition from Conventional Dairy

Multiple factors including health issues, ethical concerns and economic factors, contribute to the growth of plant-based dairy alternatives in India.

1. Health Concerns

Consumers are becoming more aware of health issues such as lactose intolerance and milk allergies from drinking cow's milk. There has been a rise in the number of people searching for alternatives to dairy milk products. Many of the alternative products do not contain lactose and also not cause allergies, thus providing appealing option to the

Article History

RECEIVED on 03rd February 2026 RECEIVED in revised form 12th February 2026 ACCEPTED in final form 14th February 2026

sufferers. In South America, Africa and Asia, more than 50% of the population is unable to digest lactose (Sethi *et al.*, 2016).

2. Ethics of Dairy

Animal welfare and ethical concerns related to dairy production (including the cruelty to animals associated with dairy farming) are common reasons why many people choose to adopt a vegan lifestyle or a vegan diet. Consequently, many consumers consider cow's milk as harmful to animals and detrimental for the environment; therefore, they perceive plant-based milk alternatives as more environmentally responsible and humane options for them to choose from.

3. Sustainable Choices

The production of cow milk results extensive greenhouse gas emissions and requires greater water resources. The production of plant milks, such as, oat, almond & soy, results in reduced greenhouse gas emission and uses far less water than the production of dairy milk (Ramsing *et al.*, 2023). This is advantageous for Indian consumers concerned about climate change and resource depletion by using these environmentally sustainable alternatives.

4. Economic Perspective

Plant-based milk is viewed in economic terms (supply perspective) as an economic alternative to cow's milk for people who do not have access to reliable high-quality cow's milk (*i.e.*, people living in parts of India that are remote or urban with inconsistent supply patterns of cow's milk). The fact that India has both rural and urban populations with diverse patterns of milk production and consumption makes it difficult for plant-based beverages to be used as a cost-effective means of providing nutrition to larger segments of the population, primarily lower income segments. Sensory enhancements, technologically improved processing methods (including ultra-high temperature and pressure processing) and more readily available products have increased the palatability and shelf life of plant-based milks, resulting in more consumers purchasing and consuming these products, thereby expanding the market for them (Sethi *et al.*, 2016).

5. Indigenous Traditional Knowledge

Although plant-based milk has become more popular than animal-based milk since the 2000s, evidence based on archaeological findings of traditional methods of preparing plant-based milks can be found as early as the 13th century BC in China, Asia, Europe and India. Blending fresh coconut with water and straining it has been historically used to prepare plant milk and has been an ingredient in many South Indian curries and traditional dishes. Almond milk (badam milk) has known health benefits and serves as a source of nutrition; therefore, it is frequently consumed by people.

Defining Plant-based Milk: Composition and Origins

A rapidly expanding market in the newer food product development category of functional and specialty beverages worldwide is plant-based or non-dairy milk alternatives. In the modern world, drinks are no longer only used to quench thirst; instead, consumers seek particular uses for these beverages that are integral to their way of life. These beverages may be functional in addressing a variety of needs and lifestyles, such as increasing energy, combating aging, fatigue and stress, targeting particular diseases and the industry is still growing. Almond, coconut, hazelnut, hemp, lupin, oat, peanut, quinoa, rice, sesame, tiger nut and other milk substitute other than soy milk have been the subject of some study (Sethi *et al.*, 2016).

1. Processing

Plant-based milk alternatives are fluids created by breaking down plant materials, such as cereals, pseudo-cereals, legumes, oilseeds and nuts and extracting them in water. Through a process of homogenization, these fluids achieve a particle size distribution of 5-20 µm, effectively mimicking the appearance and consistency of cow's milk (Sethi *et al.*, 2016). Various plant-based milks undergo different processing steps depending on their composition, extraction hardness, nutritional content and sensitivity to heat and other processes.

2. Classification

Classification of plant-based milk alternatives into five distinct groups, as follows:

a) Cereal based: Oat milk, Rice milk, Corn milk, Spelt milk.

b) Legume based: Soy milk, Peanut milk, Lupin milk, Cowpea milk.

c) Nut based: Almond milk, Coconut milk, Hazelnut milk, Pistachio milk, Walnut milk.

d) Seed based: Sesame milk, Flax milk, Hemp milk, Sunflower milk.

e) Pseudo-cereal based: Quinoa milk, Teff milk, Amaranth milk.

Comparison of Plant based Milk to Dairy Milk

1. Sustainability

Plant-based beverages, exhibit a reduced environmental impact which includes lower greenhouse gas emissions and lower water usage in comparison to dairy milk. Consequently, these beverages offered a more environmental friendly and sustainable option (Riofrio and Baykara, 2022). On the other hand, rearing cattle significantly contributes to large amounts of methane and greenhouse gas emission. Also, cattle cultivation requires larger quantities of lands and water which results in higher carbon dioxide emissions as compared to plant-based beverages.

2. Nutritive Analysis

In comparison to cow milk; almond, oat, rice and coconut milk typically contain lower protein contents. Soy and pea milk are comparable, although the quality of protein varies. Cow milk proteins have a higher digestible indispensable amino acid score (DIAAS) as compared to plant-based milk proteins. Despite soy milk containing similar protein quantity, its protein quality does not exactly match that of cow milk (Walther *et al.*, 2022). Oat and Pea milk have higher Fat content of nearly 4.5 g. Cow milk has higher sugar

content than most plant-based milks. Cow milk is the "Gold Standard", owing to its complete protein profile, being rich in Vit B_{12} and iodine naturally. Soy milk is the closest to cow milk with complete plant protein but also has soy as allergen. Almond Milk is low in calories and has high Vit E content but requires more water during farming. Oat milk had high Beta-glucan fiber which promotes heart health (Maras, 2023).

3. Fortification

Fortification with additional nutrients is conducted to make plant-based milk nutritionally equivalent to cow milk. Fortification of plant-based milk products with calcium, B_{12}, B_2 and D vitamins covers some of the deficiencies or nutritional gaps associated with the use of cow's milk. There can be substantial variation in the different types and degrees of fortification and the contents of plant-based milks between manufacturers or brands. For example, approximately 80% of the plant-based milks available in certain markets are fortified with additional calcium; in the same market area, many of those brands do not add iodine or vitamin B_{12} to help cover their nutritional deficiency of B_{12} (Walther *et al.*, 2022). Additionally, while vitamins A, B_2, B_{12} and D are naturally present in cow's milk, they will not be present in plant-based milks unless they have been fortified with these nutrients. As far as mineralization is concerned, cow's milk has higher levels of calcium, phosphorus, iodine, zinc, selenium, sulfur and potassium than many plant-based milk alternatives (Figure 1).

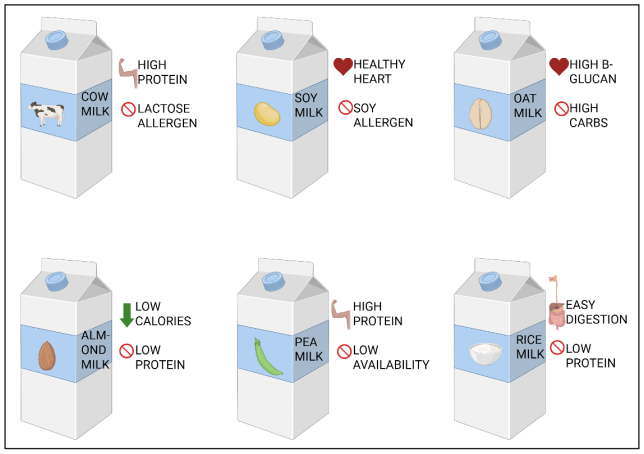

Figure 1: Reference guide stating pros and cons of cow and plant-based milks

The Future Role of Plant-Based and Conventional Dairy

Natural dairy products provide few substitutes for plant-based beverages because the complex nature of the nutrients contained in natural milk. As we know dairy milk possess more nutritional values as compared to plant-based milk that too with established health benefits. Also, there is availability of specific proteins, bioactive peptides, potassium and zinc with dairy milk. On the other hand, plant-based milks are considered as processed drinks with different nutritional profiles. Traditional dairy milk also contains bioactive peptide that helps in suppressing appetite as well as in weight management. But there are several reasons why consumers are opting for plant-based milk over traditional dairy milk. In addition to environmental sustainability, plant-based milks are associated with lower greenhouse gas emissions and water consumption than dairy milk. However, there are some plant-based milk, such as almond milk, which have a larger water footprint. These differences benefit consumers who are concerned about global climate change and animal welfare, thus increasing their selection of plant-based alternatives to traditional dairy products, including consumers who currently consume dairy products at homes. Consumers who generally place their motivation to buy on health, environmental and animal welfare-related issues tend to select plant-based dairy beverages more often than others, while consumers who focus heavily on price tend to remain with traditional dairy products (Ramsing *et al.*, 2023).

Conclusion

A shift from cow's milk to plant-based milk has been driven by consumer preferences related to health, the environment and sustainability. Despite their nutritional limitations compared to cow's milk, ongoing research seeks to enhance these beverages through advanced processing technologies to improve shelf life, stability, sensory acceptance and nutrient content (Sethi *et al.*, 2016). The fortification of plant-based milks will provide nutritional requirements while satisfying consumer needs.

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