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Milk-Cereal Fermented Foods: A Key to Sustainable Nutrition

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Abstract

Milk-cereal composite fermented foods are an emerging solution to address nutritional security and sustainability challenges. Combining dairy and cereals, these foods deliver the nutritional richness of milk, the diverse nutrient profile of cereals, and the health benefits of fermentation. Examples like *Kishk*, *Tarhana*, and *Rabadi* demonstrate cultural adaptability and nutrient synergy. These foods enhance dietary quality through improved nutrient bioavailability, reduced anti-nutritional factors, and added probiotic potential, supporting digestive and immune health. Additionally, they align with sustainability goals by efficiently using resources, utilizing local ingredients, and reducing food waste. As an affordable, nutritionally dense, and scalable food option, milk-cereal composite fermented products offer a promising pathway to strengthen nutritional security while promoting environmental sustainability.

Keywords: Composite foods, dairy, nutritional security, sustainability

Introduction

In a world grappling with food security and environmental challenges, the development of sustainable and nutritionally dense food options is essential. Milk-cereal composite fermented foods are emerging as a promising solution to address these issues. These foods combine the nutritional benefits of milk and cereals with the health advantages of fermentation, offering a potent tool for enhancing dietary quality and promoting sustainable food systems.

Milk-Cereal Composite Fermented Foods

Milk holds a unique place in the human diet due to its ability to provide nutritional adequacy and support growth and development. Milk and dairy products provide energy and high-quality protein along with a variety of essential micronutrients, particularly calcium, magnesium, potassium, zinc, and phosphorus, in forms that are easily absorbed by the body. While milk is often regarded as a complete food, it is also linked to certain health concerns, particularly due to its high levels of saturated fatty acids and lack of dietary fiber (Raju and Pal, 2014). To address these issues, traditional practices of fortifying milk with cereals, pulses, and fruits have

been used, as they help supplement dietary fiber and other essential micronutrients in the form of composite dairy foods. The Codex standard defines a composite dairy product as a food made from milk or milk products, possibly with added non-dairy ingredients, as long as they are not used to replace milk components.

Cereals are a traditional staple food and a primary source of carbohydrates in human diets. They provide significant amounts of energy, protein, and micronutrients in both animal and human nutrition. Recognized as one of the most important sources of dietary protein, carbohydrates, vitamins, minerals, and fiber worldwide, cereals account for about 50% of the average daily energy intake in many populations, and up to 70% in some developing countries. However, most cereals are relatively deficient in certain essential nutrients, including amino acids like threonine, lysine, and tryptophan. Additionally, cereals contain anti-nutrients such as phytic acid, tannins, and non-starch polysaccharides, which can reduce digestibility by binding with proteins. Plant-based proteins also typically contain fibers that limit the access of proteases, further decreasing protein digestibility (Zhang et al, 2022).

Fermentation is a cost-effective, widely used technology that enhances the nutritional content of both milk and cereals, creating sustainable foods with higher nutritional value. Fermenting milk enhances its nutritional value by increasing the bioavailability of nutrients and generating bioactive substances with beneficial biological functions. Adding milk to cereal boosts the levels of essential amino acids and fat-soluble vitamins in the final product. Furthermore, using fermented milk instead of regular milk enhances the nutritional value of dairy-cereal blends by increasing bioactive compounds, lowering anti-nutrients like phytic acid, and improving mineral bioavailability. Beyond the benefits of fermentation, the relatively high milk solid content in composite products like *Kishk* provides a significant amount of calcium, an essential nutrient for bone and dental health. Various studies have evaluated the effects of formulation (different cereals, type of starter culture used in milk fermentation) in the development of milk-cereal fermented foods (Tamime et al, 2000; Demirci et al, 2018; Gadallah and Hassan, 2017; Garrido-Galand et al, 2021). Cereals are incorporated into milk since ancient time. Some of the traditional milk-cereal fermented dairy foods are given below.

Traditional milk cereal fermented foods	**Characteristics**	**Reference**
Tarhana	Fermented milk-cereal product of Greece. Traditionally made during summer using whole fresh ewe's, goat's milk, or a mix of both and wheat flour. This product, a dried yogurt-	Tamime *et al.*, 2000

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	cereal blend, has an acidic, sour taste with a mild yeasty flavor. It is mainly used in soups and enjoyed as a snack, either dried into thin layers or nuggets. Known as Tarhana, it is rich in B-vitamins, minerals, organic acids, and free amino acids, making it especially nutritious for children, the elderly, and patients.	
Rabdi	Rabdi, or Raabadi, is a popular traditional cereal-based fermented dairy product from northwestern India, especially in Punjab, Haryana, Uttar Pradesh, and Rajasthan. It is made by mixing flour from pearl millet, barley, wheat, sorghum, or maize with homemade buttermilk in earthen or metal vessels. During the hot summer, it is left to ferment in the sun or at room temperature (35–45 °C) for 4–6 hours. After fermentation, the mixture is boiled, salted to taste, cooled, and then enjoyed as a refreshing dish.	Sreeja & Prajapati, 2020
Kishk	Kishk is a traditional dried blend of fermented milk and wheat, enjoyed either raw in its early production stages or as a thick soup after being reconstituted with water and simmered. Common in Arab countries such as Syria, Jordan, and Egypt, Kishk has been consumed in Lebanon since the 10th century, especially in the wheat-growing Bekaa region. Traditionally, it is made from Bourghol (parboiled cracked durum wheat) and plain yogurt (Laban), which are mixed and left to ferment at room temperature (23–25 °C) for 3 to 8 days before sun-drying to a moisture content of 6–12%. Kishk is nutrient-rich, offering high levels of starch and fiber, as well as iron and magnesium from the Bourghol. Its protein content is substantial, contributing essential amino acids such as phenylalanine, threonine, isoleucine, leucine, arginine, valine, tyrosine, and lysine.	ElAttar *et al*., 2015; Salameh *et al*., 2016; Hajj *et al*., 2019

How milk-cereal fermented foods contribute to nutritional security

Nutrition security is the consistent access to safe, affordable, and healthy foods that promote well-being and prevent disease. It also includes the ability to treat disease when

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needed. Milk-cereal composite fermented foods can contribute to nutritional security in different ways:

***Nutrient Synergy*:** Combining milk and cereals in fermented foods offers a balanced nutrient profile, with milk providing high-quality proteins, calcium, and vitamins, while cereals contribute essential carbohydrates, dietary fiber, and B-vitamins, creating a more nutritionally complete product.

***Enhanced Digestibility*:** Fermentation improves the bioavailability of nutrients by breaking down anti-nutritional factors (like phytates in cereals), which enhances mineral absorption (e.g., calcium, iron) and overall digestibility of proteins and carbohydrates.

***Probiotic Potential*:** Fermented milk-cereal composites support the growth of beneficial microbes such as *Lactobacillus* and *Bifidobacterium*, which promote gut health, enhance immune function, and may contribute to better metabolic outcomes.

***Cultural Relevance and Sustainability*:** These composite foods align with traditional dietary patterns in many cultures, and the use of locally available ingredients can promote food security, sustainability, and economic resilience, especially in resource-limited settings.

***Addressing Malnutrition*:** Milk-cereal composites have potential as affordable functional foods to combat malnutrition, particularly in developing regions, by improving caloric intake, providing essential micronutrients, and supporting overall health and growth in vulnerable populations like children and the elderly.

How milk-cereal fermented foods contribute to sustainability

Food sustainability refers to a food system that ensures food security by using resources efficiently, respecting biodiversity, and supporting ecosystems. It provides safe, healthy, and affordable food that is culturally acceptable, environmentally sound, and economically fair for current and future generations. The production of milk-cereal composite fermented foods aligns with sustainability goals in several ways:

***Resource Efficiency*:** Fermentation is a low-energy preservation method that extends the shelf life of perishable ingredients like milk. This reduces food waste and makes the food supply chain more efficient.

***Utilization of Local Ingredients*:** These foods can be made using locally available cereals, reducing reliance on imported or less sustainable ingredients. This supports local agriculture and reduces the carbon footprint associated with food transport.

***Reduction in Food Waste*:** Surplus milk, which might otherwise be wasted, can be utilized in these composite foods, converting potential waste into valuable nutritional products.

***Enhancing Food Security*:** By combining two widely available food sources, milk-cereal composite fermented foods can provide a reliable and nutritionally complete food option in

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regions facing food insecurity. Their long shelf life and nutrient density make them ideal for mergency food supplies or areas with limited access to fresh foods.

Challenges associated with commercial manufacture of milk-cereal fermented foods

The commercial production of milk-cereal fermented foods presents several challenges. Variability in cereal and milk quality, along with diverse fermentation processes, creates inconsistencies in flavor, texture, and nutrition, complicating product standardization. These products are prone to microbial contamination, requiring stringent control for safety, particularly during extended fermentation and drying. Additionally, the unique sour flavors and textures may not appeal to all consumers, necessitating product adjustments for market acceptance. Scaling traditional methods like sun drying is impractical, and industrialization can alter sensory and nutritional qualities. Regulatory differences on fermented foods also complicate approval and labeling. Lastly, limited consumer familiarity with these products may require educational efforts to highlight their nutritional and cultural value.

Conclusion

Milk-cereal composite fermented foods represent a promising solution for enhancing nutritional security and promoting sustainability. These foods offer a balanced blend of high-quality proteins, essential micronutrients, and dietary fiber, making them valuable in addressing malnutrition and improving dietary diversity. Fermentation adds probiotic benefits and enhances nutrient bioavailability, contributing to better digestive and immune health. From a sustainability perspective, these products reduce resource use, minimize food waste, and support agricultural biodiversity. As a scalable, affordable, and nutritious option, milk-cereal fermented foods can play a critical role in creating a more resilient and sustainable global food system.

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