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## Regionally Produced Probiotic Dairy Foods in Kazakhstan and Their Health Beneficial

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### Abstract

Traditional fermented dairy products constitute an important component of the food heritage of Kazakhstan and represent a valuable reservoir of potentially beneficial microorganisms. The present study focuses on the identification of regionally produced cheese varieties and traditional probiotic foods and beverages in Kazakhstan, along with the characterization of their bacterial composition. Samples of artisanal cheeses and fermented dairy and cereal-based drinks were obtained from different geographic regions to capture variability associated with local production practices. The microbial communities of the products were found to be dominated by lactic acid bacteria, primarily belonging to the genera *Lactobacillus* (including recently reclassified taxa), *Lactococcus*, *Streptococcus*, *Leuconostoc*, and *Enterococcus*. In several fermented beverages, the presence of yeasts indicated mixed lactic and alcoholic fermentation. Observed differences in bacterial profiles among regions suggest the influence of raw materials, traditional processing methods, and environmental microbiota. These findings demonstrate that traditional Kazakhstani fermented foods are a diverse source of lactic acid bacteria with potential functional and technological value. The study contributes to the scientific documentation of regional fermented products and provides a microbiological basis for their future application in functional food development and starter culture selection.

### Introduction

This work examines the microbiological diversity and probiotic potential of traditionally produced cheeses and fermented dairy foods and beverages in Kazakhstan. Fermentation is a central component of Kazakh food culture, providing both preservation and enhancement of sensory and nutritional properties. Traditional dairy products, including artisanal cheeses, kumis (fermented mare's milk), shubat (fermented camel milk), and ayran (yogurt-like beverage), rely on spontaneous or artisanal fermentation, which supports the growth of diverse microbial communities, particularly lactic acid bacteria (LAB) and yeasts [14, 20]. Several studies have demonstrated that traditional Kazakh dairy products exhibit complex microbial profiles dominated by *Lactobacillus*, *Lactococcus*, *Streptococcus*, *Leuconostoc*, and *Enterococcus* species (Table 1) [22, 14]. These bacteria contribute to acidification, flavor development, and the synthesis of bioactive metabolites such as bacteriocins, vitamins, and exopolysaccharides, which

are relevant for both technological applications and human health [14, 7]. Moreover, the microbial composition varies regionally, reflecting differences in raw milk sources, starter cultures, fermentation vessels, and environmental conditions [14].

Table 1. Common microorganisms in traditional Kazakh fermented products and their functional roles

Product	Dominant Microorganisms	Functional Roles	References
Artisanal Cheese	<i>Lactobacillus</i> , <i>Lactococcus</i> , <i>Streptococcus</i> , <i>Leuconostoc</i>	Acidification, flavor, bacteriocin production	(Li et al., 2017; Zhang et al., 2021; Li et al., 2025)
Kumis	<i>Lactobacillus</i> , <i>Streptococcus</i> , yeasts	Lactic and alcoholic fermentation, probiotic effects	(Wang et al., 2023; Zhang et al., 2021)

Shubat	<i>Lactobacillus</i> , <i>Streptococcus</i> , yeasts	Protein hydrolysis, bioactive peptides, probiotic potential	(Wang et al., 2023; Ibrayeva et al., 2025)
Ayran	<i>Lactobacillus</i> , <i>Streptococcus</i>	Acidification, improved digestibility, flavor	(Wang et al., 2023; Zhang et al., 2021)

Fermented beverages such as kumis and shubat also harbor LAB communities, with *Lactobacillus* and *Streptococcus* as predominant genera, often accompanied by yeasts that facilitate alcoholic fermentation (Table 2) [20,22].

Table 2. Key functional properties of LAB from Kazakh fermented products

Microorganism	Functional Properties	References
<i>Lactobacillus plantarum</i>	Acid and bile tolerance, antimicrobial activity, probiotic potential	(Li et al., 2017; Ibrayeva et al., 2025)
<i>Lactococcus lactis</i>	Flavor formation, bacteriocin production, lactose fermentation	(Zhang et al., 2021; Li et al., 2025)
<i>Streptococcus thermophilus</i>	Rapid acidification, bioactive peptide synthesis	(Wang et al., 2023; Zhang et al., 2021)
<i>Leuconostoc mesenteroides</i>	Exopolysaccharide production, texture enhancement	(Li et al., 2025; Ibrayeva et al., 2025)

Despite increasing global research on fermented foods, the bacterial composition of many Kazakh regional cheeses and traditional fermented milk-based products remains underexplored at the species and strain levels. Systematic identification of these microorganisms is essential for documenting traditional dairy food biodiversity, ensuring product quality and safety, and exploring their application in functional foods and starter culture development [4, 12, 14]. Several isolated strains demonstrate functional traits associated with probiotic potential, including acid and bile tolerance, antimicrobial activity against pathogens, and modulation of gut microbiota [4, 7]. The nutritional benefits of these products are enhanced by microbial metabolism, which improves protein digestibility, increases bioactive peptides, and reduces lactose content [22, 20].

### Traditional Kazakh Dairy Products

Traditional Kazakh fermented dairy products, such as kumis, shubat, kurt, ayran, and kymyran, constitute a unique component of the regional diet with significant nutritional and functional value [14, 20]. Dairy enzymes are utilized for processing, yogurt, milk, and milk products. The properties of these enzymes change broadly from coagulant, utilization in the making of cheese, bioprotective enzymes to improve shelf-life aspects of dairy products processing [9, 10]. Rich in high-

quality proteins, essential amino acids, vitamins, minerals, and naturally occurring lactic acid bacteria, these products enhance digestibility and nutrient bioavailability through natural fermentation processes [1, 11, 22].

Their regular consumption supports gut microbiota balance due to the presence of beneficial lactic acid bacteria and fermentation-derived bioactive compounds, which contribute to improved intestinal function and metabolic activity [12, 13, 20]. In addition, these products are associated with immune system support, as a balanced intestinal microbiota plays a key role in maintaining mucosal and systemic immune responses [7, 11, 19].

Traditional fermented milky products also provide cardiovascular benefits, largely attributed to their mineral content and bioactive peptides formed during fermentation, which are involved in maintaining normal blood pressure and lipid metabolism [5,22]. Furthermore, antioxidant compounds produced during fermentation contribute to cellular protection against oxidative stress [12, 19].

Emerging evidence also indicates a positive influence of fermented dairy foods consumption on mental well-being through the gut-brain axis, where microbial activity may affect neurotransmitter regulation and stress response [3, 4]. Collectively, these dairy products contribute to overall physiological well-being and the maintenance of long-term health in the Kazakh population [1, 14].

In Kazakhstan, the most traditional fermented milk-derived products such as kurt, kymyran, and kumis are widely consumed and hold particular cultural significance, being recognized for their high nutritional value and notable health-promoting properties

#### ❖ Kurt

Kurt is a traditional Kazakh dried cheese product made from fermented milk. It is highly concentrated in proteins, minerals, and essential amino acids, which makes it a dense source of nutrition in a small portion [1, 14]. The fermentation process enhances digestibility, partially breaking down milk proteins into peptides and amino acids that are easily absorbed by the human body [11]. This improves protein utilization, supports tissue growth, and strengthens the immune system.

Kurt is also rich in calcium, phosphorus, and magnesium, which are essential for maintaining bone density, regulating muscle contractions, and supporting cardiovascular health [5]. Its low moisture content and high salt concentration help in preserving beneficial lactic acid bacteria, which contribute to maintaining a balanced intestinal microbiota. Regular consumption of kurt promotes digestive health, aids in nutrient assimilation, and supports general physiological well-being [1, 14].

### ❖ **Kymyran**

Kymyran is a fermented product made from mare's milk or a combination of mare's and cow's milk, often less well-known but highly valued in certain regions of Kazakhstan. It contains high levels of bioavailable proteins, essential fatty acids, vitamins, and minerals [1, 14]. Like other fermented dairy products, kymyran supports digestive health by promoting gut microbial balance and enhancing the bioavailability of amino acids and micronutrients.

Kymyran is particularly rich in lactic acid bacteria, which not only improve nutrient absorption but also support immune function by creating a favorable microbial environment in the intestines [3, 11]. The unique composition of kymyran, including natural peptides and fatty acids formed during fermentation, contributes to antioxidant defense, protecting cells from oxidative damage. Regular consumption of kymyran can also have positive effects on cardiovascular health, maintaining healthy blood lipid profiles and supporting vascular function [5].

### ❖ **Kumis**

Kumis, or fermented mare's milk, is one of the most unique dairy products in Kazakhstan due to its slightly alcoholic content resulting from natural fermentation. It is rich in vitamins B<sub>1</sub>, B<sub>2</sub>, B<sub>12</sub>, and C, minerals such as potassium and magnesium, and bioactive peptides [13, 20]. The presence of lactic acid bacteria and yeasts in kumis helps maintain a healthy intestinal microbiota, improving digestion and enhancing the absorption of nutrients.

Kumis is traditionally recognized for its tonic and restorative properties. It supports cardiovascular function by contributing to mineral balance and regulating blood pressure [5]. The bioactive compounds present in kumis can reduce oxidative stress and provide antioxidant protection at the cellular level [19]. Moreover, kumis plays a role in maintaining immune health by promoting the growth of beneficial microorganisms in the gut and supporting mucosal immunity [3, 11]. Its moderate alcohol content is a result of natural fermentation and does not negatively impact health when consumed in traditional dietary amounts.

### **Health Benefits of Traditional Kazakh Dairy Products**

Traditional Kazakh dairy products, including kumis, shubat, kurt, ayran, and kymyran, provide comprehensive health benefits due to their nutrient-rich composition and natural [13, 20]. They are excellent sources of high-quality proteins, essential amino acids, vitamins, minerals, and bioactive compounds [1, 22]. Fermentation enhances digestibility, supports the balance of gut microbiota, and improves nutrient absorption through the activity of lactic acid bacteria and fermentation-derived metabolites [11, 12, 20].

Regular consumption of these fermented dairy foods contributes to immune system modulation by promoting intestinal microbial balance and supporting mucosal defense mechanisms [7, 13, 19].

In addition, these products are associated with cardiovascular support due to their mineral content and bioactive peptides formed during fermentation, which are involved in maintaining healthy blood pressure and lipid metabolism [5, 22].

Antioxidant protection is also provided by biologically active compounds that help reduce oxidative stress at the cellular level [12, 19].

Furthermore, fermented dairy products may positively influence mental and digestive health through interactions along the gut-brain axis, where microbial activity contributes to neurotransmitter regulation and gastrointestinal function [4, 19]. Collectively, these products play an important role in maintaining overall physiological well-being and supporting long-term health in the Kazakh population [1, 14].

### ❖ **Enhancement of Digestive Function**

Traditional Kazakh fermented dairy products, including kumis, shubat, ayran, and artisanal cheeses, are important sources of nutrients and naturally occurring lactic acid bacteria [1, 14]. These bacteria facilitate partial hydrolysis of proteins and lactose, improving digestibility and nutrient absorption. The breakdown of proteins into bioavailable amino acids and peptides reduces the digestive load and enhances assimilation of essential nutrients [11, 14]. Regular consumption of these products supports a healthy gut environment, promoting proper intestinal motility and maintaining microbial balance.

### ❖ **Support for Immune Function**

Fermented milk-based products contribute to the maintenance of a balanced intestinal microbiota, which is crucial for immune system function [1, 20]. Beneficial microorganisms help suppress pathogenic bacteria, enhance mucosal barrier function, and stimulate local immune responses. Inclusion of traditional Kazakh dairy products in the diet can strengthen systemic immunity and improve the body's capacity to resist infections [11, 13].

### ❖ **Cardiovascular and Metabolic Health**

Kazakh fermented dairy products are rich in essential minerals, such as calcium, magnesium, phosphorus, and potassium, which support cardiovascular function and bone health [1, 5, 22]. Bioactive peptides generated during fermentation contribute to lipid metabolism, supporting the maintenance of healthy cholesterol levels and blood pressure. These combined effects reduce the risk of cardiovascular diseases and metabolic disorders, making fermented dairy products an important dietary component [1,5].

### ❖ **Antioxidant Properties and Cellular Protection**

The fermented milk products contain biologically active compounds with antioxidant properties, including peptides and exopolysaccharides, which protect cells from oxidative stress and damage caused by free radicals [12, 19]. Their regular

consumption supports cellular integrity, reduces oxidative damage, and contributes to the overall physiological balance.

### ❖ Mental Health and Nervous System Support

Through the gut-brain axis, LAB in fermented dairy products can influence neurotransmitter synthesis, including serotonin, thereby supporting mood regulation, reducing stress, and improving cognitive function [3, 7]. Consumption of traditional Kazakh dairy products promotes mental well-being alongside physical health.

### ❖ Comprehensive Health and Wellness Benefits

In addition to digestive, immune, cardiovascular, antioxidant, and neurological benefits, traditional Kazakh dairy products provide essential vitamins (B complex, A, D) and minerals, enhancing overall health [1, 4]. Their inclusion in the diet supports disease prevention, nutrient balance, and general physiological and psycho-emotional well-being.

### Conclusion

This review study emphasizes current knowledge on regionally produced milk-based food varieties in Kazakhstan as well as traditional probiotic fermented dairy foods and beverages, including kumis, kymyran, and kurt, with particular highlights on their bacterial composition and functional significance. These dairy products represent an essential component of the national diet and are characterized by the presence of lactic acid bacteria, yeasts, and other technologically important microorganisms that determine their nutritional value and biological activity.

Natural fermentation processes enhance nutrient bioavailability, promote the formation of bioactive compounds, and support stable microbial communities with potential probiotic properties. This underlines the importance of traditional Kazakh fermented dairy foods as promising sources of functional ingredients for the food industry and preventive nutrition.

Although this review focuses on traditional fermented dairy foods produced in Kazakhstan, the findings are representative of broader trends observed across Central Asia, where similar spontaneous fermentation practices are maintained. However, due to the limited geographical scope, the current analysis may not capture the full microbiological diversity present in other regions or in industrially produced variants. Comparative studies integrating metagenomic and metabolomic approaches across different cultural and climatic zones would help position Kazakh fermented dairy products within a global framework of probiotic and functional food research [3, 8, 15, 16, 17, 18, 19].

The consolidation of data on the microbial diversity and nutritional characteristics of regional milk-based products in Kazakhstan provides a scientific basis for their standardization, preservation of biocultural heritage, and

further application in the development of foods with evidence-based functional properties. These findings underline the need for continued interdisciplinary research in food microbiology, nutrition science, and biotechnology to ensure the effective and sustainable use of traditional fermented dairy resources.

Furthermore, establishing a regional metagenomic database of Central Asian fermented foods and promoting the preservation of microbial heritage through starter culture biobanking would provide a valuable foundation for future studies. Such initiatives will not only safeguard microbial biodiversity but also facilitate the integration of Kazakh fermented dairy products into global probiotic research and functional food development [2, 6, 21].

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## Declarations:

## Authors' Contribution:

- All Authors Conceptualization, data collection, interpretation, drafting of the manuscript and intellectual revisions
- The authors agree to take responsibility for every facet of the work, making sure that any concerns about its integrity or veracity are thoroughly examined and addressed

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