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## A Review on Comprehensive Comparative Study about Kefir, Yogurt, Buttermilk with their Health Benefits



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	<b>Abstract</b>
Published on: 24 Nov 2025	<p>Fermented milk products have played an integral role in human nutrition across cultures for centuries. Among the most widely consumed are kefir, yogurt, and buttermilk, each possessing unique microbial compositions, fermentation processes, sensory characteristics, and health benefits. This paper presents a comparative study of kefir, yogurt, and buttermilk, examining their origins, production methods, physicochemical properties, nutritional profiles, microbial diversity, and therapeutic implications. The analysis also considers their commercial and cultural significance and highlights the growing interest in probiotic-rich functional foods. Findings suggest that while all three share fundamental probiotic benefits, kefir demonstrates the highest microbial diversity and strongest potential for gastrointestinal and immune health, while yogurt and buttermilk retain distinctive advantages in texture, taste, and culinary versatility.</p>
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## 1. INTRODUCTION

Fermented dairy products have been a cornerstone of human diets for millennia, serving as nutritious, preservative, and probiotic-rich foods. Among these, **kefir**, **yogurt**, and **buttermilk** are especially notable for their widespread consumption and health-promoting properties. Although all three originate from milk fermentation, they differ significantly in microbial composition, fermentation process, consistency, and bioactive compound content (Farnworth, 2005).

Recent decades have seen an increased focus on fermented milk beverages due to growing awareness of the gut microbiome's role in overall health (Marco et al., 2017). This comparative study explores kefir, yogurt, and buttermilk in terms of their historical development, microbiological characteristics, nutritional composition, functional benefits, and industrial relevance.

## 2. HISTORICAL AND CULTURAL BACKGROUND

### 2.1 Kefir

Kefir originated in the **Caucasus Mountains**, where shepherds fermented milk in animal skin bags using **kefir grains**, a symbiotic culture of bacteria and yeasts (Guzel-Seydim et al., 2011). Traditionally, kefir

grains were passed down through generations, symbolizing cultural heritage. The word “kefir” derives from the Turkish *keyif*, meaning “feeling good” after eating (Farnworth, 2005).

## 2.2 Yogurt

Yogurt traces its roots to **Central Asia and the Middle East**, where nomadic tribes fermented milk to prolong its shelf life (Tamime & Robinson, 2007). Its preparation involves controlled fermentation by *Lactobacillus delbrueckii* subsp. *bulgaricus* and *Streptococcus thermophilus*. Yogurt’s consistency and mild acidity have made it one of the most commercially successful fermented dairy products globally.

## 2.3 Buttermilk

Historically, **traditional buttermilk** was the liquid by-product of churning butter from cultured cream (Vijayendra & Gupta, 2015). In contrast, **cultured buttermilk**, common today, is produced by fermenting pasteurized milk with *Lactococcus lactis* and *Leuconostoc mesenteroides*. Its mild sourness and low fat content have made it popular in both beverages and baked goods.

# 3. FERMENTATION PROCESSES

The fermentation processes of kefir, yogurt, and buttermilk determine their texture, flavor, and microbial diversity.

## 3.1 Kefir Fermentation

Kefir fermentation utilizes **kefir grains**, which contain lactic acid bacteria (LAB), acetic acid bacteria, and yeasts embedded in a polysaccharide matrix called **kefiran** (Guzel-Seydim et al., 2011). Fermentation occurs at 20–25°C for 18–24 hours, producing carbon dioxide, ethanol, and lactic acid, resulting in a slightly effervescent texture and tangy flavor.

## 3.2 Yogurt Fermentation

Yogurt fermentation typically employs two thermophilic bacteria in symbiosis: *L. bulgaricus* and *S. thermophilus*. The process occurs at 42–45°C for 4–6 hours. These bacteria produce lactic acid, coagulating milk proteins and creating the characteristic smooth, thick texture (Tamime & Robinson, 2007).

## 3.3 Buttermilk Fermentation

Cultured buttermilk is fermented at 20–25°C for 12–14 hours with mesophilic LAB strains, including *L. lactis* subsp. *lactis* and *L. lactis* subsp. *cremoris*. The bacteria produce lactic acid and diacetyl, which contribute to buttermilk’s mild flavor and buttery aroma (Vijayendra & Gupta, 2015).

# 4. MICROBIAL COMPOSITION

**Kefir** contains the most complex microbiota among the three products, including over 30 species of bacteria and yeasts (Garofalo et al., 2015). The main genera include *Lactobacillus*, *Leuconostoc*, *Acetobacter*, *Lactococcus*, and yeasts such as *Saccharomyces* and *Kluyveromyces*.

In contrast, **yogurt** has a simpler microbial profile, dominated by *L. bulgaricus* and *S. thermophilus*.

**Buttermilk** contains mesophilic LAB, including *Lactococcus lactis* and *Leuconostoc mesenteroides*, but lacks the yeast species found in kefir.

The presence of yeasts in kefir distinguishes it as a **heterofermentative** system capable of producing ethanol and carbon dioxide, while yogurt and buttermilk are **homofermentative**, generating primarily lactic acid.

# 5. FERMENTATION DYNAMICS AND BIOCHEMICAL PATHWAYS

Kefir fermentation proceeds through a sequential process dominated by LAB in the initial phase, followed by yeast and AAB activity. LAB ferment lactose to lactic acid via homo- and heterofermentative pathways, reducing pH and creating an anaerobic environment conducive to yeast metabolism (Garofalo et al., 2015). Yeasts, in turn, produce ethanol, carbon dioxide, and flavor-active compounds such as acetaldehyde and esters. AAB oxidize ethanol to acetic acid, contributing to kefir’s tangy taste and antimicrobial stability (Walsh et al., 2016).

These interactions exemplify syntrophic relationships: LAB benefit from yeast-derived vitamins and amino acids, while yeasts utilize LAB-produced lactic acid as a carbon source. The dynamic equilibrium between these populations ensures consistent product quality and microbial homeostasis across fermentation cycles.

Temperature, inoculum size, and fermentation duration significantly influence microbial succession and metabolite profiles. Optimal fermentation typically occurs between 20°C and 25°C for 18–24 hours,

yielding a final pH around 4.2 (Gao et al., 2012). Extended fermentation increases acetic acid and ethanol concentrations, enhancing preservation but potentially compromising sensory acceptability.

## 6. ADVANCES IN MICROBIAL CHARACTERIZATION TECHNIQUES

Recent advances in **metagenomics** and **metatranscriptomics** have transformed the study of kefir microbiology. Culture-independent approaches reveal that kefir hosts more than 50 bacterial and 20 yeast species, many of which are unculturable using conventional methods (Zheng et al., 2020). High-throughput sequencing has elucidated strain-level diversity and the genetic basis for carbohydrate metabolism, exopolysaccharide production, and antimicrobial compound synthesis (Walsh et al., 2016).

Metabolomic analyses further link microbial gene expression with kefir's volatile compound profile and bioactive peptide content. Such omics-driven insights are enabling the rational design of synthetic kefir consortia with standardized performance for industrial-scale production.

## 7. PHYSICOCHEMICAL PROPERTIES

Kefir has a pH of 4.2–4.6 and a slightly effervescent texture due to CO<sub>2</sub> production. Yogurt is thicker, with a pH around 4.0–4.5, while buttermilk is more fluid with a pH between 4.5 and 4.8 (Garofalo et al., 2015).

The total solid content, viscosity, and acidity depend on milk type, fermentation temperature, and microbial activity. Yogurt exhibits the highest viscosity due to protein coagulation, whereas buttermilk's texture remains thin. Kefir's unique carbonated feel is attributed to yeast fermentation.

## 8. NUTRITIONAL COMPOSITION

Although all three products share basic dairy nutrients, differences in fermentation lead to variations in nutrient bioavailability and metabolite content.

- **Kefir:** Rich in proteins, B vitamins, calcium, and bioactive peptides; also contains small amounts of ethanol (0.5–1%) and CO<sub>2</sub> (Guzel-Seydim et al., 2011).
- **Yogurt:** High in protein and calcium; lactose content reduced due to bacterial activity, making it more digestible for lactose-intolerant individuals (McKinley, 2005).
- **Buttermilk:** Lower in fat and calories, rich in riboflavin and lactic acid; the phospholipids in buttermilk have emulsifying and cholesterol-lowering properties (Vijayendra & Gupta, 2015).

Fermentation enhances digestibility and increases the bioavailability of calcium, magnesium, and B vitamins across all three products.

## 9. HEALTH BENEFITS

### 9.1 Gut Health and Microbiota Modulation

Kefir is recognized for its probiotic effects, primarily through modulation of the gut microbiota. Studies indicate that kefir consumption enhances intestinal microbial diversity and promotes beneficial taxa such as *Lactobacillus* and *Bifidobacterium* (Kim et al., 2017). Moreover, kefir's antimicrobial compounds, including organic acids and bacteriocins, inhibit pathogens like *Salmonella*, *Helicobacter pylori*, and *Escherichia coli* (Fiorda et al., 2016).

Kefir-derived peptides have been shown to strengthen gut barrier function by modulating tight-junction proteins, thereby reducing intestinal permeability—an important factor in inflammatory bowel diseases (Bourrie et al., 2016).

### 9.2 Immunomodulatory and Anti-inflammatory Properties

Kefir's immunomodulatory effects are attributed to both microbial components and fermentation-derived metabolites. Animal studies have demonstrated that kefir consumption enhances macrophage activation and immunoglobulin A (IgA) secretion (Vinderola et al., 2019). Furthermore, kefir polysaccharides and peptides can downregulate pro-inflammatory cytokines such as TNF- $\alpha$  and IL-6, indicating anti-inflammatory potential (Bourrie et al., 2016).

### 9.3 Metabolic and Cardiovascular Effects

Emerging evidence links kefir intake with improved metabolic parameters. Regular consumption may reduce total cholesterol and low-density lipoprotein (LDL) levels while enhancing high-density lipoprotein (HDL) concentrations (Liu et al., 2019). Additionally, kefir's bioactive peptides exhibit angiotensin-converting enzyme (ACE) inhibitory activity, potentially lowering blood pressure (Fiorda et al., 2016).

Kefir's influence on glucose metabolism is another promising avenue. In diabetic models, kefir has demonstrated hypoglycemic effects, possibly through modulation of insulin signaling and gut microbiota composition (Kim *et al.*, 2017).

#### 9.4 Anticarcinogenic and Antioxidant Activities

Several *in vitro* and animal studies have reported kefir's potential anticarcinogenic activity. Kefir extracts inhibit tumor cell proliferation and induce apoptosis in certain cancer cell lines, including colorectal and breast cancers (Liu *et al.*, 2019). These effects are partly attributed to kefir's antioxidant capacity, as it scavenges free radicals and enhances endogenous antioxidant enzyme activity.

#### 9.5 Digestive Health

**Yogurt** consumption has been linked to multiple health benefits, spanning digestive, metabolic, and immune systems. Firstly, yogurt aids in **digestive health** by improving gut microbiota composition and promoting regular bowel movements. Its live cultures assist in breaking down lactose, making it an excellent dairy alternative for lactose-intolerant individuals (Vasiljevic & Shah, 2008).

#### 9.6 Metabolic Effects

Secondly, yogurt has been shown to support **metabolic health**. A meta-analysis by Chen *et al.* (2014) found that yogurt consumption is inversely associated with obesity and type 2 diabetes risk. The high protein content contributes to satiety, while calcium may influence lipid metabolism.

#### 9.7 Bone Health

Additionally, yogurt's role in **bone health** is well-documented, as it provides bioavailable calcium and vitamin D, reducing the risk of osteoporosis (Rizzoli *et al.*, 2014). Emerging evidence also suggests immunomodulatory effects, as probiotics in yogurt may enhance immune cell function and reduce infection rates, especially in children and the elderly (Paseephol *et al.*, 2008).

#### 9.8 Digestive Health

The probiotic microorganisms in buttermilk promote intestinal health by restoring beneficial gut flora and inhibiting pathogenic bacteria. Regular consumption may alleviate symptoms of irritable bowel syndrome and improve stool consistency (Saarela *et al.*, 2002). Moreover, the lactic acid in buttermilk enhances nutrient absorption and maintains optimal intestinal pH levels.

#### 9.9 Cardiovascular Health

Several studies have reported the **cholesterol-lowering potential** of buttermilk due to its phospholipid content. Conway *et al.* (2013) demonstrated that consumption of buttermilk reduced total and LDL cholesterol levels in hyperlipidemic adults without affecting HDL cholesterol. The mechanism involves the inhibition of intestinal cholesterol absorption by sphingomyelin and phosphatidylcholine components of MFGM.

#### 9.10 Hydration and Thermoregulation

In tropical climates, buttermilk has traditionally been consumed as a cooling drink. Its electrolyte content—especially potassium and calcium—helps maintain hydration and prevent heat-induced fatigue (Sarkar & Mishra, 2014). This makes it a functional beverage for athletes and laborers engaged in strenuous physical activity.

#### 9.11 Immune and Anti-inflammatory Effects

Bioactive peptides and lipids in buttermilk exhibit immune-modulating and anti-inflammatory properties. Research suggests that MFGM proteins can reduce cytokine-mediated inflammation, offering potential benefits for metabolic disorders (Spitsberg, 2005). Additionally, the probiotic bacteria enhance immune responses by increasing mucosal immunity and producing bacteriocins.

#### 9.12 Antimicrobial and Antioxidant Properties

Kefir exhibits potent antimicrobial effects due to organic acids, hydrogen peroxide, and bacteriocins (Guzel-Seydim *et al.*, 2011). Yogurt also inhibits pathogenic bacteria through lactic acid production. The antioxidant potential of kefir is generally higher because of its yeast-derived metabolites.

#### 9.13. Tolerance, Digestibility and Consumer Considerations

The enhanced lactose digestion in kefir is a notable advantage: the enzymatic breakdown of lactose during fermentation and delayed gastric emptying may make kefir more tolerable to individuals with lactose malabsorption. [Cambridge University Press & Assessment](#) Meanwhile yogurt is also often better tolerated than milk in lactose-intolerant persons, but less so than kefir in some studies. In terms of sugar content, plain unsweetened forms of both are preferable; however, many commercial yogurts may contain significant added sugars, potentially attenuating their health benefits. Some sources note that flavored kefir may likewise carry

added sugars. [Healthline+1](#) From a consumer standpoint, texture and flavor preferences differ: yogurt is generally spoonable, thicker, and mild in taste, whereas kefir is more fluid, drinkable, tangy (sometimes mildly effervescent) and may contain yeasty or slightly alcoholic notes. [diffen.com+1](#) These sensory attributes influence consumer acceptance, frequency of use, and suitability in dietary contexts (e.g., smoothies vs. breakfast bowls).

#### 9.14. Commercial and Technological Aspects

Yogurt dominates the global fermented dairy market due to its consumer acceptance and industrial standardization. Buttermilk is primarily used as a beverage and bakery ingredient. Kefir, although gaining popularity in Europe, North America, and Asia, remains a niche product due to shorter shelf life and complex starter culture management (Guzel-Seydim *et al.*, 2011).

Modern biotechnology has facilitated the production of **freeze-dried starter cultures**, improving kefir's commercial scalability (Leite *et al.*, 2013). All three products are also used as matrices for delivering functional ingredients, such as vitamins, minerals, and plant extracts.

### 10. COMPARATIVE SUMMARY

Feature	Kefir	Yogurt	Buttermilk
<b>Microbial diversity</b>	High (LAB + yeasts + acetic acid bacteria)	Moderate (2 main species)	Low (mesophilic LAB)
<b>Fermentation temperature (°C)</b>	20–25	42–45	20–25
<b>Texture</b>	Slightly fizzy, thin	Thick, creamy	Thin, smooth
<b>pH</b>	4.2–4.6	4.0–4.5	4.5–4.8
<b>Probiotic content</b>	Very high	High	Moderate
<b>Shelf life</b>	Short	Long	Moderate
<b>Major benefits</b>	Gut health, immunity	Digestibility, weight control	Heart health, low-fat option

### 11. KEFIR AS A FUNCTIONAL FOOD

Functional foods are defined as foods that provide health benefits beyond basic nutrition. Kefir fits this category due to its probiotic activity, metabolic byproducts, and potential to mitigate chronic disease risks (Fiorda *et al.*, 2016). Its versatility allows for production using various substrates—such as cow, goat, soy, or coconut milk—making it suitable for diverse dietary preferences.

In the functional food industry, kefir's applications extend beyond beverages. Kefir-derived bioactive compounds are being incorporated into dairy alternatives, supplements, and cosmetic formulations. However, challenges remain in standardizing kefir production, given its microbial variability and artisanal nature (Garofalo *et al.*, 2015).

### 12. FUTURE PROSPECTS AND CHALLENGES

**Kefir** represents a bridge between traditional fermentation and modern biotechnology. Its future depends on advances in **microbial research, production technology, and consumer engagement**.

Overcoming current challenges related to standardization, storage, and regulation will be critical for integrating kefir into the mainstream functional food market. Through interdisciplinary collaboration and innovation, kefir has the potential to become a globally recognized probiotic beverage contributing to public health and sustainable nutrition.

Future research on **yogurt** focuses on enhancing probiotic viability, developing personalized nutrition approaches, and exploring sustainable production methods. Integrating **novel fermentation technologies**, such as precision fermentation and the use of non-traditional starter cultures, may further improve nutritional and sensory qualities (Zheng *et al.*, 2020).

Challenges include maintaining microbial stability during storage, ensuring labeling accuracy for probiotic counts, and addressing environmental concerns related to dairy production. As consumer preferences shift toward health and sustainability, the yogurt industry must balance innovation with ecological responsibility.

Despite its benefits, **buttermilk** faces challenges in global markets due to limited consumer awareness and misconceptions about its sensory properties. The sour taste may deter some consumers unfamiliar with fermented foods. Future innovations may involve **flavor optimization, fortification with vitamins or fibers**, and the development of **non-dairy analogs** using plant-based substrates.

Research opportunities lie in exploring buttermilk's **bioactive compounds**, **microbiome interactions**, and **therapeutic potentials** for chronic diseases such as obesity and diabetes. Advances in biotechnology may allow the development of **targeted probiotic strains** for specific health outcomes.

### 13. CONCLUSION

Kefir, yogurt, and buttermilk, though all derived from milk fermentation, differ markedly in their microbial profiles, sensory qualities, and health-promoting properties. Kefir stands out for its microbial richness and diverse health effects, particularly in gastrointestinal and immune modulation. Yogurt remains a globally dominant fermented dairy product, balancing taste, nutrition, and probiotic benefits. Buttermilk, while less complex, offers valuable nutritional and functional properties, particularly for heart health and low-fat diets.

Understanding these distinctions helps consumers and food technologists select the most suitable product for specific dietary and therapeutic needs. As functional food markets evolve, innovations in microbial culture technology and non-dairy alternatives are likely to expand the accessibility and benefits of these ancient fermented beverages.

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