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## Kefir As a Living Food: Fermentation, Function, and Health

Yeşim ÖZOĞUL<sup>1</sup>[0000-0001-7769-9225] and Fatih ÖZOĞUL<sup>2</sup>[0000-0002-0655-0105]

<sup>1</sup> Çukurova University, Faculty of Fisheries, Department of Seafood Processing Technology, Adana, Turkey

<sup>2</sup> Çukurova University, Biotechnology Research Centre, Adana, Turkey

fozogul@cu.edu.tr

**Abstract.** Milk kefir and water kefir are the two main varieties of kefir, a fermented beverage recognized for its probiotic qualities and health advantages. People in the mountainous area between Europe and Asia have been consuming kefir milk for thousands of years. The process of making milk kefir involves fermenting milk (often from cows, goats, or sheep) with milk kefir grains, which are symbiotic cultures of yeasts and lactic acid bacteria. A tangy, creamy beverage full of vitamins, probiotics, and bioactive components is the end product. By fermenting sugar water or fruit juice with water kefir grains, which have a distinct microbial population suited to a non-dairy environment, water kefir, on the other hand, is a dairy-free substitute. In addition to providing probiotic advantages, this results in a mildly carbonated, sweet-tart beverage that is appropriate for vegetarians and others who are lactose intolerant. Both varieties of kefir support intestinal health. These grains are inhabited by a varied symbiotic ecosystem of yeasts, lactic acid bacteria, acetic acid bacteria, and other microorganisms. In kefir grains, the most prevalent bacteria are lactic acid bacterial taxa, such as *Lactobacillus*, *Lactococcus*, *Leuconostoc*, and *Streptococcus*. These grains also frequently contain yeast species such as *Candida*, *Saccharomyces*, *Kluyveromyces*, *Kazachstania*, and *Pichia*. Kefir drinks have been linked to several significant health benefits, including as improved lactose digestion, anti-carcinogenic, anti-hypertensive, and anti-diabetic properties, among others. In addition, kefir supports intestinal health by keeping the intestinal flora in balance. All of these health benefits are brought about by the kefir bacteria, their interactions, and the metabolic products they produce throughout the fermentation process. Thus, this review aims to provide information on fermentation, function, and health benefits of kefir.

**Keywords:** Kefir, Fermentation, Health benefits.

### 1 Introduction

Kefir has health-promoting properties, making it one of the most popular functional foods. According to [1] kefir is a fermented carbonated beverage with a low alcohol content and an acidic character that is produced by the proto cooperation of bacteria and yeasts that settle in a substrate matrix with milk or water. Water and milk kefir are generated by usage of distinct gelatinous particles that harbor probiotic microorganisms, referred to as water kefir grains and milk kefir grains. These two beverages, fermented from these grains, exhibit differing physical, chemical, and microbiological properties [2]. Kefir is categorized as a natural probiotic beverage by FAO (Food and Agriculture Organization) and WHO (the World Health Organization) because of its microbial composition, which includes multiple lactic acid bacteria (LAB) species with known health benefits. The primary microorganisms found in kefir are



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typically yeasts, acetic acid bacteria, and LAB, despite their varying microbiological compositions [3]. The type of milk used, fermentation circumstances, geographical origin of the grains, and processing techniques are some of the variables that affect the microbial diversity and composition of kefir grains [4].

Lactic acid bacterial taxa, including *Lactobacillus*, *Lactococcus*, *Leuconostoc*, and *Streptococcus*, are the most common bacteria found in kefir grains. Furthermore, *Kluyveromyces*, *Kazachstania*, *Candida*, *Saccharomyces*, and *Pichia* are frequent yeast species that are present in these grains [5]. Notably, local production methods and the unique properties of the fermentation substrate can have a substantial effect on the predominance of these microorganisms. Metabolites such as ethanol, carbon dioxide, organic acids, and bioactive peptides that are created during the fermentation of kefir are essential in determining the drink's sensory and functional characteristics. Kefir's pH is lowered by organic acids like lactic and acetic acid, which also have antibacterial properties that prevent the growth of infections. The drink's unique texture and effervescent quality are caused by carbon dioxide and ethanol, byproducts of the yeast's metabolic activities. Bacteria break down milk proteins to produce bioactive peptides, which have antibacterial, immunomodulatory, and antioxidant properties and may be able to control the body's inflammatory response [6]. In addition, antimicrobial, antimutagenic, anticancer, antioxidant, immune system-stimulating, cholesterol-lowering, and anti-apoptotic properties are just a few of the many health advantages of kefir [7]. Thus, this review aims to provide up-to-date information on fermentation, function, and health benefits of kefir.

## 1.1 Fermentation

Due to the growing interest in healthy nutrition and its numerous benefits, fermentation, a method of food preservation that has been utilized for centuries, has recently drawn more attention. Due to its cheap energy cost and capacity to maintain and improve the product's qualities, this metabolic process is priceless [8]. It is well recognized that this technique may improve food items' sensory qualities, add functional qualities, and increase their nutritional value. Food items' nutritional content, acceptability, and sensory qualities can all be enhanced by the safe process of fermentation. A common method for creating fermented foods and food additives is microbial fermentation. Nowadays, a variety of additional products are made using microbial fermentation in addition to fermented meals like cheese, wine, and beer [9].



Traditionally, milk kefir and water kefir are made from distinct gelatinous particles called "milk kefir grains" and "water kefir grains" that contain probiotics. The two unique fermented drinks made from these grains have different microbiological compositions, as well as diverse physical and chemical properties. Both milk kefir and water kefir possess functional characteristics. Water kefir can be a highly essential source of probiotics, prebiotics, and antioxidants for vegans and those who are allergic to or intolerant to dairy products, even as milk kefir offers substantial quantities of protein along with these nutrients. Because of their possible health advantages, both of these grains are significant [2].



**Fig. 1.** Characteristics of milk and water kefir grains [2]

**Table 1.** Comparison of milk and water kefir grains (adapted by [10] and [2]).

Water kefir	Milk Kefir
<ul style="list-style-type: none"> <li>-Made with water kefir grains</li> <li>-Uses a sucrose solution enriched with dried fruits or fruit extracts as the medium</li> <li>-Able to ferment a broader range of substrates</li> <li>-Grains appear translucent, gelatinous, and comparatively fragile</li> <li>-The main exopolysaccharide of the grains is <math>\alpha</math>-glucan</li> <li>-Strains of acetic acid bacteria occur more frequently</li> <li>-Saccharomyces species are the predominant yeasts</li> <li>-Lactococcus bacteria are scarcely detected</li> <li>-Candida yeasts are rarely encountered</li> <li>-Appropriate for people who follow a vegan diet or are lactose intolerant</li> </ul>	<ul style="list-style-type: none"> <li>-Prepared with milk kefir grains</li> <li>-The main medium is milk derived from bovine animals (such as cow or goat)</li> <li>-Capable of fermenting a more limited variety of substrates</li> <li>-Grains are opaque, usually white or cream, and comparatively tougher</li> <li>-The key exopolysaccharide in the grains is kefiran</li> <li>-Acetic acid-producing bacteria occur less frequently</li> <li>-Saccharomyces yeasts represent only a small fraction of the microbiota</li> <li>-Lactococcus species are generally more prevalent</li> <li>-Candida yeasts tend to be found more often</li> <li>-Unsuitable for people with lactose intolerance or those following a vegan diet</li> </ul>

Inoculating milk with kefir grains is the standard process for making milk kefir. Kefir grains consist of lactic acid bacteria (LAB), acetic acid bacteria, yeasts, and the matrix of protein and polysaccharide



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arising from their metabolic processes. The fermentation process of kefir is significantly impacted by the wide variety of bacterial species found in kefir grains. The most frequently co-occurring genus include *Lactobacillus*, *Lactococcus*, *Leuconostoc*, *Acetobacter*, *Bifidobacterium*, *Streptococcus*, *Enterobacter*, and *Acinetobacter*. In addition, the most frequently co-occurring yeasts genera are *Kazachstania*, *Saccharomyces*, *Kluyveromyces*, *Dipodascaceae*, and *Dekkera*. Whole, semi-skimmed, or skimmed pasteurized milk from goats, cows, camels, sheep, or buffalo can be used to make kefir. The most popular is kefir made from cow's milk. As a starting culture, the kefir grains can be introduced to the fermentation substrate. Following fermentation, the grains are filtered out of the fermented milk. Following grain separation, kefir can be consumed right once or stored in the refrigerator for later use. Alcoholic fermentation causes CO<sub>2</sub>, ethanol, and vitamin B complex to build up during the cooling phase. Because of this maturing stage, the product has less lactose, which makes it suitable for ingestion by those with diabetes and lactose intolerance. Kefir's nutritional composition varies greatly and is affected by the kind of milk, the origin of the grains used, the fermentation period and temperature, and storage conditions [11].

Water kefir, often known as aqua kefir or sugary kefir, is created from several special probiotics that contain water kefir grains, which are gelatinous grains. Water kefir grains consist of a polysaccharide matrix (mainly dextran and to a lesser extent levan) in which microorganisms are embedded. Grains include lactic acid bacteria, acetic acid bacteria, yeasts and occasionally bifidobacteria [12].

The comparisons of milk kefir and water kefir were made comprehensively by [2] and [10] (Table 1). It was reported that water kefir and milk kefir are different symbiotic systems. First, each grain is made up of a different matrix of polysaccharides: the heteropolysaccharide glucogalactan, called kefiran, which is made by *Lb. kefiranofaciens*, and the homopolysaccharide  $\alpha$ 1,6-glucan, which is made by *Lactobacillus hilgardii* in the case of water kefir grains. Second, even though milk kefir grains may grow in non-dairy substrates, the disaccharide that bacteria digest is different; lactose for milk kefir and sucrose for water kefir [13]. Milk kefir grains can occasionally be produced in plant-based "milk," but they need milk or whey-based medium. Water kefir grains need solutions made of vegetables, fruits, or cereals that provide enough fermentable fructose or sucrose [14]. Thirdly, the species present in the two types of grains are different. Table 1 shows the comparison of water kefir and milk kefir. Guzel-Seydim et al. [2] reported that the microbiological composition, chemical characteristics, and even color of milk



kefir grains and water kefir grains differ significantly, with milk kefir having a greater nutritious value than water kefir.

There are wide variations in the microbial diversity of kefir reported in the literature. Lynch et al. [10] indicated that bacteria such as lactic acid bacteria (*Lactococcus*, *Lactobacillus*, *Bifidobacteria*, *Leuconostoc*, *Oenococcus* and *Pediococcus*), acetic acid bacteria (*Gluconobacter*, *Gluconacetobacter* and *Acetobacter*), and other bacteria (*Zymomonas*) have been found in water kefir grains. They also have yeast such as *Kluyveromyces*, *Saccharomyces*, *Hanseniaspora*, *Dekkera*, *Torulaspora*, *Kazachstania*, *Zygorulasporea*, *Pichia*, and *Yarrowia*. Ouyang et al. [15] reported that water kefir grains from Lincang in China were primarily dominated by members of *Acetobacter*, *Phenyllobacterium*, *Lactobacillus*, and *Sediminibacterium* and fungi that were members of *Issatchenkia*, *Kodamaea* and *Saccharomyces*.

While milk kefir grain contains around 65% to 80% lactobacilli, 5–25% lactococci and *Leuconostoc* spp., and 10–15% yeasts, milk kefir itself has a microbial makeup of roughly 80% lactococci and *Leuconostoc* spp., 10%–15% yeasts, and 5–10% lactobacilli [16]. *Lactocaseibacillus paracasei*, *Lactobacillus kefirianofaciens*, *Lactobacillus acidophilus*, *Lactiplantibacillus plantarum*, and *Lactobacillus delbrueckii* subsp. *bulgaricus* are the primary bacterial species present in kefir grains [1]. In both milk and water kefir, lactic acid bacteria execute a lactic fermentation, which increases the fermented beverage's acidity and viscosity; acetic acid bacteria give fermented milk a more pronounced sour flavor; and yeast ethanol and CO<sub>2</sub> enhance the product's flavor. The kefir microbes have probiotic potential because they can produce antagonistic substances like organic acids and bacteriocins, which prevent pathogenic bacteria from adhering to the intestinal mucosa and improve gut health [1]. They also show high resistance to the low pH and bile salts in the gastrointestinal tract.

## 1.2 Health Benefits of Kefir

The gut microbiota is a virtual organ system that is crucial for preserving health and wellbeing. The varied microbiota and the large range of bioactive chemicals created during fermentation are responsible for these effects. Figure 1 shows a schematic layout of the possible positive impacts of kefir on human physiology and health.



Fig 2. A schematic layout of the possible positive impacts of kefir on human health.

Kefir-derived LAB has been demonstrated to have positive effects on intestinal microbiota (improved digestion and gut health), inflammation, type 2 diabetes, anti-carcinogenic effects, cholesterol levels, cardiovascular diseases, hypertension and immunomodulatory activities [11, 17, 18, 19, 20]. Furthermore, recent research has shown encouraging outcomes regarding antiviral effects, notably in the instance of COVID-19 [21]. But in order to produce a consistent end product, time requires the creation of a standard kefir production procedure.

## 2 Conclusion

Because of their high probiotic content, milk kefir and water kefir are both beneficial fermented drinks with many health advantages. Water kefir is a great dairy-free substitute that is appropriate for people who are lactose intolerant or on a vegan diet, even though milk kefir offers a more nutrient-dense choice with greater amounts of protein, calcium, and vitamins. Both promote digestive health, strengthen the immune system, and improve general well-being despite variations in their microbial compositions and substrates.

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