Fermentation: A Short Scientific and Culinary Overview of Kefir

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Introduction
Fermented foods usually have long storage lives and interesting nutritional values, which makes fermentation a very popular transformation technique all over the world, including for drink production. Among these, kefir is a fermented drink produced by the action of a Symbiotic COmmunity of Bacteria and Yeasts (SCOBY) contained in grains, made from a protein and polysaccharide matrix. It is supposed not only to be tasty but also to have many health benefits, including anticarcinogenic, antiviral and antifungal properties, although most of these claims still need further support from medical studies. However, even without sound scientific proof, consumers are generally encouraged by popular media to improve their health through fermented diets that bring a good amount of useful probiotics, making kefir (like other fermented foods and beverages) increasingly fashionable (Debailly et al., 2018).

Origin, Production and Consumption
Two types of kefir exist today: “milk” and “water” (also called “sugar”) kefir.

Milk kefir, thought to have its origins in the north Caucasus mountains, is still consumed by a lot of Russians. It is traditionally made by inoculating milk (cow, goat or sheep) with kefir grains and keeping it in skin bags at room temperature for a day or more, depending on the conditions and fermentation level desired. The milk kefir grains contain yeasts (including Saccharomyces and Kluyveromyces species) and lactic acid bacteria (including Lactobacillus, Lactococcus, Streptococcus and Leuconostoc species), which produce a viscous, sour, carbonated and slightly alcoholic beverage (Farnworth, 2005; Prado et al., 2015). According to the Codex Alimentarius Standard for Fermented Milks (CODEX STAN 243–2003), milk kefir contains milk protein (>2.8% w/w), milk fat (<10% w/w), titratable acidity expressed as percentage of lactic acid (minimum 0.6% w/w), ethanol (not stated), and specific microorganisms constituting the starter culture (minimum 10^7 colony forming units (cfu)/g, in total including as a minimum 10^4 cfu/g of yeasts).

Water kefir has a more mysterious origin and is not yet defined by the Codex Alimentarius: it might come from the evolution of milk kefir grains cultivated in watery conditions or, as sometimes claimed, it might have appeared spontaneously in the sugar-rich juice of Opuntia cactus. It is made by inoculating a solution of water, sugar and added dry and fresh fruit (usually fig, lemon, etc.) with kefir grains and keeping it for a day or more at room temperature (Figure 47.1). The water kefir grains contain yeasts (including Saccharomyces and Candida species) and bacteria (including Lactobacillus, Streptococcus and Leuconostoc species), which also produce a sour, carbonated and slightly alcoholic beverage.

Once strained (to separate the grains from the liquid), kefir drinks can be stored for several days, undergoing a second (slower) fermentation, which will enhance the sourness and amount of gas. Water kefir is an increasingly popular drink throughout the world, mainly due to its ease of production, its alleged health benefits and the fact that it is suitable for vegans.

Scientific Investigations
The microbial species diversity of water kefir consists of a consortium of mainly lactic acid and acetic acid bacteria and yeasts (Fiorda et al., 2017). Microbial analysis of kefir samples taken from different locations worldwide shows differences in microbiological populations, which reflect the colonization of cultures...
by opportunistic yeasts and bacteria found in the environment (Gulitz et al., 2011; Laureys and De Vuyst, 2014).

We collected about 100 different kefir grains in our lab and started a thorough biochemical (using controlled fermentation; Figure 47.2) and microbiological analysis (through metagenomics; Figure 47.3) of each of them. The goal of this ongoing study is to show (1) the link between the microbiological content (bacteria, yeasts) and the physiological/sensory parameters (metabolites, taste) of the drink and (2) the high diversity of kefir.

Previous studies have already shown that sucrose is mainly converted into ethanol, lactic acid (which gives the sour taste), polysaccharides (which create a new matrix for the grains), and, to a lower extent, glycerol, acetic acid and mannitol (Laureys and De Vuyst, 2014). More studies are needed to address many unanswered questions, such as the influence of various parameters (light, oxygen, ingredients added, liquid/grains ratio, etc.) on the final result, as well as to test some “fancy” statements (never use metal tools, never use white sugar, etc.) often found in popular papers and on social media (Debailly et al., 2018).

Regarding the microbial composition, some studies have pointed out the differences between kefir strains (Nalbantoglu et al., 2014), making it difficult to characterize what a “standard” kefir could be. Indeed, we found totally different profiles in our collection, with major species varying from one strain to another (Figure 47.3). Again, further studies are needed to reach a more complete “landscape” of what kefir is (or, indeed, are)! Biochemical, metagenomic and metabolomic studies provide evidence of the large number of microorganisms in starting strains and the variety of possible bioactive compounds that could be formed during fermentation, and have to be followed by medical/clinical studies aimed at characterizing the potential health effects of regular kefir consumption (Farnworth, 2005; Lopitz-Otsoa et al., 2006). This is especially true for water kefir, for which fewer studies exist compared with milk kefir (Fiorda et al., 2017).
Culinary Uses

There is no need to wait for medical studies to enjoy kefir for its taste! Milk kefir has been traditionally used for a long time in various recipes from former Soviet Union countries (mainly in soups like cold bortsch and okrochka). More recently, water kefir has also become quite popular among chefs, who have started using it in various preparations (breads, sauces, sorbets, etc.; Figure 47.4) or directly serving it as a drink to accompany the meal as a way to replace wine in food/drink pairing menus. This is probably the perfect occasion for collaborative work between cooks and scientists!

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