by Tara McHugh and Amanda Sinrod

Kombucha: How Is It Processed?

This month's column is a continuation of our "How is it processed?" series, focusing on kombucha. Thousands of years old, kombucha is a functional, fermented tea currently consumed around the world. I wish to thank my co-author, Amanda Sinrod, food specialist at the University of California, Davis, and the U.S. Department of Agriculture, Agricultural Research Service, for contributing to this column.

History and Market

From home brew to a major consumer product, kombucha has recently made its mark on the American beverage industry. This nonalcoholic fermented tea beverage owes its newfound popularity to its vast health claims as a homeopathic remedy for everything from decreasing signs of aging to preventing cancer. Kombucha, also known as tea kvass, tea fungus, and Manchurian, has a fruity vinegar flavor and mild carbonation, which is commonly considered an acquired taste and loved by many.

Manchurian was first brewed in northeast China around 220 BCE and was revered for its magical detoxifying and energizing properties. Six hundred years after its invention, the beverage was brought to Japan as a cure for digestive issues. Manchurian became known as tea kvass as it spread along trade routes into Russia and Eastern Europe. Kombucha was not introduced to Western Europe until it reached Germany during World War II and became popular in France and North Africa in the 1950s.

Kombucha's presence in the American beverage sector has skyrocketed in the past few years and is expected to continue growing. Sales of kombucha reached $689 million during 52 consecutive weeks in 2017–2018.

Stores sell a large variety of kombucha drinks from both craft brewers and large producers like GT's Living Foods and Health-Ade. Beverage giants are also entering the kombucha space. PepsiCo purchased the kombucha brewer KeVita for $200 million in 2016.

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SCOBY

A symbiotic colony of bacteria and yeast, SCOBY is the key to kombucha fermentation and consists of a cellulosic pellic layer that floats on the kombucha's surface. Every SCOBY is a unique combination of acetic acid bacteria and osmophilic yeast species that vary by climate, geography, culture, and wild microorganisms. Acetic acid bacteria polymerize the glucose in the fermenting kombucha solution to generate cellulose and hemi-cellulose as a secondary metabolite, forming the SCOBY's zoogleal mat. After 10 to 14 days of fermentation, a new SCOBY culture reaches 2 cm thick and separates from the inoculation mother culture. This new SCOBY is clear with a gel-like consistency. Once the fermentation is complete, the SCOBY can be saved in a small volume of kombucha and used to inoculate new batches.

Commercial kombucha brewing produces large volumes of SCOBY as a new SCOBY forms with every batch. SCOBY is an excellent animal feed as it contains high concentrations of crude protein, fiber, and lysine. Studies have also shown that dried SCOBY can act as a biosorbent to collect metal pollutants from wastewater.

Brewing Kombucha

To make the kombucha base, tea and sugar are added to boiling water and steeped for about 10 minutes before being filtered to remove the tea leaves. The solution is then cooled to room temperature, at which point a thin layer of mother SCOBY and a small amount of fermented kombucha are added to begin the fermentation. Ingredient proportions vary between brewers and kombucha beverages but generally consist of 5%–15% sugar, 2% SCOBY, and 8%–17% fermented kombucha. Incorporating fermented

Kombucha is mildly carbonated *and has a fruity vinegar flavor.*
Photo courtesy of Pixabay

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kombucha increases the initial yeast cell concentration to decrease fermentation time and also lowers the pH to inhibit the growth of harmful microorganisms. The sweet tea mixture is transferred into a sterile wide-mouthed jar and covered with a secured cloth to prevent insect contamination. The kombucha is then stored between 20°C and 30°C (20°–22°C is preferred) for 6 to 14 days to ferment.

During the first days of fermentation, the kombucha loses its sweetness and gains a sour and fruity flavor. This flavor continues to develop into a mild vinegar taste. To begin the fermentation, the SCOBY's yeast hydrolyzes the sucrose into glucose and fructose. The yeast further digests the fructose into ethanol. The SCOBY's acetic acid bacteria transform the yeast's glucose and ethanol into multiple types of organic acids. The specific organic acids and their concentrations vary between brews; acetic and gluconic acids are two of the primary organic acids in kombucha, however. The SCOBY also produces carbon dioxide, giving kombucha a carbonated fizz. Compounds from each stage of the fermentation process remain in the final beverage, contributing to kombucha's distinctive taste.

Correctly timing the fermentation is essential to brewing kombucha. Incomplete fermentation produces kombucha that lacks its characteristic flavor. However, fermenting kombucha for too long increases the organic acid concentration to potentially harmful levels. The alcohol content also increases as anaerobic fermentation begins. Beverages must contain less than 0.5% alcohol to be sold as nonalcoholic in the United States. If the sugar or yeast concentration is too high during fermentation or the kombucha is fermented too long, the drink can reach 1.5% alcohol. While fermentation time depends on specific ingredients, their concentrations, and environmental conditions, a 7-day fermentation is generally considered ideal.

Kombucha Town operates *a 3,500-square-foot brewery in Bellingham, Wash. The company packages its kombucha in 16-ounce cans.* Photo courtesy of Kombucha Town

Once the fermentation is complete, the SCOBY is removed and the kombucha is filtered through cheesecloth, bottled, and refrigerated at 4°C. Some producers choose to leave small pieces of SCOBY in their kombucha, which are safe to consume.

Each batch of kombucha has a distinctive taste caused by its individual combination of ingredients, environmental brewing conditions, and microbial composition. While the kombucha base of tea and sweetener is largely the same, the specific ingredients and concentrations fluctuate. Black tea is considered the best fermentation medium and is most commonly used; however, green tea and herbal infusions are sometimes substituted. A 5% solution of white sugar is the optimal carbon source for kombucha fermentation, but other sweeteners can be used instead. Additionally, some companies add cold-pressed fruit and vegetable juices to their mix to produce different kombucha flavors.

Effects of Fermentation

Kombucha fermentation generates organic acids commonly including acetic, gluconic, lactic, and glucuronic acids. Kombucha's organic acids do more than provide flavor. Along with the ethanol and microbe-fighting molecules produced during fermentation, the low pH from the acids prevent pathogenic bacteria and mold from growing in the kombucha. Studies show extremely low rates of kombucha contamination even when brewed in non-sterile conditions.

Depending on the kombucha base, fermentation conditions, and SCOBY, kombucha's fermentation can produce a multitude of beneficial micronutrients such as folic acid, amino acids, and active enzymes as well as vitamins C, B-1, B-2, B-6, and B-12. Kombucha's concentrations of copper, iron, manganese, nickel, zinc, and other minerals also increase during fermentation. Additionally, the enzymes produced by the yeast and bacteria break down the tea's polyphenols and antioxidants into low molecular weight compounds, boosting the drink's antioxidant capacity.

Health Benefits

In addition to being a tasty drink, kombucha is used as a homeopathic remedy. Drinkers have assigned kombucha a long list of health claims as a functional beverage. According to these claims, kombucha lowers blood pressure and cholesterol, fights diabetes, cures insomnia, improves asthma, increases hair growth, and turns gray hair dark, among its many other examples. Scientists have yet to significantly research kombucha's health benefits, however some studies show promising results.

Current studies associate kombucha's health benefits with its fermentation. The antioxidants, vitamins, and minerals created during fermentation have known health benefits. Glucuronic acid acts as a detoxification agent for metabolic wastes, drugs, and poisons. Additionally, the organic acids, catechins, and large proteins generated in kombucha's fermentation can kill multiple foodborne and pathogenic gram-positive and gram-negative bacterial strains. This effect is heightened when the kombucha is made with black tea. Kombucha can also act as a probi-

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otic much like other fermented foods.

Recent studies have shown that kombucha has the potential to help prevent and fight liver disease and certain cancers. According to small animal studies, kombucha is hepatoprotective against environmental pollutants like cadmium chloride. By preventing hepatoxicity, kombucha reduces oxidative stress and therefore decreases resulting liver diseases. Additionally, multiple studies on various cancer cell lines show kombucha's fermented tea polyphenols induce anticancer mechanisms. These include inhibiting gene mutation, cancer cell proliferation, and metastasis in addition to instigating apoptosis in cancer cells.

Many of kombucha's health claims are almost unbelievable, and little scientific research has been done to support or refute them. Much more research, particularly human trials, is necessary to determine kombucha's true health benefits as a functional beverage.

Precautions

According to the U.S. Food and Drug Administration, kombucha is safe to drink based on microbiological and biochemical analysis. Furthermore, rat studies have not shown signs of kombucha-induced toxicity. However, as with many food products, some care should be taken. Kombucha is contraindicated for women who are pregnant or lactating and poses risks for people with certain preexisting conditions such as being HIV positive. Bacterial enzymes like β-glucuronidase sometimes produced during kombucha fermentation can also interfere with certain chemotherapy drugs.

Reported severe illnesses from kombucha are rare, isolated, and affect very few people. If it is made improperly, kombucha can contain pathogenic microbes or an unsafe concentration of organic acids. Additionally, instances of lead poisoning have been reported from kombucha brewed in ceramic pots as the organic acids are thought to leach lead from the pot's glaze into the beverage. Many of these concerns apply only to home brewing of kombucha and are addressed thoroughly through commercial processing of kombucha. **FT**

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