**Abstract**

*Kombucha*, Tea Kvass, Japanese or Indonesian tea fungus and Manchurian are the most common names for the symbiotic association of bacteria and osmophilic yeast in a form of thick jelly membrane which is cultured in sugared tea. It is slightly sweet, acetic acid-flavoured beverage also called tea eider the traditional substrate for *kombucha* preparation is black tea sweetened with 5 to 15% of sucrose and produced during 6 to 10 days of fermentation under aerobic conditions, at a temperature range of 20 to 30°C. The fermentation is two steps fermentation in which, the yeasts ferment the sugar to ethanol, which is further oxidised by the acetic acid bacteria to produce acetic acid which reduces the pH of medium. Except black tea, different types of other tea’s such as orthodox tea and herbal tea have been used for the production of apple tea wine, using natural and inoculated fermentation. Besides acetic acid, the fermented liquid contains gluconic, glucuronic and lactic acid, among them all glucuronic acid is the main therapeutic agent in *Kombucha*. *Kombucha* metabolism produces glucose, fructose, small amounts of ethanol, carbon-dioxide, vitamins C, B₁, B₂, B₆, B₁₂, folic acid, different organic acids, mainly acetic, gluconic, L-lactic, glucuronic, enzymes and some antibiotically active compounds, and many others. Beverage also contains most of tea ingredients like tea catechines and caffeine. The beverage has been claimed is considered a prophylactic agent and is considered beneficial to human health.

**Keywords:** Kumbucha, tea, fermentation, Manchurian, tea kvass, glucuronic acid, therapeutic value

Tea (*Camellia sinensis* L.) is the most important non-alcoholic beverage having worldwide popularity. It is consumed as a morning drink by 2/3rd of the world population. It is mainly consumed in the form of ‘fermented tea’ or ‘black tea’, ‘non-fermented’ or ‘green tea’ and ‘semi-fermented’ or ‘oolong tea’ which is also popular in Japan and China. Tea leaves have more than 700 chemical constituent, among which flavonoids, amino acids, vitamins (C,E,K), caffeine and polysaccharides are important to human health. However, the stimulative effect of tea is due to caffeine (1.25-45.5%) (Kurian and Peter, 2007). Tea, mostly black tea, is the second most consumed drink in the world after water and well ahead of coffee, beer, wine and carbonated soft drinks (Hui, 1992). The black tea infusion contains proteins, amino acids, volatile compounds, lipids, enzymes and polyphenols, which make it as a good fermentation medium (Hui, 1978). Microbial fermentation of black tea leads to production of *Kombucha* or tea cider, known to have therapeutic values. (Rosma et al., 2016)

Black tea is produced by a process that oxidizes the polyphenols in the leaves to such substances as are characteristics of black tea and responsible for the
colour, the caffeine content and taste of infusion. Black tea has a strong body due to tannins, which are a group of astringent polyphenolic compounds such as flavonoids (theaflavin and thearubigin) and others derivatives of polyphenols. The natural tannins are powerful reducing agents and exhibit a marked tendency to absorb oxygen, thereby, making tea infusions a possible health drink due to its antioxidant property. Not only in tea, tannins impart body to various fermentation products especially in wines and fermented fruit juices, besides enhancing their flavour profile (Fleet, 2001). Black tea is a good fermentation medium because its infusion contains proteins, aminoacids, volatile compounds, lipids, enzymes and more importantly polyphenols (Martin and Arnold, 1978). Black tea fermented with yeast accumulates the vitamins A, C and B complex, making it a nutritious and a therapeutic agent (Chand and Gopal, 2005), besides increasing shelf-life (Liyanage et al. 1988).

Tea cider also known as Kombucha (traditional fermented product), is a fermented tea that is often drunk for medicinal purposes. Kombucha tea has been used in Russia for several centuries. The modern form of Russian Kombucha tea is widely popular and is known as “tea kvass” or simply “kvass” (Murugesan et al. 2009). This refreshing beverage tasting like sparkling apple cider is often produced at home by fermentation using a tea fungus passed from house-to-house (Dufresne and Farnworth, 2000). Fermented tea decoctions such as “Kombucha” have been prepared by co-fermentation with yeast and acetic acid bacteria, and are known to have health benefits (Guţ apadu et al. 2000).

The purpose of this review is to bring out the technology, microbiology, production, composition, therapeutic value and try to establish a better understanding of Kombucha and its possible health benefits. A thorough knowledge of tea, its composition and effects on metabolism and health provides a starting point in understanding the potential of Kombucha.

**HISTORY**

Most of the world population, especially people in highly developed countries, has demonstrated increased awareness and interest in functional food, i.e., food that positively effects upon bio-regulatory functions and human health. Such an interest lasted for a few decades, having great impact in the development of food industry. The consumption of Kombucha was first practiced in 220 B.C. in Manchuria (Jayabalan et al., 2014), the tea was sought for its magical properties. As trade routes extended beyond the Far-East, it, then, spread to Russia where Kombucha is called teakvas. This beverage was introduced into Germany during World War II, in the 50’s arrived into France and France-dominated North Africa (Blanc, 1996). Presently, Kombucha is popular in the United States, due to its refreshing power and curative effects.

**MICROBIOLOGY**

Acetic acid bacteria (Acetobacter xylinum, Acetobacter aceti, Acetobacter pasteurianus, Gluconobacter oxydans) (Greenwalt et al. 2000) and yeast (Saccharomyces sp., Zygosaccharomyces sp., Torulopsis sp., Pichia sp., Breânomyces sp.) are the main microbes having the symbiosis in tea fungus responsible for kombucha fermentation. The variation of its composition could be due to geographic, climatic and cultural conditions as well as depends on the types of wild yeast and bacteria that exist locally (Petrovska and Tozi, 2000 and Teoh et al. 2004). The fermentation is two steps fermentation in which, yeasts ferment the sugar to ethanol, which is further oxidised by the acetic acid bacteria to produce acetic acid in the second fermentation. The result is reduced pH of medium. Both ethanol and acetic acid have antimicrobial activity against pathogenic bacteria, thereby, providing protection against contamination of the tea fungus (Liu et al. 1996). Besides acetic acid, the fermented liquid contains gluconic, glucuronic and lactic acid. Glucuronic acid is the main therapeutic agent in Kombucha, as a detoxification agent (Loncar et al. 2000). Many flavour compounds, including alcohols, aldehydes, ketones, esters and amino
acids have been identified from fermented broth (Teoh et al. 2004). A culture of Kombucha is a living organism exposed to many influences, which gives the final beverage a different chemical composition and taste (Petrovska and Tozi, 2000). Besides these, recently Kumar (2014) reported that the bacteria responsible for the natural fermentation of apple tea wine belong to Bacillus whereas the yeast responsible for the natural fermentation of apple tea wine belong to genus Saccharomyces. List of bacteria and yeasts associated with fermentation of Kombucha is presented in Table 1.

Table 1: Microbial Population of Kombucha

<table>
<thead>
<tr>
<th>Microorganism</th>
<th>References</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Bacteria</strong></td>
<td></td>
</tr>
<tr>
<td>Acetobacter ketogenum</td>
<td>Morales and Sanchez, 2003</td>
</tr>
<tr>
<td>Bacterium gluconicum</td>
<td>Morales and Sanchez, 2003; Mrdanovic et al. 2007</td>
</tr>
<tr>
<td>Bacterium katogenum</td>
<td>Mrdanovic et al. 2007</td>
</tr>
<tr>
<td>Bacterium xilinum</td>
<td>Morales and Sanchez, 2003; Mrdanovic et al. 2007</td>
</tr>
<tr>
<td>Bacterium xilinoides</td>
<td>Morales and Sanchez, 2003; Mrdanovic et al. 2007</td>
</tr>
<tr>
<td><strong>Yeast</strong></td>
<td></td>
</tr>
<tr>
<td>Brei anomyces sp.</td>
<td>Kozaki, 1972; Mayser et al. 1995</td>
</tr>
<tr>
<td>Brei anomyces bruxellensis</td>
<td>Liu et al. 1996; Mrdanovic et al. 2007</td>
</tr>
<tr>
<td>Brei anomyces intermedius</td>
<td>Greenwalt et al. 2000, Jankovic and Stojanovic, 1994</td>
</tr>
<tr>
<td>Candida</td>
<td>Jankovic and Stojanovic, 1994</td>
</tr>
<tr>
<td>Candida guilliermondii</td>
<td>Kozaki, 1972; Greenwalt et al. 2000</td>
</tr>
<tr>
<td>Candida famata</td>
<td>Greenwalt et al. 2000, Jankovic and Stojanovic, 1994</td>
</tr>
<tr>
<td>Candida stellata</td>
<td>Jankovic and Stojanovic, 1994</td>
</tr>
<tr>
<td>Mycoderma</td>
<td>Jankovic and Stojanovic, 1994</td>
</tr>
<tr>
<td>Mycotorula</td>
<td>Jankovic and Stojanovic, 1994</td>
</tr>
</tbody>
</table>

PREPARATION OF KOMBUCHA

The process of preparation of Kombucha is shown in Fig. 1 and described here.

![Diagram of Kombucha preparation](image-url)
Raw material

Brewed tea is the substrate on which the microorganisms grow to produce the final product that is *Kombucha*. Black tea is usually used for *Kombucha* preparation, green tea and herbs are also used (Kumar, *et al.* 2016). It has been shown that green tea has a more stimulating effect on the *Kombucha* fermentation than black tea, yielding the fermentation in a short time frame (Greenwalt, *et al.* 1998). Black tea and white sugar are the best substrates for the preparation of *Kombucha*, although green tea can also be used (Reiss, 1994).

Radomir *et al.* (2006) conducted research on influence of black tea concentrate on *Kombucha* fermentation and reported that it is possible to perform *Kombucha* fermentation in substrates with higher black tea concentration than is the traditional one, but metabolites content in fermentative liquids is not proportional to the amount of used tea and sucrose. When solution with tea concentration of 15 g/L was diluted with cold tap water in such ratio that final solution is corresponding to standard substrate for fermentation with 1.5 g/L of black tea and 70 g/L of sucrose, the compared metabolites contents in fermentative samples of standard and diluted concentrate were very similar.

Recently, Kumar *et al.* (2015) and Kumar *et al.* (2016) conducted studies to check the suitability of different types of tea (black tea, orthodox tea and herbal tea) at different concentrations (2 to 5%) for the preparation of apple tea wine and reported that apple tea wine prepared using 4% CTC tea was the best on the basis of physico-chemical and the sensory quality characteristics.

Must Preparation

Tea leaves are added to boiling water and allowed to infuse for about 10 min after which the leaves are removed and sweetened with sucrose 50 to 150g/ml (5 to 15%). Sucrose (Greenwalt *et al.* 2000) is dissolved in the hot tea. This must is allowed to cool at room temperature (Jayabalana *et al.* 2014).

Recently, Joshi and Kumar (2016) conducted studies to check the effect of different sugar sources (apple juice concentrate, sucrose and honey), nitrogen sources (DAHP, ammonium sulphate and peptone) and inocula (*Saccharomyces cerevisiae* var. *ellipsoideus*, consortia 1 and 2) on the quality characteristics of tea wine and reported that the wine prepared by ameliorating the apple tea must with apple juice concentrate, DAHP and inoculated with *Saccharomyces* was the best.

Inoculation and fermentation

Tea is poured into a wide-mouthed clean vessel and the microbial mat or colony from previous batch of *Kombucha* is added to the sweetened tea with about 100 ml of *Kombucha* from previous fermentation. Markov *et al.* (2006) reported that isolated strains of yeasts and acetic acid bacteria from tea fungus may be used as started cultures for obtaining of *Kombucha*. Further, it was revealed that, the fermentation was faster in medium inoculated with fermentation broth compared to the fermentation with the starter cultures. The fermentation time is dependent on initial count of yeasts cells.

The tea fungus is laid on the tea surface, and the jar is carefully covered with a clean cloth and fastened properly. The preparation incubated at room temperature (between 20° and 30°C) for 7-10 days. If the fermentation is allowed to continue beyond the 10 days, the acidity may rise to levels potentially harmful to consume. During fermentation, a daughter tea fungus is formed at the tea surface. The tea fungus is removed from the surface and kept in a small volume of fermented tea. The beverage is passed through cheese-cloth and stored in capped bottles at 4°C (Jayabalana *et al.* 2014). It has been reported the taste of the *Kombucha* changes during fermentation from a pleasant fruit sour-like lightly sparkling flavour after a few days, to a mild vinegar-like taste with prolonged incubation (Blanc, 1996; Reiss, 1994; Sievers *et al.* 1995). The schematic description of *Kombucha* manufacture is presented in Fig. 2.

*Kombucha* is traditionally prepared by fermentation of sweetened (sucrose) black tea. This medium (freshly prepared medium) is usually inoculated
with cellulose pellicle formed during the previous cultivation and incubated statically under aerobic conditions for 7-10 days.

![Chemical structures of important ingredients present in Kombucha](image)

**Fig. 2:** Important ingredients present in Kombucha

*Source:* Harbowy and Balentine, 1997

The media for tea fungus cultivation could also be successfully inoculated with fermented liquid from previous fermentation, where the concentration of cells is generally higher than those in cellulosic pellicles (Liu *et al.* 1996). Production of vitamin C and other valuable compounds, in Kombucha during fermentation process, is strongly related to the process duration, fermentation temperature, Kombucha symbiosis and inoculum concentration, source of carbon atoms and other working conditions by Petrovic *et al.* (1995–1996). It has also been reported (Petrovic *et al.* 1995–1996) that the product of 7th day of fermentation possesses optimal sensory characteristics; increase of acidity during fermentation longer than 7 days makes liquor of the Kombucha too sour and unpleasant. However, some authors (Chen and Liu, 2000) have investigated changes in major compounds of tea fungus metabolites during prolonged fermentation of up to 60 days. Temperature of fermentation significantly influences kinetics of substrate intake and product formation. It was proved that the composition of fermented tea greatly depend on the individual Kombucha association (Reiss, 1994; Blanc, 1996) as well as on the concentration of inoculum solution. As far as sucrose substrate is concerned, it seems that concentration of 50 g L⁻¹ gives optimal concentration of both ethanol and lactic acid (Reiss, 1994).

The composition and properties of tea are well documented, but scarce scientific information is available, concerning the composition and the effects of Kombucha on health. Benefits have been reported by testimony of users in different conditions and with variable consumption.

**BIOCHEMICAL CHANGES IN KOMBUCHA**

The tea fungus produces a cellulosic pellicle or mat, oxidized ethanol, produced acetic, L(+)lactic acid, gluconic acid and glucuronic acid (Frank, 1991). The fermentation and oxidation processes starts, when the tea fungus is placed in a freshly prepared infusion of tea and sugar. When grown in sucrose medium, the yeast break down sucrose in glucose and fructose, then produce carbon dioxide and ethanol, which are oxidized to acetaldehyde by acetic acid bacteria. The tea fungus produces many other substances, like gluconic acid and vitamins, which with the supply of tea nutrients, give the drink its unusual flavor and healing properties. During the process, the glucose is polymerized and produces cellulose and hemi-celluloses (Greenwalt *et al.* 1998; Bauer and Petruseshevska, 2000).

To produce Kombucha, black tea ingredients and sucrose undergo progressive modification by the action of the tea fungus. The main metabolites identified in the fermented beverage are: acetic, lactic, gluconic and glucuronic acids, ethanol and glycerol (Blanc, 1996; Liu *et al.* 1996). Some chemical structures of important ingredients reported in Kombucha are given in Fig. 2. The presence of usnic acid in Kombucha reported once has not been confirmed in recent studies (Blanc, 1996). Usnic acid had been previously identified in lichens and can deactivate some groups of viruses. The metabolite composition and concentration depends on the tea fungus source, sugar concentration, and the time course of fermentation. With 50 g/l sucrose, concentrations of ethanol and of lactic acid are optimal (Reiss, 1994). Yeast and bacteria in the tea fungus make use of substrates by different and complementary ways. Yeast cells hydrolyse sucrose into glucose and fructose, and produce ethanol, with a preference for fructose as a substrate (Sievers *et al.* 1995). Acetic bacteria utilize glucose to produce gluconic acid (Sievers *et al.* 1995),
and ethanol to produce acetic acid (Yurkevich and Kuty Shenko, 1998). The presence of lactic acid was not observed in these studies but has been reported in another. In this study, the lactic acid synthesis is attributed to the action of lactic bacteria on ethanol and acetic acid (Reiss, 1994). It is also reported that the fermentation process induces the synthesis of the B complex of vitamins and folic acid. The pH value of Kombucha decreases during the fermentation process following the increase in the organic acid content (Blanc, 1996; Riess, 1994; Sievers et al. 1995). Similar finding have been observed by Kumar et al. (2015), Kumar et al. (2016) and Joshi and Kumar (2016) during the fermentation of apple tea wine.

**Components of Kombucha**

Kombucha contains the organic acids, active enzymes, amino acids, and polyphenols produced by these microbes. The precise quantities of these component a sample can only be determined by laboratory analysis. Finished Kombucha may contain any of the following components. These components are acetic acid (mildly antibacterial), butyric acid, B-vitamins (Aleksandra et al. 2007), alcohol, gluconic acid, lactic acid, malic acid, oxalic acid and usnic acid.

Normal Kombucha contains less than 0.5% alcohol, which classifies kombucha as a non-alcoholic beverage. Older, more acidic, kombucha might contain 1.0% or 1.5% alcohol, depending on more anaerobic brewing time and higher proportions of sugar and yeast.

**Nutritive and Therapeutic Value**

Tea cider (Kombucha) is associated with many health benefits. It possesses characteristics of functional food and known for a few thousand years. It originated in China, 220 BC, Korea and Japan. There, it was popular due to detoxifying and energizing properties as well as curing digestive problems (Jayabalan et al. 2014). It contains liver detoxifiers, antioxidants, polyphenols, probiotics and free-form amino acids. Kombucha has been studied intensively since 1852; few of the health properties have been demonstrated by scientific and experimental studies (Dufresne and Farnworth, 2000). As a traditional medicine, the Kombucha drink was used as healing liquor in the treatment of many diseases, and at present it is considered to be a folk-remedy (Petrovska and Tozi, 2000). Hence, it is used as an alternative therapy (Blanc, 1996). Beneficial effects attributed to consumption of Kombucha (mushroom) tea have included prevention of a few cancer, relief of arthritis, treatment of insomnia, hemorrhoids, digestive disorders, heart disease, allergies, asthma, decrease of blood pressure, increase of vitality, increase of T cell count and stimulation of regrowth of hair. Because, the tea is believed to stimulate the immune system, it has become popular among the elderly persons (Sreeramulu et al. 2000, Cavusoglu and Guler, 2010).

The recommended consumption of Kombucha ranges from 100 to 300 ml per day (Frank, 1991). The beverage has been claimed to be a prophylactic agent and to be beneficial to human health as a diuretic in edemas, in atherosclerosis, in case of gout, sluggish bowels, for stones, etc. (Kaufmann, 1966). Fermentation also induces biosynthesis of ascorbic acid. Vitamin C is an important natural antioxidant, which serves as human health protector and a drug. One who has started with application of vitamin C as a drug was a leading vitamin C clinician (Klenner, 1971). Petrovic and Loncar (1996) and Malbasa et al. (2002), have determined content of vitamin C in fermentative liquids of tea fungus. Activity of vitamin C as well as activities of other compounds present in Kombucha fermentation system is modified in a positive way by the chemical environment in the fermented beverage. For example, it has been reported that tocopherol and ascorbic acid exert strong synergetic effects on the antioxidant of tea catechins (Hara et al. 1995). Therefore, vitamin C and other constituents of Kombucha beverage protect human health more efficient than the same isolated compounds. Vitamin C is also an essential component of the human diet. It enhances iron adsorption (Cook and Redd, 2001; Halberg and Hulthen, 2000), prevents megaloblastic anemia (Jacob, 1994) and reduces stomach cancer (Hemila and Herman, 1995). Ascorbic acid inhibits iron absorption by tannins. Decreased tannins and increased ascorbic acid concentration, in fermented tea, are very useful for iron absorption and improved
digestion (Pasha and Reddy, 2005). Due to the rich biomass in tea fungus (*Medusomyces gisevii*), it can be utilized as a protein supplement in animal feed (Jayabalan *et al.* 2010). They further revealed that tea fungus is rich in crude protein, crude fibre, and amino acid lysine. The biochemical characteristics of tea fungus studied were increased throughout the fermentation time during the study of biochemical characteristics of tea fungus produced during Kombucha fermentation.

Petrovska and Tozi, (2000) quantified contents of minor and trace elements viz., manganese, iron, nickel, copper, zinc, lead, cobalt, chromium and cadmium in the Kombucha drink and sweet tea infusion which are presented in Table 2.

<table>
<thead>
<tr>
<th></th>
<th>Kombucha drink</th>
<th>Tea decocts</th>
<th>Increasing or decreasing factor</th>
</tr>
</thead>
<tbody>
<tr>
<td>Manganese</td>
<td>0.462 ± 0.024</td>
<td>0.362 ± 0.015</td>
<td>1.28</td>
</tr>
<tr>
<td>Iron</td>
<td>0.353 ± 0.018</td>
<td>0.257 ± 0.013</td>
<td>1.37</td>
</tr>
<tr>
<td>Nickel</td>
<td>0.346 ± 0.016</td>
<td>0.282 ± 0.008</td>
<td>1.23</td>
</tr>
<tr>
<td>Copper</td>
<td>0.237 ± 0.004</td>
<td>0.160 ± 0.007</td>
<td>1.48</td>
</tr>
<tr>
<td>Zinc</td>
<td>0.154 ± 0.008</td>
<td>0.132 ± 0.004</td>
<td>1.17</td>
</tr>
<tr>
<td>Lead</td>
<td>0.005 ± 0.001</td>
<td>0.012 ± 0.001</td>
<td>0.42</td>
</tr>
<tr>
<td>Cobalt</td>
<td>0.004 ± 0.0008</td>
<td>0.004 ± 0.0009</td>
<td>0</td>
</tr>
<tr>
<td>Chromium</td>
<td>0.001 ± 0.0001</td>
<td>0.002 ± 0.0001</td>
<td>0.5</td>
</tr>
<tr>
<td>Cadmium</td>
<td>0.001 ± 0.0001</td>
<td>0 ± 0.0000</td>
<td>0</td>
</tr>
</tbody>
</table>

(*n* = 5)


The average mineral composition of the essential elements was in concentrations from 0.004 µg mL⁻¹ for cobalt to 0.462 µg mL⁻¹ for manganese. Investigations of some toxic elements gave the following concentration values: 0.005 µg mL⁻¹ for lead, 0.001 µg mL⁻¹ for chromium. Cadmium was not detected.

Mineral content of the essential elements (Cu, Fe, Mn, Ni and Zn) for normal physiological processes in the organism increased as a result of the Kombucha cultivation in the sweet black tea infusion. The cobalt content did not increase in Kombucha beverage probably because of its incorporation in vitamin B₁₂. Cadmium was not found in the investigated samples. Decreased lead concentration in the drink proved the Kombucha was able to detoxify beverages, possibly by its high glucuronic acid content. Kombucha also decreased the very low chromium concentration present in the investigated tea decoct sample. They further revealed that, an average consumption of approximately 0.3µ litre per day, could satisfy all Ni and Co daily needs, partial Fe and Cu needs, but not the Zn and Mn daily needs.

The product has the bacterial β-glucuronidase enzyme that can interfere with proper disposal of a chemotherapeutic agent, and that antibiotics against gut bacteria can prevent toxicity of some chemotherapy drugs (Srinivasan *et al.* 1997), supporting the idea that glucaric acid is an active component of Kombucha. Low alcoholic beverages have gained importance in preventing cardiovascular diseases, by preventing the formation of LDL and increases the HDL levels (having protective effect against heart disease (Joshi *et al.* 1999).

Glucuronic acid, a constituent of Kombucha, forms compound with metabolic wastes as well as drugs and poisons and aids in detoxication. The tea fungus has been recommended as a therapy for gout, rheumatism, furunculosis, early atherosclerosis, high blood pressure, nervousness, and the symptoms of old age. Kombucha made the blood more acidic, it rejuvenates the elderly, causes grey hair to become dark again, tightens the skin, and enhances feelings of vitality and health. Among the Vitamins, Vitamin B₁₂, B₆, B₉, B₃, B₂ and folic acids is also produced in Kombucha (Frank, 1991).

The beneficial effects of Kombucha tea are attributed to the presence of tea polyphenols, gluconic acid, glucuronic acid, lactic acid, vitamins, aminoacids, antibiotics and a variety of micronutrients produced during the fermentation (Jayabalan *et al.* 2008). Many of these compounds are found in the tea composition (Table 3).
Table 3: The Composition of a Typical Tea Beverage, per cent (wt/wt) Solids

<table>
<thead>
<tr>
<th></th>
<th>Green Tea</th>
<th>Black Tea</th>
</tr>
</thead>
<tbody>
<tr>
<td>Catechins</td>
<td>30%</td>
<td>9%</td>
</tr>
<tr>
<td>Theaflavins</td>
<td>—</td>
<td>4%</td>
</tr>
<tr>
<td>Simple polyphenols</td>
<td>2%</td>
<td>3%</td>
</tr>
<tr>
<td>Flavonols</td>
<td>2%</td>
<td>1%</td>
</tr>
<tr>
<td>Other polyphenols</td>
<td>6%</td>
<td>23%</td>
</tr>
<tr>
<td>Theanine</td>
<td>3%</td>
<td>3%</td>
</tr>
<tr>
<td>Aminoacids</td>
<td>3%</td>
<td>3%</td>
</tr>
<tr>
<td>Peptided Protein</td>
<td>6%</td>
<td>6%</td>
</tr>
<tr>
<td>Organic acids</td>
<td>2%</td>
<td>2%</td>
</tr>
<tr>
<td>Sugars</td>
<td>7%</td>
<td>7%</td>
</tr>
<tr>
<td>Other carbohydrates</td>
<td>4%</td>
<td>4%</td>
</tr>
<tr>
<td>Lipids</td>
<td>3%</td>
<td>3%</td>
</tr>
<tr>
<td>Caffeine</td>
<td>3%</td>
<td>3%</td>
</tr>
<tr>
<td>Other methylxanthines</td>
<td>&lt;1%</td>
<td>&lt;1%</td>
</tr>
<tr>
<td>Potassium</td>
<td>5%</td>
<td>5%</td>
</tr>
<tr>
<td>Other mineralash</td>
<td>5%</td>
<td>5%</td>
</tr>
<tr>
<td>Aroma</td>
<td>Trace</td>
<td>Trace</td>
</tr>
</tbody>
</table>

Source: Harbowy and Balentine, 1997

Jayaban et al. (2008) demonstrated that Kombucha tea prepared from green tea, black tea and tea waste material have excellent antioxidant activities. Kombucha exhibited increased free-radical scavenging activities during fermentation. The extent of the activity however, depends upon the fermentation time, type of tea material and the normal microbiota of Kombucha culture, which in turn determined the forms of their metabolites. Although free-radical scavenging properties of Kombucha showed the time-dependent profiles, prolonged fermentation was not recommended because of accumulation of organic acids, which might reach harmful levels for direct consumption. The identification of extracellular key enzymes responsible for the structural modification of components during Kombucha fermentation and potent metabolites responsible for the free-radical scavenging abilities are necessary to elucidate the metabolic pathway during Kombucha fermentation. Metabolic manipulations may be one of the effective methods to elevate he antioxidant activities and fermentation efficiency of Kombucha.

Pasha and Reddy (2005) reported the nutritional and medicinal improvement of black tea by yeast fermentation. During experiment, black tea was fermented with D. hansenii for 10 days which resulted in accumulation of major vitamins, such as A, B1, B2, B12 and C in sufficient quantities to fulfill the recommended dietary allowances (RDA). Fermentation of tea by yeast resulted also in reduction of caffeine and excess tannins in significant amounts. After fermentation, the amount of theophylline was increased to make fermented tea a potent bronchodilator.

However, Kombucha consumption has proven to be harmful for individuals with preexisting conditions or illness or if incorrectly prepared (Greenwalt et al. 2000). Some results by researchers revealed that Kombucha can become contaminated with potentially harmful microorganisms, such as mould which may make it harmful for human consumption (Maysaer et al. 1995, Cavusoglu and Guler, 2010). Contamination may potentially produce serious adverse effects, and consumption of this may cause several problems such as nausea, jaundice, shortness of breath, throat tightness, vomiting, akathasia, headache, xerostomia, dizziness, liver inflammation, chronic liver disease and neck pain (Perone et al. 1995, Jayabalan et al. 2007, Cavusoglu and Guler, 2010).

Antimicrobial Activity of Kombucha

Application of natural antibacterial agents has been increasingly noticed as a novel trend in biological preservation of foods in recent years (Schillinger et al. 1996). Natural antibacterial agents have been increasingly applied for the biological preservation of food in recent years (Kumar et al., 2016). Antimicrobial activities of microbial fermented tea are much less known than its health beneficial properties. These antimicrobial activities are generated in natural microbial fermentation process with tea leaves as substrates. The antimicrobial components produced during the fermentation process have shown inhibitory effects against several food-borne and pathogenic bacteria (Sreeramulu et al. 2001). With the trend of increasing use of natural and biological...
preservatives in food products, natural antimicrobial agents from microbial fermented tea may offer an innovative and interesting measure for such applications (Kumar et al., 2016).

The acidity and mild alcoholic element of kombucha resists contamination by most airborne molds or bacterial spores. As a result, kombucha is relatively easy to maintain as a culture outside of sterile conditions. The bacteria and yeasts in kombucha may also produce antimicrobial defense molecules. Kombucha is a home-brewing product which means the preparation conditions are not sterile. Majority of the tests for Kombucha indicated that a low rate of contamination from spoilage and pathogenic microorganisms, suggesting that Kombucha has antimicrobial properties to pathogenic and other “bad” microorganisms (Mayer et al., 1995).

Some studies reported that antimicrobial activity of Kombucha against a range of bacteria, made with a low tea usage level (4.4 g/L), was at ributable to the acetic-acid content (Steinkraus et al. 1996, Greenwalt et al., 1998). While Sreeramulu et al. (2001) revealed that the antimicrobial components of Kombucha are compounds other than organic acids, ethanol, proteins or tannins in tea or their derivates after systematic investigation.

Rodrigo et al. (2009) conducted research on antimicrobial activity of broth fermented with Kombucha colonies. They reported that The fermented growth was efficient against Microsporum canis (LM-828), Escherichia coli (CCT-0355) and Salmonella typhi (CCT-1511). The best conditions of inhibition against M. canis (>32mm) and E. coli (16 mm) was observed at pH 4.0, 55% of commercial sugar and 0.10 g/l of MgSO₄ and for S. typhi (32 mm) without MgSO₄. Gut apadu et al. (2000) investigated antimicrobial activity of Kombucha against a number of pathogenic microorganisms.

Staphylococcus aureus, Shigella sonnei, Escherichia coli, Aeromonas hydrophila, Yersinia enterolytica, Pseudomonas aeruginosa, Enterobacter cloacae, Staphylococcus epidermis, Campylobacter jejuni, Salmonella enteritidis, Salmonella typhimurium, Bacillus cereus, Helicobacter pylori, and Listeria monocytogenes were found to be sensitive to Kombucha. Acetic acid is considered to be responsible for the inhibitory effect toward a number of microbes tested. However, Kombucha proved to exert antimicrobial activities against E. coli, Sh. sonnei, Sal. typhimurium, Sal. enteritidis, and Cm. jejuni, even at neutral pH after thermal denaturation. They also suggests the presence of antimicrobial compounds other than acetic acid and large proteins in Kombucha.

Greenwalt et al. (1998) conducted research to determine and characterization of antimicrobial activity of the fermented tea Kombucha. They reported that the fermented samples containing 33g/l total acid (7g/l acetic acid) was significant against the tested gram positive and gram negative pathogenic organisms (Agrobacterium tumefaciens, Bacillus cereus, Salmonella cholerasuis serotype typhimurium, Staphylococcus aureus and Escherichia coli). Candida albicans was not inhibited by Kombucha. Tea, at drinkable levels, demonstrated no antimicrobial properties, even at the highest levels tested; 70 g/l (7%) dry tea. The antimicrobial activity of Kombucha was at ributed to its acetic acid content. Kumar et al. (2016) studied the antimicrobial effect of different types of apple tea wine prepared using different types of tea at different concentrations against Escherichia coli (IGMC), Enterococcus faecalis (MTCC 2729), Listeria monocytogenes (MTCC 839), Staphylococcus aureus (MRSA 252) and Bacillus cereus (CRI) and reported that all apple tea wines showed antimicrobial activity (inhibition zone >7 mm) against all these microbes.

**Conclusion and future prospects**

Tea cider known as “Kombucha” or “tea kvass”, tasting like sparkling apple cider is commonly produced at home by fermentation using a tea fungus (acetic acid bacteria and yeast). No doubt, black tea and white sugar are the common substrates for the preparation of the Kombucha but recently researchers took shift and used different types of the tea and sugar sources as well as nitrogen sources for Kombucha preparation with improved quality characteristics. A glimpse of literature revealed that Kombucha is a good source of the bioactive compounds which make
it as a functional beverage. But, still a few aspects are untouched in the Kombucha industry such as utilization of fruit juices as a substrate along with the tea for the preparation of Kombucha, maturation of Kombucha and effect of Kombucha on human being in in-vitro trials which need to be explored for further improvement in Kombucha.

References


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