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Kombucha and Health

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Abstract: Kombucha is a fermented drink produced by fermentation of sweetened black and/or green tea with kombucha culture, it is known to have health benefits. The microflora of this fermented beverage mostly consists of AAB (acetic acid bacteria) and yeasts. Depending on its origin, LAB (lactic acid bacteria) sometimes will also be able to be found in the microflora. The production of kombucha and formation of its beneficial components are the result of the metabolic activities of this microflora. This fermented tea has been produced and consumed in the Far East for hundreds of years as a tradition; it is used as an adjunctive treatment for certain diseases. The interest in this tea has increased recently, and kombucha has spread worldwide. Its microflora diversity and metabolites are becoming important subjects of scientific studies. Although there are a few companies in Turkey that manufacture and market kombucha, there is no comprehensive scientific study on this subject. The liquid portion of kombucha is claimed to have various medicinal effects on human health. Recent studies have suggested that kombucha tea prevents paracetamol induced hepatotoxicity and chromate induced oxidative stress in albino rats. As kombucha tea is rich in compounds known to be strong antioxidants, it is expected to ameliorate liver damage. This beneficial effects of kombucha tea are attributed to the presence of tea polyphenols, gluconic acid, glucuronic acid, lactic acid, vitamins, amino acids, antibiotics and a variety of micronutrients produced during fermentation. The functional character of the kombucha should be investigated by a larger number of scientific studies. Co-use or self-use with various foods of this tea should be widespread.

Key words: Kombucha, health, food.

1. Introduction

Dietary habits are of the leading social concepts that change because of increase in world population, urbanization, industrialization, and globalization at the present time. Health problems which are increased with the changing dietary habits have put the importance of healthy, balanced, and conscious nutrition and have raised the interest of people on natural, functional, and reliable foods. Traditional fermented foods that are both natural and functional meet this interest. Recently, scientific studies aiming to increase popularity of different fermented foods which are traditionally produced and consumed in numerous regions in the world, to determine their functionality, and to define active substances providing this functionality have been conducted. Kombucha tea is one of these traditional fermented foods [1].

Kombucha tea is a traditional fermented beverage that is produced by fermenting sweet black and/green tea by using kombucha culture and has been consumed for thousands of years. This fermented beverage, origin of which is from far east countries has spread to several parts of the world in time particularly Russia and Germany and has started to be traditionally produced and consumed [2-4].

Kombucha tea is produced by using the kombucha culture floats in the nutrient solution of tea and sugar under aerobic conditions during the fermentation period [5]. Kombucha culture playing a role as a natural starter in the fermentation is a gel-like membranous layer containing primary AAB (acetic acid bacteria) and yeasts in its microflora. Microbiota of this membranous layer differs depending on its origin and sometimes also includes lactic acid bacteria. As is in all fermented products, content and activity of starter culture in kombucha tea and metabolites produced as a result of this activity affect functionality of the final product.

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2. Functionality of Kombucha Tea

The most significant known functional property of kombucha tea is that it has positive effect on health. This fermented beverage which has been produced and consumed for centuries particularly in Far East is also known to be used by the public to prevent disorders. Positive effect of kombucha tea on health is especially associated with microorganisms playing role in fermentation process and their metabolites. The amount, ratio, and diversity of microorganisms found in microbiota of kombucha culture and fermentation time and temperature of the tea is effective in the content of bioactive components of the final product obtained after fermentation. In addition, differences in raw material (black tea, green tea, etc.) used in the production may also differ the content of kombucha tea.

Generally, the beneficial effects of kombucha tea are attributed to the presence of tea polyphenols, gluconic acid, glucuronic acid, lactic acid, vitamins, amino acids, antibiotics and a variety of micronutrients produced during fermentation [6]. Day by day, people are increasingly concerned about protection from similar diseases such as cardiovascular diseases, atherosclerosis, cancers, gene mutations, and diabetes. Many studies have been reported where the protective effect of tea against these diseases have been evaluated.

3. Kombucha Tea and Biochemical Activity

3.1 Antioxidant Activity of Kombucha Tea

Foods rich in some phytochemicals such as polyphenols, flavonoids, isoflavons, phenolic acids, carotenoids, cumarins which prevent formation of free radical, decrease oxidative stress, and help humans to protect against degenerative disorders have high antioxidant activity [7]. Previous studies have indicated that black tea or green tea are rich in antioxidant substances such as polyphenols and flavonols (theaflavins and thearubigins), catechins, caffeine [8]. Therefore, the variety and amount of tea used as raw material in production of kombucha tea and the end product of fermentation are supposed to influence antioxidant activity. Jayabalan et al. [9] investigated free-radical scavenging abilities, total phenolic compound contents, and reductive ability of kombucha teas in an 18-day fermentation process. It was determined that there were temporal increases and decreases in reductive ability values of all samples during the fermentation process, values (especially, 0.6 absorbance value at 700 nm on 15th day) of kombucha tea produced using green tea were higher compared to others. Total phenolic compound content of teas was observed to increase at the rate of ~20% in green tea sample and at the rate of ~10% in samples of black tea and tea wastes during fermentation process. DPPH scavenging ability and inhibitory ability against linoleic acid peroxidation and superoxide radical scavenging ability also increased in all samples during fermentation process, but hydroxyl radical scavenging ability and anti-lipid peroxidation ability decreased. These changes were explained with increased acidity occurring in fermentation process of complex phenolic compound in samples and degradation of the enzymes liberated by bacteria and yeast in tea consortium.

Malbaša et al. [10] investigated the effect of the use of black and green tea used with natural starter kombucha tea layer, mixed culture of AAB + *S. cerevisiae* (SC1) band mixed culture of AAB + *Zygosaccharomyces* spp. (SC2) on antioxidant activity. While kombucha tea produced from black tea showed the highest antioxidant activity to both types of radicals with starter SC1, the green tea showed the highest activity with native kombucha. This result was thought to arising from culture difference. This is because interactions between microorganisms are known to play an important role in diversity of bioactive component in fermented products including rich microbiota and their production amount.

Chakravorty et al. [11] determined scavenging activity of kombucha tea against DPPH, ABTS, hydroxyl, and nitric oxide radicals by using the concentration (IC50 mg/mL) allowing 50% inhibition of radicals. IC50 value was reported to decrease at the rate of 39%, 96%, 92%, and 96% for DPPH, ABTS, hydroxyl, and nitric oxide radicals during a 21-day fermentation process, respectively. Decreased IC50 value was shown as the proof of increased antioxidant capacity. Chu and Chen [12] determined that antioxidant activity of kombucha tea increased at the rate of approximately 70%, 40%, and 49% respectively according to tests of DPPH, ABTS radical scavenging activity, and inhibition of linoleic acid peroxidation at the end of 15-day fermentation process. However, ferrous ion binding ability, which is another test for determination of antioxidant activity, was inversely diminished by 81%. Reduction of ferrous ions by components like ascorbic acid (Vitamin C) synthesized during fermentation of kombucha tea was shown as the cause of this interesting case [13].

3.2 Kombucha Tea and Vitamin C

Kombucha tea is a beverage substantially rich in vitamin C. Particularly some AAB strains found in microflora of this fermented tea are known to play a role in synthesizing vitamin C (vitamin C content in kombucha tea before and after fermentation is to about 0.71-1.51 mg/mL, respectively) [14]. Vitamin C possessing numerous positive effects on health such as strong immune system, collagen production, wound healing, tooth and gingiva health, regeneration of skin, cartilage, tendon, connective tissue and blood vessels is also one of the most common antioxidant vitamins. Therefore, vitamin C helps ward off many illnesses associated with oxidation [15].

In the above-mentioned study by Malbaša et al. [10], AAB and two different yeast isolates used as starter were found to have different effects on synthesizing of vitamin C during fermentation process. The increase in vitamin C content of kombucha tea produced by using black tea during fermentation process was similar for those in which SC1 starter culture and natural starter culture were used and was higher than tea in which SC2 starter culture was used. The increase in vitamin C content of kombucha tea produced using green tea was the highest in the sample with natural starter. In addition, it was stated that there was a positive correlation between vitamin C content and antioxidant activities of the samples.

Locar et al. [16] stated that temperature increased during a twenty-one day fermentation process at 22 ^{o}C, 30 ^{o}C, and 35 ^{o}C in kombucha tea produced using black tea positively affected vitamin C content of samples. Vitamin C content of kombucha tea was determined as ~1.51 mg/mL by Bauer-Petrovska and Petrushevska-Tozi [14].

3.3 Antimicrobial Activity of Kombucha Tea

Antimicrobial components in kombucha tea are very likely metabolites produced by the bacteria and/or yeasts responsible for the fermentation of Kombucha. The most important one among these components is high acetic acid content. Additionally, ethanol and various organic acids also play a role in antimicrobial activity [17, 18].

Greenwalt [17] prepared teas by using leaves of black tea and green tea. Samples in which the same tea type was used as raw material were then divided in two, fermented kombucha tea was produced (until total acid content reached up to 33 g/L) from one half, and the other half was not fermented. Samples taken from fermented teas were also divided in two parts again and pH of one half was adjusted at 7 in order to eliminate the effect of organic acids (especially acetic acid). Fermented kombucha tea was determined to display antimicrobial activity against *Agrobacterium tumefaciens, Bacillus cereus, Salmonella choleraesuis serotype typhimurium, Staphylococcus aureus*, and *Escherichia coli* but not against *Candida albicans* 12983 strain. Non-fermented tea and neutralized fermented tea, on the other hand, did not show significantly antimicrobial activity. Therefore, it was stated that antimicrobial activity of kombucha tea was concluded to be arising from acetic acid (~6.5 g/L).

Sreeramulu et al. [18] established that kombucha tea showed antimicrobial activity against microorganisms of *Staphylococcus aureus, Shigella sonnei, Escherichia coli, Aeromonas hydrophila, Yersinia enterolitica, Pseudomonas aeruginosa, Enterobacter cloacae, Staphylococcus epidermidis, Campylobacter jejuni, Salmonella enteritidis, Salmonella typhimurium, Bacillus cereus, Helicobacter pylori*, and *Listeria monocytogenes*; and showed antimicrobial activity particularly against *E. coli, Sh. sonnei, Sal. typhimurium, Sal. enteritidis, and Cm. jejuni* at neutral pH and after thermal denaturation. This result suggests the presence of antimicrobial compounds other than acetic acid and large proteins in Kombucha.

Antimicrobial activities of 3 fermented teas produced by separately using isolates of Lactobacillus acidophilus, Lactobacillus casei, and Lactobacillus plantarum isolated from kefir together with kombucha culture layer and 1 fermented tea produced as control by using only kombucha culture layer, and non-fermented tea were compared by Nguyen et al. [19]. It was determined that kombucha culture layer and LABs used together increased antimicrobial activity; fermented tea in which kombucha culture layer and isolates of L. plantarum were used together as starter culture displayed the highest antimicrobial activity against tested *E. coli, B. cereus*, and *S. typhimurium* strains (17, 15, 17.8 mm, respectively).

In the study by Deghrigue et al. [20], antimicrobial activities of kombucha teas produced using black and green teas and non-fermented tea as control against Gram-positive (*Staphylococcus epidermidis, Staphylococcus aureus, Micrococcus luteus, Enterococcus faecalis* and *Listeria monocytogenes*) and Gram-negative (*Escherichia coli, Salmonella enterica serovar typhimurium* and *Pseudomonas aeruginosa*) bacteria were examined by determining minimum inhibition concentration (MIC µg/mL). Generally, kombucha teas showed higher antimicrobial activity to strains of *E. coli* (150 µg/mL) and *P. aeruginosa* (228 µg/mL) from Gram-negatives and *M. luteus* (216 µg/mL, only green tea) and *E. faecalis* (225 µg/mL) from Gram-positive pathogens. It was determined that type of tea used in the used in the production showed difference only in terms of strains of *S. epidermidis* and *L. monocytogenes* and the use of black tea was more effective.

3.4 The İmportant Two Bioactive Compounds of Kombucha Tea

Components with different functional properties form as a result of activities of microorganisms during kombucha tea fermentation. Glucuronic acid is the most crucial one from these components [4, 21]. Glucuronic acid, is an uronic acid with the ability of detoxifying numerous toxic substances such as pollutants, exogenous chemicals, excess steroid hormones, and bilirubin from the human body via the urinary system [22]. Glucuronic acid also acts as a precursor in biosynthesis of vitamin C [23]. Glucuronic acid content of kombucha tea is associated with AAB with the ability of synthesizing glucuronic acid in its microflora. It was also stated that there was a symbiotic relationship between ABB species and yeasts producing glucuronic acid.

Nguyen et al. [21] determined that 2 of 4 isolates isolated from kombucha culture layer had the ability of producing glucuronic acid and *Gluconacetobacter intermedius* KN89 was the isolate producing this acid at most. They developed *Gluconacetobacter intermedius* KN89 AAB strain and *Dekkera bruxellensis* KN89 yeast strain together by combining them at different rates in order to investigate AAB and yeast interaction on the ability of producing glucuronic acid. The optimal combination was 4/6 (yeast/bacteria) and this combination made glucuronic acid content reach up to 175.8 mg/L at the end of 7-day fermentation in medium.

Nguyen et al. [19] also determined that the use of kombucha culture layer together with Lactobacillus casei or Lactobacillus plantarum strain in production of kombucha tea increased the amount of glucuronic acid compared to single kombucha culture, and the highest increase was obtained in its use together with strain of *Lactobacillus casei* (42.3 mg/L).

Another component examined in kombucha teas is (DSL) D-saccharide acid 1,4 lactone which may also be expressed as D-glucaric acid. DSL is among the investigated topics due to its cholesterol decreasing effect in Ca-D-glucarat form and its usability in fields such as diabetes treatment and cancer chemotherapy [24, 25]. Furthermore, the compound is believed to be a key ingredient behind the hypocholesterolemic effects [26], and also the hepatoprotective property of Kombucha tea against acetaminophen induced hepatotoxicity [3, 26, 27]. In the study by Yang et al. [28], the use of all of 10 different LAB strains together with *Gluconacetobacter* spp. A4 as the starter was found to increase DSL production. The LAB promoted DSL production of *Gluconacetobacter* spp. A4 to different extents, ranging from 4.86% to 86.70%. LAB's metabolites, xylitol, and acetic acid were utilized by *Gluconacetobacter* spp. A4, and it promoted the growth of *Gluconacetobacter* spp. A4 and yield of DSL.

3.5 Some Medical Experimental Studies on Kombucha Tea

In some of the studies on medical field, it was reported that kombucha tea inhibited the angiogenesis of prostate cancer cells [29], prevented paracetamol-induced hepatotoxicity [30], inhibited pancreatic alpha-amylase in the small intestine [31], and had potent antioxidant properties such as decrease of the degree of lipid oxidation and DNA fragmentation [2, 32].

Gharib [33] studied the effect of kombucha tea on nephrotoxicity induced by TCE (trichloroethylene) which is a nephrotoxic agent, in rats. In this study, twenty male albino rats were divided into four groups: (1) the control group treated with vehicle, (2) Kombucha (KT)-treated group, (3) TCE-treated group, and (4) KT/TCE-treated group. Renal lipid peroxidation, glutathione content, nitric oxide, and total free radical concentration in the blood were measured. This study indicated that Kombucha may repair damage caused by environmental pollutants such as TCE and may be beneficial to patient suffering from renal impairment.

In their study, Jayabalan et al. [34] examined prophylactic and therapeutic effect of kombucha tea prepared using non-fermented black tea and green tea on aflatoxin B1 induced liver damage in male albino rats. Consequently, it was revealed that kombucha tea was stronger in preventing hepatotoxicity compared to non-fermented tea.

Aloulou et al. [35] investigated and compared hypoglycemic and antilipidemic effects of kombucha and black teas in diabetic rats. Compared to black tea, kombucha tea was revealed to inhibit α-amylase and lipase activities in plasma and pancreas better and to suppress increased blood glucose levels better.

In the study conducted by Bhattacharya et al. [36] to compare non-fermented black tea and kombucha tea, kombucha tea was indicated to have a significant antidiabetic potential in diabetic rats induced with ALX (alloxan is a potent generator of reactive oxygen species).

Deghrigue et al. [20] studied antiproliferative effect of kombucha tea on two human cancer cells (A549, lung cell carcinoma and Hep-2, epidermoid carcinoma) and stated that treatment with kombucha tea inhibited growth of cancer cells depending on dose.

4. Conclusions and Future Trends

In the light of this information, it will be possible to assert that kombucha tea which may also be used traditionally in alternative medicine has important functional properties. According to results obtained from the study, differences are known to occur in its functional property based on raw material, starter culture, and fermentation conditions used in the production. Therefore, the effects of these factors on production of components revealing the known benefits of kombucha tea need to be clarified by thoroughly studying the methods of kombucha tea production. Studies to be conducted on this field would ensure a more beneficial and standard kombucha tea production and thus production would be likely shifted in large-scale industrial business enterprises. This conclusion would allow Kombucha tea production both responding to utility demand of the consumer better and being more economical.

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