Myths and Potential Benefits of Kombucha as a Functional Food: A Review

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ABSTRACT

Functional foods, known for their health benefits, are gaining popularity with increased public health awareness, and fermented foods and beverages like kombucha are remarkably esteemed. Kombucha, a fermented Japanese tea, ferments sugared black tea with a SCOBY, creating a drink rich in polyphenols, organic acids, vitamins, amino acids, and micronutrients. This review explores kombucha's health benefits, including antihypertensive effects, blood glucose regulation, antidiarrheal properties, and antithrombotic activity. Additionally, kombucha enhances immune function through riboflavin production, exhibits antihyperglycemic effects in diabetic models, and shows antiproliferative activities against cancer cells. Its cardiovascular benefits are linked to improved blood cholesterol, blood pressure, and endothelial function. The fermentation process also produces a cellulose biofilm with diverse applications. As a functional food, Kombucha holds promise for preventing and managing various health conditions, warranting further research into its bioactive components and mechanisms.

Keywords: Kombucha, Bioactive compounds, Functional food, Health benefits, Fermentation.

INTRODUCTION

Functional foods are those that offer health benefits to consumers (Das et al., 2011). With increasing public awareness of healthy eating, these foods have become trendy. Fermented foods and beverages are a popular type of functional food among people. The health benefits of certain foods have long been recognised. Building on extensive anecdotal evidence, recent studies have investigated various potential advantages, such as antihypertensive effects, particularly in fermented foods. (Ferreira et al., 2007 Nakamura et al., 2013 Koyama et al., 2014 Ahren et al., 2014), Blood glucose-bringing down advantages (Kamiya et al., 2013; Goodness et al., 2014), antidiarrheal (Kamiya et al., 2013; Parvez et al., 2006), and antithrombotic properties (Kamiya et al., 2013). The extensive assessment of matured nourishment substances and how they may give medical advantages has prompted the focus on recognisable proof of specific vitamins, minerals, amino acids, and phytochemicals (e.g., phenolics, unsaturated fats, and saccharides) that recognise aged sustenances from their nonfermented frames (Rodgers, 2008 Rodriguez et al., 2009 Capozzi et al., 2012 Sheih et al., 2014 Xu et al., 2015). Furthermore, the evidence for bioactive components resulting from the fermentation of plants and animal products is rapidly increasing with the application of new technologies, such as metabolomics (Lee *et al.*, 2009; Yang *et al.*, 2009; Kim *et al.*, 2012; Liu *et al.*, 2014). Fermented drinks are widely known by the people: kefir, yoghurt, tepache, wine, and kombucha.

Kombucha, a fermented tea beverage from Japan, is believed to have body-nourishing properties. It is made by fermenting sugared black tea with a symbiotic culture of acetic acid bacteria and yeast, forming a cellulose-like pellicle on the surface over about 14 days. Kombucha comprises a floating cellulose pellicle layer and a sour liquid broth (Chen & Liu, 2000). This beverage has been consumed in Asia for over two millennia and is famous worldwide among traditional fermented foods. The putative health benefits associated with drinking

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kombucha have been primarily attributed to the polyphenolic components of kombucha that have been transformed from black tea. In addition, organic acids, vitamins, amino acids, antibiotics and a variety of micronutrients produced during the fermentation of kombucha may also have a role in the health benefits to some extent (Vijayaraghavan *et al*., 2000). This journal will discuss the myth of the benefits of consuming kombucha.

LITERATURE REVIEW

Kombucha

Kombucha is a fermented beverage globally consumed because of the health benefits reported by the users. This product has a slightly acidic, carbonated, sweet taste and is mainly prepared at home. The fermentation process results from the metabolic activity of kombucha culture (*symbiosis of bacteria and yeasts*) on sweetened black or green tea, the most common substrate. During fermentation, acetic acid bacteria also produce the cellulosic pellicle layer, and this biofilm has numerous applications (Jayabalan et al., 2016). Successful kombucha fermentation is conducted in glass vessels under static conditions, on substrates that contain a source of carbon (mainly sucrose) and nitrogen (different tea components) atoms, protected from direct sunlight at room temperature.

Kombucha is made by fermenting the sugar present in the tea solution using SCOBY (*symbiotic culture of bacteria and yeast*), which consists of bacteria in the form of *Acetobacter aceti* and yeast in the form of *Saccharomyces cerevisiae*. In addition to *Acetobacter xylinum* and *Saccharomyces cerevisiae*, according to Greenwalt *et al*. (2000), kombucha culture consists of *Acetobacter xylinum*, Acetobacter aceti, Acetobacter pasteurianus, Gluconobacter and yeast species Brettanomyces (*Bretanomyces bruxellensis, Brettanomyces intermedius*), Candida (*Candida fatama*), Mycoderma, Mycotorula, Phichia (*Pichia membrana efacius*), Saccharomyces (*Saccharomyces cerevisiae* subp. Aceti, *Schizosaccharomycees*), Torula, (*Torulaspora delbbrueckii, Torulopsis*), Zygosaccharomyces (*Zygosaccharomyces bailii, Zigosaccharomyces rouziz*).

Acetobacter xylinum and *Saccharomyces cerevisiae* initiate reshuffle by breaking sucrose into glucose and fructose (Chen & Liu, 2000; Loncar *et al*., 2006 in Kustyawati and Ramli, 2008). Then, glucose and fructose are continuously broken down into organic acids and alcohol until the sugar in the kombucha solution runs out. So, the resulting acid will continue to increase as the fermentation time gets longer (Aditiwati & Kusnadi, 2003).

Fermentation occurs when carbohydrates, amino acids, and fats are broken down with the help of enzymes from certain microbes that can produce organic acids, carbon dioxide, and other substances. The fermentation process can change the physical and chemical properties of foodstuffs, including starch content, alcohol content, total acid, and pH (Winarno, 2002). The longer kombucha fermentation increases acidity (Aditiwati & Kusnadi, 2003).

The yeast grown in a medium with a high sugar concentration will synthesise glucose by 3-20%, while the remaining glucose will be utilised through the fermentation pathway (Moat et al., 2002). Fermentation through the glycolysis pathway produces pyruvic acid. Under anaerobic conditions, pyruvate decarboxylase will decompose pyruvic acid into ethanol and carbon dioxide (Madigan *et al*., 2002).

According to Wood (1998), the process of fermenting sugar (conversion of glucose into alcohol and O_2) by yeast occurs through the following reactions:

$$\underset{\text{(Glucose)}}{C_6H_{12}O_6} \xrightarrow[\text{anaerobic}]{\text{Yeast}} \underset{\text{Ethyl alcohol (ethanol)}}{2C_2H_5OH} + \underset{\text{(Carbon diokside)}}{2CO_2}$$

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Moat *et al*. (2002) add that yeast's ability to ferment sugar is determined by a transportation system and an enzyme system that hydrolyse sugar with an alternative electron acceptor other than oxygen under anaerobic facultative conditions.

In the yeast fermentation process, *Saccharomyces cerevisiae* produces alcohol anaerobically. Then alcohol stimulates *Acetobacter xylinum* growth to produce acetic acid in aerobic, while acetic acid stimulates Saccharomyces cerevisiae's growth. This continues until the sugars in the kombucha solution turn into organic acids needed by the body, such as acetic acid and others (Chen & Liu, 2000; Loncar *et al*., 2006 in Kustyawati and Ramli, 2008). *During fermentation, saccharomyces cerevisiae can produce 70% organic acids such as acetic, malic, succinic, and pyruvic acid* (Akita, 1999 in Gandjar *et al.*, 2006). Yeast of the genus *Issatchenkia, Kluyveromyces, Saccharomyces* and *Zygosaccharomyces* can also ferment glucose (Barrnet *et al*., 1990; Kurzman and Fell., 1998).

Acetobacter xylinum can simultaneously oxidise glucose to gluconic acid and other organic acids. In addition, Acetobacter xylynum can synthesise glucose into polysaccharides or cellulose as white fibres. Cellulose forms a gradual jelly-like layer until it reaches a thickness of about 12 mm at the end of fermentation, which can be used as an inoculum in the further fermentation process (Aditiwati & Kusnadi, 2003).

According to Dufresne and Farnword (2000), kombucha has efficacy for human health, including Atherosclerosis and cardiovascular diseases, cancer and gene mutations, Diabetes and renal failures, Antibacterial and antiviral activity, etc. Kombucha also contains organic acids, vitamins, amino acids, antibiotics, and various micronutrients (Vijayaraghavan *et al*., 2000).

Health Benefits from Kombucha

Imune Sistem Source

The types of polyphenols and flavonoids serve to keep the immune system, but some can also turn into riboflavin. Riboflavin serves as a precursor for the coenzymes flavin adenine dinucleotide (FAD) and flavin mononucleotide (FMN) and, therefore, plays a crucial role in energy metabolism, especially metabolism of fats, ketone bodies, carbohydrates, and proteins, as well as drug metabolism. Riboflavin supports the immune and nervous system, forms red blood cells, produces cells, and activates folate and pyridoxine. Riboflavin also has a powerful antioxidant potential derived from its role as a precursor to FMN and FAD. Consequently, riboflavin deficiency is associated with increased lipid peroxidation (Frias *et al*., 2017)

In 1970, van Veen and Steinkraus reported an increase of riboflavin in fermented food that was confirmed in 1984 by Murdock and Fields, who observed that the riboflavin content in fermented cornmeal was increased compared to the unfermented control. The changes in vitamin content mainly occur at the beginning of fermentation. The riboflavin concentration in cornmeal increased from 1.4 μg/g in the control to 2.9 μg/g after one day and 4 μg/g after two days of fermentation (Friaz *et al*., 2017).

In kombucha fermentation, the bacterial Candida fatama can produce riboflavin. It is the same line with (Burgess *et al*., 2006; LeBlanc *et al*., 2011; Russo *et al*., 2014). They said that the screening of strains for riboflavin generation brought about an impressive number of microbial varieties, for example, *B. subtilis, Ashbya gossypii, Candida famata, Corynebacterium ammoniagenes,* and a few LAB. Among Them, *the most promising were Lactobacilli, Leuconostoc, Lactococci, and Propionibacterium*.

Diabetes Mellitus

Diabetes mellitus is a gathering of metabolic issues portrayed by hyperglycaemia coming about because of deformities in insulin discharge, activity or both. Some thoughts outline the antihyperglycemic impacts of lyophilised concentrates from kombucha in streptozotocin-prompted mice. After the test time of 45 days, we watched that kombucha supplementation with 6 mg/kg bw fundamentally diminished glycosylated haemoglobin (HbA1c) and expanded the levels of plasma insulin, haemoglobin and tissue glycogen, which was diminished up on streptozotocin (STZ) treatment and essentially switched the adjusted exercises of gluconeogenic proteins, glucose-6-phosphatase, fructose-1,6-bisphosphatase and glycolytic catalysts, for example, hexokinase in the tissues of trial rats. In this way, our outcomes substantiate that kombucha was found to have a hypoglycaemic impact on STZ-prompted diabetic rats. These discoveries recommend that kombucha might be considered a potential utilitarian sustenance contender for future applications as a helpful nourishment supplement for the treatment and anticipation of diabetes (Srihari et al., 2013a)

Anticancer

Chemoprevention utilising a mix of dietary phytochemicals with various components has been proposed as a fruitful way to control diverse kinds of disease with fewer symptoms. Kombucha tea has been genuinely asserted to have anticancer properties by kombucha consumers for a long time. It has been asserted to have anticancer properties, given individual perceptions and tributes. A populace has likewise guaranteed its contemplation led in Russia by the "Focal Oncological Exploration Unit" and the "Russian Institute of Sciences in Moscow" in 1951 (Dufresne & Farnworth, 2000). Cetojevic-Simin and others (2008) researched the antiproliferative action of kombucha drinks from dark tea and winter savoury tea (*Satureja montana* L.) on HeLa cells (cervix epithelial carcinoma), HT-29 (colon adenocarcinoma), and MCF-7 (bosom adenocarcinoma) utilising the sulforhodamine B colourimetric test. They detailed that the antiproliferative impact of kombucha winter exquisite tea was tantamount to that of conventional kombucha dark tea and reasoned that kombucha arranged from winter appetising tea may have more dynamic antiproliferative parts than basic water concentrates of winter savoury tea. An ethyl acetic acid derivation part of kombucha dark tea, which contained dimethyl 2-(2-hydroxy-2-methoxypropylidene) malonate and vitexin at a convergence of 100 μg/mL, caused cytotoxic consequences for 786-O (human renal carcinoma) and U2OS (human osteosarcoma) cells, altogether lessened the cell attack and cell motility in A549 (human lung carcinoma), U2OS and 786-O cells, and decreased the exercises of framework metalloproteinase-2 (MMP-2) and MMP-9 out of 786-O cells and MMP-2 movement in A549 cells (Jayabalan, et al 2011). Lyophilised kombucha tea remove altogether diminished the survival of prostate tumour cells by downregulating the declaration of angiogenesis stimulators like network metalloproteinase, cyclooxygenase-2, interleukin, endothelial development factor, and human inducible factor-1α (Srihari et al., 2013b). This examination demonstrated the exceptional capability of kombucha in repressing angiogenesis through modifications in the outflow of angiogenic stimulators. The conceivable anticancer components of tea polyphenols acknowledged by most analysts presently are as per the following: (1) restraint of quality transformation; (2) hindrance of malignancy cell multiplication; (3) enlistment of growth cell apoptosis; and (4) end of metastasis (Conney and others 2002; Ioannides & Yoxall, 2003; Stop and Dong 2003). Anticancer properties of kombucha tea may be because of the nearness of tea polyphenols and their corruption items shaped amid ageing.

Lowering of blood cholesterol, blood pressure and incidence of cardiovascular diseases

Kombucha is produced using different kinds of tea, from dark to green. The mitigation of MetS by tea is relied upon to diminish the hazard of CVDs (Deka & Vita, 2011; Di Castelnuovo et al., 2012; Munir et al., 2013). Two investigations from China and Japan accounted for the relationship between the utilisation of tea and the diminished danger of stroke (Liang et al., 2009; Kokuboyo et al., 2013). A meta-examination of 14 forthcoming investigations, covering 513,804 members with a middle follow-up of 11.5 years, found a reverse relationship between tea utilisation and the danger of stroke, and the defensive impact of green tea had all the earmarks of being more grounded than that of dark tea (Shen, L. et al., 2012). Many, yet not all, examined in the U.S. Furthermore, Europe exhibited a converse relationship between dark tea utilisation and CVD chance (Deka & Vita, 2011; de Koning et al., 2010; Mukamal et al., 2006; Sesso et al., 2003). A meta-examination, including six case-control and 12 partner ponders (5 estimated green tea and 13 estimated dark tea as the introduction), found a decreased danger of coronary supply route illness by 28% utilizing green tea utilisation; nonetheless, there was no critical defensive impact from dark tea (Wang et al., 2011).

Green tea has appeared to diminish plasma cholesterol levels and pulse and additionally enhance insulin affectability and endothelial capacity in people (Munir et al., 2013; Hartley et al., 2011). A deliberate audit and meta-investigation of 10 preliminaries (834 members) on the impacts of green tea on circulatory strain in pre-hypertensive and hypertensive people indicated huge decreases in systolic and diastolic pulse with tea

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utilisation (Yarmolinsky et al., 2015). A comparative meta-investigation of 14 RCTs additionally found that GTE supplementation caused a little, however critical, decrease in circulatory strain among overweight and fat grown-ups (Li G et al., 2015).

Useful impacts of tea catechins in bringing down plasma cholesterol levels, anticipating hypertension and enhancing endothelial capacity add to the counteractive action of CVDs. The cholesterol-bringing impact is likely due to the lessening of cholesterol assimilation or reabsorption by catechins and, in addition, the decline of cholesterol combination employing the restraint of HMGR (intervened by the initiation of AMPK). Upgraded nitric oxide flagging has been recommended as a typical instrument for catechins to diminish pulse and the seriousness of myocardial dead tissue (Munir et al., 2013). A few investigations have demonstrated that green tea or dark tea polyphenols expanded endothelial nitric oxide synthase (eNOS) movement in cow-like aortic endothelial cells and rodent aortic rings (Jouchmann et al., 2008; Aggio et al., 2013; Ng HL et al., 2017). An ongoing report in rodent skeletal muscle proved that the EGCG-instigated vasodilation was intervened by eNOS (Ng HL et al., 2017). Tea catechins may likewise stifle the declaration of caveolin-1, a negative controller of eNOS, bring down the statement of endothelin-1, and lessen vasoconstrictor tone; along these lines, expanding bioavailability of nitric oxide to enhance endothelial capacity (Li Y., 2009; Akiyama et al., 2009). EGCG has appeared to initiate the outflow of heme oxygenase 1 in aortic endothelial cells (Pullikotil et al., 2012), and this may increment calming action to profit the cardiovascular framework. While direct measurements of EGCG have yielded advantageous impacts, a high dosage (1% in eating less carbs) has appeared to advance, as opposed to lessening, vascular irritation in hyperglycemic mice (Pea M et al., 2012). In an ongoing traverse RCT with 19 hypertensive patients, supplementation with dark tea (150 mg polyphenols twice a day by day for 8 days) expanded practically dynamic circling angiogenic cells and stream interceded enlargement (Grassi et al., 2016). These discoveries exhibit that dark tea likewise has vascular defensive properties.

CONCLUSION

Kombucha is a beverage fermented by a mixed microorganism culture between bacteria and yeasts derived from various types of tea. Kombucha can be used as functional food because it is an anticancer source, reducing blood pressure, reducing the occurrence of degenerative diseases. microorganisms present in kombucha can produce Riboflavin which is useful for health

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