



## Brief communication

## Kombucha: a systematic review of the empirical evidence of human health benefit

Julie M. Kapp, MPH, PhD, FACE <sup>a,b,\*</sup>, Walton Sumner, MD <sup>c</sup><sup>a</sup> Department of Health Management and Informatics, School of Medicine, University of Missouri, Columbia<sup>b</sup> Harry S Truman School of Public Affairs, University of Missouri, Columbia<sup>c</sup> St. Louis, MO

## ARTICLE INFO

## Article history:

Received 30 July 2018

Accepted 2 November 2018

Available online 10 November 2018

## Keywords:

Human  
Kombucha  
Microbiome  
Probiotic  
Review

## ABSTRACT

**Purpose:** Kombucha tea, a fermented beverage, has recently become popular in the United States as part of the functional food movement. This popularity is likely driven by its touted health benefits, coupled with the recent scientific movement investigating the role of the microbiome on human health. The purpose of this systematic review is to describe the literature related to empirical health benefits of kombucha as identified from human subjects research.

**Methods:** In July 2018, we searched the term “kombucha” for all document types in the following databases across all available years: PubMed, Scopus, and Ovid. To identify federal research grants related to kombucha, we searched the National Institutes of Health Research Portfolio Online Reporting Tools. Finally, to identify ongoing human subjects research, we searched [clinicaltrials.gov](http://clinicaltrials.gov) and [clinicaltrialsregister.eu](http://clinicaltrialsregister.eu). We reviewed a total of 310 articles.

**Results:** We found one study reporting the results of empirical research on kombucha in human subjects. We found no results for kombucha in Research Portfolio Online Reporting Tools, [clinicaltrials.gov](http://clinicaltrials.gov), or [clinicaltrialsregister.eu](http://clinicaltrialsregister.eu).

**Conclusions:** The nonhuman subjects literature claims numerous health benefits of kombucha; it is critical that these assertions are tested in human clinical trials. Research opportunities are discussed.

© 2018 The Authors. Published by Elsevier Inc. This is an open access article under the CC BY-NC-ND license (<http://creativecommons.org/licenses/by-nc-nd/4.0/>).

## Introduction

Although fermented foods have been a staple of cultures internationally for thousands of years, kombucha has only recently become popular in the United States. Kombucha is reported to have originated in northeast China about 220 B.C., disseminated to Japan in 414 A.D. as a medicine, and spread through trade routes to Russia and eastern Europe [1,2]. Kombucha's worldwide popularity has fluctuated since World War II [1]. Recognizing the growing market, in 2016, PepsiCo purchased KeVita, a popular functional probiotic and kombucha beverage maker. In 2017, retail sales of kombucha and other fermented beverages increased 37.4% [3], and in 2018, kombucha showed a +49% dollar growth over the past 52 weeks [4]. Kombucha is reportedly the fastest growing product in the functional beverage

market [5] and one of the most popular low-alcoholic fermented beverages in the world [6].

“Kombucha” is a beverage made by fermenting tea (generally black tea or sometimes green and oolong tea) and sugar, with a Symbiotic Culture Of Bacteria and Yeast (SCOBY) [7], generally for 7–10 days. The SCOBY is a biofilm of microorganisms resembling a mushroom cap, which becomes a starter for subsequent brews. The SCOBY comprises various acetic acid bacteria (e.g. *Acetobacter xylinum* [8,9], *Acetobacter aceti* [9,10], *Acetobacter pasteurianus* [9,10], and *Gluconobacter oxydans* [8,10]) and yeasts (e.g. *Saccharomyces* sp. [10], *Zygosaccharomyces kombuchaensis* [10], *Torulopsis* sp. [10], *Pichia* spp. [9,10], *Brettanomyces* sp. [10], and *Zygosaccharomyces bailii* [8,9]). Several lactic acid bacteria have also been isolated [10]. After fermentation, kombucha is a cocktail of chemical components [11,12], including sugars; tea polyphenols; organic food acids; fiber; ethanol; amino acids including lysine; essential elements such as Cu, Fe, Mn, Ni, and Zn; water-soluble vitamins such as vitamin C, and several B vitamins; carbon dioxide; antibiotic substances; and hydrolytic enzymes [1].

Disclosure: The authors have no conflicts of interest to disclose.

\* Corresponding author. Department of Health Management and Informatics, School of Medicine, University of Missouri, 1 Hospital Drive, Columbia, MO 65212.

E-mail address: [kappj@health.missouri.edu](mailto:kappj@health.missouri.edu) (J.M. Kapp).

<https://doi.org/10.1016/j.annepidem.2018.11.001>

1047-2797/© 2018 The Authors. Published by Elsevier Inc. This is an open access article under the CC BY-NC-ND license (<http://creativecommons.org/licenses/by-nc-nd/4.0/>).

Kombucha's popularity as a functional food [8,13] is driven by its purported health benefits, which include “multiple functional properties such as anti-inflammatory potential and antioxidant activity,” [14] and “the reduction of cholesterol levels and blood pressure, reduction of cancer propagation, the improvement of liver, the immune system, and gastrointestinal functions [7].” This popularity developed in parallel with the scientific movement investigating the role of the microbiome on health [15–17].

Direct evidence supporting kombucha's benefits for human health is lacking. A systematic review published in 2003 found no clinical studies related to kombucha [18]. The purpose of our systematic review is to identify the empirical health benefits of kombucha from human subjects research and characterize opportunities for future research.

## Methods

### Data sources and search strategy

In July 2018, we searched the term “kombucha” for all document types in the following databases across all available years: PubMed,

Scopus, and Ovid (Fig. 1). When the search engine allowed, we restricted the search to English language articles and human subjects.

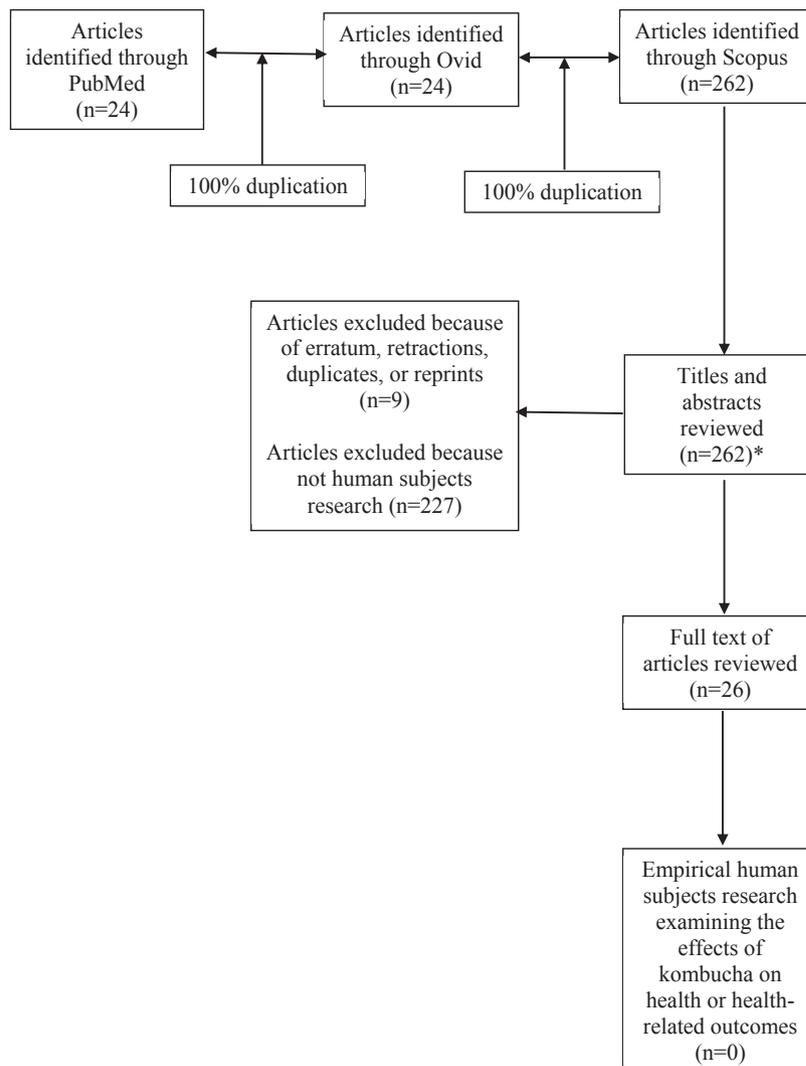
To identify federal research grants related to kombucha, we searched the National Institutes of Health (NIH) Research Portfolio Online Reporting Tools ([report.nih.gov](http://report.nih.gov)) using a text search for “kombucha” spanning all fiscal years.

To identify ongoing human subjects research, we searched [clinicaltrials.gov](http://clinicaltrials.gov) and EU clinical trials register ([www.clinicaltrialsregister.eu](http://www.clinicaltrialsregister.eu)) for “kombucha” using the widest possible search.

Finally, we checked the supporting references of select articles for human studies.

### Eligibility criteria and article selection

We reviewed article titles and abstracts for duplication across search engines. Authors then independently reviewed article titles and abstracts to exclude studies not conducted on human subjects, that is, examining mechanisms of disease or the properties of the kombucha. When we noted discrepancies in article selection



\* One human subjects study was discovered from the references of a microbiology study.

**Fig. 1.** Flow diagram of 310 kombucha articles identified through a search and selection process. \*One human subjects study was discovered from the references of a microbiology study.

between authors, we retrieved the full texts. Inclusion criteria consisted of empirical research testing the effects of kombucha on any human health or health-related outcome.

## Results

We reviewed a total of 310 articles (Fig. 1). The PubMed search restricted to “humans” and “English” language identified 24 articles published between 1994 and 2017. The Ovid Medline search (1946 to present) restricted to “humans” and “English” language also identified 24 articles, published between 1994 and 2017. We compared these two lists, identifying 100% duplication. The Scopus search restricted to “English” language identified 262 articles published between 1945 and 2018. We compared the Scopus list to the 24 Ovid/PubMed articles, identifying 100% duplication.

We reviewed the abstracts of the remaining 262 articles. Two articles were retraction statements by the publishers regarding the validity of the research, excluding four articles total [19–22]. Two articles duplicated other articles. An erratum and its associated article were excluded [23,24]. One article [25] was a reprint of an article published elsewhere [26]. Of the remaining 253 articles, 227 were excluded as not relating to human subjects research. We reviewed the full text of the remaining 26 articles for the following reasons: no abstract was available [27–33] ( $n = 7$ ); it was a relevant chapter, review, or article and we reviewed the references for additional human subjects studies [1,2,6–10,14,18,34–40] ( $n = 16$ ); or the title and abstract left ambiguity [12,41,42] ( $n = 3$ ).

When reviewing the references of the full texts, we identified several articles for further review. Dufresne et al [2] referenced medical studies conducted between 1925 and 1950 by doctors and physicians that “confirmed” kombucha’s health benefits (“antibiotic properties, regulation of gastric, intestinal, and glandular activities, relief of joint rheumatism, gout and haemorrhoids, positive influence on the cholesterol level, arteriosclerosis, toxin excretion and blood cleansing, diabetes, nervousness, and aging problems”); however, the primary reference of Allen (1998) revealed a website [43] that lists anecdotal information collected from individuals on a mailing list, with a warning that the contents are unverified. We found additional reference to the 1925–1950 studies in Kaczmarczyk and Lochynski [12]; however, their primary reference was Dufresne et al [2]. Because the 1925–1950 studies cannot be confirmed, and additionally predate the modern Institutional Review Board (IRB), they were excluded. Dufresne et al [2] referenced six other studies we explored: four were websites no longer working [44–47]; one was an article published in another language and predated the modern IRB [48]; and one [49] appeared to be a private website blog written in collaboration with Allen [43]. Finally, we could not retrieve the full text of Ishida [30]; however, Scopus identified this as a letter and not original research.

Separately, from a 2013 report [50] exploring SCOBY microbiology, we found a citation suggesting a human subjects study [51,52]. The full text [51] reported that daily consumption of 60 mL of kombucha for 90 days was associated with normalized blood sugar values in 24 subjects aged 45–55 years with non-insulin-dependent diabetes mellitus. The lead author’s dissertation [53] also describes improvements associated with the same intervention in individuals with mild hypertension or diverse medical problems. Neither report describes a control group.

Our systematic literature review found no articles on the empirical health benefits of kombucha as identified from human subjects research. One study was identified through the references of a microbiology study.

Our search found no results for “kombucha” in Research Portfolio Online Reporting Tools, [clinicaltrials.gov](https://clinicaltrials.gov), nor [www.clinicaltrialsregister.eu](https://www.clinicaltrialsregister.eu).

## Discussion

### *Evidence of Kombucha’s health benefit from human subjects research*

Our literature search identified no controlled studies of human subjects, only one study [51,53] examining any health benefits of kombucha from human subjects research and no studies in the 15 years since Ernst’s [18] review. Nonetheless, significant commercial shelf space is now dedicated to kombucha products, and there is widespread belief that the products promote health [8].

### *Touted health benefits from in vitro and animal studies*

The nonhuman subjects literature suggests that kombucha’s health benefits are derived from the tea and the products of fermentation, including glucuronic acid, acetic acid, polyphenols, phenols, and B-complex vitamins, including folic acid [6]. Health benefits reported from in vitro and in vivo studies include antimicrobial benefits, liver and gastrointestinal functions, immune stimulation, detoxification, antioxidant, anti-tumor properties, health prophylactic and recovery effects through immune stimulation; inhibiting the development and progression of cancer, cardiovascular disease, diabetes, and neurodegenerative diseases; and normal central nervous system function [6]. To date, biological activities of kombucha have been studied in rats [10,53], mice [10], rabbits [10,54], ducks [10], dogs [10], pigs [55], cattle [55], broiler chickens [56], and human peripheral blood lymphocytes [1,8,10].

### *Potential health risks to humans*

Kombucha has been implicated (but not necessarily confirmed) in a number of case reports, including hyponatremia [57]; lactic acidosis [58]; toxic hepatitis after consuming kombucha tea daily for two years [59]; a patient newly diagnosed with human immunodeficiency virus who presented with a case of hyperthermia, lactic acidosis, and acute renal failure within 15 hours of ingesting kombucha [60]; anti-Jo1 antibody-positive myositis [61]; symptomatic lead poisoning from brewing kombucha in a ceramic pot [62]; an outbreak of cutaneous anthrax reportedly from applying the kombucha mushroom to the skin as a painkiller [31]; pellagra [63]; an allergic reaction, jaundice, and nausea, vomiting, head and neck pain [64]; metabolic acidosis [26]; hepatotoxicity [32]; and cholestatic hepatitis [65].

Kombucha contains small amounts of alcohol. In a Food and Drug Administration investigation, the alcohol content of samples ranged from 0.7% to 1.3%; no methanol was detected [26]. Kombucha is contraindicated in pregnant women [7] and likely people with significant renal, pulmonary, or liver disease.

Despite these implications, kombucha is not considered harmful if about 4 oz per day is consumed by healthy individuals; potential risks are associated with a low pH brew leaching heavy metals from containers, excessive consumption of highly acidic kombucha, or consumption by individuals with pre-existing health conditions [26,66]. Proper brewing methods are described in detail [66].

### *Envisioned human subjects research opportunities*

As first steps, scientists might examine associations in food consumption trends with population health outcomes. For thousands of years, fermented foods contributed to food security [6] by extending the shelf life of fresh produce past the harvest season. The availability of off-season produce negates the need for traditional food security practices. Although yogurt, cheese, and cottage cheese are widely available, the current U.S. culture is largely absent

of traditionally prepared fermented foods, including kimchi [34], kefir [34], clabbered milk [34], sauerkraut [34], and switchel, among others [6]. Population-level assessment of historical and geographic trends could help answer the questions: Are U.S. population health outcome trends (such as diabetes and obesity [67,68]) inversely correlated with consumption trends of fermented foods? Are there ecological-level correlations between kombucha and fermented food consumption and population health outcomes across cultures and countries?

Cross-sectional and cohort studies are practical next steps to explore associations. These observational studies should attempt to control for the likelihood that kombucha drinkers are a subpopulation with different lifestyle habits, socioeconomic status, health insurance or health care access than the general population. Well-designed observational studies could help address the question: Is the use of kombucha associated with improved human health or health-related outcomes?

The human health benefits of kombucha need to be tested in clinical trials [6]. Several reviews [1,2,6–10] describe potential health benefits of kombucha that warrant testing. Also warranted is replication of kombucha's health benefits on blood sugar and hypertension [51,53] in a controlled study. This would add to the emerging scientific movement investigating the role of the microbiome on health [15–17]; the NIH human microbiome project investigators published over 650 scientific articles by the end of 2017 [69]. Other fermented foods, including fermented milk [34] and other probiotics [6] are being studied in humans. Fermented milk is shown to prevent diet-induced insulin resistance in humans [70]. Clinical trials should address health topics for which observational or animal studies suggest benefit to answer the question: Does kombucha improve health or health-related outcomes in humans?

If kombucha has health benefits, important subsequent studies will need to address the following: At what dosage, frequency, and duration? In what populations and subpopulations? To facilitate comparison across studies, a standardized process flow is recommended for brewing [66]; other considerations include the role of the weather, geographic location, and medium on the brewing process.

Finally, mechanisms to explain human health outcomes will need to be studied. How might kombucha improve health or health-related outcomes in humans? The exact microbial composition of kombucha varies [1,39], the underlying mechanisms of action are not well understood [39], and SCOBY biology and byproducts are complex and dynamic mixtures [39].

### Limitations

Our findings are limited to the published English language literature and to the described methodology used to identify articles, although we made every effort in reviewing article references to identify additional studies.

### Conclusions

Our systematic literature review identified one uncontrolled empirical human subjects study examining the effects of kombucha on health or health-related outcomes. The opportunities to examine the potential health benefits of kombucha in humans are vast and potentially important for U.S. population health.

### References

- Jayabalan R, Malbaša RV, Lončar ES, Vitas JS, Sathishkumar M. A review on kombucha tea-microbiology, composition, fermentation, beneficial effects, toxicity, and tea fungus. *Compr Rev Food Sci Food Saf* 2014;13(4):538–50.
- Dufresne C, Farnworth E. Tea, Kombucha, and health: a review. *Food Res Int* 2000;33(6):409–21.
- Watson E. Fermentation on fire: US retail sales of kombucha and other fermented beverages surged 37.4% in 2017. 2018. <https://www.foodnavigator-usa.com/Article/2018/02/13/Fermentation-on-fire-US-retail-sales-of-kombucha-and-other-fermented-beverages-surged-37.4-in-2017#>. [Accessed 12 July 2018].
- No signs of fizzing out: america's love of sparkling water remains strong through August. 2018. <https://www.nielsen.com/us/en/insights/news/2018/no-signs-of-fizzing-out-americas-love-of-sparkling-water-remains-strong.html>. [Accessed 17 October 2018].
- Troitino C. Kombucha 101: demystifying the past, present and future of the fermented tea drink. 2017. 2018. <https://www.forbes.com/sites/christinatroitino/2017/02/01/kombucha-101-demystifying-the-past-present-and-future-of-the-fermented-tea-drink/#261ea4684ae2>. [Accessed 12 July 2018].
- Baschali A, Tsakalidou E, Kyriacou A, Karavasiloglou N, Matalas AL. Traditional low-alcoholic and non-alcoholic fermented beverages consumed in European countries: a neglected food group. *Nutr Res Rev* 2017;30(1):1–24.
- Leal JM, Suárez LV, Jayabalan R, Oros JH, Escalante-Aburto A. A review on health benefits of kombucha nutritional compounds and metabolites. *CYTA J Food* 2018;16(1):390–9.
- Watawana MI, Jayawardena N, Gunawardhana CB, Waisundara VY. Health, wellness, and safety aspects of the consumption of kombucha. *J Chem* 2015;2015.
- Greenwalt CJ, Steinkraus KH, Ledford RA. Kombucha, the fermented tea: microbiology, composition, and claimed health effects. *J Food Prot* 2000;63(7):976–81.
- Vina I, Semjonovs P, Linde R, Denipa I. Current evidence on physiological activity and expected health effects of kombucha fermented beverage. *J Med Food* 2014;17(2):179–88.
- Miranda B, Lawton NM, Tachibana SR, Swartz NA, Hall WP. Titration and HPLC characterization of Kombucha fermentation: a laboratory experiment in food analysis. *J Chem Educ* 2016;93(10):1770–5.
- Kaczmarczyk D, Lochyński S. Products of biotransformation of tea infusion - properties and application. *Polish J Nat Sci* 2014;29(4):381–92.
- Hasler CM, Brown AC, American Dietetic A. Position of the American dietetic association: functional foods. *J Am Diet Assoc* 2009;109(4):735–46.
- Villarreal-Soto SA, Beaufort S, Bouajila J, Souchard JP, Taillandier P. Understanding Kombucha tea fermentation: a review. *J Food Sci* 2018;83(3):580–8.
- NIH HMP Working Group, Peterson J, Garges S, Giovanni M, McInnes P, Wang L, et al. The NIH human microbiome project. *Genome Res* 2009;19(12):2317–23.
- Bull MJ, Plummer NT. Part 1: the human gut microbiome in health and disease. *Integr Med (Encinitas)* 2014;13(6):17–22.
- Shreiner AB, Kao JY, Young VB. The gut microbiome in health and in disease. *Curr Opin Gastroenterol* 2015;31(1):69–75.
- Ernst E. Kombucha: a systematic review of the clinical evidence. *Forsch Komplementarmed Klass Naturheilkd* 2003;10(2):85–7.
- Barati F, Javanbakht J, Adib-Hashemi F, Hosseini E, Safaie R, Rajabian M, et al. Histopathological and clinical evaluation of Kombucha tea and nitrofurazone on cutaneous full-thickness wounds healing in rats: an experimental study. *Diagn Pathol* 2013;8(1).
- Barati F, Javanbakht J, Adib-Hashemi F, Hosseini E, Safaie R, Rajabian M, et al. Retraction note: histopathological and clinical evaluation of Kombucha tea and nitrofurazone on cutaneous full-thickness wounds healing in rats: an experimental study [Diagn Pathol., 8 (2013) (120)]. *Diagn Pathol* 2016;11(1).
- Retracted. Evaluation of the stability of the total antioxidant capacity, polyphenol contents, and starch hydrolase inhibitory activities of kombucha teas using an in vitro model of digestion (Journal of Chemistry (2015) 2015 (684561)). *J Chem* 2016;2016.
- Watawana MI, Jayawardena N, Ranasinghe SJ, Waisundara VY. Evaluation of the stability of the total antioxidant capacity, polyphenol contents, and starch hydrolase inhibitory activities of kombucha teas using an in vitro model of digestion. *J Chem* 2015;2015.
- Watawana MI, Jayawardena N, Choo C, Waisundara VY. Erratum: application of the Kombucha “tea fungus” for the enhancement of antioxidant and starch hydrolase inhibitory properties of ten herbal teas (Food Chem. 194 (2016) (304–311) doi: 10.1016/j.foodchem.2015.08.033). *Food Chem* 2016;209:366.
- Watawana MI, Jayawardena N, Choo C, Waisundara VY. Application of the Kombucha “tea fungus” for the enhancement of antioxidant and starch hydrolase inhibitory properties of ten herbal teas. *Food Chem* 2016;194:304–11.
- Currier RW, Goddard J, Buechler K, Quinlisk MP, Wolfe SL, Carroll TJ, et al. Unexplained severe illness possibly associated with consumption of Kombucha tea - Iowa, 1995. *J Am Med Assoc* 1996;275(2):96–8.
- Unexplained severe illness possibly associated with consumption of Kombucha tea-Iowa, 1995. *MMWR Morb Mortal Wkly Rep* 1995;44(48):892–3. 899.
- Katsnelson A. Fermented foods offer up a versatile microbial model system. *Proc Natl Acad Sci U S A* 2017;114(10):2434–6.
- Konings EJM, Barrett WB, Beshore M, Beshore T, Buscher J, Crum H, et al. AOAC SMPR(®) 2016.001. *J AOAC Int* 2016;99(4):1120–1.
- Is Kombucha tea safe to drink? *Mayo Clinic Womens Healthsource* 2011;15(7):8.
- Ishida Y. Kombucha. *Med J Aust* 1999;170(9):454.

- [31] Sadjadi J. Cutaneous anthrax associated with the Kombucha 'mushroom' in Iran. *JAMA* 1998;280(18):1567–8.
- [32] Kombucha "mushroom" hepatotoxicity. *Ann Emerg Med* 1995;26(5):660–1.
- [33] Monson N. Kombucha tea: a controversy brews among patients and physicians. *Altern Complement Therapies* 1995;1(5):281–3.
- [34] Cherniack EP. Fermented foods: from traditional diets to clinical trials. *Complementary medicine and culture: the changing cultural territory of local and global healing practices*. Hauppauge, New York: Nova Science Publishers, Inc; 2017. p. 225–40.
- [35] Martini N. Kombucha. *J Prim Health Care* 2018;10(1):93–4.
- [36] De Roos J, De Vuyst L. Acetic acid bacteria in fermented foods and beverages. *Curr Opin Biotechnol* 2018;49:115–9.
- [37] Rashid K, Sinha K, Sil PC. An update on oxidative stress-mediated organ pathophysiology. *Food Chem Toxicol* 2013;62:584–600.
- [38] Kozyrowska NO, Reva OM, Goginyan VB, Devera JP. Kombucha microbiome as a probiotic: a view from the perspective of post-genomics and synthetic ecology. *Biopolym Cell* 2012;28(2):103–13.
- [39] Schiano TD. Hepatotoxicity and complementary and alternative medicines. *Clin Liver Dis* 2003;7(2):453–73.
- [40] Steinkraus KH, Shapiro KB, Hotchkiss JH, Mortlock RP. Investigations into the antibiotic activity of tea Fungus/Kombucha beverage. *Acta Biotechnol* 1996;16(2-3):199–205.
- [41] Yuniarto A, Anggadiredja K, Aqidah RAN. Antifungal activity of kombucha tea against human pathogenic fungi. *Asian J Pharm Clin Res* 2016;9(5):253–5.
- [42] Neffe-Skocińska K, Sionek B, Ścibisz I, Kotożyn-Krajewska D. Acid contents and the effect of fermentation condition of Kombucha tea beverages on physicochemical, microbiological and sensory properties. *CYTA J Food* 2017;15(4):601–7.
- [43] Allen CM. Kombucha unveiled. part six - research and test results. 2000. <http://users.bestweb.net/~om/~kombu/FAQ/part06.html#BMallen>. [Accessed 6 July 2018].
- [44] Ferguson B, Estelle A. Benefits of Kombucha. 1998. 2018. <http://bawue.de/~kombucha/benefits.htm>. [Accessed 13 July 2018].
- [45] Full Circle Press. Kombucha tea culture – The ancient rejuvenating health drink. 1998. 2018. <http://www.h2olily.com/~insect/kombuch2.html>. [Accessed 13 July 2018].
- [46] Roussin M. Kombucha research.com. 1999. 2018. <http://www.kombucha-research.com>. [Accessed 13 July 2018].
- [47] Hoffmann N. The ubiquitous co-enzyme UDPGlucuronic acid. 1998. 2018. <http://www.stolaf.edu/people/hoffman/glucuron.htm>. [Accessed 13 July 2018].
- [48] Stadelmann E. Der teepilz und seine antibiotische wirkung. *Zentralb Bakteriol Parasitenkd Infektionskr Hyg* 1961;180:401–35.
- [49] Roche J. The history and spread of Kombucha. <http://users.bestweb.net/~om/~kombu/roche.html>. [Accessed 12 July 2018].
- [50] Marsh AJ, O'Sullivan O, Hill C, Ross RP, Cotter PD. Sequence-based analysis of the bacterial and fungal compositions of multiple kombucha (tea fungus) samples. *Food Microbiol* 2014;38:171–8.
- [51] Hiremath US, Vaidehi MP, Mushtari BJ. Effect of Fermented tea on the blood sugar levels of NIDDM Subjects. *Indian Pract* 2002;55(7):423–5.
- [52] Hiremath US, Vaidehi MP, Mushtari BJ. Effect of Fermented tea on the blood sugar levels of NIDDM Subjects. 2002. 2018. <http://medind.nic.in/imvw/imvw632.html>. [Accessed 1 November 2018].
- [53] Hiremath US. Nutritional and Dietetic Studies of Microbiologically Fermented (Kargosak) Tea. Bangalore: Department of Rural Home Science, University of Agricultural Sciences; 2000.
- [54] Zhu C, Liu F, Qian W, Wang Y, You Q, Zhang T, et al. Esophageal replacement by hydroxylated bacterial cellulose patch in a rabbit model. *Turkish J Med Sci* 2015;45(4):762–70.
- [55] Fu N, Wu J, Lv L, He J, Jiang S. Anti-foot-and-mouth disease virus effects of Chinese herbal kombucha in vivo. *Braz J Microbiol* 2015;46(4):1245–55.
- [56] Afsharmanesh M, Sadaghi B. Effects of dietary alternatives (probiotic, green tea powder, and Kombucha tea) as antimicrobial growth promoters on growth, ileal nutrient digestibility, blood parameters, and immune response of broiler chickens. *Comp Clin Pathol* 2014;23(3):717–24.
- [57] Bailowitz Z, Grams II R, Teeple D, Hew-Butler T. Exercise-associated hyponatremia in a lactating female. *Clin J Sport Med* 2017;27(4):e55–7.
- [58] Holbourn A, Hurdman J. Kombucha: is a cup of tea good for you? *BMJ Case Rep* 2017;2017.
- [59] Kovacevic Z, Davidovic G, Vuckovic-Filipovic J, Janicijevic-Petrovic MA, Janicijevic K, Popovic A. A toxic hepatitis caused the kombucha tea – case report. *Open Access Maced J Med Sci* 2014;2(1):128–31.
- [60] Kole AS, Jones HD, Christensen R, Gladstein J. A case of Kombucha tea toxicity. *J Intensive Care Med* 2009;24(3):205–7.
- [61] Derk CT, Sandorfi N, Curtis MT. A case of anti-Jo1 myositis with pleural effusions and pericardial tamponade developing after exposure to a fermented Kombucha beverage. *Clin Rheumatol* 2004;23(4):355–7.
- [62] Phan TG, Estell J, Duggin G, Beer I, Smith D, Ferson MJ. Lead poisoning from drinking Kombucha tea brewed in a ceramic pot. *Med J Aust* 1998;169(11-12):644–6.
- [63] Wood B, Rademaker M, Oakley A, Wallace J. Pellagra in a woman using alternative remedies. *Australas J Dermatol* 1998;39(1):42–4.
- [64] Srinivasan R, Smolinske S, Greenbaum D. Probable gastrointestinal toxicity of Kombucha tea: Is this beverage healthy or harmful? *J Gen Intern Med* 1997;12(10):643–4.
- [65] Gedela M, Potu KC, Gali VL, Alyamany K, Jha LK. A case of hepatotoxicity related to Kombucha tea consumption. *S D Med* 2016;69(1):26–8.
- [66] Nummer BA. Kombucha brewing under the food and drug administration model Food Code: Risk analysis and processing guidance. *J Environ Health* 2013;76(4):8–11.
- [67] Institute of Medicine. U.S. health in international perspective: shorter lives, poorer health. Washington, DC: National Academies Press; 2013.
- [68] Hales CM, Carroll MD, Fryar CD, Ogden CL. Prevalence of obesity among adults and youth: United States, 2015–2016. Hyattsville, MD. 2017.
- [69] National Institutes of Health. Human Microbiome Project. 2018. <https://commonfund.nih.gov/hmp>. [Accessed 17 October 2018].
- [70] Hulston CJ, Churnside AA, Venables MC. Probiotic supplementation prevents high-fat, overfeeding-induced insulin resistance in human subjects. *Br J Nutr* 2015;113(4):596–602.