Exploring the characteristics of kombucha tea fermented with soursop (*Annona muricata*), Noni (*Morinda citrifolia*) and pineapple (*Ananas comosus*)

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Abstract. The current study aims to determine the physico-chemical and sensory properties of kombucha tea fermented with soursop (Annona muricata), noni (Morinda citrifolia), and pineapple (Ananas comosus) juices. The infused kombucha drink was prepared by adding 30% selected fruit juices in kombucha tea. It was fermented using SCOBY (symbiotic culture of bacteria and yeast) for 14 days at room temperature. The results revealed that the infusion of soursop, noni, and pineapple in kombucha tea contributed to increased pH value, Brix value, and higher percentage of yield biomass. Regarding color, the L, a, and b values of infused kombucha drinks were significantly different ($p<0.05$) from simple kombucha tea. There was also a significant difference ($p<0.05$) in proximate properties of infused and simple kombucha tea except for the crude protein content. The antioxidant analysis showed that addition fruit juices enhanced the antioxidant level of kombucha drinks. In case of sensory evaluation, it was observed that overall soursop and pineapple had higher overall acceptability followed by. The results of the current work indicate that the addition of selected fruit juices such as soursop, noni, and pineapple significantly improved the nutritional value and antioxidant attributes of kombucha tea and thus possess the opportunity to be marketed as a new tea with good flavor, taste and health prospects.

1 INTRODUCTION

Kombucha is a fermented tea that has been consumed for thousands of years and is popular due to its beneficial probiotic properties. Kombucha originated in northeast China and has been reported since 220 B.C. It was disseminated to Japan in 414 A.D. as medicine and

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spread to Russia, Eastern Europe, and worldwide through trade routes, and its popularity has fluctuated since World War II [1]. Kombucha is generally made using tea, sugar, and a specific symbiotic culture of bacteria and yeast (SCOBY) [2]. The fermentation process for Kombucha tea takes at minimum 3 days up to 60 days, depending on the cultural practices [3]. During fermentation, the possible pathogenic microbial cells get diminished in the tea, and thus a safe beverage is obtained for consumption [3].

Nowadays, the trend of food consumption has been changing among consumers. They are more concerned about their health and progressively shifting towards healthy food consumption in their diet. Even though healthy food is costly, still consumers demand products with high nutritional values to maintain good health. In this regard, a new development of kombucha drink products is made from fruit juices such as pineapple, noni, and soursop as additional ingredients to increase the variety and the quality of beverages available in the market. Several factors such as antioxidant levels might be responsible for health benefits of kombucha drinks made from additional fruit ingredients. The higher antioxidant level in kombucha drinks determines the best quality of production, whereas, the sensory evaluation of every sample identifies the best preference formulation of kombucha drink.

This study aims to determine the physico-chemical properties and sensory attributes of fruits (pineapple, noni, soursop) used as additional ingredients in kombucha drinks. Besides, microorganisms in kombucha drinks may be contaminated if not appropriately fermented. Therefore, it is crucial to observe food safety levels to avoid producing a high-risk contaminated product.

2 Materials And Method

2.1 Samples Preparation

The black tea and coarse grain sugar were purchased from Hero Mart supermarket (Selangor, Malaysia). Soursop and pineapple were purchased from the Selayang wet market, and noni was obtained from orchard at Desa Melor, Serendah (Selangor, Malaysia).

2.2 Preparation of Kombucha Drinks

2.2.1 Standard Kombucha Tea

Standard kombucha tea was prepared based on the method performed by [4] with a slight modification. A 25 g of white sugar was dissolved in 475 mL of boiling water in a tea bag for 5 min. Next, the tea was filtered and cooled at room temperature before being transferred into a sterile glass jar. At the end, the tea was inoculated with 50 g of SCOBY and fermented for 14 days at room temperature.

2.2.2 Soursop Kombucha Drink

Soursop kombucha drink (500 mL) was prepared with 30% soursop juice, 5% sugar, and 50 g of SCOBY (1:1 (w/v)). The ripe soursop was peeled, unseeded, and cut into a smaller size (3 cm x 3 cm). After that, 500 g of soursop was grinded with water in a 1:1 (w/v) ratio. The juice was filtered and pasteurized at 63 °C for 30 min. After that, 142.5 mL of pasteurized juice was poured into the glass jar and topped with 332.5 mL of black tea. A total of 25 g of sugar was dissolved into it and cooled at room temperature. Then, the cooled tea was inoculated with 50 g of SCOBY, and the fermentation was carried out for 14 days at room temperature.

2.2.3 Noni Kombucha Drink

Noni kombucha drink (500 mL) was prepared using 30% noni juice, 5% sugar, and 50 g of SCOBY (1:1 (w/v)). Half-ripe noni was peeled, unseeded, and cut into a smaller size (3 cm x 3 cm). Further, 500 g of noni was grinded with water in the ratio of 1:1 (w/v). The juice was filtered and pasteurized at 63°C for 30 min. After that, 142.5 ml of pasteurized juice was poured into the glass jar and topped with 332.5 mL of black tea. A total of 25 g of sugar was dissolved into it and cooled at room temperature. Then, the cooled tea was inoculated with 50 g of SCOBY, and the fermentation was carried out for 14 days at room temperature.

2.2.4 Pineapple Kombucha Drink

Pineapple kombucha drink (500 mL) was prepared using 30% pineapple juice, 5% sugar, and 50 g of SCOBY (1:1 (w/v)). The ripe pineapple was peeled, unseeded, and cut into a smaller size (3 cm x 3 cm). Next, 500 g of pineapple was grinded with water in a ratio of 1:1 (w/v). The juice was filtered and pasteurized at 63°C for 30 min. After that, 142.5 mL of pasteurized juice was poured into the glass jar and topped with 332.5 mL of black tea. A total of 25 g of sugar was dissolved into it and cooled at room temperature. Then, the cooled tea was inoculated with 50 g of SCOBY, and the fermentation was carried out for 14 days at room temperature.

2.3 Physico-chemical analysis

2.3.1 pH Value

The pH value of each sample was determined by measuring the samples using a pH meter (3505 pH meter, Jenwey, UK) at room temperature and was performed in triplicate. Before measuring it, the pH meter was calibrated using a standard buffer solution at pH 4 and 7 Brix°.

2.3.2 Biomass Yield

The percentage of biomass yield of SCOBY from each sample was calculated according to Equation 1,

$$\text{Final mass- Initial mass)} / \text{Final mass} \times 100 \qquad \text{(Equation 1)}$$

2.3.3 Color

The color of the samples was determined using a Colorimeter (Ultra Scan Pro, Hunter Associates Laboratory, Inc., VA) and measured in triplicate. The colorimeter was calibrated using a standard white porcelain plate before use. In this color system, L* shows the lightness; meanwhile, a* represents the red coordinate (+a) and green coordinate (-a), and b* represents the yellow coordinate (+b) and blue coordinate (-b). The color becomes more saturated or chromatic as values of a* and b* increase. However, these values come to zero for neutral colors.

2.4 Proximate Analysis

The moisture and the ash contents of the samples were analyzed according to [5] method. The fat and protein contents were determined using Soxhlet extraction and Kjeldahl method, respectively. The carbohydrate composition was determined by calculating the remaining percent after all other components [5].

2.5 Antioxidant Activity

2.5.1 Total Phenolic Content (TPC)

The total phenolic content was determined using the Folin-Ciocalteu reagent described in [6]. Gallic acid was used as a standard. The Fiolin reagent was prepared by dissolving 10 ml of Fiolin-Ciocalteu into 90 mL distilled water. A 0.01 g of the extract was added to 10 mL of methanol and a 0.5 ml of sample aliquot was mixed with 2.5 mL of Fiolin-Ciocalteu reagent, and the reaction was allowed for 5 min. Then, 2.0 mL of 7.5% sodium carbonate solution was added. The mixture was mixed with vortex and put at room temperature in the dark for 2 h. The absorbance of the aqueous phase was measured at 765 nm using a spectrophotometer.

2.5.2 Determination of DPPH Radicals Scavenging Activity

The antioxidant activity of samples was measured in terms of hydrogen-donating or radical scavenging ability using the DPPH method [6]. Firstly, 0.2 mM DPPH solution was prepared by dissolving 0.0078 g into 100 mL ethanol. Then, 0.01 g of the extract was added to 10 mL of ethanol to give a concentration of 1 mg/mL. A 2 mL of sample aliquot was added into 2 mL of DPPH in ethanol and shacked with vortex before incubated in the dark for 30 min. The absorbance of the solution was measured at 517 nm using a spectrophotometer. Next, the inhibition percentage was calculated.

2.5.3 Determination of Ferric Reducing Antioxidant Power (FRAP)

The ferric-reducing antioxidant power of kombucha drinks was estimated based on the reaction of FRAP reagent with some modifications. The FRAP reagent was prepared by mixing 100 mL of acetate buffer, 10 mL of TPTZ in 40 HCL, and 10 mL of 20mM Ferric chloride with a ratio of 10:1:1. Next, 1.5 mL of freshly prepared FRAP reagent was mixed with 0.05 mL of extracted sample in a cuvette. The mixture was combined thoroughly and incubated at room temperature for 5 min. The absorbance readings were measured at 593 nm using a spectrophotometer (Thero Spectronic GENESYS 20 Visible Spectrophotometer, Thermo Fisher Scientific, CA). Ascorbic acid was used as a reference of the standard for the calibration curve. All the determinations were made in triplicate. The calibration curve was compared between the plotting of absorbance at 593 nm of different concentrations of FeSO4. The FRAP values of samples were determined using the standard curve and expressed as mM Fe2+/g DW.

2.6 Sensory Evaluation

The sensory analysis was performed on taste, aroma, color, and overall acceptance by 50 untrained students using a 9-point scale: 1= the least likable; 9 = the most likable. The kombucha samples were coded with three-digit random numbers and presented on a tray for individual booths of the panelists. In this sensory evaluation, water was provided to each panelist between samples as a palate cleanser.

2.7 Statistical Analysis

Data were analyzed statistically using Minitab statistical software version 19.0 (Minitab, Inc., State College Pennsylvania, USA). One-way analysis of variance (ANOVA) was used to find the significant differences with a significant level of ($p<0.05$). The results were expressed as the mean values ± standard deviations with significance letters obtained through Turkey's test.

3 RESULTS AND DISCUSSION

3.1 Physico-chemical Analysis

3.1.1 pH Value

The result shows that among four samples of kombucha teas, soursop kombucha tea has a higher significant value than others as shown in Figure 1. The control samples presented the lowest pH value; there is no significant difference ($p<0.5$) between noni and pineapple kombucha tea samples. The pH value of kombucha tea contributed by the dominant Acetobacter and Glucona- acetobacter bacteria due to acetic acid production. According to Jayabalan et al.,2014, the pH decreases from 5.44 to 3.0 after 5 to 7 days of fermentation. If the pH does not drop to 4.6 or below within seven days of fermentation, contamination may occur in Kombucha [7]. It is also mentioned that after fermentation, the ideal pH value of Kombucha ranges between 2.5 to 3.0. The pH results of standard kombucha tea differ slightly as compared to the findings of [8], who reported a pH value of 2.83. Even though, there was a contradiction, the standard kombucha tea is still considered safe for consumption due to the range of pH between 2.5-4.6 [8].

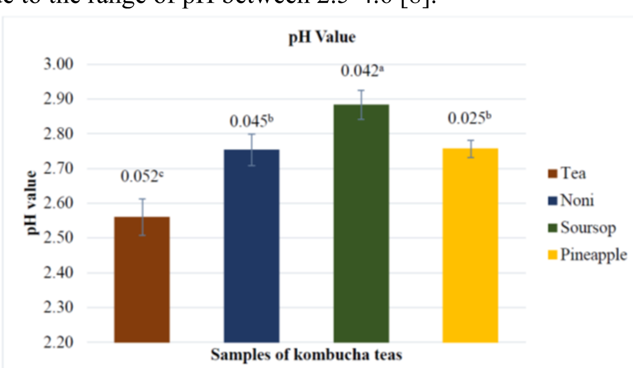

Fig. 1. The pH value of kombucha drinks after 14 days of fermentation. The same superscripts ($^{a-c}$) denote no significant difference ($p>0.05$).

3.1.2 Brix Value

The results of brix value reveal that the soursop kombucha tea sample has a higher brix value than the noni, pineapple, and control samples as presented in Figure 2. The sugar content in kombucha teas decreased as the fermentation time was longer due to the conversion of sugar to ethanol during the fermentation process. The control sample was in line with the findings of Quiao-Won and Teves 2018, in which kombucha tea made from black tea and white sugar has a Brix value of 7 and 5 Brix in this study. The reason behind the higher values of soursop, pineapple, and noni samples relative to control samples is due to the additional sucrose and fructose in the juices of the raw materials.

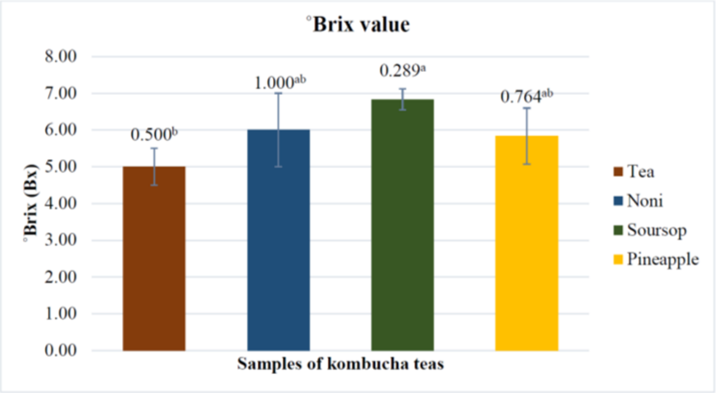

Fig. 2. The Brix value of kombucha drinks after 14 days of fermentation. The same superscripts ($^{a-ab}$) denote no significant difference (p>0.05).

3.1.3 Biomass Yield

The pineapple kombucha tea had the highest percentage of biomass yield as compared to others as shown in Figure 3. According to [8], the biomass yield is based on the carbon source in the system, higher the sugar content, the higher the biomass yield will be produced. It is also reported that fermented kombucha with high sucrose concentration had the highest biomass (Malbasa et al., 2019). Therefore, as expected, the pineapple kombucha tea contains higher amount of sugar, a carbon source for the SCOBY to grow.

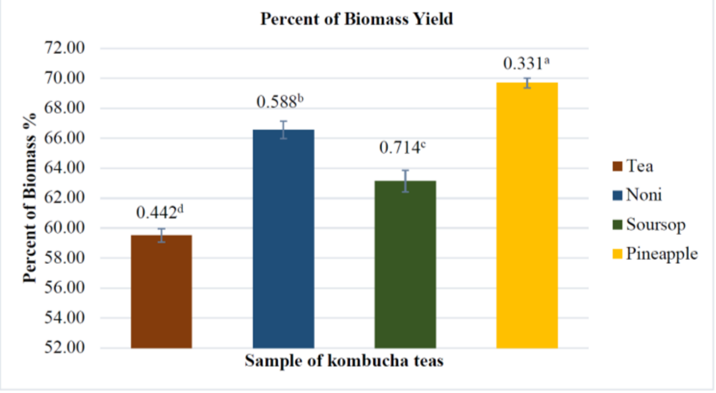

Fig. 3. The percent of biomass yield in kombucha drinks after 14 days of fermentation. The same superscripts ($^{a-d}$) denote no significant difference (p>0.05).

3.1.4 Color

The results of color values are presented in Table 1. The L- value for each kombucha drink has significant difference (p<0.05). The lightness of the standard kombucha tea is higher than that of other teas. Kombucha tea is dark brown at the beginning of production. During the fermentation process, the dark brown color turns lighter, and this is due to the ability of microbes to perform color degradation. Color degradation occurs because of the utilization of total soluble solids by microbes as energy. Over time, the solvent in the media will run out, making the liquid more explicit or colorless. For a-value, all kombucha drink samples have significant differences (p<0.05), as the value of standard kombucha tea is greener. Moreover, the b-values were found positive, hence the standard kombucha tea, noni kombucha tea, soursop kombucha tea, and pineapple kombucha tea were yellowish.

Table 1. The L-value, a-value, and b-value of standard kombucha tea, noni kombucha tea, soursop kombucha tea, and pineapple kombucha tea.

Samples	Color		
	L*	a*	b*
Tea	72.337 ±0.130a	-1.477 ±0.012d	30.953 ±0.165b
Noni	56.513 ±0.234d	8.320 ±0.050a	49.520 ±0.099a
Soursop	58.227 ±0.639c	3.557 ±0.150c	20.127 ±0.359c
Pineapple	62.597 ±1.105b	5.273 ±0.470b	48.980 ±0.971a

Note: Each value is the mean of triplicate determinations ± standard deviation. The same superscripts ($^{a-d}$) denote no significant difference (p>0.05).

3.2 Proximate Analysis

According to the data given in Table 2, every sample of each kombucha drink was significantly different (p<0.05), and the standard kombucha tea was highest among others due to a higher amount of liquid content. For ash content, soursop kombucha tea has a higher amount than standard kombucha tea. However, due to its high inorganic residue, noni kombucha tea and pineapple kombucha tea had significant differences (p<0.05). Next, in case of crude fat content, standard kombucha tea offered the lowest value, while soursop kombucha tea had the highest significant value. For crude protein content, kombucha drink samples had no significant difference (p>0.05). The carbohydrate content for each kombucha drink sample differed significantly (p<0.05). The pineapple kombucha tea contains the highest carbohydrate content among others. Meanwhile, the standard kombucha tea had the lowest amount of carbohydrates. For crude fiber content, soursop has a higher value than others, while standard kombucha tea shows the lowest value. The result of crude fiber content related to the brix value is stated by [9], who states that increasing the fiber can also increase the brix for the juice. Therefore, it shows that the Brix value indicated the presence of high dietary fiber content in the sample. To sum up, adding fruit juice to kombucha drinks increases the content of crude ash, crude fat, crude protein, carbohydrate, and crude fiber while decreasing its moisture content.

Table 2. The proximate content of kombucha drinks produced.

Sample	Moisture Content (%)	Ash Content (%)	Crude Fat Content (%)	Crude Protein Content (%)	Carbohydrate Content (%)	Crude Fibre Content (%)
Tea	95.36 ± 0.155a	0.11 ± 0.005c	0.00 ± 0.000c	0.03 ± 0.047a	4.51 ± 0.202d	0.07 ± 0.056d
Noni	94.07 ±	0.30 ±	0.04 ±	0.08 ±	5.50 ± 0.063c	0.40 ±

	0.042b	0.047b	0.001bc	0.002a		0.039c
Soursop	92.63 ± 0.088c	0.52 ± 0.093a	0.16 ± 0.037a	0.11 ± 0.045a	6.60 ± 0.098b	1.68 ± 0.146a
Pineapple	92.28 ± 0.098d	0.23 ± 0.035bc	0.08 ± 0.002b	0.11 ± 0.050a	7.31 ± 0.155a	0.96 ± 0.064b

Note: Each value is the mean of triplicate determinations ± standard deviation. The same superscripts ($^{a-d}$) denote no significant difference (p>0.05).

3.3 Antioxidant Activity

3.3.1 DPPH

As depicted in Figure 4, significant differences (p<0.05) can be observed between fresh and fermented samples. Standard kombucha tea showed a decreasing amount of DPPH after the fermentation process. This result aligned with the study by [10] who stated that antioxidant activity decreased after 7 days of fermentation due to an acidic atmosphere caused by phenolic compounds, releasing protons that can further bind to DPPH. Even though DPPH content in standard kombucha tea drops after fermentation, other samples show a significant increase after fermentation. The rise of antioxidant activity in kombucha tea is caused by the metabolism of microorganisms in kombucha during fermentation [11]. Only the sample of standard kombucha tea has significant differences (p<0.05) from noni kombucha tea, soursop kombucha tea, and pineapple kombucha tea after 14 days of fermentation. It shows that additional fruit juice in kombucha tea may increase the antioxidant level.

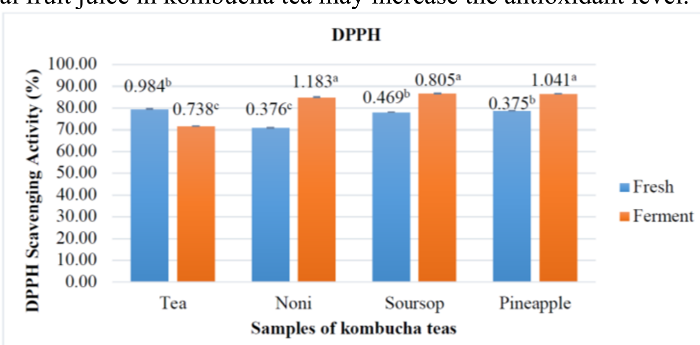

Fig. 4. DPPH Radical Scavenging Activity of different kombucha drink samples on the first day of production (fresh) and 14 days after fermentation (ferment).

Note: Each value is the mean of triplicate determinations ± standard deviation. The same superscripts ($^{a-c}$) denote no significant difference (p>0.05).

3.3.2 TPC

In Figure 5, There were significant differences (p<0.05) in TPC between each sample of kombucha tea before and after the fermentation process, as demonstrated in Figure 5. Only the control sample of kombucha tea shows a decrease in value after fermentation. The decreased I value in TPC is related to a study from [12] that analyzed the antioxidant activity of kombucha tea using leaf substrate containing phenol. The result obtained showed optimum antioxidant activity of 88.24% up to 92.97% during fermentation day eight. The antioxidant activity decreased from day 9 to day 14 as an acidic atmosphere caused the phenolic compounds to become stable, suggesting that the functional properties of the beverage had been reduced. Among all samples, Noni kombucha tea shows the highest significant increase in TPC, which might be due to its nutritional contents such as vitamins C, E, per ulosidic acid, and quercetin [13]. Therefore, it shows that adding fruit juice to kombucha tea increased the total phenolic compound of the sample.

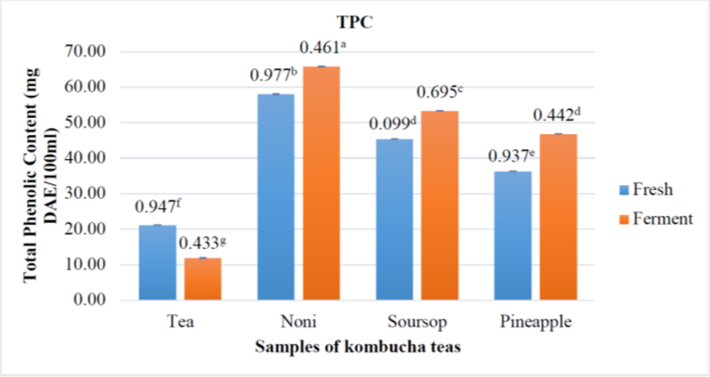

Fig. 5. Total phenolic content of different kombucha drink samples.

Note: Each value is the mean of triplicate determinations ± standard deviation. The same superscripts ($^{a-g}$) denote no significant difference (p>0.05).

3.3.3 FRAP

The FRAP result reveals that the standard kombucha tea was the only sample that decreased after fermentation (Figure 6). This outcome shows antioxidant activity in kombucha tea and show optimum levels on seven days of fermentation and decreased after 10th day. Noni kombucha tea has a higher FRAP reading than other samples. Noni fruit, rich in micronutrients and phytochemicals, such as vitamin C, E, asperulosidic acid, and quercetin, can contribute to the high antioxidant activity [14]. This shows that noni may have the highest reducing ability among all samples and contribute to the significant increase in FRAP results.

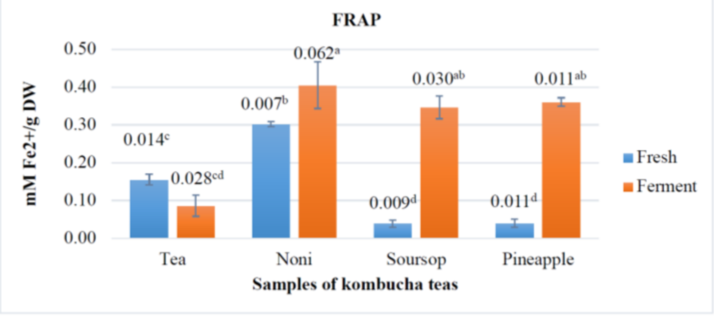

Fig. 6. The ferric reducing ability (FRAP) of different kombucha drink samples.

Note: Each value is the mean of triplicate determinations ± standard deviation. The same superscripts ($^{a-c}$) denote no significant difference (p>0.05).

3.4 Sensory Evaluation

Based on the results presented in Figure 7, soursop kombucha tea, pineapple kombucha tea, and noni kombucha tea have no significant difference (p>0.05) with each other. However, in terms of appearance and color, there were significant differences (p<0.05) towards standard kombucha tea. The panelists were more familiar with kombucha tea, which has a transparent color than others, and it has a cloudy appearance. Next, for odor, there was a significant difference (p<0.05) between noni kombucha tea and other samples. This is because noni kombucha tea has a strong noni odor, which influences its overall odor. Besides, there was a significant difference (p<0.05) in sourness between noni kombucha tea, standard kombucha tea, soursop kombucha tea, and pineapple kombucha tea. The panelist preferred the sourness of standard kombucha tea over other samples. The sour taste of kombucha drinks is considered a distinctive quality in functional beverages. Next, for the sweetness, there was no significant difference (p>0.05) between soursop kombucha tea and pineapple tea. Still, they were significantly different (p<0.05) with noni kombucha tea and standard kombucha tea. The result also shows that panelists preferred more on the sweetness of standard kombucha tea.

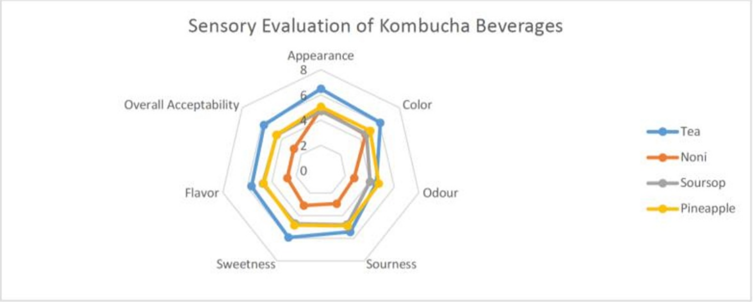

Fig. 7. The sensory evaluation of kombucha tea as compared with soursop kombucha tea, pineapple kombucha tea, and noni kombucha tea.

In this study, adding three different fruits to kombucha tea evaluates the importance of sensory attribution to each sample to standard kombucha tea. The result shows that there were no significant differences (p>0.05) between standard kombucha tea, pineapple kombucha tea, and soursop, but there were significant differences (p<0.05) with noni kombucha tea. Next, regarding overall acceptability, panelists prefer standard kombucha tea over other samples. In comparison, noni kombucha tea was the least preferable. The most preferred kombucha tea was the standard kombucha tea, followed by soursop, pineapple, and noni kombucha tea.

4 Conclusion

The overall results of the current study reveal that adding fruit juice to a kombucha drink could improve its nutritional value. Soursop kombucha tea provides fiber, protein, and ash content to kombucha tea. At the same time, pineapple kombucha tea offers many carbohydrates and protein. Every sample of kombucha teas produced shows a low pH value between 2.5 and 3.0, which meets the optimum pH value for kombucha tea production. Besides, adding fruit juice to kombucha tea affects the Brix value and biomass yield due to the amount of sugar in fruit juice. Next, the antioxidant and total compound analysis shows that adding fruit juice such as noni increases the antioxidant activity and provides a high-quality value to the kombucha drink. The fruit juice samples also show an increase in antioxidant activity after the fermentation process. Even though adding fruit juice increases the nutritional value and antioxidant activity in kombucha tea, most panellists still prefer standard kombucha tea over other tea samples with fruit juice.

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Competing Interests

The authors declare that they have no competing interests.

References

1. Jayabalan, R., Malbaša, R. V., Lončar, E. S., Vitas, J. S., & Sathishkumar, M. (2014). A review on kombucha tea—Microbiology, composition, fermentation, beneficial effects, toxicity, and tea fungus. Comprehensive Reviews in Food Science and Food Safety, 1, 538–550.
2. Teoha, A. L., Heard, G., & Cox, J. (2004). Yeast ecology of Kombucha fermentation. International Journal of Food Microbiology, 95(2), 119-126.
3. Watawana, M. I., Jayawardena, N., Gunawardhana, C. B., & Waisundara, V. Y. (2015). Health, wellness, and safety aspects of the consumption of kombucha. Journal Chemistry-NY, 1, 1–11.
4. Tan WC, Muhialdin BJ and Meor Hussin AS. 2020. Influence of Storage Conditions on the Quality, Metabolites, and Biological Activity of Soursop (Annona muricata. L.) Kombucha. Frontier in Microbiology. 11:603481. https://doi: 10.3389/fmicb.2020.603481.
5. AOAC. (1990). Official methods of analysis of AOAC International (18th edition). Virginia, USA: Association of Official and Analytical Chemists International.
6. Marina, A. M., Man, Y. C., Nazimah, S. A. H., & Amin, I. (2009). Chemical properties of virgin coconut oil. Journal of the American Oil Chemists' Society. 86(4), 301-307.
7. Nummer, B. A. (2013). Kombucha brewing under the food and drug administration model food code: Risk analysis and processing guidance abstract. Journal of Environmental Health, 76(4), 8–12.
8. Muhialdin, B., & Meor, H., A., S., & Sapawi, C., & Wen, Y., V. (2019). Effects of sugar sources and fermentation time on the properties of tea fungus (kombucha) beverage. International Food Research Journal. 26. 481-487.
9. Brown, A. (1967). Correlation between Brix in juice and fibre in commercial hybrid sugar cane populations. 12.
10. Ayu S, Yan R, Eka L. 2013. Determination of Antioxidants in Local Kombucha Black Tea in Bali with Fermentation Time. Udayana University Bali
11. Goh, S.G., Noranizan, M., Leong, C.M., Sew, C.C., & Sobhi, B. (2012) Effect of thermal and ultraviolet treatments on the stability of antioxidant compounds in single

strength pineapple juice throughout refrigerated storage. International Food Research Journal 19: 1131-1136.

12. Suhardini, P. N., & Zubaidah, E. (2016). Study of Antioxidant Activities in Kombucha Tea from different leaves During Fermentation. Journal Food and Agroindustry Vol. 4 No. 1 p.221- 229
13. Vuanghao, L., & Laghari, M. H. (2017). Morinda citrifolia (Noni): A comprehensive review on its industrial uses, pharmacological activities, and clinical trials. Arabian Journal of Chemistry, 10, 691-707. https://doi.org/10.1016/j.arabjc.2015.06.018.
14. Quiao-Won, M.E. & Teves, F.g. (2018). Characteristics of Kombucha Fermentation from Different Substrates and Cytotoxicity of Tea Broth. Sustainable Food Production. 4. 11 19. 10.18052/www.scipress.com/SFP.4.11.