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# Effect of different sweetener and concentration on sensory and chemical attributes of peeled and un-peeled coffee kombucha

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**KEYWORDS**

Kombucha
Unpeeled coffee
Sweetener

**ABSTRACT**

The exocarp and mesocarp of the coffee bean are traditionally not peeled in some regions of Indonesia when producing coffee using traditional methods. Even though it has been a long practice among traditional coffee farmers, unpeeled coffee has a very limited market due to its sensory weakness and thus hardly meets international coffee standards. Therefore, product diversification can be a strategic approach to improving this sub-grade coffee's economic value. One of the alternatives is developing the coffee into kombucha. Kombucha processing has been well known for its ability to transform non-delightful sensory attributes into something more acceptable. In this study, the effects of different sweeteners and concentrations were investigated and designed as a nested experiment. Both peeled and unpeeled coffee were brewed with the French-press technique and used as a medium for kombucha. Different sweeteners, such as sucrose, glucose, and a mixture of sucrose and honey, were also applied in ratios of 5, 10, and 15%. It was observed that both peeled and unpeeled coffee kombucha have a competitive level of sensory preference with similar total sugar, total acidity, and total dissolved solids (p-value > 0.05). Those were achieved by adding 15% sucrose for peeled coffee kombucha and 10% sucrose-honey mix for the unpeeled one.

## Introduction

Indonesia is one of the fourth-largest coffee-producing countries in the world. Indonesia can produce as much as 637,000 tons of coffee with a plantation area of 1.1 million ha. Even though Indonesia is the world's largest coffee bean exporter, there is still potential to increase domestic coffee consumption. Coffee consumption in Indonesia increased by 9% from 2014 to 2018 because coffee has become part of people's lifestyles. However, coffee bean processing can produce waste such as bean skin, fruit skin, and pulp (Arya et al., 2022). Therefore, processing coffee without peeling can be a solution to utilize this waste.

Implement the zero-waste concept for post-harvest coffee fruit without involving the coffee hulling stage is a prospective opportunity. Zero-waste is an innovation that can protect the environment without producing waste and maximize the nutritional potential of all food components. However, based on preliminary studies, processing whole coffee beans without peeling results in a low sensory quality of coffee due to the presence of several off-notes, such as strong grassy and burnt flavors (Fibrianto et al., 2023).

A fermented drink, namely kombucha, is utilized to enhance the sensory quality of unpeeled coffee. Kombucha is a functional drink that contains secondary metabolites, namely phenol, which can be used as a drug to prevent cancer and has antibacterial properties (Destiani et al., 2019). Coffee kombucha is a beverage that can be produced through the fermentation process involving brewing coffee, sugar, and a SCOBY starter. The choice of coffee as a medium in kombucha is attributed to its several ingredients that can have positive effects on the body, such as antioxidants and caffeine. According to (Watawana et al., 2015; Parhusip et al., 2022), a hypothesis suggests that the fermentation process

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using kombucha culture has the ability to enhance the antioxidant activity and caffeine content of coffee.

This study aims to determine the effect of adding variations in the ratio of sweeteners to sucrose, glucose, and honey in peeled and unpeeled kombucha coffee. According to Rukman et al. (2023), the degradation capability of SCOBY microorganisms depends on the type of sweetener employed as a carbon source, each containing distinct saccharides. The unprocessed simple sugar remaining in kombucha is measured as sugar reduction during fermentation. Additionally, the overall quality of kombucha is influenced by its acceptance of flavor. Consequently, it is essential to assess the impact of various sweeteners on total acid, total sugar, total dissolved solids, and the sensory evaluation of kombucha to comprehensively evaluate its properties.

## Research and Methods

***Material***

The ingredients used in making kombucha coffee are sugar, mineral water, starter kombucha, coffee flower honey, peeled and unpeeled robusta coffee grounds from Dampit District, Malang Regency, East Java.

***Research design***

This study used a nested model design method (Nested), which consisted of three factors: the use of peeled and unpeeled coffee in kombucha coffee; the use of sucrose, glucose, and coffee flower honey; and the use of sweet ratios of 5%, 10%, and 15%. The responses used were taste intensity, level of preference, and several chemical tests (total acid, total sugar, and total dissolved solids). Result data were analyzed using the *software* Minitab 19 with analysis of variance *(ANOVA)*, *random* or Nested, *factor or covariate* (minor), and Nested *in factors (major)*. When the response shows the significance of a p-*value* < 0.05, then a Tukey post hoc test was carried out. Multiple attribute Zeleny was then further conducted to determine the best-treated coffee kombucha. Multiple regression analysis was also carried out to determine the correlation for all parameters tested.

***Research stages***

*a. Kombucha sample process of peeled coffee and unpeeled coffee*

Peeled and unpeeled coffee grounds with a ratio of 1:7 (214 g of coffee grounds and 1500 ml of drinking water) brewed with drinking water at approximately 95°C using the French Press method. Then, given the addition of sucrose sweetener (6 jars for peeled coffee kombucha and without peel) and glucose (3 jars of kombucha for kombucha peeled coffee) with a ratio of 5%, 10%, and 15%, After the brew reaches room temperature, the starter is added (5% starter and 5% culture). Then the jar is covered with a cloth and fermented for 14 days at a temperature of 20–30 °C. When it has reached the $14^{th}$ day, separate the *starter* kombucha and pour it into the bottle. Then, three jars of kombucha peeled coffee and unpeeled sucrose were added to coffee flower honey in a ratio of 5%, 10%, and 15%. After that, the kombucha is fermented for one day in the refrigerator.

*b. Analysis Procedure*

Sensory analysis includes method analysis (Rate-All-That-Apply) and hedonic scales using 102 panelists (Su et al., 2022). Chemical analysis includes the analysis of total acid, total sugar, and total dissolved solids (Rune et al., 2023). The results of sensory and chemical attributes were analyzed to find out the best treatment results using *multiple attribute* Zeleny and *multiple regression* to determine the effect of the preference level response on chemical factors such as total acid, total sugar, and total dissolved solids.

## Results and Discussion

***Sensory attributes***

***Sweet taste***

As shown in Table 1, there is a significant difference (p-value<0.05) in sweetness between the peeled and the unpeeled coffee kombucha. It was observed that the unpeeled coffee kombucha tended to be sweeter (p-value<0.05) than that of the peeled one. This can be supported by the fact that the reducing sugar content of unpeeled coffee was reported to be 0.76% (Fibrianto et al., 2023), while the peeled one was 0.44% (Wandani, 2018). It was also observed that the addition of sucrose and the mix of sucrose-honey tended to improve the sweetness intensity of kombucha (p-value<0.05). However, additional glucose tended to have a constant sweetness level. According to Wandani (2018) and Zakidou et al. (2021) as well as Arawwawala and Hewageegana, (2017), one of the compounds that contributes to the sweet taste of coffee is a carbohydrate derivative. Thus, the more additional sugar, the sweeter coffee will be.

**Table 1.** Effect of peeling, type, and concentrations of sweetener on sensory intensity and preferences of coffee kombucha

| Type of Coffee | Type of Sweetener | Sweetener Concentration | Sweet Taste | Sour Taste | Bitter Taste | Earthy flavor | Preferences |
|---|---|---|---|---|---|---|---|
| **Unpeeled** | Sucrose | 15% | $3.46^{a}$ | 2.57ab | $2.41^{ef}$ | $2.04^{abc}$ | $3.13^{a}$ |
| | | 10% | $3.11^{ab}$ | $2.69^{ab}$ | $2.53^{cdef}$ | $2.15^{abc}$ | $3.00^{ab}$ |
| | | 5% | $2.62^{c}$ | $2.65^{ab}$ | $2.70^{bcdef}$ | $2.33^{ab}$ | $2.84^{abc}$ |
| | Sucrose + Honey | 15% | $3.45^{a}$ | $2.34^{b}$ | $2.23^{f}$ | $1.87^{bc}$ | $3.18^{a}$ |
| | | 10% | $3.14^{ab}$ | $2.50^{ab}$ | $2.47^{def}$ | $2.03^{abc}$ | $3.01^{ab}$ |
| | | 5% | $2.76^{bc}$ | $2.54^{ab}$ | $2.63^{bcdef}$ | $2.00^{abc}$ | $2.65^{bc}$ |
| **Peeled** | Sucrose | 15% | $2.68^{bc}$ | 2.98a | $2.80^{bcde}$ | $1.92^{abc}$ | $2.64^{bc}$ |
| | | 10% | $2.51^{c}$ | $2.77^{ab}$ | $2.98^{abcd}$ | $1.89^{abc}$ | $2.46^{cd}$ |
| | | 5% | $1.88^{d}$ | $2.55^{ab}$ | $3.35^{a}$ | $2.06^{abc}$ | $2.11^{de}$ |
| | Sucrose + Honey | 15% | $3.43^{a}$ | $2.34^{b}$ | $2.38^{ef}$ | $1.74^{c}$ | $2.96^{ab}$ |
| | | 10% | $2.98^{abc}$ | $2.52^{ab}$ | $2.52^{cdef}$ | $1.85^{bc}$ | $2.85^{abc}$ |
| | | 5% | $2.60^{c}$ | $2.52^{ab}$ | $2.77^{bcde}$ | $2.11^{abc}$ | $2.48^{cd}$ |
| | Glucose | 15% | $1.81^{d}$ | $2.57^{ab}$ | $3.05^{ab}$ | $2.21^{abc}$ | $2.04^{de}$ |
| | | 10% | $1.68^{d}$ | $2.82^{ab}$ | $3.01^{abc}$ | $2.13^{abc}$ | $1.94^{e}$ |
| | | 5% | $1.87^{d}$ | $2.72^{ab}$ | $3.14^{ab}$ | $2.37^{a}$ | $1.89^{e}$ |

(Different letter notations indicate significant difference at 95% confidence level)

***Sour taste***

As represented by Table 1, it was observed that there is no significant difference in terms of sourness (p-value>0.05). The sour taste in kombucha comes from the metabolic processes sugar into alcohol and several other types of acids. According to research conducted by Wicaksono (2022), the total acid in peeled coffee kombucha is higher (5.87%), compared to the use of unpeeled coffee (5.27%). This is because unpeeled coffee contains sugar-reducing agents as much as 0.76% which can suppress the appearance of sour taste. Neither the peeling treatment nor the sweetener type and concentration affect the sourness. The presence of a sour taste in kombucha is obtained from the process of sugar metabolism into alcohol and several acids such as lactic acid, acetic acid, citric acid, gluconic acid, and others (Khamidah and Antarlina, 2020; Tran et al., 2020). These organic acids, as end products of metabolism, can contribute to sour taste.

***Bitter taste attribute***

The bitter taste in coffee can result from the degradation process of several compounds, such as carbohydrates, alkaloids, chlorogenic acid, volatile compounds, and trigonelline. Carbohydrates can be degraded to form sucrose and simple sugars to produce a sweet taste. Alkaloids or caffeine will undergo an endothermic process to form caffeine (Purnamayanti et al., 2017). As listed in Table 1, it was observed that the bitterness intensity of unpeeled coffee kombucha tended to be higher than that of the peeled one (p-value<0.05). This may be affected by the contribution of additional high phenolic content in the coffee peel, as suggested by Abduh et al. (2023). According to Delgado et al. (2019), the components of flavanol compounds easily bind to sugar molecules in amounts that depend on the temperature and the extraction process. Thus, the less added sweetener to coffee kombucha, the less flavanol compounds contained and the higher phenol content (Huang et al., 2021). Then, it can cause coffee or kombucha to taste bitter. In addition, chlorogenic acid compounds can produce a bitter taste sensation that is formed during the roasting process (Wei et al., 2014). However, in this study, additional sweetener concentration was not related to suppression of bitterness (p-value>0.05) except for peeled coffee kombucha with 15% of sucrose (p-value<0.05).

***Earthy flavor attributes***

Earthy flavor as a negative note in coffee quality, as listed in Table 1, was also noted by the panelists. Neither the peeling treatment nor the sweetener's type and concentration could modify the earthy flavor of coffee kombucha. Even though unpeeled coffee tended to have higher xanthophylls that lead to a vegetative earthy taste sensation (Wicaksono, 2022; Dwitama, 2018), the earthy flavor was also noted from the peeled coffee kombucha. Furthermore, it was suggested that the compound methanothiol may also be related to an earthy or vegetative taste as a result of lactic acid fermentation

(Yang et al., 2010; Di Cagno et al., 2015). The addition of 5% glucose is the best result. This can be related to that in the fermentation process of lactic acid bacteria the use of glucose is more difficult compared to sucrose. This was because the fermentation process begins with activity yeast that breaks down sucrose into glucose and fructose with the help of enzymes extracellular invertase (Abedi and Hashemi, 2020; Wang et al., 2021).

***Sensorial preference***

As suggested by Table 1, the respondents preferred the unpeeled coffee kombucha than that of the peeled one (p-value<0.05). This may be related to the fact that the unpeeled coffee kombucha tended to be superior in terms of sweetness and bitterness than the peeled one. Adding sugar to food has a sensational effect (*good mood),* and the body is able to absorb tryptophan to produce serotonin (Oliphant et al., 2019). High serotonin levels can cause feelings of happiness (Hassan et al., 2021).

***Acidity***

As shown in Figure 1, there is no significant difference in acidity (p-value>0.05) regardless the peeling treatment as well as type and concentration of sweetener. This finding complements the sensory observation that suggests equal sourness for all tested treatments. The acid content in kombucha is caused by the sugar fermentation process, which can produce acids such as citric acid, acetic acid, lactic acid, gluconic acid, etc. According to Gomes et al. (2018) and Li et al. (2022), sugar can produce gluconic acid, giving rise to a refreshing and soft sour taste.

***Total Sugar***

As represented by Figure 2, the total sugar of coffee kombucha tended to be affected significantly by sweetener concentration (p-value<0.05). This observation was also well corresponded by the sweetness intensity sensed by the panelists. It is important to note that the total sugar found in kombucha after fermentation is the remaining sugar (Akbarirad et al., 2017). The use of honey also contributes to reducing total sugar. According to Ocvilia (2005), honey contains 38.5% fructose, 31.0% glucose, 1.5% sucrose, 7.2% maltose, etc.

***Total dissolved solids***

As shown by Figure 3, the total dissolved solids of coffee kombucha tended to be affected significantly by sweetener concentration (p-value<0.05). The data shows that improvement of sugar concentration, increases the total dissolved solids as also suggested by Makroo et al. (2019). The total dissolved solids are contributed mostly by carbohydrates (i.e., simple sugars, monosaccharides, disaccharides, etc.).

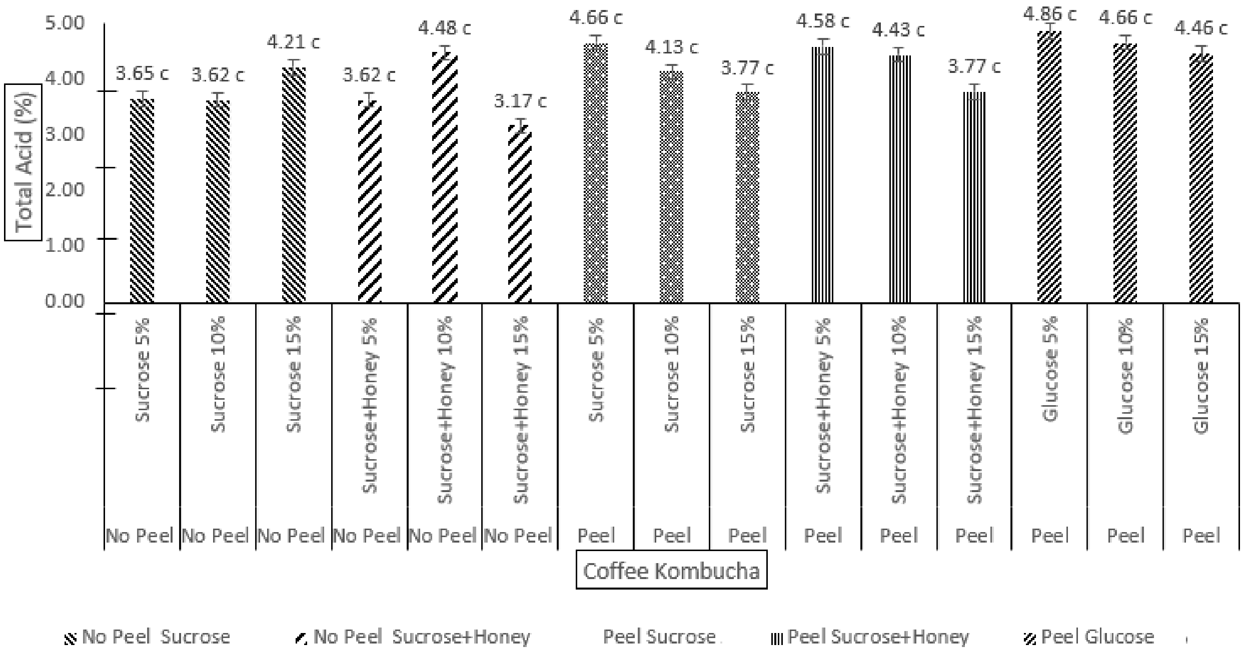


**Figure 1.** Effect of peeling, type, and concentrations of sweetener on total acid of coffee kombucha.different letter notations indicate significant differences at a 95% confidence level.

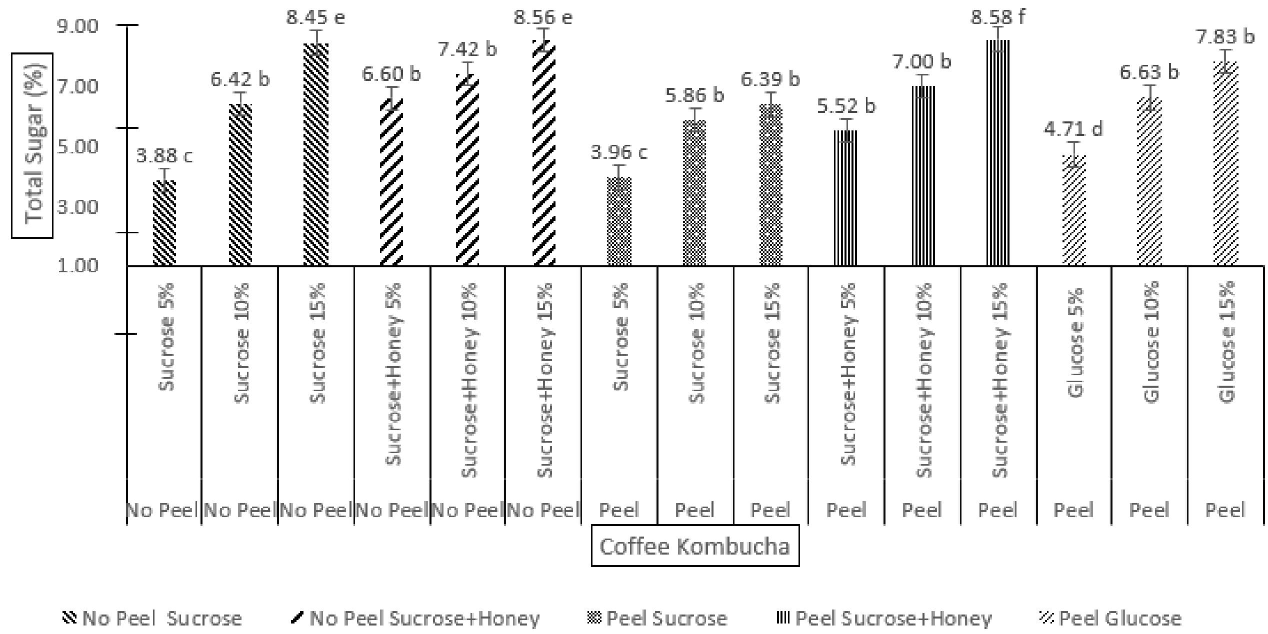


**Figure 2.** Effect of peeling, type, and concentrations of sweetener on total sugar of coffee kombucha. Different letter notations indicate significant differences at a 95% confidence level.

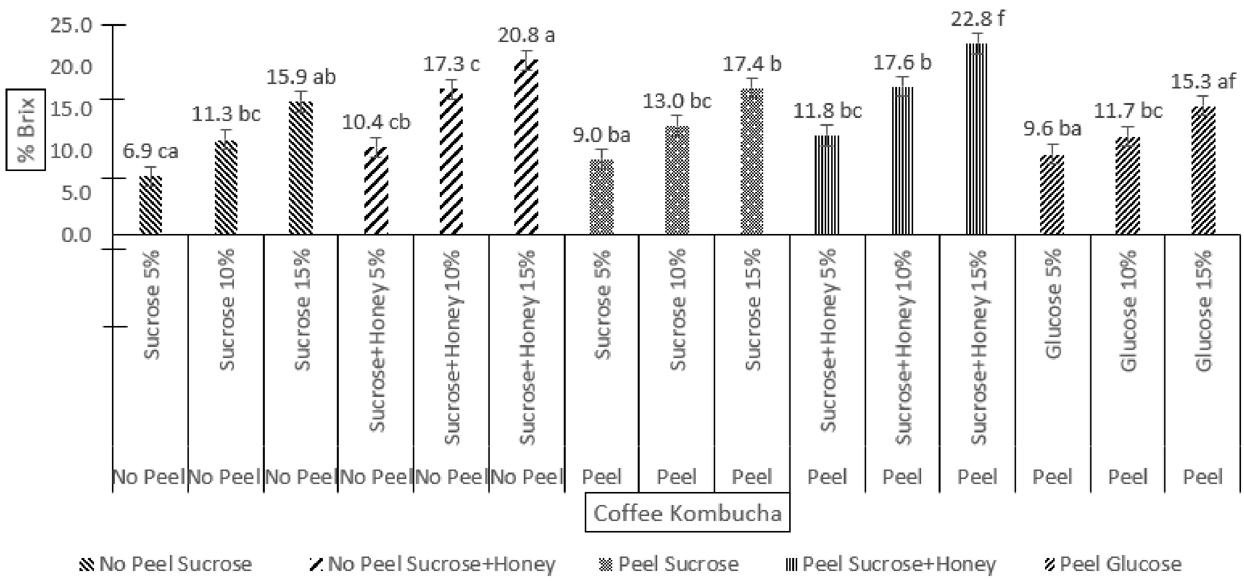


**Figure 3.** Effect of peeling, type, and concentrations of sweetener on total dissolved solids of coffee kombucha. Different letter notations indicate significant differences at a 95% confidence level.

***Sensory and chemical parameters relationship***

As per multiple regression conducted, a strong correlation was observed for intensity of sour taste, total acid, sweetness intensity, and total sugar ($R^2$ of 81.52%). This shows that the level of liking is influenced by the presence of total sugar and the intensity of the sweet taste. Despite this, preference may be influenced by the content of other marked components with a low correlation of total sugar compared to the intensity of sweetness. However, the correlation was low when it was correlated to sensorial preference. According to Wahidah (2010) and Lamusu (2018), the complexity of a taste can be caused by the diversity of sensory perceptions. According to Lamusu (2018) and Genovese et al. (2021), several factors influence taste perception, such as smell, taste, and mouth stimulation (hot and cold), involving different sensory receptors (Zhou et al., 2021).

**Table 2.** Characteristics of the best treated coffee kombucha

| Sample | Sweetener Ratio | Preference Level | Total Acidity (%) | Total Sugar (%) | Total Dissolved Solids (mg/L) |
|---|---|---|---|---|---|
| Peeled Coffee Kombucha | Sucrose (15%) | 2.63 ± 0.92 | 3.77 ± 1.63 | 6.39 ± 1.41 | 17.4 ± 0.92 |
| Unpeeled Coffee Kombucha | Sucrose Honey (10%) | 3.02 ± 0.93 | 4.47 ± 2.50 | 7.42 ± 1.25 | 17.3 ± 3.06 |

### *Best treatments*

Based on *Multiple Attribute* determination (Table 2), the unpeeled coffee kombucha with 10% sucrose honey mix *is* considered equally competitive (p-value>0.05) to peeled coffee kombucha with 15% sucrose in terms of sensory and chemical characteristics. This may suggest that unpeeled coffee kombucha processed with an additional 10% sucrose honey mix is sufficiently preferable by consumers.

## Conclusions

Considering the conducted observations in this study, it can be concluded that both peeled and unpeeled coffee kombucha have a competitive level of sensory preference with similar total sugar, total acidity, and total dissolved solids (p-value > 0.05). Those were achieved by adding 15% sucrose for peeled coffee kombucha and 10% sucrose-honey mix for the unpeeled one. It is important to note that earthy flavour as a negative sensory attribute still existed among all coffee kombucha. Further study on either reducing or masking this negative note would benefit for coffee kombucha improvement.

## Declarations

**Conflict of interests** The authors declare no competing interests.

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