

SENSORY ACCEPTABILITY, ANTIOXIDANT ACTIVITIES, AND TOTAL PHENOLICS OF KOMBUCHA FROM TAYU GREEN TEA (*Camellia sinensis L.*)

*Daya Terima Sensoris, Aktivitas Antioksidan, dan Total Fenol Kombucha dari
Daun Teh Hijau Tayu (Camellia sinensis L.)*

Sutyawan^{1*}, Novidiyanto¹

¹Program Studi DIII Poltekkes Kemenkes Pangkalpinang, Pangkalpinang, Indonesia
Email: sutyawan@poltekkespangkalpinang.ac.id/ Phone: 087770517003

ABSTRACT

Kombucha is a fermented tea beverage with health benefits due to its antioxidant, antidiabetic, and antibacterial properties. Kombucha can be made from various types of tea. Green tea from Tayu leaves is a specialty of Ketap Village, West Bangka Regency. Previous research has shown that kombucha from Tayu black tea has a higher antioxidant content than commercial tea. This study compared the sensory acceptability, antioxidant activity, and total phenols of kombucha made from Tayu green tea to commercial tea. The research design used was purely experimental in food production. The sensory characteristics were determined through organoleptic testing involving 30 semi-trained panelists. Total phenolics were tested using the Folin-Ciocalteu method, and antioxidant activity using the FRAP (Ferric Reducing Antioxidant Power) method. Statistical analysis was conducted using an independent sample t-test and Mann Whitney u test. The results showed that the acceptability of kombucha from Tayu green tea was significantly higher ($p < 0.05$) in all aspects (color, smell, and taste) than commercial tea. The antioxidant activity of kombucha from Tayu green tea was higher than that of commercial tea, but not significantly different ($p > 0.05$). The total phenol content was the same for both types of kombucha. The acceptability and antioxidant activity of green kombucha made from Tayu green tea are higher than those made from commercial tea. Research recommends examining the effect of fermentation duration and sugar concentration on the antioxidant activity, polyphenols, and acceptability of Tayu tea leaf kombucha.

Keyword : *antioxidant activity; kombucha, sensory evaluation; tayu green tea leaves (Camellia sinensis L.)*

ABSTRAK

Kombucha adalah minuman teh fermentasi yang memiliki manfaat kesehatan karena sifat antioksidan, antidiabetes, dan antibakterinya. Kombucha dapat dibuat dari berbagai jenis teh. Teh hijau dari daun Tayu merupakan produk khas Desa Ketap, Kabupaten Bangka Barat. Penelitian sebelumnya menunjukkan bahwa kombucha dari teh hitam Tayu memiliki kandungan antioksidan yang lebih tinggi dibandingkan teh komersial. Penelitian ini membandingkan daya terima sensori, aktivitas antioksidan, dan total fenol kombucha yang terbuat dari teh hijau Tayu dengan teh komersial. Desain penelitian yang digunakan adalah murni eksperimental dalam produksi pangan. Karakteristik sensori ditentukan melalui uji organoleptik yang melibatkan 30 panelis semi-terlatih. Total fenolik diuji menggunakan metode Folin-Ciocalteu, dan aktivitas antioksidan menggunakan metode FRAP (Ferric Reducing Antioxidant Power). Analisis statistik dilakukan dengan menggunakan uji-t sampel independen dan mann whitney u test. Hasil penelitian



menunjukkan bahwa daya terima kombucha dari teh hijau Tayu secara signifikan lebih tinggi ($p < 0.05$) pada semua aspek (warna, aroma, dan rasa) dibandingkan teh komersial. Aktivitas antioksidan kombucha dari teh hijau Tayu lebih tinggi daripada teh komersial, tetapi tidak berbeda secara signifikan ($p > 0.05$). Total kandungan fenol sama untuk kedua jenis kombucha. Daya terima dan aktivitas antioksidan kombucha hijau yang terbuat dari teh hijau Tayu lebih tinggi daripada yang terbuat dari teh komersial. Penelitian merekomendasikan untuk meneliti pengaruh durasi fermentasi dan konsentrasi gula terhadap aktivitas antioksidan, polifenol, dan daya terima kombucha daun teh Tayu.

Kata Kunci : aktivitas antioksidan; daun teh tayu (*camellia sinensis L.*); evaluasi sensoris, kombucha

INTRODUCTION

Kombucha is a functional drink that is growing rapidly and is widely consumed by the public because of its effects on health. Kombucha is a fermented beverage made from sugar, tea, and a symbiotic microbial culture or Symbiotic Culture of Bacteria and Yeast (SCOBY). Kombucha has potential as a functional beverage because it contains various bioactive compounds such as polyphenols, flavonoids, and organic acids (Onsun, Toprak and Sanlier, 2025). Several studies report that consuming kombucha can provide antioxidant and antibacterial activity and support digestive health and the immune system (de Oliveira *et al.*, 2023; Andrade *et al.*, 2025). One important factor in determining the functional value of kombucha is its total phenol content and antioxidant activity. Fermentation is known to increase the availability of phenolic compounds through biotransformation processes, thus impacting antioxidant

capacity. Phenolic compounds are important in neutralizing free radicals, which is closely related to preventing degenerative diseases (Kitwetcharoen *et al.*, 2023).

West Bangka Regency has the potential of local resources in the form of tayu tea leaves (local tea plant) traditionally consumed by the community as a brew. Tayu tea has unique characteristics compared to other teas. Tayu tea can grow in lowland areas with an altitude of between 0-25 meters above sea level with an average temperature of 26.7°C. The process of picking Tayu tea is carried out for a certain period every 10-14 days in the morning before 10 a.m. Meanwhile, the process of processing tayu tea become dry green tea still uses traditional tools and methods to produce a distinctive taste and smell. Tayu tea has a fresh and slightly bitter taste, after drinking it there is a taste of resin or astringency (BPTP Bangka Belitung, 2018). In terms of bioactive composition from previous research, tayu tea



has a polyphenol content that meets national standards for tea leaves (Mariana, 2017). Furthermore, Tayu tea brewed water's antioxidant activity is higher than commercial tea (Novidiyanto and Sutyan, 2022). This potential of tayu tea leaves was then developed into kombucha. The results showed that kombucha made from black tayu tea leaves had higher antioxidant activity and carbohydrate content than kombucha made from commercial black tea. However, the differences were not statistically significant (Sutyan and Novidiyanto, 2021). Meanwhile, further research compared the sensory properties and total phenol content of Kombucha from black tayu tea with that of commercial tea. The results showed variations in organoleptic profiles and differences in phenol content that could provide unique advantages to black tayu tea-based kombucha (Sutyan and Novidiyanto, 2022).

However, previous research has been limited to using black tayu tea as a raw material for kombucha. However, processing black tea through enzymatic fermentation can cause a decrease in catechin content. Some catechin compounds oxidize to theaflavins and thearubigins, particularly between the

later rolling and fermentation periods (Ito and Yanase, 2022). Besides black tea, tayu tea can be developed into green tea. The process for making dry green tea differs from that of dry black tea. The results of a study stated that green tea has higher antioxidant activity and total catechins than black tea (Wibowo et al., 2022). Studies have shown that kombucha from green tea has a higher antioxidant value based on several extraction and assay methods, making it potentially richer in antioxidants (Değirmencioglu et al., 2021). Kombucha from green tea has higher catechins than black tea, so it can increase antiproliferative activity against cancer cell lines and antibacterial activity (Cardoso et al., 2020). Therefore, this research is different from previous research by developing kombucha from Tayu green tea. The study of green tea is important because it has the potential to produce kombucha with higher antioxidant activity and phenol content, and has a different sensory profile than black tea kombucha. This study compared the sensory acceptability, antioxidant activity, and total phenols of kombucha made from Tayu green tea with commercial tea.



METHOD

Design, place and time

This research was purely experimental in the field of food production. It was conducted from July to December 2022. Green tea production from Tayu tea leaves and kombucha was carried out in the food processing laboratory of the Pangkalpinang Ministry of Health Polytechnic. Total phenol and antioxidant activity analyses were conducted at a certification laboratory in Bogor. Analysis of antioxidant activity and total phenols was repeated twice so that there were four data sets of in total.

Materials, preparation, dan Fermentation of Kombucha

The basic ingredients in this study were Tayu green tea obtained from a Tayu tea processing industry in Ketap Village, West Bangka Regency. Making dry green tea involves withering, rolling, and drying. Meanwhile, commercial green tea was obtained from a nearby minimarket. The commercial green tea used is tea with the Sariwangi brand from PT Unilever Indonesia Tbk. (Now transferred to PT Savoria Kreasi Rasa Tbk.). Bacterial cultures or SCOBY and

kombucha starters were obtained from marketplace sales in Indonesia. A total of two types of kombucha were made in this study, Tayu Green Tea Kombucha (TGTK) and Commercial Green Tea Kombucha (CGTK). Other ingredients, such as granulated sugar, the number of SCOBY bacteria, and water, were added in equal amounts for each formula. A total of 100 grams of refined sugar, 1110 ml of mineral water, and 20 grams of each type of tea were mixed. The tea-to-water ratio was 2:11, or a tea concentration of approximately 1.8% (w/v). Then the solution was heated to 90°C for 10 minutes. The next stage was to wait for the tea decoction to cool. After cooling (20°C), the tea decoction was filtered into a clean glass jar, and 10% kombucha starter was added, consisting of 5% starter solids and 5% starter liquid. The end of the jar was covered with a clean cloth and tied with a string. The fermentation process lasted for 12 days using room temperature without any temperature control. The finished kombucha was then filtered and ready for analysis.

The Determination of the Total Phenols Content and antioxidant activity



The method used to determine the antioxidant activity of kombucha is the ferric ion reducing antioxidant capacity (FRAP) test. This method applies the principles described by one study with modifications (Pisoschi and Negulescu, 2012). Determination of antioxidant activity began by mixing the FRAP reagent (a mixture of TPTZ, FeCl₃, and acetate buffer) with the sample extract. The analysis was performed based on the increase in absorbance at 593 nm and calculated as the amount of Fe²⁺ equivalent to the standard antioxidant (ascorbic acid). Meanwhile, in determining total phenols in kombucha, the method was based on the methodology described by by one study with modifications (Miah *et al.*, 2018). Total phenol content was determined using Folin-Ciocalteu reagent. Concentration variations were made with gallic acid as a standard solution from 20 to 50 ppm. 0.5 mL of gallic acid was mixed with 2 mL of Na₂CO₃ and 2.5 mL of Folin-Ciocalteu reagent. A total of 10 mg of extract was mixed with 5 mL of methanol. Then, 0.5 mL of the mixture was added to 2.5 mL of Folin-Ciocalteu reagent and 2 mL of Na₂CO₃ solution. After incubation for 35 minutes, absorbance was measured using a UV-Vis

spectrophotometer at a wavelength of 760 nm. A standard curve was created based on the absorbance value versus gallic acid concentration. Total phenol content was expressed in mg/kg.

Sensory evaluation

Two types of kombucha (tayu and commercial) were subjected to sensory testing involving 30 semi-trained panelists. Panelist inclusion criteria included willingness to serve as a panelist by providing informed consent, and students with experience in organoleptic testing. Exclusion criteria included impaired sense of smell and taste, and allergies to acidic fermented foods or beverages. This study used a 7-level hedonic scale consisting of: really dislike extremely (1), dislike (2), dislike moderately (3), neutral (4), like slightly (5), like moderately (6), and like extremely (7) (Mihai et al, 2024). The antioxidant activity, total phenols, and sensory characteristics of two types of kombucha tea were expressed as means and standard deviations (SD). Normality test using the Shapiro-Wilk. Analysis of antioxidant activity and total phenols was repeated twice so that there were four data



sets in total. The test results show that data antioxidant activity and total phenols are normally distributed ($p > 0.05$). Meanwhile, the sensory characteristics data are not normally distributed ($p < 0.05$). The antioxidant activity and total phenols were tested for differences using an independent sample t-test, and the sensory characteristics were assessed the Mann-Whitney U test.

Data analysis

Antioxidant activity, total phenols, and sensory characteristics of two types of kombucha tea were expressed as means and standard deviations (SD). Antioxidant activity and total phenols were tested for differences using an independent sample t-test. Sensory characteristics were assessed using the Mann-Whitney U test.

RESULTS AND DISCUSSION

Total Phenolic Content (TPC)

Phenolic compounds are compounds commonly found in plants. They are characterized by an aromatic ring containing one or two OH groups. This study measured the total phenol content using a spectrophotometric method and expressed it

in mg/kg. Table 1 shows that the overall phenol content was nearly the same for all types of kombucha tea, at around 0.1 mg/kg. This is supported by the results of statistical tests, which showed no significant difference ($p > 0.05$) in total phenol content between kombucha tea types. The phenol content in both types of kombucha is lower compared to the minimum total phenol content for packaged tea beverages according to the Indonesian National Standard (SNI), which is 400 mg/kg (Prawira-Atmaja *et al.*, 2021). Several studies in Indonesia showed that the phenolic content of kombucha derived from green tea ranges from 50 to 160 mg/L GAE (Nafisah *et al.*, 2024; Maghfirah *et al.*, 2025). The low total phenol content in kombucha tea is thought to be caused by several factors. The microorganisms in the SCOBY (bacteria and yeast) produce hydrolytic enzymes that can break down complex polyphenols into monomers. While this can initially increase the TPC, in later fermentation phases, enzymes can further oxidize or break down polyphenols into other metabolites, thus decreasing the detectable content (Phung *et al.*, 2023). Furthermore, prolonged fermentation in kombucha production can increase acidity and decrease the TPC.



Increased acidity during fermentation can result in the chemical degradation of phenolic compounds or inhibit their release from the tea matrix, resulting in a measurable decrease in concentration (Tejedor-Calvo and Morales, 2023). TPC may increase at certain phases (e.g., day 10), but if fermentation is prolonged, it can decrease again due to further degradation or polymerization (Zofia *et al.*, 2020). Besides the length of

fermentation, the decrease in total phenol content is also caused by the traditional drying process to make tayu tea. The manual heating process using a stovetop pan can reduce total phenol content. The main polyphenol compounds in tea (catechins) are sensitive to heat. At high temperatures, the chemical structure of polyphenols becomes unstable, leading to damage or breakdown of the molecules (Donlao and Ogawa, 2019).

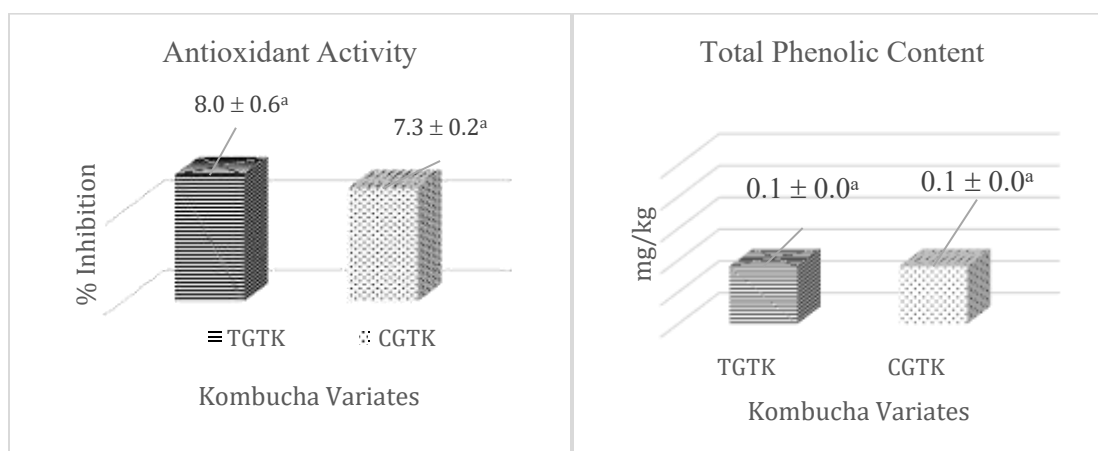


Figure 1. Total Phenol Content (mg/kg) and Antioxidant Activity (% inhibition) with Different Green Tea (TGTK: Tayu Green Tea Kombucha and CGTK: Commercial Green Tea Kombucha); Differences in letter notation indicates significant differences ($p < 0.05$)

Antioxidant activity

Antioxidants are compounds that can inhibit oxidation reactions and scavenge free radicals, making them beneficial in reducing the risk of degenerative diseases. In this study, the antioxidant activity of kombucha tea was measured using the FRAP (Ferric Reducing Antioxidant Power) method and

expressed in % inhibition. The analysis results, as shown in Figure 1, show that the antioxidant activity of kombucha tea from Tayu green tea was 8.04% higher than that of commercially produced kombucha tea, which was 7.31%. The antioxidant activity of both types of kombucha is in the low category because it is below 20% (Saefudin *et al.*,



2013). This is in accordance with the total phenols of both kombuchas which also have low values. Statistical tests did not show a significant difference ($p>0.05$) in antioxidant activity between kombucha tea from Tayu green tea and commercially produced green tea. Kombucha made from green tea has higher antioxidant activity than oolong or black tea, due to its richer catechin and polyphenol content. Local communities traditionally process Tayu green tea leaves. One study showed that handmade green tea exhibited higher phenolic content and antioxidant activity, surpassing commercially available green tea. Handmade green tea contains all kinds of phenolics such as gallic acid, catechin (C), epicatechin (EC), epigallocatechin (EGC), epicatechin gallate (ECG), epigallocatechin gallate (EGCG), and caffeine. This indicates that traditional processing techniques can significantly retain bioactive compounds (Atak *et al.*, 2024). Another study found that traditional tea extraction retained antioxidant activity better than modern refining techniques, which cause polyphenol oxidation due to the larger surface area (Peng *et al.*, 2020). Methods such as slow drying, manual heating, or blanching, common in traditional processing,

can better preserve the stability of catechins and polyphenols. This is sometimes more effective than industrial-scale processing, which may involve high temperatures or optimizing quantity over quality. One study found that heating tea with steam can maintain antioxidant activity better than oven heating. Processes in traditional green tea processing through rapid heating with a wok or frying pan that effectively deactivate the polyphenol oxidase (PPO) enzyme, preventing polyphenol oxidation and preserving antioxidant activity (Roslan *et al.*, 2020).

The low antioxidant activity of the two types of kombucha mentioned above is associated with the length of fermentation and the temperature during fermentation. In this study, the fermentation time used was 12 days. One study found that the highest polyphenol content was found in green tea kombucha with fermentation times of 7 and 10 days (Dartora *et al.*, 2023). Excessive fermentation can cause further oxidation and degradation of antioxidant compounds, resulting in decreased antioxidant activity. Furthermore, the decreased antioxidant activity is due to the acidic environment, which stabilizes phenolic compounds,



making it more difficult for kombucha to release protons that can interact with DPPH (Villarreal-Soto *et al.*, 2018; Rahmawati, 2025)

Furthermore, another factor contributing to low antioxidant activity is the high temperature during fermentation. In this study, no temperature control was used during fermentation. The temperature used was room temperature with sufficient sunlight. One study stated that the optimal fermentation temperature for kombucha to produce the highest antioxidant activity is 28°C (Pei *et al.*, 2025). Several studies have

also shown that the ideal fermentation temperature for kombucha ranges from 23°C to 28°C (Salinas-Ruiz *et al.*, 2026). Tea phenolic compounds and their fermented metabolites are sensitive to heat. When the fermentation temperature or heating increases too high, the chemical structure of the polyphenols undergoes oxidation. This process damages the phenolic compounds and decreases their ability to donate electrons or scavenge free radicals (Kim *et al.*, 2020).

Sensory acceptability

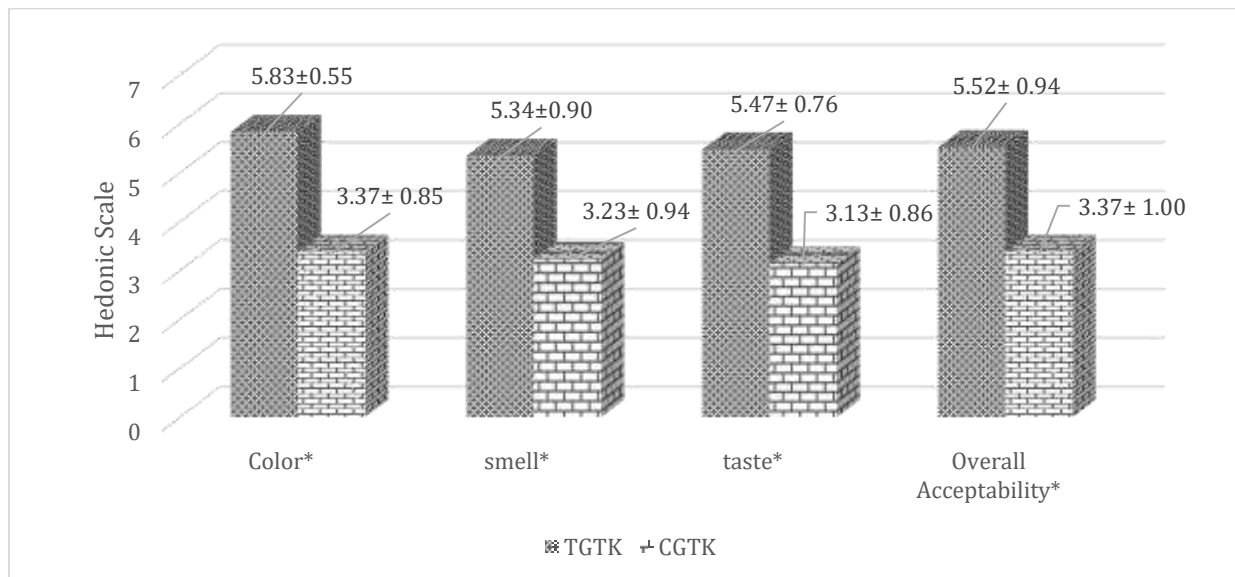


Figure 2. Sensory characteristics of two types of kombucha. (a) Tayu green tea kombucha (b) commercial green tea kombucha. The * indicates a significant difference ($p < 0.05$) in the chi-square test analysis results.

Based on Figure 2, the sensory attributes in color, taste, smell, and overall

acceptance level for kombucha from Tayu green tea are higher than those for kombucha



from commercial green tea. The average score for all attributes of kombucha made from tayu tea leaves was above 5, indicating that the panelists generally liked all of the characteristics of the kombucha. Statistical test results showed significant differences ($p < 0.05$) for all sensory attributes between kombucha made from Tayu tea leaves and commercial green tea kombucha. TGTK kombucha tends to be golden green, while CFTK kombucha has a brownish green color. The difference in color characteristics between the two types of kombucha tea is due to the traditional processing of tayu green tea, while commercial green tea is processed industrially. Tayu tea is taken to be processed into dried tea while still in its young, chlorophyll-rich form, resulting in a bright green color. Tayu tea that is freshly processed and directly made into kombucha can affect the chlorophyll content. The short shelf life of Tayu tea can maintain the chlorophyll content so that the color of the tea becomes golden green (Ošřádalová *et al.*, 2014). Furthermore, the heating process in tayu tea production uses a pan-firing method, which causes chlorophyll degradation, resulting in a more yellow or golden color. Excessive or prolonged heating causes chlorophyll to

degrade into pheophytin and its derivatives, which give it an olive or dark brown color (Adhikary *et al.*, 2024).

The panelists' preference for taste is due to its sour, astringent taste and alcohol content. Panelists preferred TGTK kombucha, which had a slightly more sour taste than CFTK kombucha. Commercial kombucha had a sweeter and less sour taste. During fermentation, bacteria convert sucrose into ethanol and CO₂. Then, acetic acid bacteria (*Acetobacter*, *Gluconobacter*) oxidize the ethanol to acetic acid. In addition, gluconic acid, lactic acid, usnic acid, and malic acid are formed, contributing to the sour taste (Jayabalan *et al.*, 2014; Abaci *et al.*, 2022).

Furthermore, Tayu kombucha has a slightly more astringent taste than commercial kombucha. This is because Tayu tea contains higher tannins, which can interact with salivary proteins, enhancing the astringency sensation when consumed (Cosme *et al.*, 2025). Based on previous studies, kombucha tayu has a high tannin content with different sugar substrates. (Sutyawan *et al.*, 2026). Beside that, the alcohol content in kombucha is thought to contribute to its taste acceptability. The



results of a study stated that the ethanol content in kombucha is generally less than 1%. When consumed, panelists should not taste any ethanol (Bishop *et al.*, 2022). Ethanol is a byproduct of kombucha fermentation, where bacteria break down sucrose into glucose and fructose via the enzyme invertase. Further fermentation can produce higher alcohol and carbon dioxide (CO₂) (May *et al.*, 2019). The high alcohol content in kombucha has an impact on reducing the taste acceptance.

Based on subjective assessments, the smell of the vinegar of CGTK kombucha is stronger. The characteristic smell of tea does not determine the smell of kombucha. The products of the fermentation process, acetic acid and volatile organic compounds, play an important role in determining the smell of kombucha. Kombucha fermentation can produce volatile acids, such as alcohols, esters, and ketones (Dartora *et al.*, 2023). Aldehydes are degraded during the bioprocess. Kombucha produces a vinegar-like smell, a byproduct of fermentation. A study showed that the vinegar smell of green tea kombucha was more palatable than kombucha made from other types of tea. This is indicated by green tea kombucha's lower

average acidity and pH values (de Miranda *et al.*, 2023) .

CONCLUSION

Kombucha made from Tayu green tea leaves and commercial green tea had relatively low total phenol content and antioxidant activity compared to standard values. The antioxidant activity of Tayu green tea kombucha was slightly higher than that of commercial green tea kombucha. The sensory preference level of Tayu green tea kombucha was significantly higher than that of commercial green tea kombucha for all attributes of color, aroma, taste, and overall. In general, Tayu green tea kombucha serves as a refreshing alternative with good sensory acceptance. Practically, the use of Tayu tea as a raw material for kombucha could open up opportunities for the development of locally sourced, functional beverages with high economic value and empower local tea farmers. Furthermore, this research can expand the scientific literature on diversifying kombucha substrates based on Indonesian endemic plants, which has been dominated by commercial tea. Analysis of other bioactive compounds in Tayu green tea



kombucha that are beneficial for health is needed. Tayu green tea kombucha can be developed by adding other ingredients to increase the antioxidant content. In addition, further studies are needed to examine various factors that influence the chemical components of Tayu green tea kombucha, such as fermentation duration, sugar concentration, and analytical methods. Tayu kombucha tea also has the potential to be developed in the form of packaged drinks. Therefore, it is necessary to identify the nutritional information in one serving of Tayu kombucha product in the future.

BIBLIOGRAPHY

- Abaci, N., Senol Deniz, F. S., & Orhan, I. E. (2022). Kombucha – An ancient fermented beverage with desired bioactivities: A narrowed review. *Food Chemistry: X*, 14. <https://doi.org/10.1016/j.fochx.2022.100302>
- Adhikary, B., Babu, A., Kashyap, B., Kanrar, B., Gogoi, R. C., & Varghese, S. (2024). Comparative evaluation of the impact of processing methods in determining the levels of health promoting chemical constituents and quality of green tea. *Beverage Plant Research*, 4. <https://doi.org/10.48130/bpr-0024-0016>
- Andrade, D. K. A., Wang, B., Lima, E. M. F., Shebeko, S. K., Ermakov, A. M., Khramova, V. N., Ivanova, I. V., Rocha, R. da S., Vaz-Velho, M., Mutukumira, A. N., & Todorov, S. D. (2025). Kombucha: An Old Tradition into a New Concept of a Beneficial, Health-Promoting Beverage. In *Foods* (Vol. 14, Number 9). Multidisciplinary Digital Publishing Institute (MDPI). <https://doi.org/10.3390/foods14091547>
- Atak, M., Yılmaz Kutlu, E., Çavuş, D., & Çomoğlu, M. (2024). Handmade green tea: Antioxidant content and activity. *Applied Food Research*, 4(2). <https://doi.org/10.1016/j.afres.2024.100626>
- Bishop, P., Pitts, E. R., Budner, D., & Thompson-Witrick, K. A. (2022). Kombucha: Biochemical and microbiological impacts on the chemical and flavor profile. *Food Chemistry Advances*, 1(1), 1–9. <https://doi.org/10.1016/j.focha.2022.100025>
- BPTP Bangka Belitung. (2018). Teh Tayu : Salah Satu SDG Bangka Belitung. *Balai Pengkajian Teknologi Pertanian (Bptp) Kepulauan Bangka Belitung*, (July), 1–2. <http://babel.litbang.pertanian.go.id/index.php/berita/4-info-aktual/769-teh-tayu-salah-satu-sdg-bangka-belitung>.
- Cardoso, R. R., Neto, R. O., dos Santos D’Almeida, C. T., do Nascimento, T. P., Pressete, C. G., Azevedo, L., Martino, H. S. D., Cameron, L. C., Ferreira, M. S. L., & Barros, F. A. R.



- de. (2020). Kombuchas from green and black teas have different phenolic profile, which impacts their antioxidant capacities, antibacterial and antiproliferative activities. *Food Research International*, 128(1), 1–10. <https://doi.org/10.1016/j.foodres.2019.108782>
- Cosme, F., Aires, A., Pinto, T., Oliveira, I., Vilela, A., & Gonçalves, B. (2025). A Comprehensive Review of Bioactive Tannins in Foods and Beverages: Functional Properties, Health Benefits, and Sensory Qualities. In *Molecules* (Vol. 30, Number 4). Multidisciplinary Digital Publishing Institute (MDPI). <https://doi.org/10.3390/molecules30040800>
- Dartora, B., Hickert, L. R., Fabricio, M. F., Ayub, M. A. Z., Furlan, J. M., Wagner, R., Perez, K. J., & Sant'Anna, V. (2023). Understanding the effect of fermentation time on physicochemical characteristics, sensory attributes, and volatile compounds in green tea kombucha. *Food Research International*, 174. <https://doi.org/10.1016/j.foodres.2023.113569>
- de Miranda, A. J., de Souza, R. A., Cardoso, F. A. R., Oviedo, M. S. V. P., Perdoncini, M. R. F. G., & Rigobello, E. S. (2023). *Physical-chemical analyzes and sensorial evaluation of vinegar developed from kombucha (Medusomyces gisevii)*. <https://doi.org/10.21203/rs.3.rs-3521812/v1>
- de Oliveira, P. V., da Silva Júnior, A. H., de Oliveira, C. R. S., Assumpção, C. F., & Ogeda, C. H. (2023). Kombucha benefits, risks and regulatory frameworks: A review. In *Food Chemistry Advances* (Vol. 2). Elsevier Ltd. <https://doi.org/10.1016/j.focha.2023.100288>
- Değirmencioglu, N., Yıldız, E., Sahan, Y., Guldas, M., & Gürbüz, O. (2021). Impact of tea leaves types on antioxidant properties and bioaccessibility of kombucha. *Journal of Food Science and Technology*, 58(6), 2304–2312. <https://doi.org/10.1007/s13197-020-04741-7>
- Donlao, N., & Ogawa, Y. (2019). The influence of processing conditions on catechin, caffeine and chlorophyll contents of green tea (*Camelia sinensis*) leaves and infusions. *LWT*, 116. <https://doi.org/10.1016/j.lwt.2019.108567>
- Ito, A., & Yanase, E. (2022). Study into the chemical changes of tea leaf polyphenols during japanese black tea processing. *Food Research International*, 160, 111731. <https://doi.org/10.1016/J.FOODRES.2022.111731>
- 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*, 13(4), 538–550. <https://doi.org/10.1111/1541-4337.12073>



- Kim, J. M., Kang, J. Y., Park, S. K., Han, H. J., Lee, K. Y., Kim, A. N., Kim, J. C., Choi, S. G., & Heo, H. J. (2020). Effect of storage temperature on the antioxidant activity and catechins stability of Matcha (*Camellia sinensis*). *Food Science and Biotechnology*, 29(9), 1261–1271. <https://doi.org/10.1007/s10068-020-00772-0>
- Kitwetcharoen, H., Phung, L. T., Klanrit, P., Thanonkeo, S., Tippayawat, P., Yamada, M., & Thanonkeo, P. (2023). Kombucha Healthy Drink—Recent Advances in Production, Chemical Composition and Health Benefits. In *Fermentation* (Vol. 9, Number 1). MDPI. <https://doi.org/10.3390/fermentation9010048>
- Maghfirah, D., Fithri Pulungan, A., Ridwanto, & Yuniarti, R. (2025). Comparison of Phenolic and Antioxidant Contents In Tea Breawing and Kombucha Tea Variants by Visible Spectrophotometry. *Journal of Pharmaceutical and Sciences*, 8(3), 1384–1397.
- Mariana. (2017). *Kadar Polifenol Daun Teh yang Ditanama di Dusun Tayu Desa Ketap Kecamatan Jebus Kabupaten Bangka Barat* [Universitas Bangka Belitung]. http://repository.ubb.ac.id/1521/1/MARIANAc%282031211013%29_cover_1.pdf
- May, A., Narayanan, S., Alcock, J., Varsani, A., Maley, C., & Aktipis, A. (2019). Kombucha: A novel model system for cooperation and conflict in a complex multi-species microbial ecosystem. *PeerJ*, 2019(9). <https://doi.org/10.7717/peerj.7565>
- Miah, M. M., Das, P., Ibrahim, Y., Shajib, M. S., & Rashid, M. A. (2018). In vitro antioxidant, antimicrobial, membrane stabilization and thrombolytic activities of *Dioscorea hispida* Dennst. *European Journal of Integrative Medicine*, 19, 121–127. <https://doi.org/10.1016/j.eujim.2018.02.002>
- Mihai, R. A., Cubi-Insuaste, N. S., & Catana, R. D. (2024). Biological Activity and Phenolic Content of Kombucha Beverages under the Influence of Different Tea Extract Substrates. *Fermentation*, 10(7). <https://doi.org/10.3390/fermentation10070338>
- Nafisah, R. F., Nuriyah, N., Putri, F. C., Andiarna, F., & Hidayati, I. (2024). Analysis of Phenolic Content in Green Tea Kombucha and Rosella (*Hibiscus sabdariffa*) Kombucha Using Spectrophotometer Uv-Vis. *The 2nd International Conference on Halal Food and Health Nutrition (ICHAFOHN)*.
- Novidiyanto, & Sutyawan. (2022). Chemical Characteristic of Green Tea “Tayu” from Bangka Belitung Province and Green Tea of Commercial. *Jurnal Gizi Dan Kesehatan (JGK)*, 2(1), 74–81. <https://doi.org/10.36086/jgk.v2i1>
- Onsun, B., Toprak, K., & Sanlier, N. (2025). Kombucha Tea: A Functional Beverage and All its Aspects. In *Current Nutrition Reports* (Vol. 14, Number 1). Springer.



- <https://doi.org/10.1007/s13668-025-00658-9>
- Ošťádalová, M., Tremlová, B., Pokorná, J., & Král, M. (2014). Chlorophyll as an indicator of green tea quality. *Acta Veterinaria Brno*, 83, S103–S109. <https://doi.org/10.2754/avb201483S10S103>
- Pei, Y., Zheng, Y., Yuen, M., Yuen, T., Yuen, H., & Peng, Q. (2025). Preparation, Quality Analysis and Antioxidant Activity of Sea Buckthorn (*Hippophae rhamnoides* L.) Kombucha Beverage at Different Fermentation Temperatures. *Foods*, 14(8). <https://doi.org/10.3390/foods14081325>
- Peng, P., Wang, L., Shu, G., Li, J., & Chen, L. (2020). Nutrition and aroma challenges of green tea product as affected by emerging superfine grinding and traditional extraction. *Food Science and Nutrition*, 8(8), 4565–4572. <https://doi.org/10.1002/fsn3.1768>
- Phung, L. T., Kitwetcharoen, H., Chamnipa, N., Boonchot, N., Thanonkeo, S., Tippayawat, P., Klanrit, P., Yamada, M., & Thanonkeo, P. (2023). Changes in the chemical compositions and biological properties of kombucha beverages made from black teas and pineapple peels and cores. *Scientific Reports*, 13(1). <https://doi.org/10.1038/s41598-023-34954-7>
- Pisoschi, A. M., & Negulescu, G. P. (2012). Methods for Total Antioxidant Activity Determination: A Review. *Biochemistry & Analytical Biochemistry*, 01(01). <https://doi.org/10.4172/2161-1009.1000106>
- Prawira-Atmaja, M. I., Maulana, H., Shabri, S., Riski, G. P., Fauziah, A., Harianto, S., & Rohdiana, D. (2021). Evaluasi Kesesuaian Mutu Produk Teh Dengan Persyaratan Standar Nasional Indonesia. *Jurnal Standardisasi*, 23(1), 43. <https://doi.org/10.31153/js.v23i1.845>
- Rahmawati, L. K. (2025). Changes in the quality of kombucha during fermentation: A study of microbial, physicochemical and sensory attributes. *Jipagi*, 2(2), 127–141. <https://doi.org/https://doi.org/10.61511/jipagi.v2i2.2243>
- Roslan, A. S., Ismail, A., Ando, Y., & Azlan, A. (2020). Effect of drying methods and parameters on the antioxidant properties of tea (*Camellia sinensis*) leaves. *Food Production, Processing and Nutrition*, 2(1). <https://doi.org/10.1186/s43014-020-00022-0>
- Saefudin, Sofnie Marusin, & Chairul. (2013). Antioxidan Activity on Six Species of Plants Sterculiaceae. *Jurnal Penelitian Hasil Hutan*, 31(2), 103–109.
- Salinas-Ruiz, J. P., Guevara García, J., Rios Tovar, D., Cruz Cabrera, R. P., & Torrico, D. D. (2026). Effects of Fermentation Time and Temperature on the Physicochemical Quality of Kombucha. *Foods*, 15(7). <https://doi.org/10.3390/foods15071226>
- Sutyawan, Kardinari, E., Sari, E. M., & Handiri, K. D. (2026). Chemical



- Characteristics and Polyphenol Content of Tayu Green Tea Kombucha (*Camellia sinensis* L.) with Different Types of Sugar]. *Jurnal Sains Dan Teknologi Pangan (JSTP)*, 11(1), 154–164. <https://doi.org/https://doi.org/10.63071/5gcdgp78>
- Sutyawan, & Novidiyanto. (2022). Perbandingan Sifat Sensoris dan Kadar Total Fenol pada Teh Hitam Kombucha dari Daun Teh Tayu dan Teh Hitam Komersil. *Jurnal Kesehatan Poltekkes Kemenkes RI Pangkalpinang*, 10(1), 49–56. <https://doi.org/10.32922/jkp.v10i1.439>
- Sutyawan, S., & Novidiyanto, N. (2021). Analisis Perbedaan Karakteristik Kimia Dan Aktivitas Antioksidan Pada Teh Kombucha Hitam Dari Daun Tayu Dan Teh Komersil. *Pontianak Nutrition Journal (PNJ)*, 4(2), 112–118. <https://doi.org/10.30602/pnj.v4i2.905>
- Tejedor-Calvo, E., & Morales, D. (2023). Chemical and Aromatic Changes during Fermentation of Kombucha Beverages Produced Using Strawberry Tree (*Arbutus unedo*) Fruits. *Fermentation*, 9(4). <https://doi.org/10.3390/fermentation9040326>
- Villarreal-Soto, S. A., Beaufort, S., Bouajila, J., Souchard, J. P., & Taillandier, P. (2018). Understanding Kombucha Tea Fermentation: A Review. In *Journal of Food Science* (Vol. 83, Number 3, pp. 580–588). Blackwell Publishing Inc. <https://doi.org/10.1111/1750-3841.14068>
- Wibowo, N. K., Rudyanto, M., & Purwanto, D. A. (2022). Antioxidant Activity of Green Tea and Black Tea. *Camellia Journal*, 1, 48.
- Zofia, N. Ł., Aleksandra, Z., Tomasz, B., Martyna, Z. D., Magdalena, Z., Zofia, H. B., & Tomasz, W. (2020). Effect of fermentation time on antioxidant and anti-ageing properties of green coffee kombucha ferments. *Molecules*, 25(22). <https://doi.org/10.3390/molecules25225394>

