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Chemical and Sensory Characteristics of Mangosteen Peel Herbal Tea Blended with Stevia Leaves Powder

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Abstract

Herbal tea refers to tea that is not produced from the Camellia sinensis species, but rather from the leaves, seeds, roots, or dried fruits of other plants. Mangosteen (*Garcinia mangostana* L.) is a fruit belonging to the Clusiaceae family. Mangosteen peel represents the largest fraction of the fruit, comprising approximately 65% of its total weight. Mangosteen peel contains bioactive compounds, including xanthones, anthocyanins, and flavonoids. A disadvantage of mangosteen peel is its bitter taste, which can be reduced by adding stevia leaf powder. Stevia leaves (*Stevia rebaudiana*) are natural sweetener containing glycosides such as stevioside and rebaudioside. This study aimed to analyze the chemical characteristics (ash content, pH, total phenolic content, flavonoid content, and antioxidant activity) as well as the organoleptic characteristics (color, aroma, taste, aftertaste, and overall quality) of the herbal tea with the combination of mangosteen peel and stevia leaves. This study used a Completely Randomized Design (CRD) with stevia leaf powder concentration as the variable (0%, 10%, 20%, 30%, and 40% w/w). Data were analyzed using ANOVA at the 5% significance level, followed by the Duncan Multiple Range Test (DMRT) if the treatment effect was significant. The study showed that variations in stevia leaf powder concentration significantly affected ash content, pH, total phenolic content, flavonoid content, antioxidant activity, and sensory characteristics (aroma, taste, aftertaste, and overall quality), but there were no significant differences in color. The mangosteen peel herbal tea with stevia in this study had antioxidant activity of 84.33%-89.72%. Based on sensory test (hedonic), the panelists preferred the mangosteen peel herbal tea with 20% stevia leaf powder concentration.

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Introduction

Herbal tea is a tea product made from plants other than *Camellia sinensis*, such as leaves, seeds, roots, fruits, or fruit peels from other plants (Prabowo et al., 2022). The ingredients used to make herbal teas generally provide health benefits and may serve as alternatives for disease prevention and treatment. Indonesia has around 9.600 plant species with medicinal benefits that can be processed into herbal tea (Gustiani and Yuliarti, 2022). One of the ingredients is mangosteen peel, which has a relatively high antioxidant activity and is known to have antihyperglycemic, antihypertensive, and anti-inflammatory effects (Tjahjani et al., 2014).

Mangosteen (*Garcinia mangostana* L.) is a fruit produced by plants belonging to the family Clusiaceae (Nidyasari et al., 2018). Mangosteen is a tropical plant and can be found in tropical countries such as Indonesia, Malaysia, and Thailand (Manasathien and Khanema, 2015). Based on Indonesia's Central Bureau Statistics 2024 data, Indonesia's total mangosteen production in 2023 reached 397.175 tons, with Lampung province producing 2.518 tons (Central Bureau Statistics, 2024). Among mangosteens, the largest component is the peel, which accounts for about 65%. Fresh mangosteen fruit consists of 17% outer skin, 48% inner skin, 31% fruit flesh, and 4% stem and petals (Kusmayadi and Mada, 2018).

Mangosteen fruit is produced in considerable quantities; however, its use is still largely limited to the pulp. Mangosteen peel, which is the largest component, is generally discarded as waste. On the other hand, mangosteen peel contains bioactive compounds in the polyphenol group, such as xanthones, anthocyanins, and flavonoids, as well as several vitamins, including vitamin C, B1, and B2 (Tri et al., 2022). Mangosteen peel powder had a total phenol content of 195.51 mg GAE/g (Roza et al., 2017) and the antioxidant activity in dried mangosteen peel was around 96.61% (Dungir et al.,

Table 1. Combination Formulation of Mangosteen Peel and Stevia Leaves

Combined Formulation	
Mangosteen peel powder	Stevia leaves powder
100%	0%
90%	10%
80%	20%
70%	30%
60%	40%

2012). Mangosteen peel has great potential as an ingredient for herbal tea, but it has a disadvantage: a bitter taste due to the presence of tannin and saponin compounds (Wehantouw and Manurung, 2011).. Several pretreatment methods have been used to reduce the bitter taste of mangosteen peel, including autoclave, ultrasound, the addition of enzyme, and the addition of calcium acetate (Nakthong and Eshtiaghi, 2024). However, blending it with another ingredient that improves acceptability, such as stevia leaf powder, may be a more suitable approach.

Stevia (*Stevia rebaudiana*) is an herbaceous plant whose leaves can be used as a natural sweetener. This is due to the presence of glycoside compounds in stevia leaves, namely steviosides and rebaudiosides, which are 300-400 times sweeter than sucrose (Limanto et al., 2017).. Stevia leaves powder has an ash content of 3.83%. In addition, stevia leaves contain minerals such as magnesium, sodium, zinc, iron, potassium, and calcium, as well as vitamins A and C, and bioactive phenolic and flavonoid compounds related to antioxidant activity (Putu et al., 2023). Dried stevia leaves in 100 grams of ingredients have 10.73 grams protein, 6.13 grams fat, and 14.97 mg vitamin C . The phenolic content of stevia leaves was 31.25 mgGAE/g, and flavonoids were 76.94 mg QE/g (Elviana et al., 2024).

A previous study on mangosteen peel herbal tea combined it with cinnamon and cloves which affected its water content, crude fiber, alkalinity, and the toxicity and this tea was categorized as non-toxic (Rahmawati et al., 2024). Another study conducted by Hadriyani (2022). reported that a drink made from a combination of virgin palm leaves and stevia leaves had a pH of 5.5. The study also reported that increasing the concentration of stevia leaf powder increased the pH. Another study on tea bags containing stevia leaves reported that increasing stevia leaves concentration increased ash content in tin leaves tea because stevia leaves have a high mineral content (Siagian et al., 2020). Stevia leaves were added to mangosteen peel herbal tea because they provide sweetness, contain antioxidants, and are low in calories, making it expected to be safer to use as an additional sweetener in herbal tea products, based on Siringoringo et al. (2022) in *Centella asiatica* tea. The purpose of this study was to analyze the chemical characteristics (ash content, pH, total phenolic content, flavonoid content, and antioxidant activity) and the organoleptic properties of mangosteen peel herbal tea combined with stevia leaf powder.

Materials and Methods

Materials

The materials used in this study include mangosteen fruit obtained from fruit shops in the Way Halim area (Bandar Lampung), stevia leaf powder, demineral water (Amidis), gallic acid (Sigma-Aldrich), Folin–Ciocalteu reagent 10% (Sigma-Aldrich), Na_2CO_3 7.5% (Pudak), quercetin powder (Medical and Laboratory Supplier), $AlCl_3$ (Merck), potassium acetate (SAP Chemical), DPPH (Smart Lab), and methanol p.a. (Smart Lab). The tools used in this study include dehydrators (WIRXASTAR FDH-20), grinders, 20 mesh sieves, analytical scales (Biobase model BA2204C), furnace (Memmert), pH meter (Biobase 920). UV-Vis spectrophotometer (Aquamate 8100), and vortex.

Methods

This study used an experimental method with a Completely Randomized Design (CRD), with the treatments presented in Table 1. Each treatment was replicated twice, and each replicate was analyzed in duplicate because of limitations in analysis time, cost, and personnel (Bower, 2013). The research was conducted in four stages: (1) making dried mangosteen peel, (2) making mangosteen peel herbal tea with the addition of stevia leaves, (3) making mangosteen peel herbal tea brewing, and (4) analyzing chemical and sensory parameters.

The Production of Dried Mangosteen Peel

The production of mangosteen peel herbal tea began by washing the mangosteen fruit under running water to remove the gum and then the pulp was separated from the peel. Next, the mangosteen peel was sorted. The mangosteen peel used in this study came from all parts of the peel, namely the hard outer part and the softer inner part. The mangosteen peel was cut into 0.2-cm-thick pieces using a knife and then arranged on a tray. The mangosteen peel that had been arranged on a tray was then dried at a temperature of 50 °C for 24 hours using a dehydrator. The dried mangosteen peel was ground and then sieved through a 20-mesh sieve. The mangosteen peel powder was then stored in vacuum-sealed plastic packaging.

The Production of Mangosteen Peel Herbal Tea with the Addition of Stevia Leaves

The herbal tea formulations were prepared by weighing mangosteen peel powder and stevia leaf powder according to the treatment (0%, 10%, 20%, 30%, and 40%). The mangosteen peel–stevia herbal tea formulations were then packaged in tea bags, with 2 g of tea per bag. Mangosteen peel herbal tea was then analyzed for ash (powder), pH, total phenolic content, total flavonoids, antioxidant activity, and hedonic test (brewing).

Mangosteen Peel Herbal Tea Brewing Process

For brewing, one bag of mangosteen peel–stevia herbal tea was placed in a glass cup, and 200 mL

of water at 80 °C was added. The tea was brewed for 5 minutes. The tea bag was then removed, and the brew was allowed to cool to room temperature (Novitasari et al., 2024).

Chemical and Sensory Parameters Procedure

Ash Content

Ash content was determined by first drying empty porcelain crucibles in an oven at 105 °C for 3 hours, then cooled in a desiccator for 30 minutes. The crucibles were then weighed using an analytical balance. Approximately 2 g of herbal tea powder was weighed and placed in each crucible. The samples were incinerated in a furnace at 550 °C for 6 hours. The samples were cooled in a desiccator for 1 hour, after which the crucible and ash were weighed (Septiani et al., 2024).

$$\text{Ash Content (\%)} = \frac{(C-A)}{B} \text{ x } 100\% \quad (1)$$

Description:
A : Weight of the empty cup
B : Sample weight
C : Cup + ash weight

pH

pH analysis was carried out using a pH meter. The pH meter was calibrated before use. The calibration of the pH meter was carried out using 4, 7, and 10 pH buffers. The electrode was then dried with tissue paper and rinsed with distilled water. The electrode was subsequently rinsed with the sample and immersed in the sample until a stable reading was obtained. The stable reading was recorded as the pH value of the sample (Yuliastuti et al., 2022).

Total Phenolic Content

Total phenolic content was determined using the Folin-Ciocalteu reagent (Martha et al., 2023). For the standard curve, 0.1 g of gallic acid was weighed, and 100 mL of distilled water was added and a 1000 ppm solution was created. The 1000 ppm solution was pipetted (1, 2, 3, 4, 5, 6) mL and diluted using distilled water up to 10 mL so that a concentration (100, 200, 300, 400, 500 and 600) mg/L of gallic acid was produced. From each concentration, 0.2 mL of solution was added to 9.8 mL of distilled water and 1 mL of Folin–Ciocalteu reagent which had been diluted 1:10 The mixture was then homogenized using a vortex mixer and allowed to stand for 5 minutes. Next, 4 mL of 7.5% Na_2CO_3 was added, and the mixture was homogenized and incubated in the dark for 60 minutes. After incubation, the absorbance was measured using a UV-Vis spectrophotometer with wavelengths in the range of 600 - 800 nm to search for the maximum wavelength and standard curve of the gallic acid.

For the sample, 0.2 mL of brewed herbal tea was mixed with 9.8 mL of distilled water. Then, 1 mL of Folin–Ciocalteu reagent was added, and the mixture was homogenized and allowed to stand for 5 minutes. Next, the solution was added with 4 mL of Na_2CO_3 7.5%, then it was re-homogenized and incubated in dark conditions for 60 minutes. After incubation, the absorbance was measured using a UV-Vis spectrophotometer at a wavelength of 660 nm.

Total phenolic content was determined using a linear regression equation of the standard curve of gallic acid. The regression equation y = ax + b was used to determine the concentration of phenolic compounds in the sample. Total phenolics were calculated using the following formula:

$$\text{Total phenol (mg GAE/mL sample)} = \text{X}\left(\frac{\text{mg}}{\text{mL}}\right) \text{x df} \quad (2)$$

Description:
x : Sample Concentration
df : Dilution Factor

Total Flavonoid

Total flavonoid content was determined using the aluminum chloride method (Lastriyanto and Aulia, 2021) with modification. For the determination of the quercetin standard curve, 5 mg of quercetin was put in a 50 mL volumetric flask and methanol was added to the limit mark until a 100 ppm quercetin solution was produced. Then, it was pipetted (1; 1.4; 1.8; 2.2; 2.6; and 3) mL and diluted using distilled water to 10 mL so that a concentration (10, 14, 18, 22, 26 and 30) mg/L of quercetin was created. From each concentration, 1 mL was mixed with 1 mL of 1.2% $AlCl_3$ and 1 mL of 120 mM CH_3COOK, homogenized using a vortex mixer, and incubated in the dark at room temperature for 30 minutes. The standard curve of quercetin was determined with the maximum wavelength which has been searched, about 400 – 500 nm.

For the sample, 1 mL of brewed herbal tea was pipetted into a test tube and mixed with 1 mL of AlCl3 1.2% and 1 mL CH_3COOK 120mM. The mixture was then homogenized and incubated in the dark at room temperature for 30 minutes. Absorbance was then measured using a UV-Vis spectrophotometer at a wavelength of 428 nm. Total flavonoid content was determined using the linear regression equation of the standard curve of quercetin. The regression equation y = ax+b served to determine the concentration of flavonoid compounds in the sample. Total flavonoids are calculated using the following formula:

$$\text{Total flavonoids (mg QE/mL sample)} = X\left(\frac{mg}{mL}\right) x\ df \quad (3)$$

Description:
x : Sample concentration
df : Dilution Factor

Antioxidant Activity

Antioxidant activity was tested using the DPPH method (Elviana et al., 2024). The test began with the preparation of the DPPH solution (1,1-diphenyl-2-pykrilhydrazil). The DPPH solution was prepared by dissolving DPPH in methanol p.a. to obtain a concentration of 100 ppm. A 2-mL aliquot of the prepared sample was transferred into a dark test tube. Then, 2 mL of 100-ppm DPPH solution was added. The mixture was incubated at room temperature in the dark for 30 minutes. The incubated sample was then measured for absorbance using a UV-Vis spectrophotometer at a wavelength of 517 nm. Free-radical scavenging activity (inhibition) was calculated using the following formula:

$$\%\ \text{Inhibition} = \frac{\text{Blanco Abs} - \text{Sample Abs}}{\text{Blank Abs}}\ x\ 100\% \quad (4)$$

Sensory Evaluation

Sensory evaluation was conducted to determine the panelists' preferences for products with several parameters such as taste, color, aroma and overall. A hedonic test was used, which was carried out by 80 untrained panelists with test parameters namely taste, color, aroma, and overall. The assessment used a five-point scale, namely: (1) very dislike, (2) dislike, (3) neutral, (4) like, (5) very like (Kehutanan and Mandalika, 2022).

Data Analysis

The data were analyzed using one-way analysis of variance (ANOVA) at a significance level of 5%, When a significant effect was observed, the data were further analyzed using Duncan's Multiple Range Test (DMRT) with a significance level of 5%.

Results and Discussion

Ash Content

Ash is an inorganic residue formed by the combustion process or oxidation of organic components in food (Andarwulan et al., 2011). Ash content is a mineral component or inorganic substance that does not evaporate in the combustion process. Ash content testing measures the amount of minerals in a material and indicates its level of purity or cleanliness (Siagian et al., 2020). Based on the results of this study, the highest ash content was 40% stevia leaf powder at 4.77%, and the lowest was 0% stevia leaf powder at 2.78%. The ANOVA results indicated that the concentration of stevia leaf powder had a significant effect ($p < 0.05$) on the ash content of mangosteen peel herbal tea. The DMRT test showed that all formulations of mangosteen peel and stevia leaf powder were significantly different from one another.

The results showed that increasing the concentration of stevia leaf powder increased the tea's ash content. This may be because mangosteen peel has an ash content of around 3.29% (Pratiwi et al., 2024), which is lower than that of stevia leaf powder at 7.26% (Yen and Quoc, 2021). The high ash content in stevia leaves is influenced by the minerals contained, including potassium, calcium, sodium, magnesium, phosphorus, and iron (Siagian et al., 2020). These results were consistent with those reported by Hadriyani (2022), which stated that an increase in the concentration or number of stevia leaves increased the ash content in tea (Elviana et al., 2024). According to SNI 3836:2013, the maximum ash content for packaged dry tea is 8%. The ash content of mangosteen peel-stevia herbal tea in this study ranged from 2.78% to 4.77% and met the ash content requirements for tea.

pH

pH is a measure of the acidity or alkalinity of a solution (Hadriyani, 2022). pH refers to the amount of concentration of hydrogen ions (H+) in a solution that expresses its acidity or alkalinity. The pH scale ranges from 0 to 14, where solutions are categorized as acidic if the pH is less than 7, alkaline if the pH is greater than 7, and neutral if the pH is 7 (Ngafifuddin et al., 2017).

Based on the results of this study, the highest pH was 40% stevia leaf powder at 5.76, and the lowest was 0% stevia leaf powder at 4.70. These results indicate that, increasing the concentration of stevia leaves resulted in tea with a higher pH. This may be attributed to the higher pH of stevia leaves than that of mangosteen peel. Stevia leaves extract had a pH of 5.2-5.5 (Rizki et al., 2023), and other studies reported that stevioside crystals extracted from stevia leaves have a pH of 5.5-6.5 (Marlina and Widiastuti, 2019). Mangosteen peel extract had a lower pH of 4.2 - 4.4 (Siagian et al., 2020) stated that the pH value of tea with the addition of stevia leaves increased with a high concentration, with a value of 7.25 - 7.72. Research by Zhafirah et al. (2024) on the effect of stevia consumption on saliva pH indicated that stevia leaves have a non-acidogenic effect, increasing oral cavity pH compared to other sweeteners. In addition, steviosides and rebaudiosides, the sweeteners in stevia, cannot be fermented by bacteria in the mouth, so they do not lower pH in the oral cavity (Limanto et al., 2017).

Total Phenolic Levels

Phenolic compounds are among the compounds associated with antioxidant activity with one or more aromatic benzene rings. Phenolic compounds are divided into several groups, namely phenolic acids, flavonoids, stilbenes, tannins, and coumarins (Rafsanjani et al., 2024). Total phenolic content was determined using the Folin-Ciocalteu method. The Folin-Ciocalteu method is based on the principle of colorimetric oxidation-reduction reactions to measure the total phenolic content of a sample. The phenolic compounds present in the sample will react with the oxidizer phosphomolybdic acid to form phenolic products and the blue tungsten-molybdenum complex (Sucianti et al., 2021).

The ANOVA showed that the concentration of stevia leaf powder had a significant effect ($p < 0.05$) on the total phenolic content of mangosteen peel herbal tea. The results of the DMRT test showed that mangosteen peel herbal tea with a 0% stevia concentration was not significantly different from that with 10%. However, it was significantly different from those with 20%, 30%, and 40%. Mangosteen peel herbal tea with concentrations of 20%, 30%, and 40% is not noticeably different. Table 2 showed that herbal teas containing 0% and 10% stevia leaf powder had higher levels of phenolic compounds. The decrease might be attributed to the lower phenolic content reported for stevia leaves compared with mangosteen peel in previous study. Total phenolic content in dried mangosteen peel was 195.51 mgGAE/g (Roza et al., 2017), while the phenolic level in stevia leaves was around 31.25 mgGAE/g (Elviana et al., 2024). Another study reported a total phenolic content of 21.52 mg GAE/g in dried stevia leaves (Dyduch-Siemińska et al., 2020). The combination of herbal tea with stevia leaves by Elviana et al. stated that tea with a concentration of kecombrang flower and stevia leaves (70:30) had a polyphenol content of 30 mgGAE/g (Elviana et al., 2024).

Flavonoid Levels

Total flavonoid content was quantified using a colorimetric method with $AlCl_3$ as the reagent. The principle of this method is that $AlCl_3$ binds to the ketone group at C4 and the OH group at C5 of flavonoid compounds, forming a stable complex (Suharyanto and

Table 2. Chemical Characteristics of Mangosteen Peel-Stevia Herbal Tea

The level of stevia leaf powder	Ash (%)	pH	Total Phenolic Content (mg GAE/mL)	Flavonoid Level (mg QE/mL)	Antioxidant Activity (%)
0%	2.78±0.13[a]	4.70±0.03[a]	0.78±0.05[b]	0.012±0.001[a]	89.72±0.08[e]
10%	3.40±0.17[b]	5.10±0.02[b]	0.81±0.05[b]	0.018±0.001[b]	88.32±0.38[d]
20%	3.96±0.24[c]	5.25±0.03[c]	0.67±0.02[a]	0.029±0.002[c]	86.81±0.05[c]
30%	4.32±0.28[d]	5.43±0.03[d]	0.60±0.06[a]	0.032±0.000[d]	84.85±0.44[b]
40%	4.77±0.29[e]	5.76±0.01[e]	0.66±0.06[a]	0.041±0.000[e]	84.33±0.18[a]

Results are mean±standard deviation (n = 4); Different superscript letters in the same column indicate the significant differences ($p < 0.05$).

Prima, 2020). In flavonoid content testing, a standard solution of quercetin is required to create a calibration curve. Quercetin was chosen as the standard solution because it is the most widely distributed compound in plants and belongs to the flavonoid group (Sinulingga et al., 2021).

Based on the flavonoid content analysis, the formulation with the highest flavonoid content was 40% stevia leaf powder at 0.041 mg QE/mL, and the lowest was 0% stevia leaf powder at 0.012 mg QE/mL. Based on the data in Table 2, increasing the concentration of stevia leaf powder led to higher flavonoid levels in the herbal tea samples. The flavonoid content increased with the high concentration of stevia leaf powder, as flavonoid compounds dominate in dried stevia leaves compared to non-flavonoid compounds. In contrast, in mangosteen peel, non-flavonoid compounds dominated. This was in line with previous research which reported that the total flavonoids in dried stevia leaves were 9.65 mg QE/g and the total phytochemicals were 21.51 mg/g (Dyduch-Siemińska et al., 2020). The flavonoid content in mangosteen peel extract was known to be 30.02 mg QE/g, while the total phenolic content was 529.40 mg GAE/g (Subroto et al., 2025). In another study, it was found that the flavonoid level in mangosteen peel was only 2.24 mg/g out of a total phenolic level of 209 mg/g (Zarena and Sankar, 2012).

Flavonoids are secondary metabolites widely found in plants. This compound has polar properties due to the presence of an -OH group that forms hydrogen bonds (Putri et al., 2024). Flavonoids belong to the group of polyphenols with a basic structure consisting of 15 carbon atoms with 2 benzene rings bonded by a propane chain. Flavonoids play an important role in plants, including providing color, flavour, and aroma to fruits, seeds, flowers, and leaves. In addition, flavonoids function in producing pigments that yield yellow, red, orange, blue, and purple colors (Ningsih et al., 2023).

Antioxidant Activity

Antioxidants are molecules that can prevent or inhibit cellular damage caused by free radicals. Antioxidants work by donating electrons to free radicals, so that the reactive properties of free radicals disappear without becoming free radicals themselves (Kamoda et al., 2021). Antioxidant activity can be expressed as a percentage inhibition. The percentage inhibition indicates the antioxidant activity of the sample in suppressing DPPH (a free radical). The higher the inhibition percentage, the greater the antioxidant activity (Anisa et al., 2023). Antioxidant activity was determined in this study using the DPPH method. The test using the DPPH method aims to measure the ability of antioxidant substances in the sample to neutralize DPPH free radicals. DPPH is purple because it has unpaired electrons; if its color changes from purple to yellow or pale yellow, the sample has antioxidant activity (Utami et al., 2016).

The formulation with the highest antioxidant activity was 0% stevia leaf powder at 89.72%, and the lowest was 40% stevia leaf powder at 84.33%. The ANOVA test showed that the concentration of stevia leaf powder had a significant effect ($p < 0.05$) on the antioxidant activity of mangosteen peel herbal tea. The DMRT test results showed that all formulations of mangosteen peel and stevia leaf powder were significantly different from each other. Based on these data, it could be seen that antioxidant activity decreased with the increasing concentration of stevia leaf powder. This showed that the antioxidant content in stevia leaf powder was lower than mangosteen peel. Antioxidant activity in dried stevia leaves was 33%-57% (Sytar et al., 2015). The antioxidant activity of dried mangosteen peel had been reported as 96.61% (Dungir et al., 2012). The antioxidant activity results in this study were lower than those in the previous study because the mangosteen peel was extracted with methanol for 24 hours. In contrast, in the previous study, it was brewed with hot water for 5 minutes. Differences in treatment can result in differences in the antioxidant compounds extracted (Suttirak and Manurakchinakorn, 2014).

Aroma

Aroma is produced by volatile compounds that can be detected by the sense of smell (Ramadayani and Swasono, 2023). The aroma in herbal tea products comes from the volatile compounds contained in the ingredients used. The mean hedonic aroma scores ranged from 3.00 to 3.57, indicating that the panelists generally somewhat liked the aroma of the mangosteen peel–stevia herbal tea. The results of the DMRT test showed that mangosteen peel herbal tea without the addition of stevia leaves was significantly different from mangosteen peel herbal tea with stevia concentrations of 10%, 20%, 30%, and 40%. Mangosteen peel herbal tea with 10%, 20%, 30%, and 40% concentrations of stevia leaf powder were not noticeably different. Mangosteen peel herbal tea had a distinctive, slightly sour aroma. It was produced by organic acids commonly found in fruits, such as citric acid and malic acid. As the amount of stevia leaves increased, the sour aroma of the mangosteen peel herbal tea was reduced and the tea developed a distinctive, slightly languorous aroma. This was due to the presence of volatile compounds in stevia

leaves, such as hexanoic acid and spathulenol (Gasmalla et al., 2017).

Color

Color is an important organoleptic parameter because it can influence consumers' perception of a product. This may be because color parameters are assessed through visual perception of a product. Products with attractive colors are generally preferred by consumers (Hadriyani, 2022). The mean hedonic color scores ranged from 3.50 to 3.74, indicating that the panelists level of preference for the color of stevia peel herbal tea was somewhat positive. The ANOVA results indicated that the concentration of stevia leaf powder had no significant effect ($p > 0.05$) on the organoleptic color parameters of mangosteen peel herbal tea. The absence of significant differences may be explained by the fact that the mangosteen peel herbal tea brewed water has a color not too different from that of tea in general, so the panelists could still accept it, and their preferences were not much different. Wiyono et al. (2022) stated that the addition of stevia did not cause the formation or change of a product to be darker because the sugar in stevia was quite stable at a temperature of 100 °C in instant cocoa drink. Research by Nizori et al. (2023) on the addition of stevia sugar to the functional drink of telang flower found that differences in stevia sugar concentration did not result in noticeable differences in color between treatments. The color of the brewed mangosteen peel–stevia herbal tea is shown in Figure 1.

Mangosteen peel herbal tea, without the addition of stevia leaves, produced a brownish-pink color in the brewed water. Herbal tea combined with stevia leaf powder produced a greenish-brown color when brewed. The lower concentration of mangosteen peel and the higher concentration of stevia leaf powder, made the color of the brewed water produced would be more intense.

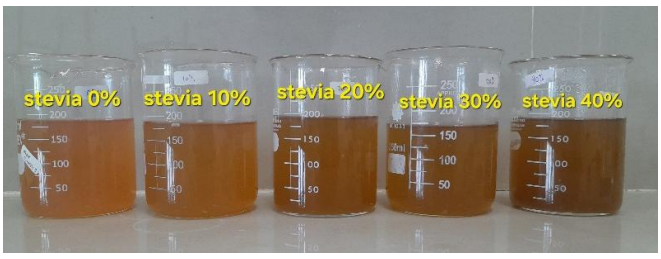


Figure 1. Brewing Color Herbal Tea Mangosteen peel – Stevia

Taste

Taste is a sensory attribute perceived by the tongue when a product is consumed. Taste can be interpreted as something that can be felt and received by the sense of taste (tongue) (Hadriyani, 2022). Taste plays an important role in determining consumer preference (Ramadayani and Swasono, 2023). The average hedonic value of taste was 2.09-3.41, which means that the panelists' level of preference for the taste of mangosteen peel–stevia herbal tea was 2 (not liked) and 3 (somewhat liked). The DMRT results showed that 0% stevia leaf powder was significantly different from all treatments. 10% and 40% stevia leaf powder were not significantly different, and 40% stevia leaf powder was not significantly different from the concentrations of 10%, 20%, and 30% stevia leaf powder. These results indicate that the panelists preferred mangosteen peel herbal tea combined with stevia leaf powder with a concentration above 10%. Differences in taste preference of mangosteen peel herbal tea was due to the influence of a combination of stevia leaf powder. As the concentration of stevia increased, the tea became sweeter of mangosteen peel herbal tea. The natural bitterness of mangosteen peel herbal tea was strong and less liked by the panelists. The bitter taste was produced by the compounds of xanthone, tannins, and saponins contained in the peel of mangosteen (Harun et al., 2014). The increasing sweetness of the mangosteen peel herbal tea with higher stevia concentrations can be attributed to the steviol glycoside, a natural sweetener (Putu et al., 2023).

Aftertaste

Aftertaste is a positive taste quality that remains in the mouth after a drink is swallowed or removed from the mouth. Aftertaste is subjective; therefore, the perception of the residual taste may differ among panelists. The mean hedonic aftertaste scores ranged from 2.09-3.37, which means that the level of the panelists' preference for the aftertaste of the mangosteen peel–stevia herbal tea was 2 (dislike) and 3 (somewhat liked). Mangosteen peel herbal tea left a bitter aftertaste. The bitter taste was produced by the compounds of xanthone, tannins, and saponins contained in the peel of mangosteen (Harun et al., 2014). Increasing the concentration of stevia leaf powder reduced the bitterness of the aftertaste in mangosteen peel herbal tea due to its natural sweetener content. However, when the concentration of stevia leaf powder was too high, it produced a bitter aftertaste, so the panelists preferred adding it at 30% rather than 40%. This was due to the presence of stevioside compounds in stevia leaves that can activate bitter taste receptors on the tongue.

Overall

The overall assessment was based on several sensory parameters, such as aroma, color, and taste. The overall score was used to assess the panelists' preferences across the sensory parameters. These parameters are similar to the overall appearance of the product (Putu et al., 2023). The mean overall hedonic scores ranged from 2.51 to 3.46, which means that the panelists level of preference for the color of mangosteen peel–stevia herbal tea was 2 (disliked) and 3 (somewhat liked). The DMRT test results showed that the overall 0% stevia leaf powder value was significantly different from those of all treatments. 10% and 40% stevia leaf powder were not significantly different from each other, and 40% stevia leaf powder was not significantly different from 10%, 20%, and 30% stevia leaf powder. These results indicate that the mangosteen peel herbal tea containing up to 20% stevia leaf powder was preferred by the panelists. The mangosteen peel herbal tea containing 20% stevia leaf powder was the most preferred by the panelists, with the highest hedonic test score of 3.46. the overall parameter was influenced not only by one factor

Table 3. Sensory Test of Mangosteen-Stevia Herbal Tea

Parameters	The level of stevia leaf powder					
	0%	10%	20%	30%	40%	P Value
Aroma	3±0.81[a]	3.34±0.82[b]	3.57±0.88[b]	3.42±0.74[b]	3.31±0.85[b]	0.000
Color	3.5±1.11	3.68±0.75	3.74±0.80	3.53±0.72	3.64±0.85	0.340
Taste	2.09±0.1 [a]	2.98±0.11 [b]	3.39±0.11[cb]	3.41±0.95 [cb]	3.23±0.1 [bc]	0.000
Aftertaste	2.09±0.87[a]	2.8±1.01[b]	3.22±1.11[c]	3.37±0.97[c]	3.05±1.05[bc]	0.000
Overall	2.51±0.91[a]	3.09±0.86[b]	3.46±0.97[c]	3.41±0.87[c]	3.27±0.98[bc]	0.000

Results are mean±standard deviation (n = 80); Different superscript letters in the same column indicate the significant differences ($p < 0.05$).

but also by several others, such as aroma, color, taste, and aftertaste, when judging a product. The likability rating was based on several predetermined parameters and reflects a product's overall appearance (Elviana et al., 2024).

The panelists preferred the mangosteen peel herbal tea containing stevia leaf powder because of its sweetness, but their preference decreased when the stevia leaf powder concentration was too high. Research conducted by Siagian et al. (2020) found that canned tea bags containing 15% stevia leaves were most preferred by the panelists. Another study on adding stevia leaves to kecombrang flower tea found that panelists preferred tea bags with 30% stevia leaves (Elviana et al., 2024).

Conclusion

Based on the results of this study, it can be concluded that the concentration of stevia leaf powder significantly affected ($p < 0.05$) ash content, pH value, total phenolic levels, flavonoid levels, and antioxidant activity in mangosteen peel herbal tea. Based on hedonic tests, variations in the concentration of stevia leaf powder significantly affected aroma, taste, aftertaste, and overall scores, but had no significant effect on color parameters. Mangosteen peel – stevia herbal tea in this study had antioxidant activity of 84.33%-89.72%. Based on the overall hedonic score, the 20% stevia formulation was the most preferred. The 30% and 40% formulations did not differ significantly; therefore, the lower concentration is preferable.

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