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PHYSICAL CHARACTERISTICS, TOTAL FLAVONOIDS, TOTAL PHENOLS AND ANTIOXIDANT ACTIVITY OF KETEPENG CINA LEAF HERBAL TEA (*CASSIA ALATA* L.)

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ABSTRACT

Ketepeng cina leaf herbal tea is a functional beverage made from the dried leaves of *Cassia alata* (ketepeng cina), which are known to contain beneficial bioactive compounds. However, its use as a herbal drink remains limited. This study aimed to investigate the effects of stevia leaf addition (0%, 6%, 12%, and 18%) and brewing time (2, 3, and 4 minutes) on the physicochemical and sensory characteristics of ketepeng cina leaf herbal tea. A completely randomized design (CRD) with a two-factor factorial pattern and three replications was employed. The parameters evaluated included color index, pH, total soluble solids (TSS), total flavonoids, total phenols, antioxidant activity, and sensory attributes. Data were analyzed using ANOVA at a 5% significance level, followed by Duncan's Multiple Range Test (DMRT) when significant differences were found. The findings showed that stevia concentration and brewing time significantly influenced the tea's characteristics. The optimal formulation was achieved with an 18% stevia concentration and a 3-minute brewing time, resulting in 3.68°Brix TSS, 0.18 mgQE/g total flavonoids, 1.93 mgGAE/g total phenols, and 49.21% antioxidant activity. This study suggests that the addition of stevia and controlled brewing time can improve the functional and sensory quality of ketepeng cina herbal tea, making it a promising alternative in the development of antioxidant-rich herbal beverages.

KEYWORDS *Cassia alata*, stevia, antioxidant activity, flavonoids, herbal tea.

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INTRODUCTION

The Ketepeng Cina leaves contain bioactive components such as alkaloids, steroids, terpenoids, saponins, flavonoids, phenols, and tannins (Asmah et al., 2020). According to Chahal and Jha (2020), these compounds exhibit immunomodulatory activity. However, the utilization of Ketepeng Cina leaves remains limited, with low market value and short storage life. Processing them into

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products is necessary to enhance their utilization, increase their market value, and extend their shelf life. One such product is herbal tea. Herbal tea is a beverage specifically formulated from plants that possess medicinal and disease-preventive properties (W. K. Dewi et al., 2017).

The process of making herbal tea from Ketepeng Cina leaves consists of sorting, washing, withering, drying, crushing, sieving, and packaging. Research on the quality of Ketepeng Cina leaf herbal tea has shown that it has an astringent and bitter taste (Yamin et al., 2017). Therefore, in this study, Ketepeng Cina leaves need to be combined with other plants that can enhance the taste, add nutritional value, and maintain the expected medicinal properties of the tea. One such plant is stevia (*Stevia rebaudiana* B.). Stevia leaves are known as natural, non-caloric sweeteners and can serve as a substitute for artificial sweeteners. Stevia leaves are sweeter than cane sugar and contain very few calories. Steviol derivatives, mainly stevioside (4-15%), rebaudioside A (2-4%), C (1-2%), and dulcoside A (0.4-0.7%), constitute the majority of stevia leaf compounds. Additionally, stevia contains flavonoids, alkaloids, and minerals (Winangadi et al., 2017).

According to research by Siringoringo et al. (2023) on the effect of adding stevia leaves on the antioxidant activity, moisture content, ash content, and sensory properties of gotu kola tea, stevia leaves can enhance the flavor score of tea. The combination of Ketepeng Cina leaves and stevia leaves as raw materials can produce a functional product with antioxidant activity. All components are blended and packaged as tea bags to increase the added value of herbal tea and facilitate its preparation. Dewitayani et al. (2019) stated that tea bags are made of fine, heat-resistant, porous paper that encloses tea powder.

Besides adding other ingredients, the brewing process also affects the final characteristics of tea beverages. Brewing is extracting one or more components using water as a solvent. One of the factors influencing the brewing process is brewing time, which significantly affects the concentration of dissolved chemical compounds, color intensity, and tea aroma. The brewing process helps retain the desired compounds, preventing the degradation of tea constituents (Nurminabari et al., 2019). A study by Dewata (2017) on the effect of temperature (70, 85, and 100℃) and brewing duration (1, 3, and 5 minutes) on the antioxidant activity and sensory properties of avocado leaf herbal tea (*Persea americana* Mill.) found that at 100℃, a brewing time of 5 minutes resulted in a decrease in total phenol content.

Previous studies have explored the enhancement of herbal teas' antioxidant properties through the addition of stevia leaves and variations in brewing time. For instance, Siringoringo et al. (2023) investigated the impact of stevia leaf addition on the antioxidant activity and sensory properties of gotu kola tea, finding that stevia improved the flavor profile without compromising antioxidant activity. Similarly, Dewata et al. (2017) examined how different brewing temperatures and durations affected avocado leaf herbal tea's antioxidant activity and sensory attributes, concluding that both factors significantly influence the tea's quality.

However, these studies did not specifically address the combination of stevia leaf addition and brewing time variations in the context of Ketepeng Cina (Cassia alata) leaf herbal tea. This research aims to fill that gap by analyzing how varying concentrations of stevia leaves (0%, 6%, 12%, 18%) and different brewing times

(2, 3, 4 minutes) affect the physical characteristics, total flavonoid content, total phenol content, and antioxidant activity of Ketepeng Cina leaf herbal tea. The findings are expected to provide insights into optimizing the formulation and preparation of this herbal tea to enhance its health benefits and consumer acceptance.

Based on the existing problems and previous research indicating a research gap, it is necessary to study the effect of varying stevia leaf concentrations and brewing durations on the physical characteristics, total flavonoid content, total phenol content, and antioxidant activity of Ketepeng Cina leaf herbal tea.

RESEARCH METHOD

The research was conducted in August 2024 at Rumah Tepung, the Laboratory of Chemical and Food Material Analysis, and the Food Technology Laboratory, Faculty of Agriculture, Universitas Sumatra Utara. The materials used for ketepeng cina herbal tea included ketepeng cina leaves and stevia leaves obtained from Patamuan District, Padang Pariaman Regency, West Sumatra. These ingredients were packaged in tea bags (food-grade kraft paper, 5.5 × 7 cm) with stevia additions of 0%, 6%, 12%, and 18%. The tea was brewed at 100℃ for 2, 3, and 4 minutes. The analysis in this study included physical characteristics (total dissolved solids, pH, and hue index), chemical characteristics (total flavonoids, total phenols, and antioxidant activity), and sensory characteristics through a hedonic test (color, taste, aroma, viscosity, and overall acceptance). Total dissolved solids were tested using a hand refractometer, where 1-2 ml of the sample was placed on the prism, and the result was expressed in °Brix (Ismawati et al., 2017). The pH measurement was performed using a digital pH meter, where a 10 ml sample was placed in an Erlenmeyer flask, and the electrode was immersed until the reading stabilized (Wahyunita et al., 2023). The hue index was measured using a Konica Minolta CR-400 color reader, obtaining L* (lightness), a* (redness), and b* (yellowness) values, with °Hue calculated as $°Hue = \tan^{-1}(b/a)$ (Khairina, 2017). The total flavonoid content was determined by adding 0.5 ml of diluted tea (1:10) to 1.5 ml of ethanol, 0.1 ml of 10% AlCl3, 0.1 ml of 1 M sodium acetate, and 2.8 ml of distilled water, incubating for 30 minutes, and measuring absorbance at 430 nm using quercetin as the calibration standard. The flavonoid content was expressed as Quercetin Equivalent per gram (QE/g) using the formula: Total Flavonoid Content (mgQE/g) = (K × V × FP) / w, where K is the sample concentration from the standard curve (mg/L), V is the sample volume (ml), FP is the dilution factor, and w is the sample weight (g) (Rahmi, 2018). The total phenol content was analyzed by adding 0.6 ml of a diluted sample (1:10) into a foil-covered test tube, followed by 2.4 ml of 10% Na_2CO_3 and 3 ml of 7.5% Folin-Ciocalteu reagent. The mixture was homogenized and incubated at room temperature for 30 minutes before measuring absorbance at 745 nm. The total phenol content was expressed as Gallic Acid Equivalent per gram (mgGAE/g) using the formula: Total Phenol Content (mgGAE/g) = (K × V × FP) / w, with the same variable definitions as the flavonoid calculation (Fibrianto et al., 2020). Antioxidant activity was determined by mixing 1 ml of 10 mg/L DPPH solution with 50 µL of the sample and adding methanol to

a total volume of 5 ml, incubating at 37℃ for 30 minutes, and measuring absorbance at 515 nm (Hassmy, 2017). The percentage of inhibition was calculated as % Inhibition = (Absorbance of control - Absorbance of sample) / Absorbance of control × 100%. Sensory evaluation was conducted using a hedonic test with 30 semi-trained panelists from the Food Science and Technology Program at Universitas Sumatra Utara. The evaluated attributes included color, taste, aroma, viscosity, and acceptance. Ketepeng cina herbal tea samples were coded with three random numbers, and panelists rated them on a numerical scale of 1-7 (1 = strongly dislike, 2 = dislike, 3 = slightly dislike, 4 = neutral, 5 = slightly like, 6 = like, 7 = strongly like) ([BSN], 2006).

RESULT AND DISCUSSION

Physical Characteristics

1. Total Dissolved Solids

Total dissolved solids (TDS) is a parameter that indicates the content of all organic and inorganic compounds dissolved in a food or beverage (Cindaramaya & Handayani, 2019). Ismawati et al. (2017) It also states that total dissolved solids consist of total sugars, pigments, organic acids, and proteins. Table 1 presents the results of the effect of varying stevia addition and brewing time on the total dissolved solids of Ketepeng Cina herbal tea infusion.

Table 1. Total Dissolved Solids of Ketepeng Cina Herbal Tea Infusion (°Brix)

Stevia Concentration (%)	Brewing Time		
	2 Minutes	3 Minutes	4 Minutes
0%	2,20 ± 0,20^{a}	2,50 ± 0,10^{ab}	2,81 ± 0,02^{bc}
6%	2,80 ± 0,20^{bc}	3,21 ± 0,38^{cd}	3,43 ± 0,15^{de}
12%	3,30 ± 0.26cd	3,47 ± 0,12^{de}	3,63 ± 0,06^{de}
18%	3,40 ± 0,00^{de}	3,68 ± 0,10^{de}	3,90 ± 0,17^{e}

Note: The values in the table represent the mean of 3 replications ± standard deviation. Different letter notations indicate a significantly different effect at a 5% significance level (α=0.05).

The highest total dissolved solids were found in the treatment with an 18% stevia concentration and a brewing time of 4 minutes, reaching 3.90°Brix. Table 1 shows that the higher the concentration of added stevia leaves, the higher the total dissolved solids in the tea. Stevia leaves contain a certain amount of dissolved solids, so the more stevia leaves added to the tea, the higher the dissolved solids content (Harto et al.). (2016) stated that sugar and sucrose are components of total dissolved solids. Stevia contains glycoside compounds composed of glucose, saphorose, and steviol. The higher the concentration of stevia leaves, the higher the glycoside content, which increases the sugar content and total dissolved solids (Nizori et al., 2023). Tandrian et al. (2024) It was also stated that stevia contains a certain amount of carbohydrates; therefore, the more stevia leaf sweetener added, the more carbohydrates are dissolved, which increases total dissolved solids.

The longer the brewing time of herbal tea, the higher the total dissolved solids. This is because the longer the brewing time, the more components are

extracted, leading to an increase in total dissolved solids. According to Tamara (2019), brewing time affects the concentration of dissolved substances. As the brewing time increases, the interaction between the brewing water and tea lasts longer, making the extraction process more effective and increasing the total dissolved solids content.

2. pH Value

pH is a value that indicates the acidity or alkalinity level of a product (Latief, 2024). The pH value affects the shelf life of a product, as it influences microbial content and the sensory properties of the product (Desy et al., 2020). The effect of varying stevia leaf addition and brewing time on the pH value of ketepeng cina herbal tea infusion is presented in Table 2.

Table 2. pH Value of Ketepeng Cina Herbal Tea Infusion

Stevia Concentration (%)	Brewing Time		
	2 Minutes	3 Minutes	4 Minutes
0%	6,35 ± 0,01^{i}	6,32 ± 0,01 hi	6,29 ± 0.01gh
6%	6,25 ± 0,02 fg	6,23 ± 0.01f	6,20 ± 0,00ef
12%	6,15 ± 0,02^{e}	6,06 ± 0,03^{d}	6,02 ± 0,04d
18%	5,96 ± 0,02^{c}	5,90 ± 0,02^{b}	5,85 ± 0,02a

Description: The values in the table represent the mean of three replications ± standard deviation. Different letter notations indicate a significant difference at a 5% significance level (α=0.05).

Table 2 shows that the higher the concentration of added stevia leaves, the lower the pH value of the tea. This is due to the presence of organic acids in stevia leaves, and based on raw material analysis, stevia leaves have a lower pH than ketepeng cina leaves. Stevia leaves have a pH value of 5.77, while ketepeng cina leaves have a pH value of 6.36. When both ingredients are mixed, the higher pH will decrease until equilibrium is reached in the solution. According to Gawel-Beben et al. (2015), stevia contains benzoic acid, caffeic acid, chlorogenic acid, ferulic acid, and protocatechuic acid. The higher the organic acid content, the lower the pH (Poltronieri & Rossi, 2019). Additionally, Hedyana and Harini (2021) stated that adding stevia sugar can affect the pH of a product because stevia contains organic acids and minerals that contribute H+ ions, including potassium salt minerals, which are acidic and can lower pH.

The longer the brewing time of the herbal tea, the lower the pH value. This is due to the prolonged brewing time, which extracts more organic acids from the ingredients. According to Safitri (2018), longer brewing times lead to a higher extraction of acidic chemical components, resulting in a lower pH. Ibrahim et al. (2015) added that increased temperature and brewing time can enhance the extraction rate. Ketepeng cina and stevia leaves contain polyphenols. Supriyanto et al. (2014) stated that during the brewing process, oxidation of polyphenol components occurs, forming theaflavins. If oxidation continues, theaflavins transform into thearubigins. The more thearubigins formed, the lower the pH, as theaflavins are strong acids.

3. Hue Index

Color is a characteristic that can be observed as a physical and sensory property. Color measurement as a physical property is expressed in °hue. The °hue value indicates the color composition in food materials (Permatasari & Deofsila, 2021). The effect of different stevia leaf concentrations and brewing times on the hue index of brewed ketepeng cina herbal tea is presented in Table 3.

Table 3. Hue Index of Brewed Ketepeng Cina Herbal Tea

Stevia Concentration (%)	Brewing Time		
	2 Minutes	3 Minutes	4 Minutes
0%	73,60 ± 0,04^{e}	71,66 ± 0.19c	67,69 ± 0.72a
6%	74,39 ± 0,09^{f}	72,44 ± 0,09^{d}	69,32 ± 0,13^{b}
12%	75,22 ± 0,24^{g}	73,29 ± 0,08^{e}	71,53 ± 0,14^{c}
18%	77,54 ± 0,61^{i}	76,52 ± 0,80^{h}	74,71 ±0.17f

Description: The values in the table represent the mean of three replications ± standard deviation. Different letter notations indicate a significant difference at a 5% significance level (α=0.05).

Table 3 shows that the higher the concentration of added stevia leaves, the higher the °hue value of the tea. This is due to the compounds present in stevia leaves. According to Desy et al. (2020) and Fadilah et al. (2023), the presence of the flavonoid glycoside rutin (quercetin 3-β-rutinoside) gives a yellow color to stevia leaves, and the stevioside content in stevia leaves will darken the color, increasing the °hue index.

The longer the brewing time of ketepeng cina herbal tea, the lower the hue index value. This is because prolonged brewing extracts more components. According to Gunawan (2023), one of these components is polyphenols, specifically theaflavins and thearubigins. Theaflavins give a reddish-brown color, while thearubigins produce a golden-yellow color. The higher the content of theaflavins and thearubigins in the brewed tea, the darker the tea color (Gunawan, 2023). Based on Khairina (2017), colors with a °hue degree of 54°–90° are classified as yellow-red. In this study, the °hue value of the tea ranged from 67.69° to 77.54°, indicating that the color of ketepeng cina herbal tea is yellow-red or reddish-yellow.

Chemical Characteristics

1. Total Flavonoids

Flavonoids are a phenolic compound widely isolated from plants due to their antioxidant, antimicrobial, and anticancer properties. The antioxidant function of flavonoids is to scavenge free radicals that can damage the body (S. R. Dewi et al., 2018). The effect of varying stevia leaf addition and brewing time on the total flavonoid content of ketepeng cina herbal tea is presented in Table 4.

Table 4. Total Flavonoid Content of Ketepeng Cina Herbal Tea (mgQE/g)

Stevia Concentration (%)	Brewing Time		
	2 Minutes	3 Minutes	4 Minutes
0%	0,10 ± 0.02a	0,13 ± 0.03cd	0,12 ± 0.01c
6%	0,11 ± 0,01^{b}	0,14 ± 0.01e	0,13 ± 0.03d
12%	0,14 ± 0.01e	0,15 ± 0.06f	0,14 ± 0.02e

18%	0,16 ± 0,03^{g}	0,18 ± 0.10i	0,17 ± 0,10^{h}

Explanation: The numbers in the table represent the mean of three repetitions ± standard deviation. Different letter notations indicate significant differences at a 5% significance level (α=0.05).

The highest flavonoid content was obtained from the treatment with 18% stevia concentration and a brewing time of 3 minutes, amounting to 0.18 mgQE/g. Table 4 shows that the higher the concentration of added stevia leaves, the higher the flavonoid content. This is because stevia leaves contain flavonoid compounds, so increasing the amount of stevia leaves added enhances the measurable total flavonoid content. The raw material of stevia leaves has a flavonoid content of 3.97 mgQE/g. According to Mlambo et al. (2022), stevia leaves contain flavonoid compounds that act as antioxidants. The flavonoids present in stevia leaves include apigenin glucoside, luteolin glucoside, kaempferol, quercetin glucoside, quercetin arabinoside, and trimethoxy flavone (Madan & Singh, 2010).

The longer the brewing time of herbal tea, the higher the flavonoid content; however, a decrease was observed at a brewing duration of 4 minutes. This is because the longer the brewing time, the more flavonoids are extracted, but excessive brewing time can also reduce flavonoid levels. Margaretta et al. (2011) stated that prolonged brewing increases total flavonoid content due to greater kinetic energy, enhancing diffusion by extending the contact time between the tea leaf powder and the solvent. However, excessive brewing time leads to a decline in flavonoid levels, as prolonged exposure can degrade flavonoid compounds within the cell components, making them unavailable for extraction. According to Kurniawan (2023), prolonged brewing exposes flavonoid compounds to excessive heat, causing degradation and a reduction in flavonoid content.

2. Total Phenols

Phenols are the largest group of secondary metabolites found in plants, present in leaves, stems, roots, and fruit peels. Phenolic compounds function as antioxidants by scavenging free radicals (Ramadhan et al., 2022). The effect of varying stevia leaf addition and brewing time on the total phenol content of ketepeng cina herbal tea is presented in Table 5.

Table 5. Total Phenol Content of Ketepeng Cina Herbal Tea (mgGAE/g)

Stevia Concentration (%)	Brewing Time		
	2 Minutes	3 Minutes	4 Minutes
0%	1,11 ± 0.01a	1,45 ± 0.02c	1,23 ± 0,01^{b}
6%	1,25 ± 0,01^{b}	1,60 ± 0.02e	1,53 ± 0.01d
12%	1,60 ± 0.02e	1,77 ± 0,01^{g}	1,60 ± 0.00e
18%	1,79 ± 0,02^{g}	1,93 ± 0,01^{h}	1,72 ± 0,01^{f}

Explanation: The numbers in the table represent the mean of three repetitions ± standard deviation. Different letter notations indicate significant differences at a 5% significance level (α=0.05).

The highest total phenol content was obtained from the treatment with 18% stevia addition and a brewing time of 3 minutes, reaching 1.93 mgGAE/g. Table 5 shows that the higher the concentration of added stevia leaves, the higher the phenol content. Stevia leaves contain phenolic compounds, so increasing the amount of stevia leaves enhances the measurable total phenol content. According to Nassag et al. (2019), stevia leaves contain phenolic compounds such as vanillic acid 4-HAI-β-D-glucopyranoside, protocatechuic acid, caffeic acid, chlorogenic acid, and cryptochlorogenic acid. Therefore, the higher the stevia leaf addition, the higher the total phenol content. A similar study by Nurhaliza (2023) found that increasing the concentration of stevia leaves also increased the total phenol content in gambier leaf tea.

The longer the brewing time of herbal tea, the higher the phenol content; however, a decline was observed at a brewing duration of 4 minutes. This is because longer brewing times extract more phenolic compounds, increasing total phenol levels. According to Dewata et al. (2017), higher temperatures and longer brewing times enhance total phenol content because heat and extended exposure promote the release of phenolic compounds from cell walls. The decrease in phenol content results from the degradation of phenolic compounds during brewing. This aligns with the study by Jahangiri et al. (2011), which stated that prolonged brewing significantly reduces total phenol content. Excessive brewing time can break down phenolic compounds within cell components, preventing their extraction. Ibrahim et al. support this finding. (2015), who reported that excessive brewing of tea leads to the degradation of phenol content in herbal avocado leaf tea.

3. Antioxidant Activity

Antioxidants are compounds that help protect the body from cell damage caused by free radicals or counteract the negative effects of oxidants in the body (Hakim et al., 2024). Antioxidant activity is measured based on the percentage of inhibition (% antioxidant activity). The inhibition percentage is one of the parameters that indicate the ability of an antioxidant to neutralize free radicals. The effect of varying stevia leaf addition and brewing time on the antioxidant activity of herbal tea infusion from *ketepeng cina* is presented in Table 6.

Table 6. Antioxidant Activity of Herbal Tea Infusion from *Ketepeng Cina* (%)

Stevia Concentration (%)	Brewing Time		
	2 Minutes	**3 Minutes**	**4 Minutes**
0%	30,77 ± 0,20[a]	35,44 ± 0.10c	31,60 ± 0,02[ab]
6%	38,33 ± 0.20c	42,28 ± 0,38[d]	38,39 ± 0.15c
12%	42,58 ± 0.26d	45,70 ± 0,12[e]	41,50 ± 0.06d
18%	45,15 ± 0,00[e]	49,21 ± 0,10[f]	44,06 ± 0,17[d]

Description: The values in the table represent the mean of three replicates ± standard deviation. Different letter notations indicate significantly different effects at a 5% significance level (α=0.05).

The highest antioxidant activity was obtained from the treatment with 18% stevia concentration and a brewing time of 3 minutes, reaching 49.21%. Table 6

shows that the higher the concentration of added stevia leaves, the higher the antioxidant activity. This is due to the antioxidant compounds found in stevia leaves. Tristanto et al. (2017) stated that stevia leaf powder contains phytochemical compounds such as alkaloids, tannins, saponins, phenolics, glycosides, steroids, triterpenoids, and flavonoids, which function as antioxidants. Additionally, flavonoid and phenol content is directly proportional to antioxidant activity because flavonoids and phenols are antioxidant compounds; therefore, the higher their content, the higher the antioxidant activity. This aligns with the study by Perwiratami (2019), which found a direct correlation between antioxidant activity and total phenol and flavonoid content. Similar research by Anggraini (2024) also confirmed that adding stevia leaf powder to red ginger dip coffee can enhance its antioxidant activity.

The longer the herbal tea is brewed, the higher the antioxidant activity; however, a decline occurs at a brewing time of 4 minutes. This is because longer brewing extracts more antioxidant compounds from the ingredients. This finding aligns with Huri (2016), who reported that increasing brewing time enhances antioxidant activity in soursop leaf tea. However, excessive brewing time can cause antioxidant compounds to degrade. According to Shonisani (2010), brewing time is a driving factor for hydrolyzing the bonds of compounds in food ingredients. During brewing, antioxidant activity increases until it reaches its optimal point, after which it begins to decline. This is further supported by the research of Sumarno et al. (2021), which found that prolonged brewing leads to oxidation of the compounds in the material, ultimately reducing antioxidant activity.

Sensory Characteristics (Hedonic)

1. Hedonic Color

Table 7 presents the effect of varying stevia leaf additions and brewing time on the hedonic color score of herbal tea infusion.

Table 7. Hedonic Color Score of Herbal Tea Infusion

Stevia Concentration (%)	Brewing Time		
	2 Minutes	3 Minutes	4 Minutes
0%	4,37 ± 0,05^{a}	5,37 ± 0,12^{d}	4,73 ± 0,15^{b}
6%	5,13 ± 0.32c	5,73 ± 0,00^{fg}	5,60 ± 0.05ef
12%	5,43 ± 0,06^{de}	5,83 ± 0,06 fg	5,83 ± 0,06 fg
18%	5,77 ± 0,15^{fg}	6,33 ± 0,15^{h}	5,97 ± 0,06^{g}

Description: The values in the table represent the mean of three replications ± standard deviation. Different letter notations indicate significantly different effects at a 5% significance level (α=0.05).

The hedonic color score of herbal tea ranged from 4.37 to 6.33, categorized as neutral to like. The highest hedonic color score was obtained with 18% stevia concentration and a brewing time of 3 minutes, reaching 6.33. Table 7 shows that the higher the concentration of stevia leaves added, the more panelists liked the tea color. This is because the color of the herbal tea beverage was not significantly different from that of commercial tea bags, making it more

acceptable to panelists. The color of the tea with added stevia leaf powder resulted in a yellow-red hue. The color of stevia leaves is influenced by the presence of steroids, tannins, flavonoids, and chlorophyll, which are easily soluble (Yulianti et al., 2014).

As the brewing time increased, the panelists' preference for tea color also increased. However, a preference decline was observed at a brewing time of 4 minutes. This may be due to the longer brewing time, which results in a darker or browner tea color. The tea beverage exhibited a yellow-red hue, attributed to the presence of theaflavin and thearubigin from stevia, which are oxidation products of tannins that contribute to the dark color of tea. Theaflavin provides a yellow hue, while thearubigin contributes to a reddish-brown color (Hutasoit et al., 2021).

2. Hedonic Taste

Taste is one of the key indicators in determining whether a product is accepted or not. A product may have high chemical, physical, and nutritional value, but it will be difficult for consumers to accept it if it does not taste good. (Yasir et al., 2019)Table 8 presents the effect of varying stevia leaf addition and brewing time on the hedonic taste value of herbal tea infusion.

Table 8. Hedonic Taste Value of Herbal Tea Infusion

Stevia Concentration (%)	Brewing Time		
	2 Minutes	3 Minutes	4 Minutes
0%	$4{,}03 \pm 0{,}01^{b}$	$3{,}94 \pm 0{,}01^{b}$	$3{,}68 \pm 0{,}01^{a}$
6%	$4{,}71 \pm 0{,}01^{de}$	$4{,}55 \pm 0{,}05^{cd}$	$4{,}48 \pm 0{,}01^{c}$
12%	$5{,}05 \pm 0{,}03^{f}$	$4{,}83 \pm 0{,}06^{e}$	$4{,}57 \pm 0{,}12^{cd}$
18%	$5{,}08 \pm 0{,}02^{f}$	$5{,}30 \pm 0{,}36^{g}$	$4{,}90 \pm 0{,}03^{ef}$

Description: The values in the table represent the mean of three repetitions ± standard deviation. Different letter notations indicate significantly different effects at a 5% significance level (α=0.05).

The hedonic taste score of herbal tea ranged from 3.68 to 5.30, categorized as neutral to slightly liked. Table 8 shows that the higher the concentration of stevia leaves, the more the panelists favored the tea's taste. According to Cahyani et al., the addition of stevia helps reduce the tea's astringent taste. (2022), stevia leaves have a naturally sweet taste. The sweetness of stevia comes from the presence of stevioside (5–10%) and rebaudioside (2–4%). Stevia leaves are 200–300 times sweeter than sucrose.

As the brewing time increased, the panelists' preference for the tea's taste decreased. This is due to the longer brewing time, which extracts more compounds from the tea and stevia leaves. Both leaves contain flavonoids, phenols, and tannins. Accor ding to Fitri (2023), these compounds contribute to a bitter and astringent taste. Gunawan (2023) also states that stevioside in stevia leaves can contribute to bitterness. Although stevioside is the sweetest compound in stevia, excessive amounts can lead to a bitter taste.

3. Hedonic Aroma

Aroma is a scent detected by olfactory nerves, stimulated by chemical compounds (Nur et al., 2018). The effect of varying stevia leaf concentrations and brewing times on the hedonic aroma score of ketepeng cina herbal tea is presented in Table 9.

Table 9. Hedonic Aroma Score of Ketepeng Cina Herbal Tea

Stevia Concentration (%)	Brewing Time		
	2 Minutes	3 Minutes	4 Minutes
0%	$5,60 \pm 0,07^{g}$	$5,48 \pm 0,02^{f}$	$5,37 \pm 0,06^{ef}$
6%	$5,48 \pm 0,03^{f}$	$5,35 \pm 0,05^{e}$	$5,21 \pm 0,09^{d}$
12%	$5,18 \pm 0.04$d	$5,05 \pm 0.03$c	$4,97 \pm 0,06^{bc}$
18%	$4,90 \pm 0,03^{b}$	$4,93 \pm 0,15^{hc}$	$4,76 \pm 0,05^{a}$

Explanation: The numbers in the table represent the average of three repetitions ± standard deviation. Different letter notations indicate significantly different effects at a 5% significance level (α=0.05).

The hedonic aroma score in this study ranged from 4.76 to 5.60, categorized as "somewhat like" to "like." The analysis showed that the higher the concentration of stevia leaves and the longer the brewing time, the lower the panelists' preference for the tea's aroma. This is due to the ketepeng cina leaves and stevia leaves having a raw, grassy aroma.

According to Cahyani et al. (2022), an increased addition of stevia leaves leads to a stronger grassy aroma. This unpleasant aroma results from dried leaves that are not properly extracted. Melianti (2019) stated that an unpleasant grassy aroma originates from aliphatic aldehyde compounds, specifically the volatile 3-Methylbutanal in stevia leaves.

The longer the brewing time, the more volatile compounds are released in the ketepeng cina herbal tea. According to Yamin et al. (2017)The decrease in aroma is due to enzymatic activity, which releases several volatile compounds during brewing.

4. Hedonic Viscosity

Viscosity is the thickness value produced in beverage products (Dari & Junita, 2020). The effect of variations in the addition of stevia leaves and brewing time on the hedonic viscosity value of ketepeng cina herbal tea infusion is presented in Table 10.

Table 10. Hedonic Viscosity Value of Ketepeng Cina Herbal Tea Infusion

Stevia Concentration (%)	Brewing Time		
	2 Minutes	3 Minutes	4 Minutes
0%	$5,27 \pm 0,01^{abc}$	$5,29 \pm 0,01^{abc}$	$5,24 \pm 0,01^{ab}$
6%	$5,33 \pm 0,01^{abcd}$	$5,57 \pm 0,12^{bcd}$	$5,34 \pm 0,01^{abcd}$
12%	$5,15 \pm 0.56$a	$5,60 \pm 0.17$cd	$5,39 \pm 0,03^{abcd}$
18%	$5,56 \pm 0,06^{bcd}$	$5,66 \pm 0,10^{d}$	$5,50 \pm 0,12^{bcd}$

Description: The numbers in the table represent the average of three repetitions ± standard deviation. Different letter notations indicate significantly different effects at a 5% significance level (α=0.05).

The hedonic viscosity score of ketepeng cina herbal tea ranges from 5.15 to 5.66, categorized as "somewhat like to like." Table 10 shows that the higher the concentration of added stevia leaves and the longer the brewing time, the more the panelists liked the tea's viscosity. However, there was a decrease in preference at a brewing time of 4 minutes.

According to Layli (2020), factors affecting the viscosity of a solution include the dissolved components within it. Astuti and Pade (2020) added that viscosity is influenced by sugar addition, as sugar has hydrophilic properties due to the hydroxyl groups in its molecular structure. The decrease in preference for viscosity is due to the tea solution becoming too thick. According to Diniyah et al. (2012), the longer the brewing time, the higher the viscosity, making the solution thicker.

5. Hedonic Overall Acceptance

The effect of variations in the addition of stevia leaves and brewing time on the hedonic overall acceptance value of ketepeng cina herbal tea infusion is presented in Table 11.

Table 11. Hedonic Overall Acceptance Value of Ketepeng Cina Herbal Tea Infusion

Stevia Concentration (%)	Brewing Time		
	2 Minutes	3 Minutes	4 Minutes
0%	4,93 ± 0,01^{bc}	4,87 ± 0,01^{b}	4,57 ± 0,06^{a}
6%	5,40 ± 0,06^{e}	5,09 ± 0.20cd	4,95 ± 0,03^{bc}
12%	5,48 ± 0,01^{ef}	5,32 ± 0,14^{e}	5,14 ± 0.01d
18%	5,60 ± 0.06 fg	5,71 ± 0,06^{g}	5,36 ± 0,22^{e}

Description: The numbers in the table represent the average of three repetitions ± standard deviation. Different letter notations indicate significantly different effects at a 5% significance level (α=0.05).

The hedonic overall acceptance score of ketepeng cina herbal tea ranges from 4.57 to 5.71, categorized as "somewhat like to like." Table 11 shows that the higher the concentration of added stevia leaves, the more the panelists liked the overall acceptance of the tea. The panelists accepted and liked the combination of color, taste, aroma, viscosity, and overall appearance of the ketepeng cina herbal tea infusion.

Kirana and Sunarharum (2020) stated that consumer preference for adding stevia leaves to ketepeng cina herbal tea infusion includes acceptance of color, aroma, and taste.

As the brewing time increases, the panelists' acceptance of the tea decreases. This is because longer brewing times result in a darker color, a more bitter taste, a stronger musty tea aroma, and excessively thick viscosity. However, overall, the panelists liked the ketepeng cina herbal tea infusion.

The study of Rahayu et al supports this. (2020), which stated that overall appearance is the first impression that can influence consumer evaluation of whether to accept a product. However, this evaluation does not determine the

panelists' preference, as other sensory attributes, such as color, taste, aroma, and viscosity, are also considered.

CONCLUSION

Based on the data, analysis, and discussion, the best treatment was the addition of 18% stevia and a brewing time of 3 minutes, resulting in a total dissolved solid of 3.68°Brix, a hue index of 76.52°, a total flavonoid content of 0.18 mgQE/g, a total phenol content of 1.93 mgGAE/g, and an antioxidant activity of 49.21%. The panelists favored this treatment, with a hedonic acceptance score ranging from 4.57 to 5.71, categorized as slightly like to like.

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