

Characterization of robusta (*Coffea canephora*) leaf tea: influence of leaf maturity and drying time

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Editor: Samuel Pereira de Carvalho

Received in November 11, 2024 and approved in May 16, 2025

ABSTRACT

The maturity level and drying duration of Robusta coffee leaves significantly affect the chemical, functional, and sensory characteristics of the resulting herbal tea, including moisture content, ash, pH, total phenols, IC₅₀, and hedonic values. Young to medium leaves dried for 120–150 minutes produced tea with higher antioxidant activity and better sensory acceptance, highlighting the importance of optimizing these factors to enhance the quality and health benefits of *Coffea canephora* leaf tea.

Key words: Antioxidant; drying duration; leaf maturity; Robusta coffee; sensory quality.

1 INTRODUCTION

Tea made from Robusta coffee leaves has become increasingly popular as a healthy beverage alternative due to its high content of bioactive compounds. According to Setiawan et al. (2015), *Coffea canephora* leaf contains antioxidant compounds such as flavonoids, polyphenols, alkaloids, and tannins, which confer health benefits. Additionally, Campa et al. (2012) have identified specific phenolic compounds in *Coffea arabica* leaves, including mangiferin.

Coffea canephora leaf tea quality is greatly influenced by two primary factors, including the maturity level of the leaf and the processing stages used. This maturity level plays an important role in determining antioxidant activity. According to Wijaya and Herlina (2021), the antioxidant activity of young *Coffea canephora* leaf is inferior to that of mature leaf, as evidenced by IC₅₀ values of 13.678 µg/mL and 7.519 µg/mL, respectively. Additionally, Pristiana, Susanti and Nurwantoro (2017) emphasized that the phenol content in extracts from both young and mature leaves measures 20.09 mg/g and 37.85 mg/g. Ratanamarno and Surbkar (2017) further indicated that the maturity level of *Coffea canephora* leaf affects caffeine content, with young, medium, and mature leaves containing 7.1 mg/g, 2.1 mg/g, and 2.4 mg/g, respectively.

In addition to leaf maturity, the processing of coffee leaves into tea involves several critical stages, with drying being a crucial step that affects the final quality of the product. Drying not only aims to reduce moisture content but also to inactivate enzymes that can degrade phenolic compounds in the leaves. Previous studies have shown that both temperature and duration of drying can influence the levels of tannins and other compounds in the tea, where

excessive drying can lead to a decline in quality. According to Christiani, Putra and Suparthana (2021), drying is a crucial determinant of the tea quality, influencing its chemical content and the resultant brew's color, aroma, and taste. Jumanio, Junardi and Darmansyah (2020) and Mahrita et al. (2022) specifically produced herbal tea with substantial antioxidant content, using specific temperatures and drying duration, including 70°C for 150 minutes and 30°C for 130 minutes. Therefore, this research aimed to ascertain the influence of leaf maturity level and drying duration on *Coffea canephora* leaf tea's chemical, organoleptic, and functional characteristics.

This study aims to investigate how variations in leaf maturity and drying time affect the chemical and sensory characteristics of Robusta coffee leaf tea.

2 MATERIAL AND METHODS

2.1 Tools and Materials

The tools used in this research comprised beaker glass, desiccator, 500mL Erlenmeyer flask, gloves, hot plate, spectronic unico cuvette, 5.5 x 7 tea bags, laminar airflow (LAF), muffle furnace, analytical balance (Ohaus, USA), “Memmert S-400” oven, “Eutech PC-510” pH meter, UV-VIS spectrophotometer “A&K Lab LK04, America”, and “Digisystem VM-1000” vortex mixer. The materials used in this study included Robusta (*Coffea canephora*) leaves, which were sourced from the Agrotech Training Center at Sriwijaya University, South Sumatra, Indonesia. DPPH (2,2-Diphenyl-1-Picrylhydrazyl), 95% ethanol “certified analysis,” Folin-Ciocalteu reagent, and “certified analysis” methanol.

2.2 Research Design

A completely randomized factorial design with two treatments, comprising leaf maturity level and drying duration, was used in this research. There were 9 treatment combinations, each repeated 3 times, and the experiment included 27 treatment combinations. The treatments were delineated as leaf maturity level (A) with subcategories A1=young leaf, A2=medium leaf, and A3=old leaf (Figure 1), and drying duration (B) with subcategories B1=90 minutes, B2=120 minutes, and B3=150 minutes.



Figure 1: Position of *Coffea canephora* leaf maturity levels

2.3 Procedure for making *Coffea canephora* leaf tea

According to Anggorowati et al. (2016), green tea from *Coffea canephora* leaf was prepared through the following steps. The harvesting of *Coffea canephora* leaves can be categorized into three groups: young leaves (first and second node), medium leaves (third and fourth node), and old leaves (fifth and sixth node). It is essential to sort the leaves to separate any damaged or defective ones. *Coffea canephora* leaves should be thoroughly washed with running water and then drained. The leaves are subjected to steam-wilting for 2 minutes at 100°C. After wilting, the leaves are shredded into a fine powder using a blender. The shredded leaves are then dried in an oven for varying durations, specifically 90 minutes, 120 minutes, and 150 minutes at a temperature of 60°C. Once dried, the coffee leaf tea powder is placed into tea bags, with each bag containing 3 grams of the powder. The tea bags are steeped in 200 mL of hot water at a temperature range of 80-90°C for approximately 5 minutes. Following this process, the *Coffea canephora* leaf tea is ready for analysis based on predetermined parameters.

Data were analyzed using analysis of variance (ANOVA) in SAS, followed by HSD testing ($\alpha = 0.05$) to identify significant differences. The research examined several key parameters, specifically:

2.3.1 Moisture content

The measurement of moisture content based on AOAC (2005) was carried out using the oven method: The process begins with drying an aluminum dish and its cover in an oven at a temperature of $135 \pm 2^\circ\text{C}$ for 2 hours to ensure the removal of any moisture present in the dish. After drying, the dish is transferred to a desiccator to cool, and then its initial mass (W1) is recorded. Approximately 2 grams of the *Coffea canephora* leaf tea sample is weighed and placed evenly in the aluminum dish. The combined mass of the dish and the sample is then recorded as W2. Subsequently, the dish containing the *Coffea canephora* leaf tea sample is placed in a preheated oven at $135 \pm 2^\circ\text{C}$, with a typical drying time set for 2 hours. The hold time begins when the oven reaches the specified temperature. After drying, quickly cover the dish and transfer it back to the desiccator to cool to room temperature. This prevents moisture from re-entering the sample. Once cooled, weigh the dish with the dried *Coffea canephora* leaf tea sample to obtain the final mass (W3). The moisture percentage is calculated using the Formula 1:

$$\text{Moisture} = \frac{(W1 - W3)}{W1 - W2} \times 100\% \quad (1)$$

Where:

W1 = weight of the sample before drying

W3 = weight of the sample after drying

W2 = weight of the empty dish

2.3.2 Ash content

Ash content measurements were carried out following the method set out by AOAC (2005). Ignite an empty porcelain crucible in a muffle furnace at 600°C for 30 minutes to remove any organic matter. Allow the crucible to cool in a desiccator and weigh it to obtain the tare weight (W1). Weigh approximately 2g of the *Coffea canephora* leaf tea sample into the prepared crucible. Record the combined weight of the crucible and sample (W2). Place the crucible containing the sample in a muffle furnace preheated to 600°C. Heat the sample at this temperature for 2 hours to ensure complete combustion of organic matter. After ashing, carefully remove the crucible from the furnace using tongs. Transfer it directly to a desiccator and allow it to cool to room temperature. Once cooled, weigh the crucible containing the ash residue (W3). Calculate the ash content as a percentage of the original sample using the following Formula 2:

$$\text{Ash content} = \frac{(W3 - W1)}{(W2 - W1)} \times 100\% \quad (2)$$

Where:

W1 = weight of empty crucible

W2 = weight of crucible + sample before ashing

W3 = weight of crucible + ash after ashing

2.3.3 pH

The pH measurement of the solution according to AOAC (2005) was carried out using a pH meter that had been calibrated beforehand with pH 4 and 7 buffers; the following procedure can be followed: Take a specific amount of the tea sample, typically around 3g. Place the measured tea sample in a suitable container and add a specific volume of distilled water, commonly around 200mL. This volume can vary based on the desired concentration and the specific method followed. Stir the mixture thoroughly to ensure that the tea is well-dispersed in the water. If necessary, use a vortex mixer to achieve a homogeneous suspension. Let the mixture sit briefly, usually around 10 to 15 minutes, to allow any solids to settle and to ensure that the pH measurement reflects the liquid phase. A calibrated pH meter is used to measure the pH of the liquid. Ensure that the pH meter's electrode is properly immersed in the liquid without touching the bottom of the container to avoid contamination from settled solids. Document the pH reading displayed on the meter. It is advisable to take multiple readings and average them for accuracy.

2.3.4 Total Phenol

The total phenol level was determined based on Marjon, Afrinaldi and Novita (2015), which can be modified as follows: Take a specific amount of *Coffea canephora* leaf tea sample from the tea bag, typically around 3g. Place the measured *Coffea canephora* leaf tea sample in a suitable container and add a specific volume of solvent, usually distilled water or ethanol, at about 1:10 (w/v). For example, if 1g of tea leaves is used, add 10 mL of solvent. Stir the mixture thoroughly to ensure that the phenolic compounds are extracted from the *Coffea Canephora* leaf tea sample into the solvent. This can be done using a magnetic stirrer or by shaking the container. Allow the mixture to incubate at room temperature or in a water bath for a specific time, typically around 30 minutes to 1 hour. This step enhances the extraction of phenolic compounds. After incubation, filter the mixture using filter paper or a centrifuge to separate the solid tea leaves from the liquid extract. Collect the filtrate, which contains the phenolic compounds. A spectrophotometer is used to measure the absorbance of the extract at a specific wavelength, commonly around 765 nm, after adding a reagent such as Folin-Ciocalteu. Prepare a calibration curve using known concentrations of a standard phenolic compound (e.g., gallic acid) to quantify the total phenolic content. Calculate the total phenolic content in the tea sample based on the absorbance readings and the calibration curve,

typically expressed in mg of gallic acid equivalents (GAE) per gram of sample.

2.3.5 IC₅₀

The antioxidant activity test was carried out by calculating the IC₅₀ value using the DPPH method (1,1-diphenyl-2-picrylhydrazyl) according to the Association of AOAC (2005) which has been modified: Weigh a specific amount of *Coffea canephora* leaf tea sample from the tea bag, typically around 3g. Place the measured *Coffea canephora* leaf tea sample into a suitable container and add a specific volume of solvent, such as distilled water or ethanol, at a ratio of about 1:10 (w/v). For example, if 1 g of tea leaves is used, add 10 mL of solvent. Stir the mixture thoroughly to ensure the phenolic compounds are extracted into the solvent. This can be done using a magnetic stirrer or by shaking the container. Allow the mixture to incubate at room temperature or in a water bath for a specified time, typically around 30 minutes to 1 hour, to enhance the extraction of phenolic compounds. After incubation, filter the mixture using filter paper or a centrifuge to separate the solid tea leaves from the liquid extract. Collect the filtrate, which contains the phenolic compounds. Perform an antioxidant activity assay using the DPPH (2,2-diphenyl-1-picrylhydrazyl) method. Prepare a series of dilutions of the tea extract to create different concentrations. Add a fixed volume of DPPH solution to each dilution and incubate in the dark for a specified time (usually 30 minutes). Measure the absorbance at 517 nm using a spectrophotometer. Calculate the percentage of DPPH inhibition for each concentration using the Formula 3:

$$\text{Percent Inhibition} = \frac{(A_0 - A_t)}{A_t} \times 100\% \quad (3)$$

Where

A₀ is the absorbance of the control (DPPH solution without extract) and A_t is the absorbance of the sample. Plot the percent inhibition against the concentration of the tea extract to create a dose-response curve. The IC₅₀ value is the concentration of the extract that inhibits 50% of the DPPH radicals, which can be determined from the curve.

2.3.6 Hedonic test

The hedonic test was determined based on Pratama et al. (2018). The sensory panel consisted of 25 semi-trained panelists who evaluated the sample's color, aroma, and taste. Each sample was rated on a hedonic scale where 4 indicated "very like," 3 indicated "like," 2 indicated "dislike," and 1 indicated "very dislike." The organoleptic quality of the product was assessed through this hedonic test, with panelists providing their feedback on their level of liking or disliking each sample. Higher numerical values on the scale reflect more favorable responses. The results

from the hedonic test will be analyzed by converting the scale into numerical data. Organoleptic data will be further analyzed using the Friedman Conover test (Meilgaard et al., 2018).

3 RESULTS

Analysis of variance revealed significant main effects of leaf maturity and drying duration on IC₅₀, total phenols, pH, moisture content, and ash content of *Coffea canephora* leaf tea. Furthermore, the Honestly Significant Difference (HSD) test ($\alpha = 0.05$) revealed significant differences in leaf maturity level and drying duration effects, as presented in Tables 1 and 2.

The IC₅₀ values of this *Coffea canephora* leaf tea ranged from 43.65 to 60.22 ppm. Specifically, treatment A3B1 had the lowest value at 43.65ppm, while treatment

A1B3 had the highest at 60.22ppm. The total phenol content of *Coffea canephora* leaf tea ranged from 16.07 to 42.29 mgGAE/g. Treatment A3B1 recorded the highest value at 42.29mgGAE/g, while treatment A1B3 had the lowest at 16.07mgGAE/g. A significant interaction effect ($p < 0.05$) was observed between leaf maturity and drying duration on IC₅₀ values and total phenolic content of *Coffea canephora* leaf tea, as presented in Table 3.

The pH of *Coffea canephora* leaf tea solutions ranged from 5.61 to 5.68, with treatment A1B1 exhibiting the lowest pH and A3B3 the highest. The moisture content in the *Coffea canephora* leaf tea varied between 3.28% and 5.24%, where treatment A1B1 had the highest moisture content at 5.24%, while treatment A2B3 recorded the lowest at 3.28%. The ash content of the tea was found to range from 5.68% to 7.11%,

Table 1: HSD test results ($\alpha = 0.05$) effect of leaf maturity level treatment on the IC₅₀, total phenols, pH, moisture content, and ash content of *Coffea canephora* leaf tea.

Variable	IC ₅₀ (ppm)	Total Phenol (ppm)	pH	Moisture Content	Ash Content
A1	58.35±0.29a	20.60±0.40a	5.63±0,01a	4.59±0.06a	6.24±0.02a
A2	53.45±0.22b	27.50±0.49b	5.65±0,01b	4.04±0.04b	6.36±0.07b
A3	47.30±0.31c	36.13±1.05c	5.66±0,01c	3.87±0.07c	6.47±0.04c

Description: Values which are followed by different letter in the same column is significantly different at level of 5% according to Honestly Significant Difference ($P < 0.05$).

Table 2: HSD test results ($\alpha = 0.05$) effect of drying duration treatment on the IC₅₀ values, total phenols, pH, moisture content, and ash content of *Coffea canephora* leaf tea.

Variable	IC ₅₀ (ppm)	Total Phenol (ppm)	pH	Moisture Content	Ash Content
B1	50.60±0.24a	33.14±0.48c	5.46±0,09a	4.88±0.09a	5.63±0.01a
B2	53.03±0.32ab	28.08±0.45b	5.52±0,13a	4.21±0.04b	6.65±0.01b
B3	55.46±0.26b	23.00±1.01a	5.60±0,10b	3.42±0.03c	6.66±0.02b

Description: Values which are followed by different letter in the same column is significantly different at level of 5% according to Honestly Significant Difference ($P < 0.05$).

Table 3: HSD test results ($\alpha = 0.05$) effect of interaction leaf maturity level and drying duration treatment on the IC₅₀ and total *Coffea canephora* leaf tea phenol.

Treatment	IC ₅₀ (ppm)	Total Phenol (ppm)
A1B1	56.64±0.27g	25.44±0.36ef
A1B2	58.19±0.38h	20.28±0.36g
A1B3	60.22±0.22i	16.07±0.48h
A2B1	51.51±0.20d	31.71±0.36c
A2B2	53.32±0.17e	27.66±0.49de
A2B3	55.52±0.30f	23.13±0.59f
A3B1	43.65±0.25a	42.29±2.30a
A3B2	47.59±0.40b	36.31±0.47b
A3B3	50.64±0.27c	29.80±0.36cd

Description: Values which are followed by different letter in the same column is significantly different at level of 5% according to Honestly Significant Difference ($P < 0.05$).

with treatment A1B1 showing the lowest ash content and the highest observed in treatment A3B3. Additionally, the interaction between leaf maturity level and drying duration did not significantly affect the total phenol content of *Coffea canephora* leaf tea.

The hedonic test was conducted by assessing the color, aroma, and taste of Robusta coffee leaf tea. The mean scores for the color, aroma, and taste of this tea ranged from 2.60 to 3.44; 2.44 to 3.00; and 1.80 to 2.72, respectively. Additionally, the mean scores for the hedonic test regarding color, aroma, and taste are presented in Figure 2.

Friedman-Conover tests were conducted on the color, aroma, and taste of Robusta coffee leaf tea, as detailed in

Table 4. The test results showed that treatment A3B2 yielded a greenish-yellow color, which had the highest preference among consumers. Both treatments A3B2 and A3B3 received top scores due to the distinctive aroma characteristic of *Coffea canephora* leaf tea.

4 DISCUSSION

The analysis results (Table 1) showed that as *Coffea canephora* leaf aged, the IC_{50} values decreased, suggesting increased antioxidant properties. This phenomenon occurred because older leaves required stronger defense mechanisms than younger ones, thereby necessitating higher concentrations

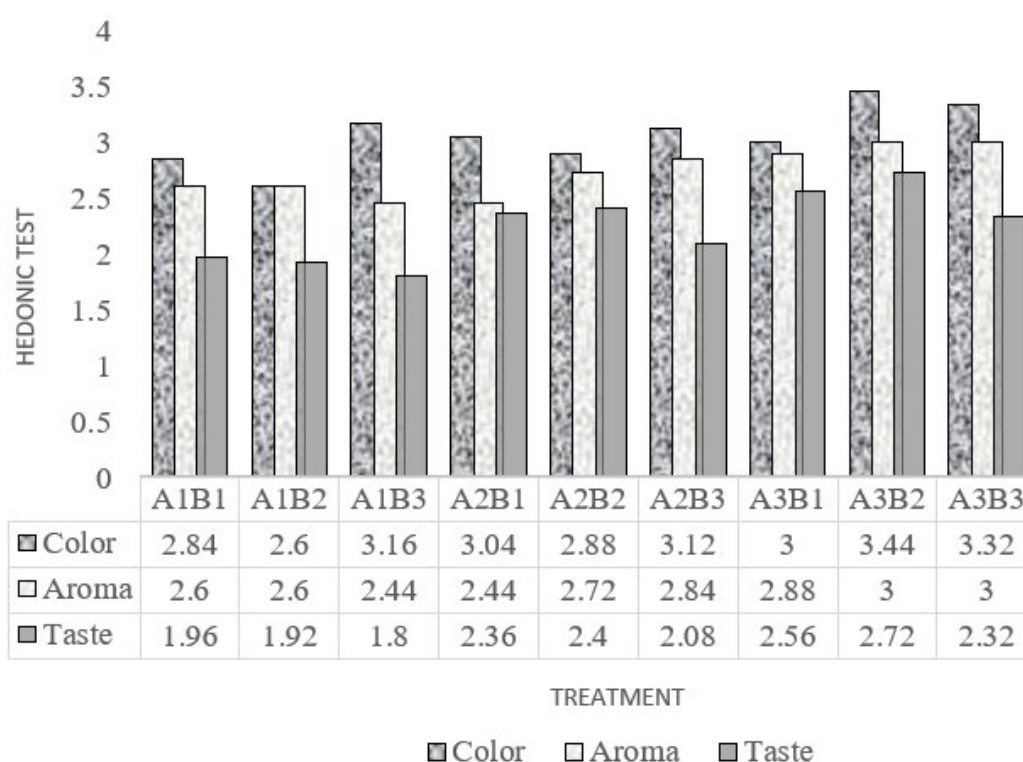


Figure 2: The results of the hedonic test for *Coffea canephora* leaf tea.

Table 4: Results of the Friedman-Conover test on the color, aroma, and taste of the tea produced.

Treatment	Color	Aroma	Taste
A1B1	106.5ab	113.5ab	108abc
A1B2	91a	115.5ab	100ab
A1B3	133bc	100.7a	94a
A2B1	121.5b	96.5a	135cd
A2B2	110ab	124.5abc	136cd
A2B3	129.5bc	134.5bc	115abc
A3B1	120b	139bc	147d
A3B2	163d	148.5c	161d
A3B3	150.5d	150c	131bcd

Description: Numbers followed by the same letter in the same column indicate no significant difference ($p < 0.05$).

of secondary metabolites. Pristiana, Susanti and Nurwantoro (2017) reported higher levels of total phenols in older *Coffea canephora* leaves compared to younger ones. Similarly, Achakzai et al. (2009) observed higher total phenol content in older leaves compared to older leaf stems.

The IC₅₀ values (Table 2) of *Coffea canephora* leaf tea increased with longer drying duration, indicating decreased antioxidant activity with prolonged drying. This phenomenon occurred due to oxidative damage to secondary metabolites such as flavonoids, a group of polyphenolic compounds renowned for their antioxidant properties, which were abundant in coffee leaf. The result was consistent with the observation of Yamin, Ayu and Hamzah (2017), who stated an increase in IC₅₀ values of herbal tea made from *Senna alata* leaf with a longer drying duration of 43.79 µg/ml for 110 minutes and 101.45 µg/mL for 190 minutes.

The results of HSD test at 5% (Table 3) indicated that *Coffea canephora* leaf tea with treatment old leaf and 90 minutes (A3B1) had the highest IC₅₀ values (43.65 ppm), differing significantly from other treatments. The tea had strong antioxidant activity, falling within the category of values below 50 ppm. Specifically, the IC₅₀ values obtained in this research were similar to the report of Koch et al. (2018), who identified a value of 48 ppm for wild tea leaf extract. However, compared to the results of Anggorowati et al. (2016) and Benti et al. (2022), the IC₅₀ values were relatively higher and lower, respectively. Anggorowati et al. (2016) reported values of 24.86-38.21 ppm for avocado leaf tea, while Benti et al. (2022) found values of 311-520 ppm for *Camellia sinensis* leaf tea processed with high-quality clones. The discrepancy was also evident when comparing the results to those reported by Tariq and Reyaz (2013), who stated a value of 70.25 ppm for green tea from *Camellia sinensis* leaf.

Table 1 presented that as coffee leaf aged, the total phenol content of the tea increased. The increase in total phenol content corresponded to greater antioxidant activity, as evidenced by the decrease in IC₅₀ values with the increasing age of *Coffea canephora* leaf. This result was supported by Campa et al. (2012) who explained that *Coffea arabica* leaf contained phenolic compounds such as mangiferin.

The results of Tukey's HSD test (Table 2) showed that longer drying duration resulted in lower total phenol content. This occurred because prolonged drying increased the duration of contact between the material and the heat source, raising the likelihood of heat damage to phenolic compounds. Putri, Yusasrini and Nocianitri (2010) explained that the stability of polyphenolic compounds was compromised when the drying temperature exceeded the optimum level, leading to a reduction in polyphenol content.

Coffea canephora leaf tea with treatment A3B1 had the highest total phenol value of 42.29 mgGAE/100g, significantly differing from the other treatments (Table 3). This total phenol

content was in line with the results of Puspaningrum and Sari (2020) on cascara tea, which recorded 8.23 mgGAE/100g. Pristiana, Susanti and Nurwantoro (2017) reported a phenols content of 20.09mgGAE/100g for young *Coffea canephora* leaf extract and 37.85 mgGAE/100g for old ones. Pulungan et al. (2022) indicated a total phenol content range of 22.16 to 25.90 mgGAE/100g for herbal mango leaf tea. However, the analysis results showed higher total phenol content compared to Dusun et al. (2017) and Setiawan et al. (2015), who respectively reported 8.23 mgGAE/100ml for *Coffea arabica* cascara tea and a range of 5.59 to 1.41 mgGAE/g for *Coffea canephora* leaf refreshment drinks. The total phenol content of *Coffea canephora* leaf tea was lower than that reported by Kristiningrum, Cahyanti and Wulandari (2016) for old *Coffea arabica* leaf tea (399.403 mgGAE/g) and green tea made from Japanese papaya leaf (1400.13 mgGAE/g). Additionally, Vitas et al. (2020) and Hsieh, Chiu and Chou (2021) found that fermented kombucha tea contained 70 mgGAE/g and 800 mgGAE/g total phenol, respectively.

The analysis of variance indicated that the leaf maturity level and drying duration significantly affected the ash content, while the interaction did not. Based on Table 1, HSD test results showed that as the coffee leaf aged, the ash content of the *Coffea canephora* leaf tea increased. Rohiqi et al. (2021) explained the ash content of young tenggulun leaf herbal tea was lower than that of old ones, with percentages of 6.45% and 13.44%, respectively. Additionally, Diputra et al. (2023) found that the ash content of soursop leaf herbal tea increased with the age of the leaf, with percentages of 5.86%, 6.13%, and 7.17%, respectively.

The longer the drying duration, the higher the ash content of *Coffea canephora* leaf tea (Table 2). This was because prolonged drying led to more water evaporation, increasing mineral concentration in the material. According to Kusuma, Putra and Darmayanti (2019), variations in ash content in food materials were influenced by factors such as the method of ashing, type of food material, temperature, and drying duration. Fitriani (2023) found that the ash content in the herbal tea leaf of *Strobilanthes crispus* increased from 2.83% to 3.73% with prolonged drying.

The ash content of the tea produced in this research complied with the National Standards Agency (2016), requiring a minimum of 4% and a maximum of 8%. Comparable to matcha tea, ranging from 4.64 to 4.99%, and polyherbal dip tea, ranging from 6.00 to 6.50% (Mohsina et al., 2022). Similarly, the ash content of *Gnetum gnemon* bark tea and gambir leaf tea with added red ginger powder ranged from 3.50 to 3.70% and 2.09 to 4.59%, respectively, Ardiyansyah and Apriliyanti. (2016). It was lower than the ash content of tenggulun leaf matcha herbal tea, ranging from 6.45 to 13.44% (Rohiqi et al., 2021) and coffee leaf tea from El Salvador, which ranged from 7.81 to 10.20% (Stegar et al., 2022).

The statistical analysis indicated that both leaf maturity and fermentation duration significantly influenced the moisture content of *Coffea canephora* leaf tea, while their interaction did not. Additionally, HSD test at 5% significance (Table 1) showed that using older leaves led to lower moisture content in the tea. This disparity could be attributed to the higher plasma content in young leaves, containing hydrophilic proteins, compared to the carbohydrate and fiber composition of older ones. The results were in line with the observation of Diputra et al. (2023), who found diminishing moisture content with the increasing age of soursop leaf used in herbal tea, ranging from 7.69 to 6.68%. Similar results were observed by Supriyanto, Darmadji and Susanti (2014) in their investigation on cocoa leaf, where younger leaf had higher moisture content compared to older ones, at 4.21 and 3.70%, respectively.

A longer drying duration was also correlated with decreased moisture content in *Coffea canephora* leaf tea (Table 2). This phenomenon occurred due to the escalated evaporation of water from the food material as the drying time increased. Purba et al. (2021) also found a similar trend in herbal matcha tea from *Melastoma malabathricum* leaf, where the drying duration of 90, 120, and 150 minutes at 70°C resulted in moisture contents of 9.38%, 8.78%, and 8.26%, respectively.

Based on the results obtained, the moisture content was in line with the criteria of SNI 3945:2016 for green tea, which specified a maximum of 8%. The moisture content produced was consistent with that of herbal leaf tea from *Sauropus androgynus* (L.) Merr leaf, ranging from 3.87 to 6.49% (Mohsina et al., 2022) and fig leaf tea, ranging from 2.67 to 6.55% (Sari; Affandi; Prabawa, 2020). However, it was lower compared to nutmeg leaf tea, ranging from 6.64 to 7.49% (Lestari; Sa'diyah, 2020) and tea made from a mixture of jackfruit leaf, gotu kola leaf, and cinnamon powder, which was 7.88% (Rozi; Silvy; Syukri, 2022).

The analysis of variance showed that the leaf maturity level, drying duration, and their interaction did not significantly affect the pH of the robusta coffee leaf tea solution. The results differed from those of (Sari; Affandi; Prabawa, 2020) and Puspaningrum and Sari (2020), who reported pH values ranging from 5.80 to 5.89, 5.80 to 5.83, and 6.88 to 7.08 for tin leaf tea, mania leaf tea infusion, and Arabica coffee cherry husk tea, respectively. Supriyanto, Darmadji and Susanti (2014) also stated pH values ranging from 5.97 to 6.45 for cocoa leaf tea solution. In contrast, Rahim, Herlianti and Rostiati (2019) reported ranging from 4.65 to 4.86 for moringa-roselle leaf tea, respectively.

The strong aroma in the tea was attributed to phenolic compounds binding to the aromatic ring. In terms of taste preference, treatment A3B2 received the highest score, having a slightly bitter taste, known as astringency, typically caused by tannins (Ioannou; Ghoul, 2012). Tannins, a type

of polyphenolic compound found in plants, were known for imparting bitterness to food items. Specifically, the color, aroma, and taste parameters complied with the National Standards Agency (2016) standards for green tea.

5 CONCLUSION

Optimizing leaf maturity and drying duration substantially improves Robusta coffee leaf tea's antioxidant capacity, bioactive compounds, and sensory attributes, as evidenced by the A3B2 treatment (IC50: 47.59 ppm, total phenols: 36.31 mg GAE/g).

6 AUTHORS' CONTRIBUTION

Conceptual Idea: Santoso, B.; Methodology Design: Defira, C.; Syafutri, M.I.; Data Collection: Sinaga, C.C.; Data Analysis and Interpretation: Syaiful, F.; Pratiwi, C.; Writing and Editing: Hermanto.

7 REFERENCES

- ACHAKZAI, A. K. K. et al. Response of plant parts and age on the distribution of secondary metabolites in plants found in Quetta. **Pakistan Journal of Botany**, 41(5):2129-2135, 2009.
- ANGGOROWATI, D. A.; PRIANDINI, G.; THUFAIL, T. The potential of *Persea americana* Miller as an antioxidant-rich herbal tea. **Innovative Industry: Journal of Industrial Engineering**, (1):1-7, 2016.
- ARDIYANSYAH, M.; APRILIYANTI, M. W. Chemical characteristics of melinjo peel tea. **Scientific Journal of Innovation**, 1(2):89-92, 2016.
- ASSOCIATION OF OFFICIAL ANALYTICAL CHEMISTS - AOAC. **Official methods of analysis**. Washington, DC: AOAC. 2005.
- BENTI, T. et al. Influence of clone and nitrogen application level on quality of green tea in some selected tea (*Camellia sinensis* (L.) O. Kuntze) in Southwest Ethiopia. **Heliyon**, 8(8):e10179, 2022.
- CAMPA, C. et al. A survey of mangiferin and hydroxycinnamic acid ester accumulation in coffee (*Coffea*) leaves: Biological implications and uses. **Annals of Botany**, 110(3):595-613, 2012.
- CHRISTIANI, E. A.; PUTRA, I. N. K.; SUPARTHANA, I. P. The Effects of temperature and drying time on the chemical and sensory properties of herbal tea infusions from *Mimosa pudica* L. leaves. **Journal of Food Science and Technology**, 10(4):589-601, 2021.

- DIPUTRA, P. M. A. S. et al. The Effect of leaf aroma level on the characteristics of soursop leaf herbal tea (*Annona muricata* Linn.). **Journal of Food Science and Technology**, 12 (2), 2023.
- DUSUN, C. C. et al. The phenolic content and antioxidant activity of guava leaf tea (*Psidium guajava* L.). **Cocos**, 9(2):1-13, 2017.
- FITRIANI, D. Effect of black tea processing method on phenol content, vitamin C, and sensory characteristics of tatat leaf herbal tea (*Bauhinia acuminata*). **Journal Functional Food and Nutraceutical**, 5(1):13-24, 2023.
- HSIEH, Y.; CHIU, M. C.; CHOU, J. Y. Efficacy of the kombucha beverage derived from green, black, and pure teas on chemical profile and antioxidants activity. **Journal Food Quality**, 1735959, 2021.
- IOANNOU, I.; GHOUL, M. Biological activities and effects of food processing on flavonoids as phenolic antioxidants. In: PETRE, M. (Ed.). **Advances in applied biotechnology**. London: IntechOpen, cap. 5, p. 101-124, 2012.
- JUMANIO, A. U.; JUNARDI, J.; DARMANSYAH, H. Analysis of water content in pandan fragrant leaf herbal tea *Pandanus amaryllifolius* Roxb. using various temperatures. **Journal of Food Security and Agroindustry**, 1(3):111-117, 2020.
- KOCH, W. et al. Green tea quality evaluation based on its catechins and metals composition in combination with chemometric analysis. **Molecules**, 23(7):1689, 2018.
- KRISTININGRUM, M.; CAHYANTI, N.; WULANDARI, L. Determination of total phenolic content and antioxidant activity in methanolic extract of robusta and arabica coffee leaves. **Proceeding ICMHS**, 3(1):96-99, 2016.
- KUSUMA, I. G. N. S.; PUTRA, I. N. K.; DARMAYANTI, L. P. T. The effect of drying temperature on the antioxidant activity of cocoa shell herbal tea (*Theobroma cacao* L.). **Journal of Food Science and Technology**, 8(1):85-93, 2019.
- LESTARI, K. A. P.; SA'DIYAH, L. Chemical and physical characteristics of kombucha green tea at different heating times. **Journal Pharmacy**, 5(1):15-20, 2020.
- MAHRITA, S. et al. The Effect of drying time on the quality of herbal tea from *Peronema canescens* jack leaves. **Journal of Scientific Cakrawala**, 2(4):1411-1422, 2022.
- MEILGAARD, M.; CIVILLE, G. V.; CARR, B. T. Sensory evaluation techniques. 4. ed. Boca Raton: CRC Press, 2016. 632p.
- MARJON, M. R.; AFRINALDI; NOVITA. Total phenol content and antioxidant activity of water extract of kersen leaves (*Muntingia calabura* L.). **Yarsi Medical Journal**, 23(3):187-196, 2015.
- MOHSINA, F. P. et al. In vitro inhibitory effect on alpha amylase enzyme by polyherbal dip tea in diabetes. **Indo Global Journal of Pharmaceutical Sciences**, 12:156-165, 2022.
- NATIONAL STANDARDS AGENCY. **SNI 3945:2016. Green Tea**. In Jakarta: National Organization for Standardization. <https://pesta.bsn.go.id/produk/detail/10772-sni39452016>
- PRISTIANA, D. Y.; SUSANTI, S.; NURWANTORO. Antioxidant and phenol content of various coffee leaf extracts (*Coffea* sp.): potential application of natural ingredients for food fortification. **Journal of Food Technology Applications**, 6(2):89-92, 2017.
- PULUNGAN, M. Z. et al. Antioxidant activity and quality of mango leaf herbal tea based on leaf position on the branch. **Andalas Journal of Agricultural Technology**, 26(2):248-253, 2022.
- PURBA, Y. M. S. et al. The effects of temperature and drying time on the characteristics of matcha herbal tea from *Protium javanicum* Burm. F. **Journal of Food Science and Technology**, 10(3), 2021.
- PUSPANINGRUM, D. H. D.; SARI, N. K. Y. The effects of drying and infusion ratio on the physical and chemical properties of arabica coffee cascara tea. **Journal of Food Science and Technology**, 6(2):710-718, 2020.
- PUTRI, K. D.; YUSASRINI, N. A.; NOCIANITRI, K. A. The effect of processing methods on antioxidant activity and characteristics of powdered herbal tea from *Vernonia amygdalina* Delile. **Journal of Food Science and Technology**, 10(1):77-80, 2010.
- RAHIM, A.; HERLIANTI, H.; ROSTIATI, R. Chemical and organoleptic characteristics of moringa leaf tea (*Moringa Oleifera* Lam.) based on the altitude of the growing place. **Ghidza: Journal of Nutrition and Health**, 3(2):59-62, 2019.
- RATANAMARNO, S.; SURBKAR, S. Caffeine and catechins in fresh coffee leaf (*Coffea arabica*) and coffee leaf tea. **Maejo International Journal Science and Technology**, 11(30):211-218, 2017.
- ROHIQI, H. et al. The effect of leaf aroma level on the characteristics of matcha tenggulun herbal Tea *Protium javanicum* Burm. F. **Journal of Food Science and Technology**, 10(3):345-356, 2021.

- ROZI, F.; SILVY, D.; SYUKRI, D. Characterization of herbal tea bags made starfruit leaves, gatu kola leaves, and cinnamon powder as functional drink. **Andalasian International Agricultural Natural Science**, 3(1):47-54, 2022.
- SARI, D. K.; AFFANDI, D. R.; PRABAWA, S. Effect of drying time and temperature on the characteristics of tin leaf tea (*Ficus carica* L.). **Journal of Agricultural Product Technology**, 12(2):68-77, 2020.
- SETIAWAN, E. S.; RAHADIAN, A. M.; SISWANDI. The Influence of roasting robusta coffee leaves (*Coffea robusta*) on the chemical and sensory characteristics of the beverage. **Journal of Food Science and Technology**, 4(2):1-9, 2015.
- STEGAR, M. C. et al. Coffee leaf tea from El Salvador: On-site production considering influences of processing on chemical composition. **Foods**, 11(17):1-34, 2022.
- SUPRIYANTO.; DARMADJI.; SUSANTI, I. Study on the production of cocoa leaf tea (*Theobroma cacao* L.) as a refreshing beverage. **Agritech**, 34(4):422-429, 2014.
- TARIQ, A. L.; REYAZ, A. L. Antioxidant activity of *Camellia sinensis* leave. **International Journal Current Microbiology Application Science**, 2(5):40-46, 2013.
- VITAS, J. et al. Kombucha fermentation of six medicinal herbs: chemical profile and biological activity. **Chemical Industry Chemical Engineering Quality**, 26:157-170, 2020.
- WIJAYA, D. P.; HERLINA, R. A. Formulation and antioxidant activity of coffee robusta leaf extract (*Coffea canephora*) in gels. **Pharmaco Bahari's Scientific Journal**, 12(2):141-149, 2021.
- YAMIN, M.; AYU, D. F.; HAMZAH, F. The effect of drying time on the antioxidant activity and quality of herbal tea from *Cassia alata* L. leaves. **Jom Faperta**, 4(2):1-15, 2017.