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Effect of Microwave Use on Kawa Daun Production: Production, Composition, and Antioxidant Properties

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ABSTRACT

Kawa daun tea is a drink made of dried coffee leaves from Western Sumatra, offering refreshing benefits for the body. The use of a microwave in the drying process proves to be an effective method due to its significantly high efficiency. Therefore, this study aimed to investigate the impact of varying drying time using microwave on the characteristics of coffee leaves, kawa daun tea, and drinking water, as well as to determine effect of microwave treatment. This study uses a complete random design with ANOVA (Analysis of Variance) and followed by a DNMRT (Duncan's News Multiple Range Test). The results showed that the difference in drying times significantly affected properties of coffee tea leaves, specifically on the total water-soluble substance test. However, there was no substantial impact on the yield, water level, polyphenols level, caffeine level, and antioxidant activity. The length was also affected by polyphenols level, total soluble solidity, and water solubility antioxidant activity, but did not impact caffeine content test. The maximum time for optimal drying coffee leaves was two minutes with a yield of 35.99% hydration, 4.33% water level, 48.56 mgGAE/g total polyphenols level, 0.56% caffeine level, 63.43% oxidative activity, and 4.61% total water-soluble material. In the chemical analysis of drinking water, the results obtained were total polyphenol content of 28.1 mg GAE/g, caffeine content of 0.45%, total dissolved solids of 1.87%, and antioxidant activity of 88.79%. Thus, it is also concluded that there is no negative effect of drying coffee leaves with a microwave.

Key words: Antioxidant; caffeine; robusta coffee leaves; microwave drying; polyphenols.

1 INTRODUCTION

Kawa daun tea is a drink made of dried coffee leaves from Western Sumatra, offering refreshing benefits for the body. Kawa daun is a beverage that is typical of West Sumatra and is created from dried coffee leaves (Ristia; Kasim; Novelina, 2023) . This tea is a healthy local drink widely recognized across three counties, including Agam, Tanah Datar, and Lima Puluh, for its distinctive aroma, taste, and appearance similar to coffee (Novita et al., 2018). Kawa daun tea grew back around 2001 in Tabek Patah Province of Western Sumatra and has been served in several variants, including original coffee leaves, milk coffee, egg milk tea, ginger tea, and candy tea. Furthermore, it has grown into an alternative drink popular with local people (Novita et al., 2018). Kawa Daun is a traditional beverage from West Sumatra made from dried coffee leaves. It is served in a coconut shell supported by bamboo, functioning as a cup, and has a tea-like appearance due to the dark color of its steeped liquid. The Minang people were familiar with coffee plants even before the Dutch colonization, valuing the leaves more highly than the beans. This drink has been a part of Sumatra's culture for generations (Ristia; Kasim; Novelina, 2023).

Coffee leaves, abundant in bioactive compounds, hold great potential as an agricultural resource and show promise for the growing functional food and nutraceutical industries (Patil; Vedashree; Murthy, 2022). The bioactive compounds found in coffee leaves, including mangiferin, trigonelline, caffeine, chlorogenic acids (CGAs), and rutin, are responsible for their antioxidant, anti-inflammatory, antihypertensive, anti-obesity, antibacterial, antifungal, anticancer, and neuroprotective properties (Yohannis et al., 2024). Coffee leaves contain various bioactive compounds that are beneficial for human health. However, there are very limited researches related to the extraction of the bioactive phytochemicals from coffee leaves (Chen et al., 2020).

The processing of coffee leaves into kawa daun tea is carried out through drying. The traditional drying was performed in two methods, firstly, by attaching leaves to two 180 cm long sticks. Secondly, the original method is further processed by piercing leaves individually with a bamboo punch and baking over a kitchen stove. The adoption of innovations in drying technology is a crucial aspect in ensuring consumer health and protecting the environment (Chojnacka et al., 2021). Dying is among the earliest preservation methods known to humanity, with its use dating back to prehistoric times (Ahmed et al., 2013) . The drying can also be carried out in the open air for 2 weeks or through air-conditioning of the top leaves at room temperature (20-25°C) for ± 1 week, followed by dryer cabinet at 40-45°C for 4 hours. Another possible method of drying coffee leaves into kawa daun tea is through the use of microwave (Ristia; Kasim; Novelina, 2023).

The operational principles of microwave includes directing the radiation waves into the water present in

the nutrient. Microwave-assisted drying is an alternative method suitable for drying foodstuffs, particularly fruits and vegetables, as it offers shorter drying times and improved energy efficiency (Horuz; Maskan, 2020). This radiation is absorbed by the water, generating heat that can lead to the disruption of cell walls in the ingredient, allowing its contents to be released. The advantages of using microwave include accelerating drying, minimizing color changes during heating, enhancing drying rate, and reducing shrinkage (Zahoor et al., 2023). The use of microwave can maintain bioactive components, antioxidant activity, and attractive food color when dried. Additionally, this technology is employed to aid in the extraction of bioactive compounds by leveraging the formation of porous structures (Paciulli et al., 2022).

Several studies have applied microwave for drying various materials. For example, the drying of tomato (Hussein et al., 2024; Suksaeree; Chankana; Monton, 2022), apple slices using microwave (Sharabiani et al., 2021) and extracting phenolic compounds from turban leaves (Izza; Tristantini, 2021). Drying of substances against antioxidant compound extracted from leaves of the turban (Coileus amboinicus L.) using microwave for a long time of 4 minutes (Izza; Tristantini, 2021). Furthermore, drying aloe vera with microwave oven (Agustian & Ruriani, 2024). These applications show the advantages of using microwave on a variety of foodstuffs, indicating its potential for drying coffee leaves such as kawa daun tea.

Previous study on the processing of coffee leaves into kawa daun uses the method of heating by fire. Consequently, this study explored the potential of processing using microwave with the title "Effect of Microwave Treatment on Production, Chemical Components, and Antioxidant Properties of Kawa Daun from Robusta Coffee (*Coffea canephora*)". Consequently, this study aimed to determine the impact of microwave drying time on the characteristics of coffee leaves, kawa daun tea, and drinking water, as well as the optimal time of drying of robusta leaves.

2 MATERIAL AND METHODS

2.1 Materials and Tools

The materials used in this study included robusta coffee leaves (*Coffea cannephora*) from the Subarang Tangah area, Jorong Balai Ahad, Nagari Lubuk Basung, Kabupaten Agam. Chemicals used were folin-ciocalteu reagents (Merck), Na_2CO_3 (Merck), aquades, simplisia, leaves tea extracts, water extract, methanol (Merck), DPPH reagents, chlorophorus, gallic acid, calcium carbonate ($CaCO_3$) (Merck) and ethanol (Merck). Furthermore, the instruments included microwave (750 watts, 220V AC/50 Hz, Medium, low), filing paper, scales, containers, reaction tubes, vortex laboratory shaker, drip pipettes, spectrophotometers UV VIS (1800 Shimadzu), vacuum rotary evaporators (Buchi R-100), glass cups, corongs, splinters, erlenmeyer, aluminum cup, oven (Memmert) , desiccator pyrex, cloves, dried cloves, as well as aluminum foil, and DPPH obtained from the laboratory.

2.2 Methods

This study consisted of 5 treatments, focusing on different durations of drying robusta coffee leaves using microwave at 2, 4, 6, 8, and 10 minutes, with three repetitions. The robusta coffee leaves (*Coffea cannephora*) obtained were cleaned by washing with running water and prepared for further processing. Further washing was carried out using running water, leaves were sliced, and placed in microwave according to the timing. Subsequently, leaves were dried in an open bear to ensure uniform dimensions. The size reduction was achieved using a blender for grinding the spices, followed by filtration. The drinking powder used was selected based on particles that passed through a 20-mesh sieve. Injection of leaves was conducted using water and coffee leaves simultaneously until boiling with the ratio of ingredients (grams) and water (mL) at 1: 100. In this study, the observations were made on fresh coffee leaves, kawa daun tea, and drinking water, including water content, yield, total water-soluble substances, total soluble solids, caffeine levels, total polyphenols, and antioxidant activity.

3 RESULT

Analysis that was carried out on coffee leaves, brown leaves tea, and decoction water included water content, degradation, total water-soluble material, and total soluble solidity, as shown in Table 1. Water content is the amount of water present in a commodity. The process of microwave drying is carried out to reduce the water content of the material to enhance durability. Furthermore, it minimizes the level of water to the limits of the organism development and stops the activity of the enzymes causing (Fontana, 2020).

The test analysis of the grape prints at the level of 5% showed no noticeable difference due to the drying of coffee leaves by microwave. This showed that caffeine levels did not suffer damage during breathing using microwave to the time of drying 10 minutes, as shown in Table 2. Based on the results, the average value of caffeine content contained in coffee leaves were 0.63.

Flavonoids can also be distinguished into flavonols, flavons, turkeys, isoflavones, flavanols, and flavanones according to their structure. Non-flavonoids include phenolic acids, tannins, astragalus lignin, and others (Di Lorenzo et al., 2021). Moreover, polyphenols are antioxidant compounds found in fruits, vegetables, and drinks, inhibiting oxidation reactions and repelling free radicals (Di Lorenzo et al., 2021; Yang et al., 2023). These compounds play a significant role as antioxidant

Table 1: Observation of Coffee Leaves, Kawa Daun Tea, and Drinking Water.

Parameter	Coffee Leaves	Kawa Daun Tea	Drinking Water
Water Content	65.39%	A = 4.33% B = 4.31% C = 4.11% D = 3.48% E = 3.28%	-
Yield	-	A = 35.99% B = 35.66% C = 35.27% D = 32.05% E = 30.49%	
Water-Soluble Material	1.66%	A = 5.78% B = 4.67% C = 4.61% D = 3.90% E = 3.65%	-
Soluble Solidity	-	-	A = 1.87% B = 1.92% C = 1.97% D = 2.02% E = 2.07%

Description :
A = Duration drying time 2 minutes
B = Duration drying time 4 minutes
C = Duration drying time 6 minutes
D = Duration drying time 8 minutes
E = Duration drying time 10 minutes

Table 2: Caffeine content of Coffee Leaves, Kawa Daun Tea, and Drinking Water.

Chemical Analysis	Coffee Leaves	Kawa Daun Tea	Drinking Water
Caffeine **(%)**	0.6322	A = 0.559%	A = 0.450%
		B = 0.547%	B = 0.445%
		C = 0.540%	C = 0.440%
		D = 0.528%	D = 0.436%
		E = 0.514%	E = 0.432%

and anti-radicals. In this study, the average level of phenol in coffee leaves was 331.7 mgGAE/g. (Table 3). The length of time exposed to coffee leaves by microwave has no significant effect on α = 5% of the total tea leaves polyphenols produced. This showed that the total polyphenols did not suffer damage during breathing using microwave to drying time of 10 minutes.

Based on the prints and further DNMRT tests, it was observed that the time of drying coffee leaves into kawa daun tea had no significant effect at a level α = 5% on antioxidant activity. The difference in the length of time the material was exposed to microwave did not affect antioxidant activity. This showed that the activity of antioxidant did not suffer damage during the drying using microwave for 10 minutes. The average value of antioxidant activity of tea leaves is shown in Table 4. Antioxidant activity of drinking water kawa daun tea found in this study ranged from 83.85% to 88.79%, with the highest value found in treatment A and the lowest in treatment E (Defri; Palupi; Dewi Yuliana, 2021).

Fresh coffee leaves and coffee leaves put into the oven can be seen in Figure 1. Fresh kawa leaves are taken directly from the coffee plantation and processed immediately to avoid damage before treatment. Robusta coffee leaves (Coffea cannephora) obtained from Subarang Tangah, Agam Regency. Plucked old leaves then cleaned by washing using running water and prepared for the next process.

Drying of coffee leaves is done by preparing 4 coffee leaves and then washed thoroughly with running water, drained and then placed in a microwave oven according to the treatment time of 2 minutes, 4 minutes, 6 minutes, 8 minutes, and 10 minutes. The leaves that have been treated are then dried in an open room so that the weight remains. Furthermore, size reduction is carried out with the aim of obtaining a uniform size. The reduction is carried out using a kitchen spice pulverizer that passes a 20 mesh sieve. Ready to be used as kahwa tea leaves as shown in Figure 2.

Figure 3 shows that the optimal time for the drying of coffee leaves into kawa daun tea to produce the drinking water obtained at treatment A was 2 minutes. This conclusion was based on all observations such as fertility, water content, total polyphenols, caffeine levels, total water-soluble substances, and antioxidant activity.

The process of brewing kahwa leaf tea drinks is done by cooking water and coffee leaves together until boiling refers to the ratio of ingredients (grams) and water (mL) which is 1: 100. as for the results of steeping each treatment can be seen in Figure 4.

Table 3: Polyphenols Content of Coffee Leaves, Kawa Daun Tea, and Drinking Water.

Chemical Analysis	Coffee Leaves	Kawa Daun Tea	Drinking Water
Polyphenols	331.7 mgGAE/g	A = 48.56mgGAE/g	A= 18.5mgGAE/g
		B = 46.96mgGAE/g	B= 20.4mgGAE/g
		C = 46.1mgGAE/g	C= 22.7mgGAE/g
		D = 44.26mgGAE/g	D= 26.7mgGAE/g
		E = 41.36mgGAE/g	E= 28.1mgGAE/g

Table 4: Antioxidant content of Coffee Leaves, Kawa Daun Tea, and Drinking Water.

Chemical Analysis	Coffee Leaves	Kawa Daun Tea	Drinking Water
Antioxidant (%)	-	A = 65.43%	A = 88.79%
		B = 63.53%	B = 87.08%
		C = 61.01%	C = 86.61%
		D = 59.64%	D = 84.90%
		E = 57.83%	E = 83.86%

Figure 1: (a) Fresh coffee leaves; (b) Coffee leaves in the oven

Figure 2: Kawa Daun Tea Powder

4 DISCUSSION

4.1 Observations on Coffee Leaves, Kawa Daun Tea, and Drinking Water

The analysis showed that the drying of coffee leaves into kawa daun tea had an unrealistic effect at the level of 5%. The results obtained at each time interval differed with a range of values of 3.28% - 4.33%. Other studies reported varying water content levels for kawa daun tea at 3.6 - 7.6% (Novita et al., 2018), and 3.32 - 4.29% (Defri; Palupi; Dewi Yuliana, 2021). Spefically, a longer drying process for coffee leaves resulted in lower water content production.

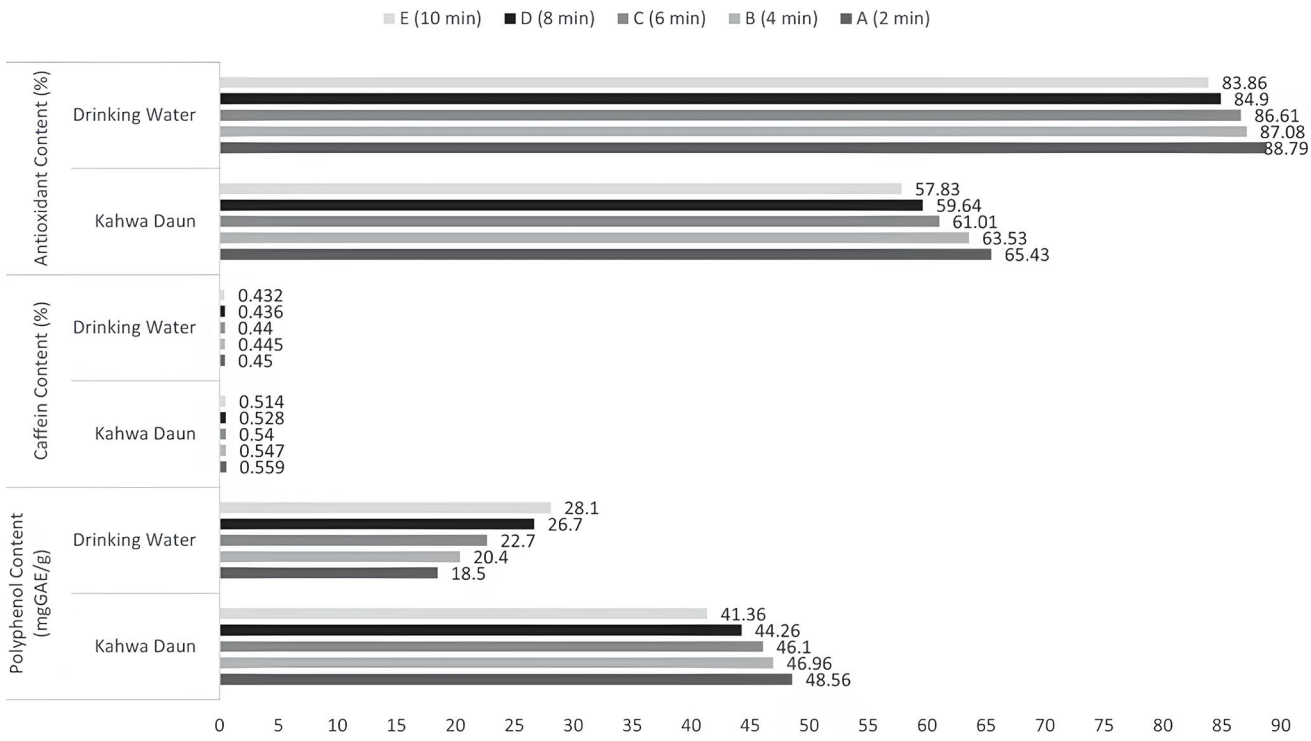

Figure 3: Recapitulation of the Characteristics of Kawa Daun.

Figure 4: (a) Product A ; (b) Product B ; (c) Product C; (d) Product D; (e) Product

Based on the analysis of prints and the DNMRT test (Duncan's New Multiple Range Test), the length of drying coffee leaves into kawa daun tea did not show a significant effect. The results obtained at each time interval ranged from 30.49% to 35.99%, while other studies obtained a yield of 10% - 38% (Novita et al., 2018). This suggested that the yield did not decrease during the breathing using microwave for all treatments. Furthermore, a longer drying time caused an increase in the length of contact with heat, resulting in a greater time of contact and lower yield. This was in line with previous investigations, where the difference between the high and yield of a foodstuff was influenced by the water content in the food substance (Sudarmadji; Dan Suhardi, 1997).

Total water-soluble materials are substances dissolved in water that cannot be filtered using filter paper, such as millipore paper with a porous size of 0.45 µm. These solids contain a variety of particles, including organic, inorganic, or other material, at a diameter < 10-3 µm, present in a solution where the solute dissolves in water (Boyd, 2020) . In this study, the total water-soluble value ranged from 3.65% to 5.78%, with the highest value obtained in treatment A (drying time of 2 minutes), and the lowest in treatment E (10-minute drying time). The total solute value was inversely compared to the water content, which, resulted in lower total water-soluble material of the product. Consequently, the reduction in water content caused the water solute material to increase (Levinsh, 2023). Total dissolved solids (TDS) are soluble solids in the

form of ions, compounds, or colloids in water (Pushpalatha et al., 2022). Furthermore, TDS materials include carbonate, bicarbonate, chloride, sulfate, phosphate, nitrate, calcium, magnesium, sodium, organic-ion, and other ions (Tiwari, 2017). The printing results showed that the average total solid concentration was significantly influenced by the duration of drying time of coffee leaves to produce kawa daun tea. As shown in Table 1, the average value of the total soluble concentration of coffee leaves ranged from 1.87% to 2.07%, with the highest value obtained in treatment E, and the smallest in treatment A.

Chemical components such as soluble solids in coffee leaves include sugar and organic acid (Sen et al., 2025). Heating is a crucial factor needed in the dissolution process to increase the total solute density (Buckle et al., 2010).

4.2 Effect of Microwave Usage on Chemical Components and Antioxidant

4.2.1 Properties Caffeine

Caffeine is a compound of alkaloids, non-alcoholic stimulant compounds resulting from the metabolism of coffee plants. This compound is characterized by a bitter taste, which acts as a medicine and relieves pain (Wijayanti; Anggia, 2020). Furthermore, it is an alkaloid compound naturally found in coffee seeds that acts as a refresher and mood booster (Esquivel ; Jiménez, 2012). Coffee leaves infusions are rich in antioxidant phenolic compounds and have a lower concentration of caffeine (Cangeloni et al., 2022). Coffee leaves tea has attracted researchers to utilize the pruning waste as a refreshing functional drink due to its phenolic compounds and other antioxidants, additionally, tannins play a role in providing astringency, a key sensory characteristic of tea (Legowo et al., 2021).

The level of caffeine found in all treatments was lower than in brown-leaves tea powder. As shown in Table 2, it was observed that a longer drying time resulted in lower caffeine levels. This occurred because the source of caffeine originated from the tea powder of coffee leaves. Based on the results, kawa daun adhered to the SNI standards (Indonesian National Standard), with caffeine content within a maximum of 2% (SNI 01-3542-2004) specified for coffee powder.

4.2.2 Polyphenols

Polyphenols are the main functional component in plants that are often hindered in the bioavailability and bioactivity of polyphenols due to their typical forms as tannins, anthocyanins, and glycosides (Yang et al., 2023). Polyphenols have been shown to have antioxidant effects, which are beneficial to the heart and can protect against oxidative stress that is directly correlated with degenerative diseases, diabetes mellitus, and cancer (Alnsour et al., 2022).Furthermore, polyphenols are mainly divided into flavonoids and non-flavonoids.

The processing methods on the phytochemicals, enzymes, bioactivities, and flavor of coffee leaves are highly needed (Chen, 2019). Based on coffee leaves print analysis, the drying time with microwaved did not significantly affect the total polyphenols of tea leather leaves at the level of 5%. As shown in Table 3, the total polyphenols of water-leaves tea leaves ranged from 18.52 to 28.15 mg GAE/g. This showed that the longer drying of coffee leaves into tea led to a decrease in the total polyphenols of water content. The analysis of the raw material showed that the highest drying time for the total polyphenols content was 28.15 mg GAE/ g. This showed that shorter drying time yielded higher polyphenols in the sewage water produced. Furthermore, drying at temperature or long time caused some polyphenols to break down. This occurs because in dry conditions, all the components present in the cell, including organelles and membranes merge, leading to difficulty in the extraction process (Zhang et al., 2022). Compared to fresh coffee leaves, the level of polyphenols in tea leaves and caffeine decreased after treatment due to the presence of drying and irrigation found in coffee leaves . Long warming times can also cause a significant decrease (Antony ; Farid, 2022) , including a reduction in the size of coffee leaves (Parwiyanti et al., 2023).

4.2.3 Antioxidant

Kawa daun tea is rich in flavonoids, alkaloids, saponins, and polyphenols. The phenolic compounds found in coffee leaves exhibit antioxidant properties, making them effective in neutralizing free radicals (Defri; Palupi; Dewi Yuliana, 2021). One of the characteristics of phenol is its antioxidant ability, which occur when in a combined state. Antioxidant is substances capable of delaying or preventing oxidative damage to the inhibition of oxidation reactions (Defri et al., 2022). Consumption of enough antioxidant can lower the risk of degenerative diseases such as cardiovascular, atherosclerosis, cancer, and osteoporosis. Furthermore, antioxidant can boost immunity and inhibit diseases causing aging (Khadim ; Al-Fartusie, 2021).

Based on a comparison with 57.83% - 65.43%, antioxidant level of kawa daun tea was higher at 83.86%-88.79%. The interaction between the material and the heat given during injection caused the extraction of the bioactive compound to take place perfectly. Previous study reported obtained similar results, showing that a temperature of 95°C with a 15-minute infusion produced the highest antioxidant activity. In this study, the maximum IC50 of kawa daun tea obtained at a temperature of 95°C with a length of extraction of 20 minutes showed a trend of continuous improvement during the trial period (Balci; Özdemir, 2016). Antioxidant activity increased with higher temperatures, thereby

increasing the heat energy supplied, which resulted in greater compound extraction. A previous investigation stated that antioxidant activity of green tea followed an increasing trend as the extraction time increased from 5 to 15 minutes (Chatterjee et al., 2016).

Several studies suggested that longer drying resulted in decreased antioxidant activity of tea leaves due to the inability to resist the heating process (Roslan et al., 2020). The process of drying causes a decrease in the active substance contained in a food ingredient. This phenomenon led to a reduction in antioxidant activity due to the enzymatic oxidation process that caused polyphenols to be oxidized and declined (Gebicki; Nauser, 2021). Consequently, the size of the given temperature corresponded to the capacity limits of the material. This is because high temperatures will also damage the active components of the compound. Previous investigations showed that various drying methods on dolomites caused a reduction in all bioactive components. Based on the results, it was discovered that among all the methods tested, the best was microwave. In conclusion, microwave drying has the promising potential to increase the drying rate, retain the color, increase the spill density, and lower oil absorption.

4.2.4 Characteristics of Kawa Daun Tea and Drinking Water

The results obtained were presented in the form of a histogram, illustrating the impact of microwave drying on coffee leaves, kawa daun tea, and water. The characteristics of brown-leaves tea and dried water produced by microwave drying yielded varied results. Leaves treatment with two, four, six, eight, and 10 minutes of drying produced total polyphenols ranging from 41.36 mgGAE/g to 48.56 mgGAe/g. This showed that a longer drying process resulted in decreased total polyphenols in the sewage water. Furthermore, at the level of caffeine, a longer drying process reduced caffeine levels. Regarding antioxidant levels, the length of the drying process resulted in lower levels of antioxidant in coffee tea leaves, compared to antioxidant in water. This phenomenon occurred because the size of the particles in the water was smaller than tea leaves. Consequently, as the surface area increases, the extraction capacity also improves (Malrianti et al., 2021). The result of a recapitulation of the characteristics of kawa daun is presented in Figure 3.

5 CONCLUSIONS

This study showed that the use of microwave on drying coffee leaves did not damage chemical components and antioxidant. The difference in the length of drying time affected the total water-soluble material. However, there was no significant effect on fertilization, water content, total polyphenols, caffeine, and antioxidant activity. The optimal length of time that can be used for drying coffee leaves into kawa daun tea using a microwave was obtained in treatment A, with an exposure time of 2 minutes.

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7 AUTHORS' CONTRIBUTION

Conceptual Idea: Arief, R.G.N; Malrianti, Y.; Kasim, A; Neswati; Methodology design: Arief, R.G.N; Kasim, A.; Malrianti, Y.; Data collection: Arief, R.G.N.; Data analysis and interpretation: Malrianti, Y., Sujatmiko,; and Writing and editing: Malrianti, Y.; Kasim, A., Sujatmiko.

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