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Effects of Soaking Time and Peppermint Oil Concentration on Chemical, Sensory, and Antibacterial Characteristics of Robusta Coffee (*Coffea canephora*)

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ABSTRACT

The increase in public coffee consumption is influenced by lifestyle, technological support and the emergence of various choices of coffee. Herbal coffee is generally made by adding herbal powder, infusion, and drying. Soaking techniques with peppermint oil to make herbal coffee have never been studied. The purpose of this study was to determine the effect of robusta coffee treated with soaking time and peppermint oil concentration on chemical characteristics, sensory and antimicrobial activity. Randomized Complete Group Design method with two factors was performed in this study. The first factor is soaking time (L) which consists of 0 (L0), 5 (L1), and 10 (L2) min. The second factor was peppermint oil concentration consisting of 0% (K0); 0.5% (K1); and 0.75% (K2). The results showed that the soaking time and concentration of peppermint oil can increase the water content and pH. The peppermint coffee showed antimicrobial activity against Salmonella typhi *and* Eschericia coli *bacteria with an inhibition diameter of 8.72-13.16 mm and 9.88-12.24 mm, respectively. The peppermint coffee of L1K1 treatment (5 min soaking time; 0.5% peppermint concentration), is preferred by panelists with sensory test scores on taste (6.15), aroma (7.09), aftertaste (5.32), and overall (6.16).*

1. INTRODUCTION

The coffee plant originates from the Abyssinia region in Africa, including Eritrea and Ethiopia, and has proliferated across plantations in Indonesia such as Sulawesi, Timor, Bali, Sumatra, and other islands. The popular types of coffee among Indonesian society are Arabica coffee (*Coffea arabica* L.) and Robusta coffee (*Coffea canephora*) (Afriliana, 2018). According to the Directorate General of Estates, coffee production in Indonesia from 2019 to 2022 increases from 752,511 to 793,193 tons (Ditjenbun, 2022). Lampung Province is the second-largest coffee producer with a production quantity of 122,053 tons in 2022. Robusta coffee production in Indonesia accounts for approximately 81% of the total production, with the remainder being Arabica coffee. Besides Robusta and Arabica, other types of coffee such as Excelsa and Liberika coffee (*Coffea liberica*) are also well-known among the community. Coffee is a beverage derived from the processing of coffee beans, which is known as one of the most widely consumed non-alcoholic beverages worldwide due to its attractive taste and health benefits (Bizzo *et al*., 2015). Brewed coffee has health benefits due to its content of bioactive compounds such as caffeine, chlorogenic acid and its derivatives, lactones, and trigonelline, which possess antioxidant properties (Anh-Dao *et al*., 2022).

Coffee consumption among the public tends to increase, influenced by lifestyle and technological support to obtain things more easily. According to the Global Agricultural Information Network, domestic coffee consumption in 2022 increased by 7% compared to the previous year, reaching 11.35 million bags @60 kg (GAIN, 2021). With the emergence of various coffee varieties, more people are interested in consuming them. Today, the consumer frenzy for coffee beverages is not only about their functional aspects but also about their healing effects.

Herbal coffee is a type of coffee beverage infused with herbs and spices (Febrianto *et al*., 2015). The combination of herbal ingredients can result in coffee with unique flavors, aromas, quality, and health benefits, making it safe for consumption. Herbs provide specific aromas to cater individual preferences with refreshing and warming effects typical of spices. One herbal ingredient commonly added to coffee is peppermint, or *Mentha piperita* L. Peppermint is an aromatic herb often used medicinally and as a spice in food and beverages, imparting a strong peppery flavor obtained from peppermint leaf extraction and possessing carminative properties (Fialová *et al*., 2015). Peppermint leaf extract contains compounds such as menthol, menthone, 1-8-cineole, neomenthol, carvone, and limonene (Sobti *et al*., 2023). Mint plants are aromatic herbal plants that produce essential oils known as peppermint oil. Menthol and menthone compounds found in peppermint essential oil exhibit antimicrobial activity, along with phenolic compounds, tannins, flavonoids, triterpenoids, and menthofuran, which have the ability to kill bacteria (Hulwah *et al*., 2022).

Essential oils are volatile aromatic components in liquid form. Essential oils are widely used as fixatives in fragrance, perfume, pharmaceuticals, cosmetics, and flavoring agents, commonly applied in the food and beverage industry, although their use is still relatively rare (BBKK, 2018). The common techniques for making herbal coffee involve adding herbal powders, infusions, and drying methods, as seen in studies by Lestari *et al*., (2021) and Rahmayulis & Mulyani (2023). However, the soaking technique for making herbal coffee has not been studied thus far. The soaking a peppermint oil solution in water as an enrichment technique aims to reduce the loss of antioxidant compounds and to add bioactive compounds from peppermint oil. Based on the aforementioned background, it is necessary to develop enriched coffee with peppermint oil to produce peppermint coffee as a form of diversified coffee product with a new flavor profile (mint) expected to have superior antimicrobial properties and health benefits

2. MATERIALS AND METHODS

2.1. Design of Experiment

This research used a two-factorial Complete Randomized Block Design with 6 replications. The first factor was the soaking time (L) and the second factor was the essential oil concentration (K). Coffee was soaked at peppermint concentrations of 0%, 0.5% and 0.75% with soaking times of 0 minutes, 5 minutes and 10 minutes. The obtained data were analyzed using the IBM SPSS Statistics version 25 program. The chemical data were analyzed using the ANOVA parametric test at a confidence level of 95% to determine the effect of treatment on water content and pH, then continued with the Duncan Multiple Range Test (DMRT) to determine the differences between samples.

2.2. Measurement and Analysis

2.2.1. Water Content

The water content of peppermint coffee was determined using the gravimetric method. An empty porcelain cup was placed in an oven at a temperature of 100-105°C for an hour and then cooled in a desiccator to reach room temperature, and its constant weight was measured. About 10 g of peppermint coffee beans were weighed and placed into the cup, and their weight was recorded. Then, the sample was dried in a controlled-temperature oven at 105°C for 16 h. Afterward, the sample was cooled in a desiccator for 15 min, and its constant weight was measured (the difference in weight between successive sample weighing should not exceed 0.02 g). The calculation was performed using the following equation (SNI 01-2907-2008).

$$\frac{(W_1-W_2)}{(W_1-W_0)} \times 100\% \quad (1)$$

where W_0 is the weight of the empty cup (g), W_1 is initial weight of the cup + coffee before drying (g), and W_2 is the weight of the cup + coffee after drying (g)

2.2.2. pH (Power of Hydrogen)

The pH testing of peppermint coffee was conducted based on the method of (Apriyantono *et al*., 1989; Wibowo *et al*., 2014). The pH meter was standardized using standard pH 4 and pH 7 buffer solutions. The measurement was carried out by rinsing the electrode with distilled water and drying it with tissue paper. The sample was poured into a 100 ml beaker, then the electrode was immersed until submerged in the sample solution and left for approximately one minute until a stable reading, and then the value was recorded.

2.2.3. Analysis of Bacterial Inhibition using Disc Diffusion Method

Bacterial inhibition starts with the preparation of Muller Hinton Agar (MHA) media and the preparation of bacterial suspensions. A solution containing cultures of *E. coli* and *S. typhi* bacteria was taken in 0.5 ml and placed into a petri dish containing Muller Hinton Agar (MHA) media, then spread evenly. Subsequently, empty paper discs were dipped into brewed coffee because they will test the inhibitory effect of brewed coffee on *E. coli* and *S. typhi*. The paper discs containing brewed coffee were placed in the MHA and incubated at 35°C for 24 hours. After 24 hours, the diameter of the inhibition zones that occur was measured (Poelongan *et al*., 2006; Nurhayati *et al*., 2020).

3. RESULTS AND DISCUSSION

3.1. Moisture Content

The analysis of variance results indicated that the duration of soaking and the concentration of peppermint oil significantly affect the water content of peppermint coffee. The further test results with Duncan's test on the water content of peppermint coffee can be seen in Table 1. Water content is one of the physical properties of a substance that indicates the amount of water present in the material (Agustina *et al*., 2019). The lowest water content in mint coffee produced was found in the L0K0 treatment, which was 1.92%, and the highest was in the L2K2 treatment, which was 13.88%. Based on the ANOVA results, a significance value of 0.000 was obtained, indicating that the soaking duration and peppermint oil concentration have a significant effect on the water content. The Duncan test further revealed that the water content in treatments L0K0, L1K1, L1K2, L2K1, and L2K2 significantly differed from each other. This discrepancy could be due to the absence of peppermint oil soaking treatment in L0K0, resulting in no increase in water content. Meanwhile, there was no significant difference between treatments L1K1 and L1K2. According to Table 2, as the soaking time and peppermint oil concentration increase, the water content also increases. This was because longer soaking times allow more water to enter the material, leading to an increase in water content. According to Pratiwi *et al*., (2013), soaking materials could cause water to penetrate into the material, resulting in a diffusion process. This diffusion process was characterized by an increase in material weight and a decrease in the amount of soaking water.

Table 1. Results of water content analysis of peppermint coffee

Treatment	Moisture Content (%)
L0K0 (without soaking)	$1,92 \pm 0,12^{a}$
L1K1 (soaking duration of 5 minutes & peppermint oil concentration of 0.5%)	$11,89 \pm 0,39^{b}$
L1K2 (soaking duration of 5 minutes & peppermint oil concentration of 0.75%)	$12,15 \pm 0,71^{b}$
L2K1 (soaking duration of 10 minutes & peppermint oil concentration of 0.5%)	$13,07 \pm 0,71^{c}$
L2K2 (soaking duration of 10 minutes & peppermint oil concentration of 0.75%)	$13,88 \pm 0,52^{d}$

Note: Numbers with different letters indicate significantly differences according to the DMRT at a 95% confidence level.

3.2. pH (Power of Hydrogen)

The analysis of variance results indicated that the soaking duration and concentration of peppermint oil significantly affect the pH of peppermint coffee. The further analysis with Duncan's test on the pH of peppermint coffee can be seen in Table 2. The suitability of coffee for consumption can be determined through its acidity level or pH. The ANOVA test results showed that the soaking duration and concentration of peppermint essential oil significantly affected the pH value of peppermint coffee, hence the continuation with Duncan's test. The highest pH value of mint coffee was found in

treatment L2K2 at 6.13, while the lowest was in treatment L0K0 at 5.80. According to the Duncan test results, treatments L2K1 and L2K2 do not significantly differ, but they differ significantly from treatments L0K0, L1K1, and L1K2. Table 3 showed that as the concentration and soaking duration of peppermint oil increased, the pH value also increased, although not significantly. Coffee beans contain carboxylic acids such as acetic acid, lactic acid, formic acid, oxalic acid, quinic acid, malic acid, and citric acid. These acids are transformed into phosphoric acid, malic acid, acetic acid, and citric acid during the coffee roasting process, contributing to the formation of acidic flavors in coffee. The pH value of coffee beans was also influenced by factors such as the location or growing conditions of the plants, roasting temperature, type of roaster, and brewing method (Aditya *et al*., 2016).

Table 2. Results of pH analysis of peppermint coffee

Treatment	pH
L0K0	5,80 ± 0,090[a]
L1K1	5,91 ± 0,022[b]
L2K1	5,97 ± 0,022[c]
L1K2	6,07 ± 0,023[d]
L2K2	6,13 ± 0,019[d]

Note: Numbers with different letters indicate significantly differences according to the DMRT at a 95% confidence level.

Research on the effect of peppermint extract on the pH of food or beverages was still limited. Most studies have focused on adding mint extract to mouthwash, gargle preparations, toothpaste, medicines, etc. Therefore, there were few references regarding the effect of mint extract on the pH change of food or beverages. Based on previous studies, such as the research by Meylia & Rimbyastuti (2014), the increase in coffee pH with the addition of peppermint extract was believed to be due to the presence of menthol oil in peppermint, which created a spicy and fresh cooling sensation, thus stimulating taste receptors that may affect the pH of coffee to increase.

3.3. Inhibition Activity using Disc Diffusion Method

The evaluated result was the diameter of the inhibition zone measured using a ruler in millimeters (mm). The results of the antibacterial activity testing of peppermint coffee were expressed in inhibition zone diameters (mm) and can be seen in Figure 1. The inhibition diameter of coffee with peppermint oil soaking against *Escherichia coli* ranged from 9.88 to 12.24 mm, while against *Salmonella typhi*, it ranged from 8.72 to 13.16 mm. Based on the research results, peppermint coffee has the ability to inhibit the growth of bacteria, *Escherichia coli*, and *Salmonella typhi*. This inhibitory effect is evidenced by the clear zones on Muller Hinton Agar (MHA) containing *Escherichia coli* and *Salmonella typhi* bacteria

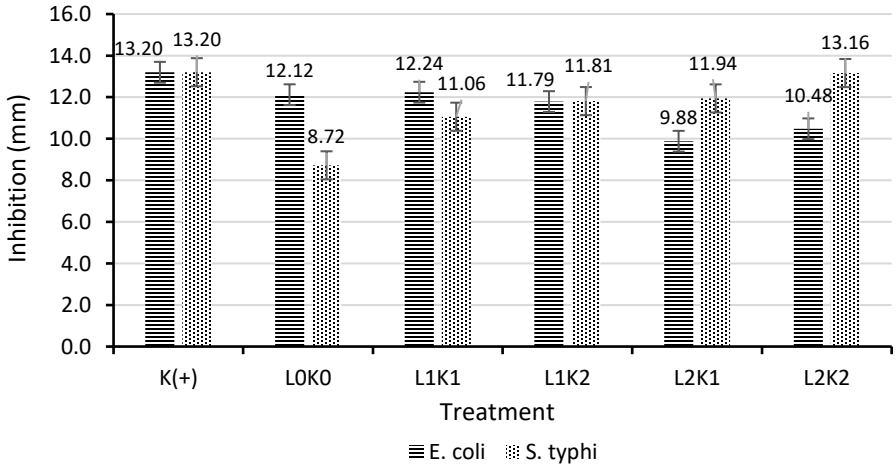

Figure 1. Bacterial inhibition zones of various coffee treatments against *E. coli* and *S. typhi*

that have been treated with peppermint coffee extract with different soaking durations and concentrations. From the research results, it was known that coffee with peppermint oil soaking treatment may inhibit the growth of *Salmonella typhi* and *Escherichia coli* bacteria. According to (Fayed, 2019; Widyastuti *et al*., 2019), all parts of *Mentha piperita* L plant was able to inhibit the growth of pathogenic bacteria. Mint leaf extract has antioxidant and antibacterial activities against both gram-positive and gram-negative bacteria (Singh *et al*., 2015).

An inhibition zone diameter >20 mm is categorized as very strong inhibition response, a zone diameter of 11–20 mm falls into the category of strong inhibition response, a zone diameter of 5–10 mm falls into the category of moderate inhibition response, and a zone diameter <5 mm falls into the weak inhibition category (Zeniusa *et al*., 2019). In treatment L0K0, the inhibition zone diameter against *Salmonella typhi* is 8.72 mm; for L1K1, it was 11.06 mm; for L1K2, it is 11.81 mm; for L2K1, it was11.94 mm; and for L2K2, it was 13.16 mm. Higher concentrations result in increased average inhibition zone diameter. When viewed in terms of inhibiting bacterial growth response, treatments L1K1, L1K2, L2K1, and L2K2 were classified as strong responses in inhibiting the growth of *Salmonella typhi*. Meanwhile, treatment L0K0 (coffee without soaking) fell into the category of moderate inhibition response in inhibiting the growth of *Salmonella typhi*. According to Singh *et al*., (2015), the essential oil of M. piperita has minimum inhibitory concentration (MIC) against pathogenic bacteria such as *Staphylococcus aureus, Streptococcus pyogenes*, *Escherichia coli*, *Klebsiella pneumonia*, ranging from 0.4% to 0.7% v/v. Based on the research by Hasibuan & Dalimunthe (2022), mint leaf powder or extract contained secondary metabolite chemical compounds such as alkaloids, saponins, tannins, flavonoids, steroids/triterpenoids, and glycosides which act as antibacterial agents. This is supported by the research by Sofidiana *et al*., (2022), which also suggested that the main active components contained in peppermint with antibacterial properties include tannins, steroids, flavonoids, saponins, and terpenoids.

There are 3 mechanisms of action of flavonoids, namely by inhibiting energy metabolism, inhibiting cell membrane function, and inhibiting nucleic acid synthesis. The ability of tannins as antibacterial agents lies in their ability to pass through the cell membrane. This is because tannins can precipitate on proteins. Tannins can also suppress the amount of glucosyltransferase enzyme. The mechanism of steroids as antibacterials is related to lipid membranes and sensitivity to steroid components that cause leakage in lysosomes. Steroids can interact with the phospholipid membrane of cells, which is permeable to lipophilic compounds, thereby causing a decrease in membrane integrity and a change in cell membrane morphology, making the cells fragile and prone to lysis. The mechanism of terpenoids as antibacterial agents is to react with transmembrane proteins on the outer membrane of bacterial cells and form strong polymer bonds, resulting in damage to transmembrane proteins. The damage to these proteins can reduce the permeability of the bacterial cell wall, leading to a lack of nutrients in the bacterial cell, thereby inhibiting bacterial growth or causing cell death. Saponins can increase the permeability of bacterial cell membranes, thereby altering the structure and function of the membrane, causing denaturation of membrane proteins, resulting in membrane damage and lysis. The role of these active components can suppress the growth of *E. coli* and *S. typhi*.

The diameter of the inhibition zone of *Escherichia coli* for bacterial inhibition mechanisms varies. In treatment L0K0, the diameter of the inhibition zone of *Escherichia coli* was 12.12 mm; L1K1 was 12.24 mm; L1K2 was 11.79 mm; L2K1 was 9.88 mm; and L2K2 was 10.48 mm. *Escherichia coli* and *S. thypi* bacteria belong to the group of gram-negative bacteria. *E. coli* bacteria are resistant to several antibacterial compounds due to having three layers of cell walls, making it difficult for some antibacterial compounds to damage the tissue of *E. coli* bacterial cell walls. The cell wall structure of *E. coli* bacteria is more complex compared to gram-positive bacteria. There are three polymers contained in the cell wall of gram-negative bacteria, namely the outer layer of lipoprotein, the middle layer of lipopolysaccharide, and the inner layer of peptidoglycan, and an outer membrane in the form of a bilayer (which has better resistance to compounds entering or leaving the cell, causing toxic effects) (Septiani *et al*., 2017). In treatment L0K0, there is strong inhibition against *Escherichia coli* bacteria. This is because coffee beans contain antibacterial and antioxidant compounds. Caffeine compounds in coffee beans act as antioxidants to neutralize free radicals and protect immune cells from long-term damage. Additionally, caffeine found in coffee beans is a xanthine alkaloid compound that functions as an antibacterial. Alkaloid compounds can inhibit cell wall synthesis, leading to cell lysis and subsequent cell death. Other compounds in coffee beans that can act as antibacterials are chlorogenic acid and phenol. These compounds can enter bacterial cells and disrupt their cell wall structure (Widyasari *et al*., 2021). Phenol compounds are flavonoids in coffee beans. The mechanism of flavonoids in inhibiting bacteria is by damaging bacterial cell walls

through the difference in polarity between DNA-composing lipids and alcohol groups in flavonoid compounds, causing cell wall damage and allowing antibacterial compounds to enter the bacterial cell nucleus (Tanauma *et al*., 2016).

Based on the research results, peppermint coffee in various treatments has the ability to inhibit the growth of both *E. coli* and S. thypi bacteria, but with different outcomes, and some are not consistent, such as in treatment L0K0 in inhibiting *E. coli* bacteria, which is greater compared to other treatments. This is due to several factors that can affect the diameter of the bacterial inhibition zone in different samples. According to Sumarno (2000) and Zeniusa *et al*., (2019), one of these factors is the incubation temperature. To obtain optimal growth, incubation is done at a temperature of 35ºC. If the temperature used is above 35ºC, it can result in a smaller diameter of the inhibition zone. This may occur when the plates are stacked more than 2 plates during incubation. Incubation at temperatures above 35ºC can lead to poor extract diffusion. Additionally, the diameter of the inhibition zone produced is influenced by the speed of diffusion, bacterial growth rate, the number of inoculated organisms, and the concentration of chemicals. According to Rahmadeni *et al*., (2019), the size of the inhibition zone is not always proportional to the antibacterial concentration. This is likely due to differences in the diffusion rate of antibacterial compounds in agar media, as well as differences in the concentration and types of antibacterial compounds in each sample, which esult in different inhibition zone diameters.

3.4. Sensory

The Friedman analysis results indicate that the duration of immersion and the concentration of peppermint oil affect the sensory attributes (taste, aroma, aftertaste, and overall) of peppermint coffee. The follow-up test results with the Wilcoxon test can be seen in Table 3.

Table 3. Results of Sensory Analysis of Peppermint Coffee.

Sample	Analysis			
	Taste	Aroma	Aftertaste	Overall
L0K0	7,15 ± 1,40^{a}	6,40 ± 1,63^{a}	5,53 ± 1,67^{bc}	7,08 ± 1,22^{a}
L1K1	6,15 ± 1,57^{b}	7,09 ± 1,46^{b}	5,32 ± 1,42^{b}	6,16 ± 1,43^{b}
L1K2	5,29 ± 1,73^{cde}	5,67 ± 1,46^{d}	5,13 ± 1,44^{b}	5,41 ± 1,52^{d}
L2K1	5,53 ± 1,50^{d}	6,16 ± 1,53^{cd}	5,87 ± 1,57^{bc}	6,04 ± 1,47^{bc}
L2K2	5,07 ± 1,52^{e}	4,85 ± 1,82^{e}	4,96 ± 1,49^{ab}	4,89 ± 1,44^{e}
P	0,000	0,000	0,001	0,000

Note: Significance (P) value <0.05 indicates a significant difference in the Friedman test
Different letters in the columns indicate significant differences according to the Wilcoxon test
Sensory values range from 1 to 9 (1= extremely dislike; 2= very dislike; 3= dislike; 4= slightly dislike; 5= neutral (average); 6= slightly like; 7= like; 8= very like; 9= extremely like)

3.4.1. Taste

Taste, an essential attribute in sensory analysis, can influence consumer acceptance of food or beverages. Based on the Friedman test results, both soaking duration and peppermint oil concentration affect the taste of coffee. The Wilcoxon post-hoc test indicates significant differences between treatments: L0K0 differs significantly from L1K1, L1K2, L2K1, and L2K2. Treatment L1K1 differs significantly from L0K0, L1K2, L2K1, and L2K2. Treatment L1K2 significantly differs from L0K0 and L1K1 but not significantly from L2K1 and L2K2. Treatment L2K1 differs significantly from L0K0, L1K1, and L2K2 but not significantly from L1K2. Treatment L2K2 differs significantly from L0K0, L1K1, and L2K1 but not significantly from L1K2. In terms of taste attribute, differences in taste among the coffee treatments are evident. Coffee without peppermint oil soaking (L0K0) scores the highest at 7.15, while coffee with 0.75% peppermint oil concentration and 10 minutes soaking duration (L2K2) scores the lowest at 5.07. The second-highest score is for coffee with 0.50% peppermint oil concentration and 5 minutes soaking duration (L1K1) at 6.15, followed by L2K1 at 5.17 and L1K2 at 5.53. The highest taste score is for coffee treated with peppermint oil soaking, specifically L1K1 (5 minutes soaking and 0.5% concentration). According to the panelists, the coffee from treatment L1K1 has a balanced minty flavor. This is supported by research (Sucianti *et al*., 2021) indicating that non-bitter taste in herbal mint leaf tea is due to the presence of menthol in peppermint, resulting in a fresh (minty) taste. The addition of peppermint creates freshness and a distinctive minty flavor when brewed due to the menthol content in peppermint (Anggraini *et al*., 2014).

3.4.2. Aroma

Another important attribute in sensory testing is aroma. The aroma of a food or beverage product is crucial in determining consumer acceptance of the product. Additionally, aroma plays a significant role in determining the palatability of a food product, which consists of three components: taste, smell, and mouthfeel stimulation (Arsyad & Hulinggi, 2019). The menthol content in peppermint, which is an aromatic compound with a sharp smell and is volatile or easily evaporates. According to Ghassani's research (2009) cited in Anggraini *et al*., 2014, the aroma of peppermint effectively enhances short-term memory performance in panelists.

Based on the Friedman analysis, the peppermint oil soaking treatment with different durations and concentrations showed significant differences in the aroma of coffee. The subsequent Wilcoxon test showed that the L0K0 treatment significantly differed from the L1K1, L1K2, L2K1, and L2K2 treatments. The L1K1 treatment significantly differed from the L0K0, L1K2, L2K1, and L2K2 treatments. The L1K2 treatment significantly differed from the L0K0, L1K1, and L2K2 treatments but not significantly from the L2K1 treatment. In the L2K1 treatment, there was a significant difference from the L0K0, L1K1, and L2K2 treatments but not significantly from the L1K2 treatment. The L2K2 treatment significantly differed from the L0K0, L1K1, L1K2, and L2K1 treatments.

This is likely because the addition of peppermint oil affects the level of liking for the aroma of coffee. In terms of aroma attributes, differences can be observed in the aroma of each coffee treatment. Coffee with a soaking duration of 5 minutes and peppermint oil concentration of 0.5% (L1K1) had the highest score, at 7.09. On the other hand, coffee with a soaking duration of 10 minutes and peppermint oil concentration of 0.75% (L2K2) had the lowest score, at 4.85. The second-highest score was for coffee without peppermint oil treatment (L0K0), at 6.40, followed by L2K1 at 6.16 and L1K2 at 5.67. Panelists preferred the aroma of coffee treated with L1K1 (soaking duration of 5 minutes & concentration of 0.5%). This preference is due to the pleasant aroma or scent of mint leaves. The soaking of peppermint oil results in aroma-forming compounds in coffee, primarily consisting of essential oils that are volatile and easily reduced, thus producing a fragrant aroma in coffee (Wilanda *et al*., 2021).

3.4.3. Aftertaste

Aftertaste is the positive taste quality or impression that remains (taste and aroma) at the back of the mouth and persists after the coffee is removed from the mouth or swallowed (Saleh *et al*., 2020). Based on the Friedman analysis, the treatment of peppermint oil immersion with different durations and concentrations significantly affects the coffee's aftertaste. The Wilcoxon test results indicate that treatments L0K0, L1K1, L1K2, and L2K1 do not differ significantly, but there is a significant difference in treatment L2K2. Treatment L2K1 significantly differs from treatment L2K2. In terms of the aftertaste attribute, differences in aftertaste can be observed in each coffee treatment. Coffee with 10 minutes of immersion and 0.5% concentration has the highest score, which is 5.87. Meanwhile, coffee with 10 minutes of immersion and 0.75% concentration of peppermint oil (L2K2) has the lowest score, which is 4.96. The second-highest score is coffee without peppermint oil treatment (L0K0) at 5.53, followed by L1K1 at 5.32 and L1K2 at 5.13. According to the research findings, coffee with 10 minutes of immersion and 0.5% concentration (L2K1) is most preferred by the panelists. This is presumably due to the minty taste in the coffee. The immersion of peppermint oil in coffee aims to reduce the bitterness and acidity present in coffee and to provide a distinctive minty flavor after consumption. This flavor emerges from the menthol content in mint leaves (Hartati *et al*., 2022).

3.4.4. Overall

The assessment of the overall attribute in peppermint coffee encompasses all aspects including aroma, taste, and aftertaste. In Table 6, it can be observed that the most preferred coffee treatment is L0K0 (coffee without peppermint oil immersion) with a score of 7.08, while the least preferred coffee treatment is L2K2 (coffee with 10 minutes of peppermint oil immersion and 0.75% concentration). The second-highest score is for coffee treatment L1K1 at 6.16, followed by L2K1 at 6.04, and L1K2 at 5.41. Based on the Friedman analysis, it is evident that the duration of immersion and concentration of peppermint oil significantly affect the overall attribute of the coffee. The Wilcoxon test results indicate that treatment L0K0 significantly differs from treatments L1K1, L1K2, L2K1, and L2K2. Treatment L1K1 significantly differs from treatments L0K0, L1K2, and L2K2, but not from treatment L2K1. Treatment L1K2

significantly differs from treatments L0K0, L1K1, L2K1, and L2K2. Treatment L2K1 significantly differs from treatments L0K0, L1K2, and L2K2, but not from treatment L1K1. Treatment L2K2 significantly differs from treatments L0K0, L1K1, L1K2, and L2K1.

4. CONCLUSION

The conclusions obtained from this research are as follows:

1. The treatment of soaking duration and concentration of peppermint oil can increase the moisture content from 1.91% to 13.87% and can increase the pH value from 5.66 to 6.12.
2. The mint-flavored coffee preferred by the panelists is found in treatment L1K1 (soaking duration of 5 minutes; concentration of 0.5%), with sensory test scores for taste (6.15), aroma (7.09), aftertaste (5.32), and overall liking (6.16).
3. Coffee treated with peppermint oil soaking and concentration has activity against *Salmonella typhi* and *Escherichia coli*, with inhibition zone diameters ranging from 8.72 to 13.16 mm and 9.88 to 12.24 mm, respectively.

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