

Free radical scavenging activity-based antioxidant analysis and infrared spectroscopy of peppermint-flavored coffee drink

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Received in August 5, 2024 and approved in November 22, 2024

ABSTRACT

Peppermint essential oil conserve as a healthy flavoring additive to coffee drinks and provide health benefits by enhancing their antioxidant activity. Hence, this study aimed to examine the antioxidant activity of peppermint-flavored coffee drinks using 2,2-diphenyl-1-picrylhydrazyl (DPPH) and 2,2'-azino-bis-(3-ethylenebenzothiazoline)-6-sulfonic acid (ABTS) free radical scavenging assays. Furthermore, Fourier transform infrared-attenuated total reflectance spectroscopy was performed to investigate the profile of compounds contributing to the antioxidant property. The experiments were conducted using a Complete Randomized Block Design with six replications. Two-factor treatments were as follows: soaking time (S), 0 (S0), 5 (S1), and 10 (S2) min; peppermint essential oil concentration (E), 0 (E0), 0.5 (E1), and 0.75% (E2) (v/v). Notably, both DPPH and ABTS assays revealed increased antioxidant activity of peppermint-flavored coffee drink where the coffee was soaked for 10 min in 0.75% peppermint solution. The coffee soaked for 10 min in 0.5% and 0.75% peppermint solutions showed a high scavenging effect against ABTS free radical, with 93.73 and 94.30% inhibition activity and half-maximal inhibitory concentrations of 0.272 and 0.267 ppm, respectively. Additionally, a new peak was observed at 1640 cm⁻¹ in peppermint solution-soaked coffee beans, which corresponded to the C=C functional group in the limonene spectrum, an antioxidant compound in peppermint. Altogether, the findings show that peppermint essential oil enhanced the antioxidant activity of the coffee.

Key words: ABTS; antioxidant; DPPH; FTIR-ATR; peppermint-flavored coffee.

1 INTRODUCTION

Coffee, derived from processed coffee beans, is a non-alcoholic drink with an attractive taste and health benefits. It is widely consumed and a source of foreign exchange in Indonesia (Latunra et al., 2021). Indonesia is the fifth-largest coffee-consuming country, with 5 million bags of 60 kg, attributing to approximately 15% (5–6% increase per year) based on the International Coffee Organization in 2020–2021. The antioxidant compounds in coffee, such as caffeine and chlorogenic acid, generate a pleasant taste and aroma, along with providing health benefits. The caffeine content in Robusta coffee (182 mg/100g) is the highest compared with that in Arabia (2.2 mg/g or 154 mg/100 g) and Liberica coffee (1.6 mg/g) (Caracosta; Sirbu; Busuricu, 2021), with the 2,2-diphenyl-1-picrylhydrazyl (DPPH) free radical scavenging activity of 77.99, 75.05 and 77.75%, respectively (Mubarak et al., 2019; Tarigan et al., 2023; Yitayal; Tilahun, 2015). However, high caffeine content may cause discomfort for people who are susceptible to caffeine, suggesting the exploration of herbal coffee as an alternative. The herbal coffee includes herbs that can enhance the taste and provide health benefits with less caffeine. For instance, ginger-mixed Liberica coffee and galangal–Robusta coffee mixed with sugar have been reported to contain lower caffeine and chlorogenic acid contents than those in the original versions (Destryana et al., 2021). Many spices, including galangal, ginger, cloves, ginseng, cinnamon, and cardamom, are commonly added to coffee, and a mixture of

these may produce quality coffee with distinctive taste, aroma, and health benefits. For example, cinnamon has been reported to improve the antioxidative activity and sensorial appeal of Liberian coffee. Brewing ground Robusta coffee with encapsulated cardamom essential oil provides a distinctive taste and aroma of cardamom and enhances antioxidant activity (76.32% DPPH free radical inhibition activity) (Kustyawati; Sugiharto; Rini, 2022). The herbal coffee market presents great potential owing to its rich aroma and taste, which increases the appeal to coffee drinkers.

One of the traditional ways of preparing coffee drinks is by mixing the coffee bean powder in hot water, along with sugar, milk, or creamer, in which additional ingredients such as peppermint are not typically added. Peppermint is extracted from the leaves of or the entire peppermint plant (*Mentha piperita* L), an aromatic herb with a peppery taste and curative effects, which is commonly used as a spice and traditional medicine (Fialová et al., 2019). The peppermint extract contains menthol, menthone, 1-8-cineole, neomenthol, carvone, and limonene (Gutierrez; Barry-Ryan; Bourke, 2008), which, along with producing taste, contribute to antioxidant and antimicrobial effects (Kapp et al., 2013). Peppermint is used as a binder (fixative) in manufacturing perfumes, fragrances, cosmetics, pharmaceuticals, and the food and beverage industry; however, its use as a flavoring agent in food and beverages is limited. Reportedly, soaking Robusta coffee beans in peppermint water solution for 5–10 min increased the water content of the beans from 1.91 to 11.87%

and the pH from 5.66 to 6.12 in the peppermint-flavored coffee drink (Thaliarinanta et al., 2024). The drink presented acceptable sensory characteristics to the panelists with taste, aroma, after-taste, and an overall score of 6.15, 7.09, 5.32, and 6.16, respectively, on the hedonic scale ranging from 1 to 9. Additionally, it exhibited antimicrobial activity against *Escherichia coli* and *Salmonella typhi*. Because both peppermint and coffee beans contain flavonoids with antioxidative functions, this study aimed to assess the antioxidant activity of peppermint-added coffee drinks and determine the profile of associated chemical compounds. The antioxidant properties of peppermint-flavored coffee drinks were assessed based on the 2,2'-azino-bis(3-ethylenebenzothiazoline)-6-sulfonic acid (ABTS) and DPPH free radical scavenging activity. Additionally, the chemical profiles of the peppermint-added coffee fraction at various concentrations were analyzed based on functional groups present in the resulting compounds by Fourier transform infrared (FTIR)-attenuated total reflectance (ATR) spectroscopy.

2 MATERIAL AND METHODS

2.1 Materials

Well-roasted coffee beans (225°C for 10 min) were obtained from local farmers. Food-grade peppermint oil, DPPH (CAS 1898-66-4, Sigma Aldrich CHEMIE GmbH, USA), ABTS (CAS 30931-67-0, Sigma Aldrich, USA), potassium persulphate ($K_2S_2O_8$), ascorbic acid, distilled water, and ethanol. The following tools were used: measuring cups, Erlenmeyer and other glass equipment, volume pipettes, grinders, ovens, incubators, desiccators, ultraviolet (UV)-visible spectrophotometer, and Cary 630 type FTIR spectroscopy instrument.

2.2 Research methods

This study was conducted using a laboratory experimental setup of a Randomized Complete Block Design with six replications. The soaking time (S) and peppermint essential oil concentrations (E) were considered the treatment factors. Coffee was soaked in peppermint solution at 0% (E0), 0.5% (E1), and 0.75% (E2), with soaking times of 0 (S0), 5 (S1), and 10 (S2) min. The following solutions were analyzed: S0E0, unsoaked coffee beans; S1E1, coffee soaked for 5 min in 0.5% peppermint solution; S1E2, coffee soaked for 5 min in 0.75% peppermint solution; S2E1, coffee soaked for 10 min in 0.5% peppermint solution; and S2E2, coffee soaked for 10 min in 0.75% peppermint solution. The data obtained were analyzed using Statistical Package for the Social Sciences (SPSS; version 20, IBM), with the one-way analysis of variance at a confidence level of 95%, followed by the new Duncan multiple range test. Normality and homogeneity tests

were performed to determine if the data were normal and homogeneous, respectively.

2.3 Making peppermint-flavored coffee

To prepare the peppermint-flavored coffee, coffee beans were soaked in a peppermint solution with different concentrations and soaking durations. After soaking, the beans were drained and air-dried for 10–20 min. Finally, peppermint-flavored coffee beans were stored in a container at refrigerated temperature until further analysis.

2.4 DPPH free radical scavenging assay

The assay was performed as described by Brand-William et al. (1995) and Shimamura et al. (2014). First, 0.0078 g of DPPH was weighed and dissolved in 100 mL of 96% ethanol in the dark. Next, the absorbance at 517 nm was measured using 5 mL of 0.02 mM DPPH solution and labeled as blank absorbance. Following this, 1 mL of the extract solution being tested was pipetted and added with 2 mL of DPPH solution. The mixture was incubated at 37°C for 30 min, and its absorbance was measured at 517 nm using a UV spectrophotometer, labeled as sample absorbance. Ascorbic acid was used as the standard, and all the measurements were performed in triplicates. Finally, the sample and blank absorbances were compared to obtain the percentage of antioxidant activity. The DPPH free radical scavenging activity in each sample solution was calculated using the formula by Brand-Williams et al. (1995).

$$\text{Scavenging activity (\%)} = ([A_k - A_s]/A_k) \times 100$$

where A_k and A_s are the absorbances of the blank and sample solutions, respectively.

2.4.1 Determination of the half-maximal inhibitory concentration (IC_{50}) for DPPH scavenging

The capture of DPPH radicals by the antioxidant compound in the sample solution was quantitatively analyzed by spectrophotometry at 517 nm. The absorbance values denoting free radical capture activity were used to define the IC_{50} value, the concentration of the antioxidant compound that can capture 50% of DPPH free radicals. The IC_{50} value was determined using a curve between the sample concentration (x-axis) and antioxidant activity (y-axis), which denoted a straight-line equation. The IC_{50} value (ppm) was obtained by entering the 50% antioxidant activity value in the straight-line equation obtained.

2.4.2 Preparation of the standard curve solution and sample analyses

A 1,000 ppm standard stock solution was prepared by dissolving 5 mg of ascorbic acid in 5 mL of 96% ethanol. Next,

10, 20, 30, 40, and 50 μL of the stock solution were placed into different test tubes and added with 1 mL of 0.2 mM DPPH solution; 96% ethanol was added to make up the reaction volume of 10 mL. After 30-min incubation in the dark, the samples were transferred into a cuvette and their absorbance was measured at 517 nm.

The coffee extract was prepared by dissolving 1 g of sample in 10 mL of 96% ethanol for 24 h at room temperature. Next, the sample solution was filtered using filter paper, and 5, 10, 15, 20, and 25 μL of the extracts were pipetted and placed into individual test tubes. The test tubes were added with 1 mL of 0.2 mM DPPH solution, and the reaction volume was made up to 10 mL with 96% ethanol. After 30-min in the dark, the samples were transferred into a cuvette, and their absorbance was measured at 517 nm. Meanwhile, the control solution was prepared by adding methanol to 1 mL of 0.2 mM DPPH solution until the reaction volume reached 10 mL.

2.5 ABTS free radical scavenging assay

ABTS assay was performed as previously described by Gill et al. (1999). The assay determines the antioxidant capacity of compounds based on the ABTS radical cation scavenging results denoted by the absorbance at 734 nm. First, a 7 mM ABTS solution was prepared by adding 0.38 g ABTS in 100 mL of 96% ethanol in the dark to achieve an absorbance of 0.706 at 734 nm. The ABTS solution was mixed with 2.45 mM $\text{K}_2\text{S}_2\text{O}_8$ solution at a ratio of 1:1, followed by 16-h incubation in the dark at room temperature. To measure the antioxidant activity, the absorbance of 3 mL of ABTS solution was measured at 734 nm for 5 min, 1-min after placing the solution in the cuvette, which was labeled as the control absorption. To measure the antioxidant activity of the sample, 100 μL of the extract solution was pipetted and added with 3 mL of ABTS solution. After 30-min incubation in the dark at room temperature, the absorbance was measured at 734 nm, which was labeled as the sample absorbance. Finally, the percentage of antioxidant activity was calculated using the sample and control absorbances. The measurements were performed in triplicates. Ascorbic acid was used as the standard. The percent of scavenging activity of the tested samples was calculated using the following formula (Brand-Williams et al., 1995):

$$\text{Scavenging activity (\%)} = ([A_k - A_s]/A_k) \times 100$$

where A_k and A_s denote the control and sample absorbances, respectively.

2.5.1 Determination of IC_{50} for ABTS scavenging

The chelation of ABTS radicals by the antioxidant compound was quantitatively analyzed by spectrophotometry at 734 nm, and the IC_{50} value for ABTS free radical scavenging activity was determined. IC_{50} value denoted the concentration of the antioxidant compound that chelated 50% of ABTS

radicals. It was determined using a curve between the sample concentration (x-axis) and antioxidant activity (y-axis), which was denoted by a straight-line equation. The IC_{50} (ppm) value was obtained by entering the 50% antioxidant activity in the straight-line equation obtained. In the modified method, 1 mL ABTS presented an absorbance of 0.706 ± 0.001 at 734 nm, which was added to peppermint–coffee extracts (75, 150, 225, 300, and 325 μL) and antioxidant standard (vitamin C) (Simatupang et al., 2023).

2.6 FTIR analysis

The chemical profile analysis was performed referred to the method described by Bazenet et al. (2021) using an FTIR-ATR spectrophotometer (Nicolet iS 10, Thermo Scientific, USA) equipped with deuterated triglycine sulfate detector. The analyses were performed at $27 \pm 2^\circ\text{C}$ and under a dry atmosphere. The sample powder (1.0 g) was inserted into a ring-shaped mold until it was evenly distributed, and it was pressed using a hydraulic press. After removing from the mold, the sample was inserted into the FTIR spectrophotometer. The spectrum results were obtained from the average of three readings and recorded from $400\text{--}4000\text{ cm}^{-1}$ at a resolution of 8 cm^{-1} and 20 scans. The data were exported and analyzed in an Excel file.

3 RESULTS

The antioxidant activity of almost all treatments was higher in ABTS than in DPPH method. In DPPH scavenging activity, S1E1, S2E1, and S2E2 were not significantly different; however, they were significantly different to S0E0. There is a slight increase in DPPH inhibitory power in the range of 84.88 – 87.04% along with increasing soaking time and peppermint concentration of the treatments, while the coffee drink without peppermint (S0E0) was 82.31% (Table 1). In ABTS free radical scavenging effect, soaking time and peppermint oil levels influenced the percent scavenging effect against ABTS free radical. Further analysis using Duncan's test was that S2E1 and S2E2 were not significantly different but were significantly different from the other treatments (Table 1).

4 DISCUSSION

4.1 Antioxidant activity

Coffee is among the most antioxidant-rich beverages, with a higher antioxidant activity compared with tea or red wine; consequently, its daily consumption greatly contributes to a high antioxidant intake (Yashin et al., 2013). The coffee extract contains high amounts of antioxidant compounds such as total phenols and alkaloid contents, reaching up to 143.8 mg gallic acid equivalent/g extract and 356.90 mg caffeine

equivalent/g extract, respectively (Suryanti et al., 2023). However, as most free chlorogenic acid is broken down during roasting, Maillard reaction products are the major antioxidants in brewed coffee (Liao et al., 2022). The antioxidant activity of roasted coffee has been reported to increase considerably when it is blended with white turmeric, ginger (Gafar; Agustini, 2020), or horse mint leaf powder (Ali, 2023). Herein, soaking coffee beans in the peppermint oil solution markedly increased the antioxidant activity, as shown by DPPH and ABTS free radical scavenging activities (Table 1).

Table 1: Percentage of 2,2-diphenyl-1-picrylhydrazyl and 2,2'-azinobis-(3-ethylenebenzothiazoline)-6-sulfonic acid free radical scavenging activity in peppermint-flavored coffee.

Treatments	Antioxidant activity	
	% DPPH inhibition	% ABTS inhibition
S0E0	82.31 ± 0.096 ^b	91.24 ± 0.02 ^b
S1E1	84.88 ± 0.087 ^{ab}	92.26 ± 0.07 ^{ab}
S1E2	86.62 ± 0.092 ^a	92.64 ± 0.07 ^{ab}
S2E1	85.83 ± 0.09 ^a	93.73 ± 0.01 ^a
S2E2	87.04 ± 0.045 ^a	94.30 ± 0.01 ^a

Numbers labeled with the same letter in a column are not significantly different according to the Duncan Test with a significance level of 5%. S0E0=unsoaked coffee beans, S1E1= coffee soaked for 5 min in 0.5% peppermint solution, S1E2= coffee soaked for 5 min in 0.75% peppermint solution, S2E1= coffee soaked for 10 min in 0.5% peppermint solution, S2E2= coffee soaked for 10 min in 0.75% peppermint solution, DPPH = 2,2-diphenyl-1-picrylhydrazyl, ABTS = 2,2'-azinobis-(3-ethylenebenzothiazoline)-6-sulfonic acid.

The peppermint-flavored coffee presented good DPPH and ABTS radical scavenging ability (Table 1). The DPPH free radical scavenging activity of S0E0 reached $82.31 \pm 0.096\%$, which increased significantly for the S1E2 sample; the increase was not significant for the S1E1 sample. The S2E1 and S2E2 samples exhibited a significant increase in the percentage of inhibition by the peppermint-flavored coffee at 85.83 ± 0.090 or 87.04 ± 0.045 , respectively. These results indicate that at low concentrations, the effect of peppermint oil solution on antioxidant activity is observed after the application for a longer soaking time. The ABTS assay was less sensitive in measuring the effect of soaking coffee beans in the peppermint solution (Table 1). The results of the ABTS assay revealed that the antioxidant activity of the coffee significantly increased when it was soaked for 10 min in 0.75% peppermint oil solution. Notably, shorter soaking time and lower peppermint oil concentration did not affect the antioxidant activity of the coffee.

Table 1 indicates that peppermint oil can increase antioxidant activity, possibly because mint leaves contain high levels of antioxidant compounds, such as limonene,

cineole, menthone, menthol, and pulegone. Wilanda et al. (2021) reported that adding 10–40% (w/w) dried mint (*M. piperita* L) leaves markedly increased the antioxidant activity of coffee-skin tea drinks up to 41.42–75.645%. Fischer et al. (2019) reported that *M. piperita* extract exhibited excellent antioxidant activity, enhanced sensory acceptance, and controlled nutritional and antioxidant characteristics in coffee-flavored milk drinks.

Herein, the IC_{50} values denoted the concentrations of the sample solution required to inhibit 50% of DPPH and ABTS free radicals. The lower the IC_{50} value, the greater the antioxidant activity. The IC_{50} value of peppermint-flavored coffee for DPPH (Figure 1) ranged from 1587.68 (S2E2) to 1690.14 ppm (S1E1), and that for S0E0 was 1746.39 ppm, suggesting its low antioxidant properties (Molyneaux, 2004). S1E2 and S2E1 treatments were 1599.79 and 1656.43 ppm respectively. The presence of water-insoluble compounds in coffee, such as caffeine and trigonelline that dissolve in a nonpolar solvent, possibly contribute to reducing DPPH free radical scavenging activity, leading to low antioxidative properties. Notably, adding hot water to the coffee powder while preparing the coffee drinks in this experiment could not extract the antioxidative nonpolar component, resulting in low antioxidant activity in peppermint-flavored coffee drinks. Caffeine and trigonelline are known to have antioxidant properties. Latief et al. (2022) reported a high IC_{50} value of Robusta coffee (8.98 ppm) because of the methanol fraction.

The SPSS analysis of the ABTS free radical scavenging results indicated that soaking time and peppermint oil levels affected the ABTS free radical scavenging activity. Further analysis using Duncan's test (Table 1) revealed that the activity in S2E1 and S2E2 samples exhibited no significant difference with each other but exhibited significant differences with that of other treatments. This indicates that peppermint oil contributed to chelating free radicals, increasing antioxidant activity, and thereby presenting a higher scavenging effect; however, the contribution was not significant, as indicated by the small IC_{50} value (Figure 2). IC_{50} values of S1E1, S1E2, S2E1, and S2E2 samples were 0.350, 0.324, 0.272, and 0.267 ppm, respectively, whereas that of S0E0 (control) was 0.273 ppm. The IC_{50} value for the ABTS assay was smaller compared with that of DPPH, possibly because of the sensitivity of the method. The DPPH assay denotes the ability of an antioxidant compound to donate hydrogen ions (H_3O^+), whereas the ABTS method is based on the ability of a compound to stabilize free radical compounds by donating proton radicals (Munteanu; Apetrei, 2021). The ABTS method measures the antioxidant activity in both hydrophilic and lipophilic systems, whereas the DPPH method can only be used for lipophilic systems. This may contribute to the higher sensitivity of the ABTS assay compared with that of the DPPH assay in this study.

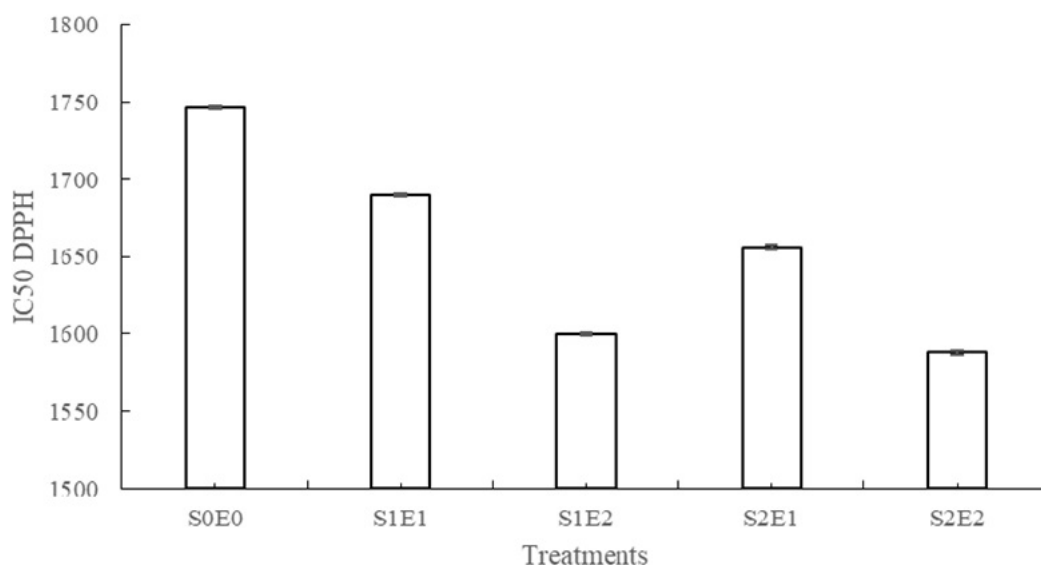


Figure 1: IC₅₀ of peppermint-flavored coffee at different treatments using the DPPH assay.

S0E0 = unsoaked coffee beans, S1E1 = coffee soaked for 5 min in 0.5% peppermint solution, S1E2 = coffee soaked for 5 min in 0.75% peppermint solution, S2E1 = coffee soaked for 10 min in 0.5% peppermint solution, S2E2 = coffee soaked for 10 min in 0.75% peppermint solution, DPPH = 2,2-diphenyl-1-picrylhydrazyl, IC₅₀ = half-maximal inhibitory concentration.

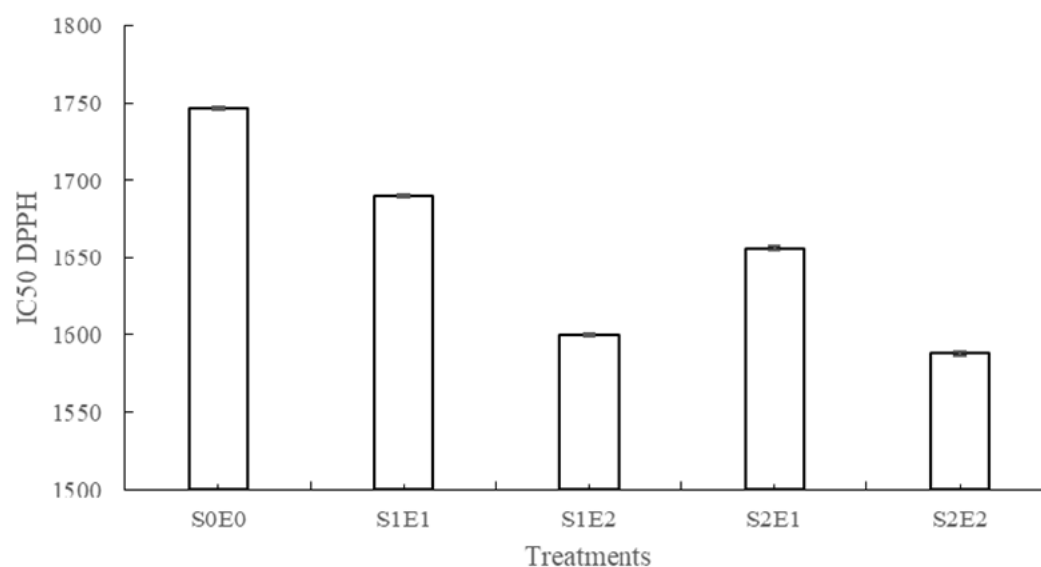


Figure 2: IC₅₀ of peppermint-flavored coffee at different treatments using the ABTS assay.

S0E0 = unsoaked coffee beans, S1E1 = coffee soaked for 5 min in 0.5% peppermint solution, S1E2 = coffee soaked for 5 min in 0.75% peppermint solution, S2E1 = coffee soaked for 10 min in 0.5% peppermint solution, S2E2 = coffee soaked for 10 min in 0.75% peppermint solution, ABTS = 2,2'-azinobis-(3-ethylenebenzothiazoline)-6-sulfonic acid, IC₅₀ = half-maximal inhibitory concentration.

4.2 FTIR spectroscopy of peppermint-flavored coffee drink

The FTIR spectra of peppermint-flavored coffee samples are presented in Figure 3. The similar spectrum patterns indicate the similarity of chemical compounds in the samples (Figure 3). A new peak at wave number 1640 cm⁻¹ was observed in coffee beans soaked with peppermint

solution (Figure 3, blue arrow). The following band is possibly attributed to the stretching vibration of the C=C group or aromatic ring deformations (Barrios-Rodriguez et al., 2022). This band indicated the presence of a characteristic stretching band of C=C (1640 cm⁻¹) in the limonene spectra (Derdar; Belbachir; Harrane, 2019). The soaking of coffee beans with peppermint solution increased the limonene concentration in peppermint-flavored coffee drinks.

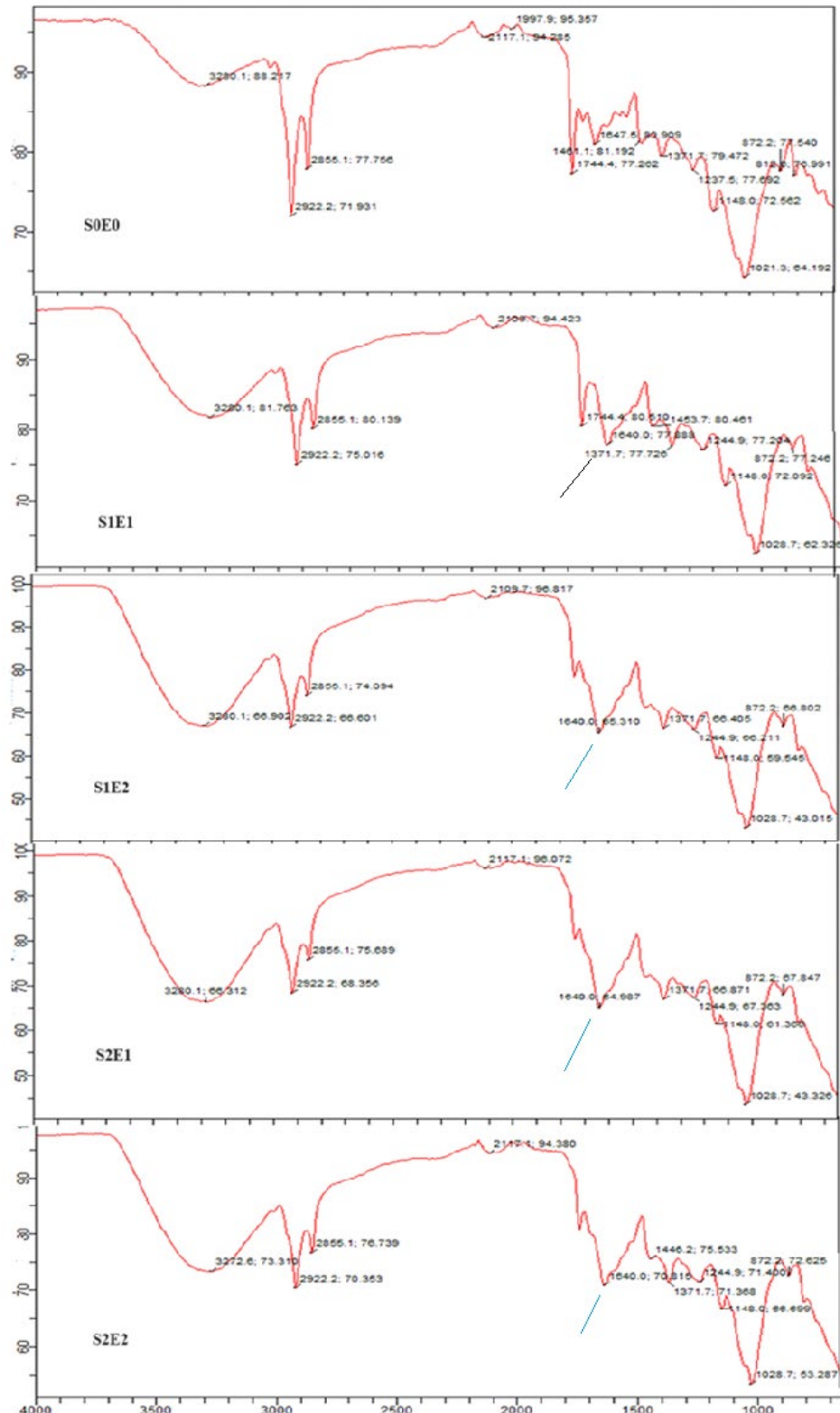


Figure 3: Fourier transform infrared-attenuated total reflectance spectra of ground peppermint-flavored coffee at various treatments.

S0E0 = unsoaked coffee beans, S1E1 = coffee soaked for 5 min in 0.5% peppermint solution, S1E2 = coffee soaked for 5 min in 0.75% peppermint solution, S2E1 = coffee soaked for 10 min in 0.5% peppermint solution, S2E2 = coffee soaked for 10 min in 0.75% peppermint solution.

The FTIR spectra peaks at wave numbers 3272.6–3280.1 cm^{-1} indicated the presence of O-H groups from phenol, carboxylic acid, and alcohol groups. Peaks at wave numbers 2855.1–2922.2 cm^{-1} indicated the presence of O-H and C-H groups, which denoted the presence of alkane and carboxylic acid compounds. Wave numbers 2109.7–2117.1 cm^{-1} indicated the presence of a $\text{C}\equiv\text{C}$ group attached to the alkyne group compound. The wave number 1997.9 cm^{-1} indicated the presence of a C-H group, denoting the presence of an aromatic group. The wave number 1744.4 cm^{-1} indicated the presence of a C=O group, representing the presence of ester compounds and aliphatic acids. Wave numbers 1640–1647.5 cm^{-1} indicated the presence of a $\text{C}=\text{C}$ group bound to alkene group compounds. Wave numbers 1446.2–1461.1 cm^{-1} indicated the presence of the C–C group, denoting the presence of aromatic compounds. The wave number 1371.7 cm^{-1} indicated the presence of an O-H group, denoting the presence of an alcohol compound. Wave numbers 1237.5–1244.9 cm^{-1} indicated the presence of a C–N group, representing aromatic amine compounds. The wave number 1148 cm^{-1} indicated the presence of a C–O group, representing the presence of alcohol, carboxylic acid, ester, and ether compounds. Wave numbers 1021.3–1028 cm^{-1} indicated the presence of a C–N group, representing aliphatic amine compounds. Basically, the middle infrared wave number area (400–4000 cm^{-1}) was divided into the following four main areas: the triple bond area (2000–2500 cm^{-1} ; generally presenting $\text{C}\equiv\text{N}$ and $\text{C}\equiv\text{C}$ bonds); the X-H stretch area (2500–4000 cm^{-1}), comprising O-H, C-H, and N-H bonds; the fingerprint area; and the double bond region (1500–2000 cm^{-1} ; generally presenting C=C, C=O, and C=N absorption bands) (Nawrocka; Lamorska, 2013).

5 CONCLUSIONS

In conclusion, peppermint oil enhances the antioxidant activity of the peppermint-flavored coffee drink. The C=C functional group in the limonene, an antioxidant compound present in peppermint, may contribute to increased antioxidants in peppermint-flavored coffee.

6 AUTHORS' CONTRIBUTION

Conceptual idea: Kustyawati, M.E.; Methodology design: Kustyawati, M.E.; Udayana, S.U.; Data collection: Thaliarinanta, A.S.; Data analysis and interpretation: Kustyawati, M.E.; Udayana, S.U.; Writing and editing: Kustyawati, M.E.; Udayana, S.U.

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