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Liberica coffee enriched with Cinnamon (*Cinnamomum verum*): synergetic study of sensory, antioxidant activity, and chemical components

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ABSTRACT

Innovations in adding spices to coffee are developing and many are being carried out to obtain new aromas and tastes as well as to enrich the properties of coffee so that it becomes a functional drink for the body. One type of spice that has health effects or values is cinnamon. Liberica coffee with cinnamon flavor can be an alternative to coffee-based products with the addition of spices that still maintain the distinctive taste and aroma of coffee. This study aims to studi how effect of liberica coffee combined cinnamon in coffee sensory, chemical compound profiles, and antioxidant activity. The analysis included phenolic content, flavonoid content, antioxidant test, caffeine content, chlorogenic acid content, chemical compound analysis, moisture content, ash content, fat content, protein content, and carbohydrate content. Data were analyzed statistically using one-way analysis of variance (One-way ANOVA) with a 95% confidence level, and to see significant differences between treatments, Duncan's advanced test was used. The results showed that the Liberica coffee herbal combination with cinnamon can increase the final score of the Liberica coffee sensory profile from 77.7 to 81.2 - 84.2. The best ratio of Liberian coffee: cinnamon combination (99:1) with a total score of 8.42 ± 0.085. The addition of Cinnamon increased the total phenolic, flavonoid, and antioxidant activity of Liberica coffee. Apart from that, it adds bioactive compounds to Liberian coffee.

Key words: Liberica coffee; Cinnamon; Spiced coffee.

1 INTRODUCTION

Liberica coffee is a plantation crop that can grow well on peat soils, while other types of coffee (arabica and robusta) cannot grow (Saidi; Suryani, 2021). Liberica coffee has long been cultivated in Jambi, Riau, and South Sumatra Provinces, Indonesia with an agroforestry pattern on peat soils. In contrast to arabica coffee and robusta coffee, liberica coffee has a distinctive jackfruit flavor, which is called jackfruit coffee in some areas (Mawardhi; Setiadi, 2018). Liberica coffee is one of Jambi province's leading commodities known as Libtukom (Liberika Tungkal Komposit). This makes Jambi province the largest producer of liberica coffee in Indonesia and a primary source of livelihood for the local population (Waluyo; Nurlia, 2017). The antioxidant activity of liberica, robusta, and arabica coffee was 77.75% inhibition, 77.99% inhibition, and 75.04% inhibition of DPPH, respectively (Ansori; Zainol; Mohd Zin, 2021). The caffeine content in liberica coffee is lower than in arabica and robusta coffee. The caffeine content in robusta coffee is 2.15%, arabica coffee is 1.77%, and liberica coffee is 1.32% (Ansori; Zainol; Mohd Zin, 2021). Coffee containing high amounts of caffeine can harm health, especially for coffee drinkers susceptible to caffeine. Low-caffeine coffee is very widely produced, which causes the economic value of low-caffeine coffee to be better than coffee with a high caffeine content (Mubarok; Suwasono; Palupi, 2014). Adding spices to coffee drinks is believed to neutralize the caffeine content in coffee. Based on research by Artha, Wulandari and Suhartatik (2020), the caffeine content is very high in coffee without adding spices, namely 29.282 mg/g in the coffee formulation of 100 grams of 0 grams of spice. When condiments were added, the caffeine content was very low, 1.344 mg/g in the 98 grams coffee formulation, 2 grams of spice.

The innovative combination of spices in coffee aims to obtain a new aroma and taste and enrich the properties of coffee so that it becomes a functional drink for the body. The combination of coffee with spices can improve the quality of coffee by increasing chemical compounds and coffee flavors (Sumardi; Rasdiansyah; Abubakar, 2022). Spices that are usually added to coffee are cardamom (Artha; Wulandari; Suhartatik, 2020), cinnamon (Nichmah et al., 2019), ginger (Mardhatilah, 2015), swallow's nest, and black cumin (Sripoo Maheswari; Rajeshkumar, 2022). Spices can also detoxify the body and remove all diseases through urine, feces, and sweat (Mehrandish; Rahimian; Shahriary, 2019). One type of spice that has health effects or values is cinnamon. Cinnamon contains chemical compounds in the form of alkaloids, flavonoids, saponins, and tannins (Gotmare; Tambe, 2019). Based on research by (Antasionasti; Jayanto, 2021), the ethanol extract of cinnamon has a very strong antioxidant activity with an IC_{50} value of 1.939 ± 0.055 µg/ml. Compounds that act as antioxidants in cinnamon include cinnamaldehyde, eugenol, linalool, catechins, coumarins, and tannins. Cinnamon has very strong antioxidant activity, so it has the potential to be used as a food or beverage additive (Antasionasti; Jayanto, 2021; Helmalia; Putrid; Dirpan, 2019; Nichmah et al., 2019).

Nowadays, there are no studies have reported the effect of adding spices to liberica coffee. Previous studies have only focused on combining spices with arabica or robusta coffee. This study explores how adding cinnamon to liberica coffee affects coffee sensory, chemical compound profiles, and antioxidant activity. Generally, combination herbal-coffee can improve the quality, include of liberica coffee as a lifestyle drink and produce herbal coffee products that are healthy and rich in antioxidants. Consuming drinks that contain antioxidants can prevent the oxidation process from avoiding diseases caused by oxidation reactions in the body.

2 MATERIAL AND METHODS

2.1 Samples and Study Area

The sample used was Liberika Coffee obtained from Betara Village, Kuala Tungkal, West Tanjung Jabung Regency, Jambi Province from plants that had a certificate from the Indonesian Coffee and Cocoa Research Institute (ICCRI), Jember, East Java. The herbs used are Cinnamon obtained from PT. Cahaya Gemuruh Cemerlang (CGC), Perikan Tengah Village, Gunung Raya District, Kerinci District, Jambi.

2.2 Chemicals and Instrumentation

Distilled water, methanol P.A, acetone, n-hexane, HCl, Na_2CO_3, $AlCl_3$, sodium acetate, formic acid, acetonitrile, K_2SO_4, $CuSO_4$, concentrated H_2SO_4, NaOH, KI, $Na_2S_2O_3$, standard gallic acid, quercetin standard, caffeine standard, chlorogenic acid standard, ascorbic acid standard, Folin-Ciocelteu reagent, luff schoorl solution, starch indicator, Phenolphthalein indicator and DPPH ((2,2-Diphenyl-1-picrylhydrazyl) (Sigma-Aldrich, Singapura). Analyzes were performed using multiple UV-Vis spectrophotometric (Thermo-Fisher Orion Scientific AQ8100, Waltham, MA, USA, and Gas chromatography–mass spectrometry (GC-MS) (Thermo Fisher Scientific-USA)

2.3 Sample Preparation and Formulation of Spiced Coffee

Liberica green bean coffee was roasted at 203 ºC (medium roast) until slightly dark in color. Furthermore, the cold Liberica coffee beans were ground using a grinder to obtain a coffee powder. Sifted coffee powder and cinnamon powder using a 60mesh sieve to get a fine powder. The ratio of mixing Liberica coffee powder with cinnamon powder is 100:0 (HC1), 99:1 (HC2), 97:3 (HC3), 95:5 (HC4), and 0:100 (HC0).

2.3 Cupping Test

The cupping test was conducted on 8.25 grams of a sample brewed with 150 mL of hot water at 93 ºC. The cupping test refers to the Specialty Coffee Association of America (SCAA) standard with the parameters assessed: aroma, flavor, body, acidity, aftertaste, sweetness, balance, clean cup, uniformity, and overall. The cupping test was carried out by experts with an assessment of each parameter, namely a score of 6.00-6.75 (good), 7.00-7.75 (very good), 8.00-8.75 (excellent), up to 9 .00-10.00 (outstanding). Final score by adding up the scores for each parameter (Isnidayu; Sukartiko; Ainuri, 2020). Sensory analysis was performed by three panelists from Jambi Cupper Team of Robusta and Liberica Coffee. The assessment used was a system developed by SCAA, by giving a score between 1-10 on each variable tested. Score 1 was the lowest score and 10 was the highest score.

2.4 Extraction

A total of 1 g of sample was put into a centrifuge tube with 40 mL of methanol/water (50:50), then HCl was added to obtain a pH of 2 and vortexed for 3 minutes and then centrifuged at 2500 g RCF for 10 minutes. The supernatant was put into the vial (extract result 1). The remaining residue (pellet) was added with 40 mL acetone/water (70:30), vortexed for 3 minutes, and then centrifuged with 2500 g RCF for 10 min. The supernatant was taken and then mixed with the results of the first extraction to obtain a liquid extract (Somporn et al., 2011).

2.5 Determination of Total Phenolic and Flavonoids

Total Phenolic: Liquid extract of 1000 ppm and standard solution of Gallic Acid (GA) with a concentration series of 10, 20, 30, 40, and 50 ppm were taken as much as 1 mL each and then added with 0.4 ml of Folin-Ciocelteu reagent. Then shake and leave for about 4-8 minutes. Then 4 ml of 7% Na_2CO_3 solution was added and made up to 10 mL with distilled water. The mixture was left for 2 hours in a dark place at room temperature, and then its absorbance was measured at a wavelength of 745 nm with a UV-Vis spectrophotometer (Ahmad et al., 2015)

Total Flavonoid Content: Liquid extract of 1000 ppm and standard solution of Quercetin with a concentration series of 10, 20, 30, 40, and 50 ppm were taken as much as 1 mL each, then added with 3 mL of methanol, 0.2 mL of 10% $AlCl_3$ and 0.2 mL of 1 M sodium acetate and made up to 10 mL of distilled water. Afterward, the samples were left for 30 min in a dark place at room temperature (Ahmad et al., 2015). The absorbance was measured on a UV-Vis spectrophotometer with a wavelength of 510 nm (Haile; Kang, 2019).

2.6 Antioxidant Activity Test

50 μM DPPH solution was prepared by dissolving 1.97 mg of DPPH powder in 100 mL of methanol to form a dark

purple solution, prepared a standard solution of ascorbic acid with a concentration series of 10, 30, and 50 and a test solution with a concentration series of 10, 30 and 50 ppm. Pipette 0.2 mL of the standard, test, and negative control solution and then add 3.8 ml of 50 µM DPPH solution. The solution mixture was homogenized and incubated for 30 minutes in a dark place. The absorbance of the mixed solution was measured by UV-Vis spectrophotometry at a wavelength of 517 nm (Selvi; Joseph; Jayaprakasha, 2003). The scavenging activity was expressed as percentage inhibition and calculated using the following Equation 1:

$$\text{DPPH scavenging activity (\%)} = (A_0 - A_1)/A_0 \times 100\% \quad (1)$$

Where A_0 is the absorbance of the control and A_1 is the absorbance of the sample. The IC_{50} values were calculated using linear regression analysis and used to indicate antioxidant capacity.

2.7 Determination of Caffeine and Chlorogenic Acid Content

2.7.1 Caffeine Content

While stirring, the test solution was prepared by adding 1 g of sample to 150 mL of hot distilled water (93 ºC). The sample solution was filtered, the filtrate was put into a separatory funnel, 1.5 g of calcium carbonate ($CaCO_3$) was added, and then extracted by adding 25 mL of chloroform. The bottom layer is taken, then the extract (chloroform phase) is evaporated with a water bath until the chloroform has completely evaporated. The caffeine extract from each solvent-free sample was put into a 100 mL volumetric flask, added with distilled water up to the marked line, and homogenized. Then take 50 mL and add distilled water to a volume of 100 mL. Furthermore, the maximum wavelength measurement was carried out at 200-400 nm using a UV-Vis spectrophotometer. Then the test and standard caffeine solutions with a concentration series of 5, 10, 15, 20, and 25 ppm were measured for absorbance using a UV-Vis spectrophotometer at the maximum wavelength (Arwangga; Asih; Sudiarta, 2016).

2.7.2 Chlorogenic Acid Content

The test solution was prepared by adding 4.8 mL of extract to 25 mL of distilled water. The solution was stirred with a magnetic stirrer for 1 hour, accompanied by heating to 100°C. After the solution cooled, liquid-liquid extraction was carried out using 25 mL dichloromethane to separate the caffeine from chlorogenic acid and then stirred for 10 minutes. The aqueous phase and the dichloromethane phase were separated using a separatory funnel. Water containing chlorogenic acid was collected, and its absorbance was measured. Furthermore, the maximum wavelength measurement was carried out at 200-400 nm using a UV-Vis spectrophotometer. Then the absorbance of the test solution and standard chlorogenic acid solution with concentration series of 10, 20, 30, 40, and 50 ppm were measured using a UV-Vis spectrophotometer at the maximum wavelength (Furqan; Nurman, 2020)

2.8 Volatile Compound

The liquid extract solution was injected into the GC-MS tool as much as 1 µL. The GC-MS system used was with a column flow rate of 1.18 mL/min, with an injection temperature of 80 °C, and held for 2 min. The temperature was increased by 10 °C/minute for 10 minutes until it reached 270 °C. The separation ratio used was 100. The scan mode used in analyzing volatile components is classified as full scan mode, with an ion range of 35 to 500 m/z. The data for each peak of the molecular fragments obtained from GC-MS were compared with the data source in WILEY7. LIB (Nugraha et al., 2020). GC-MS with the following conditions: injector temperature 280 ºC; mode splitless injector; column temperature 40 ºC (10 ºC/minute); retention time 3 minutes (30 ºC/min) to reach the temperature of 299 ºC with total program time of 29,633 min; detector temperature 280 ºC; Helium gas was used as the carrier gas; flow control mode pressure at 4.3367 psi; total of flow 8.4 mL/m; column current 0.9 mL/m; split ratio 5:1, column type Rtx-5MS; and column length 30.00 m (Ifmalinda et al., 2018).

2.9 Proximate Analysis

2.9.1 Determination of Water Content

Put the cup and lid into the oven at 105 ºC for 1 hour. It was then cooled in a desiccator for 20 minutes. After cooling, the empty cup was weighed. Then weigh 2 grams of the sample into the cup and put it in the oven at 105 ºC for 1 hour. It was then cooled in a desiccator for 20 minutes. After cooling, the cup containing the sample was weighed, and the procedure was repeated until the sample weight was constant (SNI, 2014).

$$\%\ Water\ content = \frac{W_1 - W_2}{W_1 - W_0} \times 100\% \quad (2)$$

Where:
W_0: empty cup weight (g)
W_1: weight of cup and sample before drying (g)
W_2: weight of the cup and sample after drying (g)

2.9.2 Determination of Ash Content

Put the sample tested for water content into the furnace at 525 ºC until it becomes white ash. After that, it was cooled in a desiccator for 30 minutes and weighed (SNI, 2014).

$$\%\ Ash\ content = \frac{W_2 - W_0}{W_1 - W_0} \times 100\% \quad (3)$$

Where:
W_0: empty cup weight (gr)
W_1: weight of cup and sample before incineration (gr)
W_2: weight of cup and sample after incineration (gr)

2.9.3 Determination of Protein Content

One gram of the sample is weighed, including 7 grams of K_2SO_4 and 0.8 grams of $CuSO_4$. Then put it in a 100 mL Kjeldahl flask and add H_2SO_4 concentrated to 15 mL. Then the Kjeldahl flask is heated, starting with a small fire. After a while, little by little, the fire is raised so that the temperature rises. Destruction can be stopped when a clear greenish solution is obtained. In the distillation stage, the digestion results obtained were then cooled, after which they were diluted with distilled water up to 100 ml. Add 10 ml of a 30% NaOH solution through the wall of the distillation flask. The distillate flask is installed and connected to the condenser, and the end of the condenser is immersed in the holding liquid. The steam from the boiling liquid will flow through the condenser to the holding Erlenmeyer. The Erlenmeyer container was filled with 10 ml of 0.1 N HCl solution and five drops of PP indicator. In the titration stage, the distillation results collected in an Erlenmeyer are titrated using a 0.1 N NaOH solution. The endpoint of the titration is marked with a colourless solution that turns pink. A blank titration was carried out with the same treatment without a sample (SNI, 2014).

$$\%\ Protein\ content = \frac{(V_1 - V_2) \times N \times 0,014 \times CF \times DF}{W} \times 100\% \quad (4)$$

Where:
W: sample weight (g)
V_1: volume of 0.1 N NaOH used in sample titration (mL)
V_2: volume of 0.1 N NaOH used in the blank titration (mL)
N: normality of NaOH
CF: conversion factor
DF: dilution factor

2.9.4 Determination of Fat Content

A total of five grams of sample was weighed and put into a paper sleeve lined with cotton. Then plug the paper that already contains the sample with cotton. Then the sleeve is inserted into the soxhlet apparatus. Add n-hexane until n-hexane flowed into the flask, then n-hexane until the sample was submerged. Then the soxhlet device is connected to the condenser. The bath temperature is set at 69°C, which is adjusted to the boiling point of n-hexane. Extraction was carried out for ± 12 cycles with a time of ± 6 hours. The extraction result is then distilled to separate the n-hexane from the fat. The fat formed is then baked in the oven at 105 ºC for 1 hour, and the fat flask is cooled in a desiccator for 15 minutes and then weighed (SNI, 2014).

$$\%\ Fat\ content = \frac{W - W_1}{W_2} \times 100\% \quad (5)$$

Where:
W: sample weight (g)
W_1: fat volumetric flask weight before extraction (g)
W_2: fat volumetric flask weight after extraction (g)

2.9.5 Determination of Carbohydrate Content

Weigh the coffee sample to 1 g and input it into Erlenmeyer. Added 50 ml of aquadest and 10 mL of 25% HCl and refluxed for 3 hours at 100 ºC. The solution is then cooled, and then 3 drops of PP indicator are added and neutralized with 20% NaOH (check the pH with a universal indicator). Transfer to a 250 mL volumetric flask, then add distilled water to the mark. Pipette 10 mL of sample solution, add 10 mL of *Luff school,* and reflux for 10 minutes, counting from the start of boiling. It was then cooled in a bath filled with ice. After cooling, 5 ml of 20% KI and 5 mL were slowly added to H_2SO_4 25%. Rapid titration with $Na_2S_2O_3$ 0.1 N until it changes color to straw yellow, then add 3 drops of starch indicator. Continue titration until the blue color disappears. Titration was carried out on a blank with the same treatment without using a sample (the sample solution was replaced with distilled water) (SNI, 2014).

$$V_{tio} : (V_{black} - V_{sample}) \times N_{tio} \times 10 \quad (6)$$

$$\%\ Carbohydrate\ content = \frac{W_1 \times DF}{W} \times 0.90 \times 100\% \quad (7)$$

Where:
V_{tio}: volume of $Na_2S_2O_3$ used (mg)
V_{blanko}: volume of $Na_2S_2O_3$ used during titration on blank (mL)
V_{sampel}: volume of $Na_2S_2O_3$ used when titrating the sample (mL)
N_{tio}: the concentration of $Na_2S_2O_3$
W: sample weight (mg)
W_1: glucose contained for ml $Na_2S_2O_3$(mg)
DF: dilution factor

3 RESULTS

3.1 Sensory Profile

Three trained panelists conducted the sensory testing of spice coffee by cupping test. The taste of coffee is significant, so the panelists will act as a measuring tool, which must be sensitive and consistent. The sensitivity of the panelists includes sensitivity to recognize, sensitivity to differentiate, and sensitivity to compare. The difference in the concentration of cinnamon spices added to liberica coffee has a different effect on the taste assessment given by trained panelists. The results of the cupping test showed that of the four samples with

very good results, namely the original liberica coffee (HC1) sample, which was categorized as a premium coffee group. Excellent results were obtained on the spice coffee samples HC2, HC3, and HC4 (95:5), which were categorized as a specialty coffee group (Table 1).

Table 1: Results of the Sensory Cupping Test Assessment.

Parameter	Sample			
	HC1	HC2 (99:1)	HC3 (97:3)	HC4 (95:5)
Aroma	7.58	7.75	7.75	7.58
Flavor	7.67	7.83	7.67	7.33
Aftertaste	7.67	7.75	7.33	7.25
Acidity	7.77	7.67	7.58	7.25
Body	7.67	7.75	7.50	7.25
Uniformity	8.00	10.00	10.00	10.00
Balance	7.67	7.67	7.50	7.25
Clean Cup	8.00	10.00	10.00	10.00
Sweetness	8.00	10.00	10.00	10.00
Overall	7.67	7.50	7.37	7.25
Total Score	$7.77^{a} \pm 0.085$	$8.42^{c} \pm 0.085$	$8.27^{b} \pm 0.059$	$8.12^{b} \pm 0.126$
Category	Very good	Excellent	Excellent	Excellent
Final Score	77.7	84.2	82.7	81.2

HC1= Original Liberica Coffee, HC2 = Coffee:Cinnamon (99:1); HC3= Coffee:Cinnamon (97:3); HC4 = Coffee:Cinnamon (95:5); Superscripts with different lowercase letters in the same column indicate highly significant differences (P<0.05), SD = Standard Deviation.

Figure 1 shows the advantages of spiced coffee flavor in almost all parameters. Based on the results of the cupping test, the most preferred coffee by the panelists was aimed at HC2 spice coffee, and the lowest result was aimed at original liberica coffee HC1.

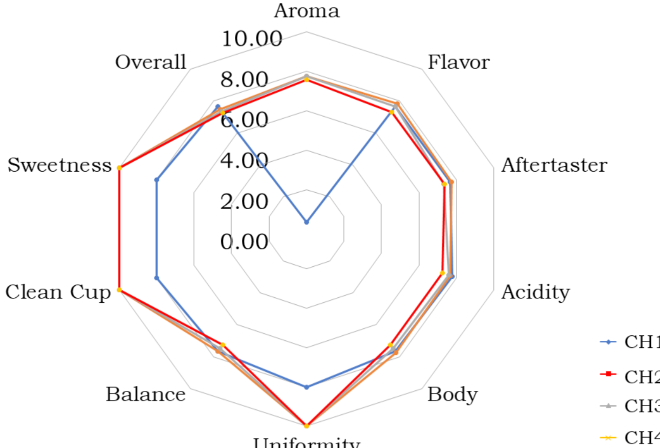

Figure 1: Sensory profile of Original Liberica Coffee with Herbal Additions.

3.2 Total Phenolic and Flavonoids Content

Determining the total phenolic content, the Folin-Ciocalteu method was used with the principle that phenolic compounds are oxidized by the Folin-Ciocalteu reagent to form a blue-colored complex whose absorbance can be measured with a UV-Vis spectrophotometer. The bluer the solution, the higher the absorbance and total phenolic content. The total phenolic content of the original liberica coffee HC1 was 42.271 mgGAE/g, and cinnamon was 102.271 mgGAE/g. While the total phenolic levels of HC3, and HC4 were 47.219 mgGAE/g, 49.927 mgGAE/g, and 53.469 mgGAE/g, respectively. When coffee was added to cinnamon with several ratios, the total phenolic content and cinnamon content increased, due to cinnamon total phenolic content is higher than coffee, adding cinnamon can increase the total phenolic content of the original Liberica coffee (Table 2). Moreover, it shown that the interaction between phenolic compounds in coffee and phenolic compounds in cinnamon is synergistic (Durak et al., 2014; Erskine et al., 2022). Chlorogenic acid is a phenolic compound and is the main component in coffee which acts as an antioxidant. Cinnamaldehyde is cinnamon's main component, which has very strong antioxidants and belongs to the phenylpropanoid group (phenolic derivatives) (Durak et al., 2014). Phenolic compounds have a linear contribution to antioxidant activity, so the higher the total phenolic content, the better the antioxidants. Organic coffee presented a different quantity of polyphenol compounds compared to the conventional one (Górecki; Hallmann, 2020).

Table 2: Result of Total Phenolic Content.

Sample	Total fenolic (mgGAE/g sample)	Total Flavonoids (Average ± SD
HC1	$42.271^{a} \pm 0.037$	$8.430^{a} \pm 0.076$
HC2	$47.219^{b} \pm 0.037$	$10.634^{b} \pm 0.000$
HC3	$49.927^{c} \pm 0.037$	$11.172^{d} \pm 0.000$
HC4	$53.469^{d} \pm 0.037$	$11.548^{e} \pm 0.009$
HC0	$102.271^{e} \pm 0.110$	$11.011^{c} \pm 0.076$

HC0= Cinnamon; HC1 = Original Liberica Coffee; HC2 = Coffee:Cinnamon (99:1); HC3= Coffee:Cinnamon (97:3); HC4 = Coffee:Cinnamon (95:5); Superscripts with different lowercase letters in the same column indicate highly significant differences (P<0.05), SD = Standard Deviation.

The higher the total level of flavonoids in a sample, the darker the yellow color will be. The total flavonoid content of original liberica coffee HC1 was 8.430 mgQE/g, and that of cinnamon HC0 was 11.011 mgQE/g. While the total levels of flavonoids HC2, HC3, and HC4 were 10.634 mgQE/g, 11.172 mgQE/g, and 11.548 mgQE/g respectively. When HC1 was added to HC0 with several ratios, the total flavonoid content and cinnamon content increased. Because the total flavonoid

content of Cinnamon is higher than Coffee, adding cinnamon can increase the total flavonoid content of the original liberica coffee. Flavonoid compounds are one of the plants' most abundant groups of phenolic compounds. Flavonoids are one of the secondary metabolites in plants that function as antioxidants. The value of the total phenolic content obtained was more significant than the total flavonoids due to the high levels of phenolics in the sample were not all flavonoid compounds [32].

3.3 Antioxidant Activity

Antioxidant activity test was carried out using the DPPH (1,1-diphenyl-2-picrylhyd-razyl) method with the principle of the reaction of capturing hydrogen atoms from antioxidant compounds by DPPH which acts as a free radical so that the DPPH radical (1,1-diphenyl-2-picryhydrazyl) which is purple will be reduced to a non-radical compound DPPH-H (1,1-diphenyl-2-picryhydrazin) which is yellow. Ascorbic acid as positive control showed an IC_{50} value of 45.393 ppm, which indicated that to reduce the DPPH concentration by 50%, an ascorbic acid concentration of 43.393 ppm was required. This value indicates that ascorbic acid has intense antioxidant activity because it has an IC_{50} value of less than 50 ppm. The IC_{50} value of original liberica coffee (HC1) is 72.122 ppm, which is included in the category of strong antioxidant activity because it has an IC_{50} value of 50-100 ppm.

In comparison, the IC_{50} value of cinnamon is 6.286 ppm, which is included in the very strong antioxidant activity category. The IC_{50} values of HC2, HC3, and HC4 are 12.449 ppm, 7.072 ppm, and 4.923 p p m, respectively, which are included in the very strong antioxidant activity category (Table 3). When Cinnamon was added to Coffee with several ratios, the antioxidant act i vity increased along with the added cinnamon content. Because the antioxidant activity of Cinnamon is greater than that of Coffee, adding cinnamon can increase the antioxidant activity of the original liberica coffee. This shows that the effect of mixing the two to scavenge free radicals is very strong, and the resulting antioxidant activity is synergistic, where the antioxidant activity of the combination results is greater than tha t of original liberica coffee HC1. Compounds that act as antio x idants in cinnamon include cinnamaldehyde, eugenol, linalool, catechins, coumarins, and tannins (Błaszczyk et al., 2021) In comparison, compounds that act as antioxidants in coffee include chlorogenic acid, caffeic acid, ferulic acid, sinapic acid, and coumaric acid (Erskine et al., 2022)

3.4 Caffeine and Chlorogenic Acid Content

Separation of analytes from coffee is carried out by liquid-liquid extraction method. The principle of liquid-liquid extraction is the difference in the solubility of a compound in two different solvents. When the original liberica coffee was added with cinnamon in several ratios, the caffeine content decreased as the cinnamon content was added (Table 4). Because cinnamon does not contain caffeine, adding cinnamon can reduce the caffeine content of the original liberica coffee. According to provious study (Heckman et al., 2010), caffeine is contained in various types of plants, such as coffee, tea, cocoa, and cola. In addition, previous studies described that computationally there is a strong interaction between phenolic compounds and caffeine in the form of complex interactions (Heckman et al., 2010). The formation of this interaction affects caffeine levels when the original coffee is formulated with cinnamon. The results of the analysis of caffeine content in cinnamon-flavored coffee have met the quality requirements of ground coffee based on SNI 01-3542-2004, where the allowable caffeine content in ground coffee ranges from 0.9-2% and 0.45-2%.

Table 3: Antioxidant Activity.

Sample	IC_{50} (ppm) ± SD	Antioxidant activity
HC4	$4.923^{a} \pm 0.000$	Very Strong
HC3	$7.072^{c} \pm 0.188$	Very Strong
HC2	$12.449^{d} \pm 0.021$	Very Strong
Ascorbic Acid	$45.393^{e} \pm 0.000$	Very Strong
HC0	$6.286^{b} \pm 0.004$	Very Strong
HC1	$72.122^{f} \pm 0.051$	Strong

HC1= Original Liberica Coffee, HC2 = Coffee:Cinnamon (99:1); HC3= Coffee:Cinnamon (97:3); HC4 = Coffee:Cinnamon (95:5); HC0: Cinnamon. Superscripts with different lowercase letters in the same column indicate highly significant differences (P<0.05), SD = Standard Deviation.

Table 4: Results of Caffeine and Chlorogenic Acid Content.

Samples	Average % Caffeine content ± SD	Average % Chlorogenic Acid Content ± SD
HC4	$0.678^{a} \pm 0.004$	$2.785^{a} \pm 0.003$
HC3	$0.736^{b} \pm 0.003$	$2.806^{b} \pm 0.001$
CH2	$0.759^{c} \pm 0.004$	$2.891^{c} \pm 0.001$
HC1	$0.858^{d} \pm 0.001$	$2.984^{d} \pm 0.005$
HC0	$0.000^{d} \pm 0.000$	$0.000^{d} \pm 0.000$

HC1= Original Liberica Coffee, HC2 = Coffee:Cinnamon (99:1); HC3= Coffee:Cinnamon (97:3); HC4 = Coffee:Cinnamon (95:5); HC0: Cinnamon. Superscripts with different lowercase letters in the same column indicate highly significant differences (P<0.05), SD = Standard Deviation.

When the original Liberica coffee was added with Cinnamon, the chlorogenic acid levels decreased along with the added cinnamon levels. Because Cinnamon does not contain chlorogenic acid, adding Cinnamon can reduce the chlorogenic acid levels of the original liberica coffee. Chlorogenic acid can be found in coffee, apples, betel, eggplant, grapes, kiwi, pears, potatoes, tea, tobacco, and tomatoes (Santana-Gálvez et al., 2017).

3.5 Volatile Compound

Compound analysis was carried out to qualitatively and quantitatively determine the content of chemical compounds in liberica coffee, cinnamon, and liberica coffee that had added cinnamon. Based on the results of GC-MS analysis on Liberica coffee, several peaks were detected with varying percentage areas. The high or low peak area (%) indicates the high or low concentration of the identified compounds. The higher the peak, the higher the concentration of the compound. Based on the chromatogram obtained, it can be seen that the highest peak belongs to the compound Dodecanoic acid, 1,2,3-propanetriyl ester ($C_{39}H_{74}O_6$). From the results of the cinnamon chromatogram, 19 peaks were obtained, with the highest peaks belonging to the compound Hexadecanoic acid, 2-[(1-oxododecyl)oxy]-1 ,3-propanediyl ester ($C_{47}H_{90}O_6$) (Table 5). In comparison, the results of the chromatogram of coffee spices obtained 18 peaks, with the highest peaks belonging to the compounds Dodecanoic acid, ethenyl ester (CAS) Vinyl dodecanoate ($C_{14}H_{26}O_2$) (Table 6). Based on the results of the GC-MS analysis, it can be seen that Liberica coffee added with cinnamon will increase the chemical compounds contained in coffee where there is the addition of compounds to coffee spices, Octadecanoic acid, 3-[(1-oxododecyl)oxy]-1,2-propanediyl ester ($C_{51}H_{98}O_6$) which is a compound component belongs to cinnamon (Table 7).

Table 5: Volatile Compounds in Liberica Coffee.

Peak Componds	R. Time (Minute)	Area (%)	Molecular Formula	Compound Name
1	22.307	7.98	$C_{39}H_{74}O_6$	Dodecanoic Acid, 1,2,3-Propanetriyl Ester
			$C_{27}H_{52}O_5$	Dodecanoic Acid, 1-(Hydroxymethyl)-1,2-Ethanediyl Ester
			$C_{57}H_{10}O_6$	Glyceryl Tridodecanoate
2	22.447	30.97	$C_{39}H_{74}O_6$	Dodecanoic Acid, 1,2,3-Propanetriyl Ester
			$C_{27}H_{52}O_5$	Dodecanoic Acid, 1-(Hydroxymethyl)-1,2-Ethanediyl Ester
			$C_{57}H_{10}O_6$	Glyceryl Tridodecanoate
3	22.622	10.30	$C_{39}H_{74}O_6$	Dodecanoic Acid, 1,2,3-Propanetriyl Ester
			$C_{57}H_{10}O_6$	Glyceryl Tridodecanoate
			$C_{49}H_{94}O_6$	Octadecanoic Acid, 2,3-Bis[(1-Oxotetradecyl)Oxy]Propyl Ester
4	22.800	7.16	$C_{39}H_{74}O_6$	Dodecanoic Acid, 1,2,3-Propanetriyl Ester
			$C_{57}H_{10}O_6$	Glyceryl Tridodecanoate
			$C_{35}H_{66}O_6$	2-Lauro-1,3-Didecoin
5	22.875	5.79	$C_{39}H_{74}O_6$	Dodecanoic Acid, 1,2,3-Propanetriyl Ester
			$C_{57}H_{10}O_6$	Glyceryl Tridodecanoate
			$C_{27}H_{52}O_5$	Dodecanoic Acid, 1-(Hydroxymethyl)-1,2-Ethanediyl Ester
6	22.945	9.84	$C_{39}H_{74}O_6$	Dodecanoic Acid, 1,2,3-Propanetriyl Ester
			$C_{57}H_{10}O_6$	Glyceryl Tridodecanoate
			$C_{35}H_{66}O_6$	2-Lauro-1,3-Didecoin
7	23.091	15.82	$C_{39}H_{74}O_6$	Dodecanoic Acid, 1,2,3-Propanetriyl Ester
			$C_{57}H_{10}O_6$	Glyceryl Tridodecanoate
			$C_{26}H_{48}F_3NO_2$	Dodecanamide, N-Dodecyl-N-(Trifluoroacetyl)
8	23.152	8.41	$C_{39}H_{74}O_6$	Dodecanoic Acid, 1,2,3-Propanetriyl Ester
			$C_{57}H_{10}O_6$	Glyceryl Tridodecanoate
			$C_{26}H_{48}F_3NO_2$	Dodecanamide, N-Dodecyl-N-(Trifluoroacetyl)
9	23.285	2.35	$C_{39}H_{74}O_6$	Dodecanoic Acid, 1,2,3-Propanetriyl Ester
			$C_{47}H_{90}O_6$	Hexadecanoic Acid, 2-[(1-Oxododecyl)Oxy]-1,3-Propanediyl Ester
			$C_{55}H_{106}O_6$	Eicosanoic Acid, 2-[(1-Oxohexadecyl)Oxy]-1-[[(1-Oxohexadecyl) Oxy]Methyl]Ethyl Ester
10	23.444	1.03	$C_{35}H_{66}O_6$	2-Lauro-1,3-Didecoin
			$C_{14}H_{26}O_2$	Dodecanoic Acid, Ethenyl Ester
			$C_{17}H_{36}$	Tetradecane, 2,6,10-Trimethyl
11	23.545	0.35	$C_{39}H_{74}O_6$	Dodecanoic Acid, 1,2,3-Propanetriyl Ester
			$C_{14}H_{26}O_2$	Dodecanoic Acid, Ethenyl Ester
			$C_{27}H_{52}O_5$	Dodecanoic Acid, 1-(Hydroxymethyl)-1,2-Ethanediyl Ester

Table 6: Volatile Compounds in Cinnamon.

Peak Componds	R. Time (Minute)	Area (%)	Molecular Formula	Compound Name
1	21.513	2.72	$C_{39}H_{74}O_6$	Dodecanoic Acid, 1,2,3-Propanetriyl Ester
			$C_{57}H_{10}O_6$	Glyceryl Tridodecanoate
			$C_{27}H_{52}O_5$	Dodecanoic Acid, 1-(Hydroxymethyl)-1,2-Ethanediyl Ester
2	21.565	1.11	$C_{39}H_{74}O_6$	Dodecanoic Acid, 1,2,3-Propanetriyl Ester
			$C_{57}H_{10}O_6$	Glyceryl Tridodecanoate
			$C_{27}H_{52}O_5$	Dodecanoic Acid, 1-(Hydroxymethyl)-1,2-Ethanediyl Ester
3	21.656	2.49	$C_{39}H_{74}O_6$	Dodecanoic Acid, 1,2,3-Propanetriyl Ester
			$C_{57}H_{10}O_6$	Glyceryl Tridodecanoate
			$C_{27}H_{52}O_5$	Dodecanoic Acid, 1-(Hydroxymethyl)-1,2-Ethanediyl Ester
4	21.858	4.80	$C_{39}H_{74}O_6$	Dodecanoic Acid, 1,2,3-Propanetriyl Ester
			$C_{57}H_{10}O_6$	Glyceryl Tridodecanoate
			$C_{27}H_{52}O_5$	Dodecanoic Acid, 1-(Hydroxymethyl)-1,2-Ethanediyl Ester
5	21.940	9.45	$C_{39}H_{74}O_6$	Dodecanoic Acid, 1,2,3-Propanetriyl Ester
			$C_{57}H_{10}O_6$	Glyceryl Tridodecanoate
			$C_{27}H_{52}O_5$	Dodecanoic Acid, 1-(Hydroxymethyl)-1,2-Ethanediyl Ester
6	22.106	10.04	$C_{39}H_{74}O_6$	Dodecanoic Acid, 1,2,3-Propanetriyl Ester
			$C_{57}H_{10}O_6$	Glyceryl Tridodecanoate
			$C_{27}H_{52}O_5$	Dodecanoic Acid, 1-(Hydroxymethyl)-1,2-Ethanediyl Ester
7	22.260	7.60	$C_{39}H_{74}O_6$	Dodecanoic Acid, 1,2,3-Propanetriyl Ester
			$C_{57}H_{10}O_6$	Glyceryl Tridodecanoate
			$C_{27}H_{52}O_5$	Dodecanoic Acid, 1-(Hydroxymethyl)-1,2-Ethanediyl Ester
8	22.352	13.86	$C_{39}H_{74}O_6$	Dodecanoic Acid, 1,2,3-Propanetriyl Ester
			$C_{57}H_{10}O_6$	Glyceryl Tridodecanoate
			$C_{27}H_{52}O_5$	Dodecanoic Acid, 1-(Hydroxymethyl)-1,2-Ethanediyl Ester
9	22.450	4.96	$C_{35}H_{66}O_6$	2-Lauro-1,3-Didecoin
			$C_{39}H_{74}O_6$	Dodecanoic Acid, 1,2,3-Propanetriyl Ester
10	22.649	17.76	$C_{39}H_{74}O_6$	Dodecanoic Acid, 1,2,3-Propanetriyl Ester
11	22.757	3.27	$C_{39}H_{74}O_6$	Dodecanoic Acid, 1,2,3-Propanetriyl Ester
			$C_{57}H_{10}O_6$	Glyceryl Tridodecanoate
			$C_{47}H_{90}O_6$	Hexadecanoic Acid, 2-[(1-Oxododecyl)Oxy]-1,3-Propanediyl Ester (CAS) Glyceryl-2-Laurate-1,3-Dipalmitate
12	22.816	3.33	$C_{39}H_{74}O_6$	Dodecanoic Acid, 1,2,3-Propanetriyl Ester (CAS) Glyceryl Tridodecanoate
			$C_{57}H_{10}O_6$	Glyceryl Tridodecanoate
			$C_{14}H_{26}O_2$	Dodecanoic Acid, Ethenyl Ester
13	22.892	0.58	$C_{39}H_{74}O_6$	Dodecanoic Acid, 1,2,3-Propanetriyl Ester
			$C_{57}H_{10}O_6$	Glyceryl Tridodecanoate
			$C_{14}H_{26}O_2$	Dodecanoic Acid, Ethenyl Ester
14	23.022	3.19	$C_{39}H_{74}O_6$	Dodecanoic Acid, 1,2,3-Propanetriyl Ester
			$C_{51}H_{98}O_6$	Octadecanoic Acid, 3-[(1-Oxododecyl) Oxy]-1,2-Propanediyl Ester
			$C_{57}H_{10}O_6$	Glyceryl Tridodecanoate
15	23.163	5.13	$C_{39}H_{74}O_6$	Dodecanoic Acid, 1,2,3-Propanetriyl Ester (CAS) Glyceryl Tridodecanoate
			$C_{57}H_{10}O_6$	Glyceryl Tridodecanoate

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Table 6: Continuation.

Peak Componds	R. Time (Minute)	Area (%)	Molecular Formula	Compound Name
			$C_{51}H_{98}O_6$	Octadecanoic Acid, 3-[(1-Oxododecyl) Oxy]-1,2-Propanediyl Ester
16	23.250	3.83	$C_{39}H_{74}O_6$	Dodecanoic Acid, 1,2,3-Propanetriyl Ester
			$C_{57}H_{10}O_6$	Glyceryl Tridodecanoate
			$C_{51}H_{98}O_6$	Octadecanoic Acid, 3-[(1-Oxododecyl) Oxy]-1,2-Propanediyl Ester
17	23.365	3.26	$C_{47}H_{90}O_6$	Hexadecanoic Acid, 2-[(1-Oxododecyl)Oxy]-1,3-Propanediyl Ester
			$C_{39}H_{74}O_6$	Dodecanoic Acid, 1,2,3-Propanetriyl Ester
			$C_{35}H_{66}O_6$	2-Lauro-1,3-Didecoin
18	23.760	1.77	$C_{39}H_{74}O_6$	Dodecanoic Acid, 1,2,3-Propanetriyl Ester
			$C_{51}H_{98}O_6$	Octadecanoic Acid, 3-[(1-Oxododecyl)Oxy]-1,2-Propanediyl Ester
			$C_{51}H_{98}O_6$	Octadecanoic Acid, 2-[(1-Oxododecyl)Oxy]-1,3-Propanediyl Ester
19	23.857	0.83	$C_{39}H_{74}O_6$	Dodecanoic Acid, 1,2,3-Propanetriyl Ester
			$C_{35}H_{66}O_6$	2-Lauro-1,3-Didecoin
			$C_{57}H_{10}O_6$	Glyceryl Tridodecanoate

Table 7: Volatile Compounds in Spiced Coffee.

Peak Componds	R. Time (Minute)	Area (%)	Molecular Formula	Compound Name
1	22.080	0.81	$C_{39}H_{74}O_6$	Dodecanoic Acid, 1,2,3-Propanetriyl Ester
			$C_{57}H_{10}O_6$	Glyceryl Tridodecanoate
			$C_{27}H_{52}O_5$	Dodecanoic Acid, 1-(Hydroxymethyl)-1,2-Ethanediyl Ester
2	22.240	1.56	$C_{39}H_{74}O_6$	Dodecanoic Acid, 1,2,3-Propanetriyl Ester
			$C_{57}H_{10}O_6$	Glyceryl Tridodecanoate
			$C_{27}H_{52}O_5$	Dodecanoic Acid, 1-(Hydroxymethyl)-1,2-Ethanediyl Ester
3	22.315	1.75	$C_{39}H_{74}O_6$	Dodecanoic Acid, 1,2,3-Propanetriyl Ester
			$C_{57}H_{10}O_6$	Glyceryl Tridodecanoate
			$C_{27}H_{52}O_5$	Dodecanoic Acid, 1-(Hydroxymethyl)-1,2-Ethanediyl Ester
4	22.497	6.87	$C_{39}H_{74}O_6$	Dodecanoic Acid, 1,2,3-Propanetriyl Ester
			$C_{57}H_{10}O_6$	Glyceryl Tridodecanoate
			$C_{27}H_{52}O_5$	Dodecanoic Acid, 1-(Hydroxymethyl)-1,2-Ethanediyl Ester
5	22.588	2.74	$C_{39}H_{74}O_6$	Dodecanoic Acid, 1,2,3-Propanetriyl Ester
			$C_{57}H_{10}O_6$	Glyceryl Tridodecanoate
			$C_{27}H_{52}O_5$	Dodecanoic Acid, 1-(Hydroxymethyl)-1,2-Ethanediyl Ester
6	22.678	4.45	$C_{49}H_{94}O_6$	Octadecanoic Acid, 2,3-Bis[(1-Oxotetradecyl) Oxy]Propyl Ester (Cas) 1-Stearo-2,3-Dimyristin
			$C_{57}H_{10}O_6$	Glyceryl Tridodecanoate
			$C_{27}H_{52}O_5$	Dodecanoic Acid, 1-(Hydroxymethyl)-1,2-Ethanediyl Ester
7	22.725	2.42	$C_{39}H_{74}O_6$	Dodecanoic Acid, 1,2,3-Propanetriyl Ester
			$C_{57}H_{10}O_6$	Glyceryl Tridodecanoate
			$C_{27}H_{52}O_5$	Dodecanoic Acid, 1-(Hydroxymethyl)-1,2-Ethanediyl Ester
8	22.837	12.02	$C_{14}H_{26}O_2$	Dodecanoic Acid, Ethenyl Ester
			$C_{57}H_{10}O_6$	Glyceryl Tridodecanoate
			$C_{27}H_{52}O_5$	Dodecanoic Acid, 1-(Hydroxymethyl)-1,2-Ethanediyl Ester

Continua...

Table 7: Continuation.

Peak Componds	R. Time (Minute)	Area (%)	Molecular Formula	Compound Name
9	22.908	11.61	$C_{39}H_{74}O_6$	Dodecanoic Acid, 1,2,3-Propanetriyl Ester
			$C_{57}H_{10}O_6$	Glyceryl Tridodecanoate
			$C_{27}H_{52}O_5$	Dodecanoic Acid, 1-(Hydroxymethyl)-1,2-Ethanediyl Ester
10	23.025	4.34	$C_{39}H_{74}O_6$	Dodecanoic Acid, 1,2,3-Propanetriyl Ester
			$C_{27}H_{52}O_5$	Dodecanoic Acid, 1-(Hydroxymethyl)-1,2-Ethanediyl Ester
			$C_{57}H_{10}O_6$	Glyceryl Tridodecanoate
11	23.083	9.38	$C_{35}H_{66}o_6$	2-Lauro-1,3-Didecoin
			$C_{26}H_{48}F_3NO_2$	Dodecanamide, N-Dodecyl-N-(Trifluoroacetyl)
			$C_{57}H_{10}O_6$	Glyceryl Tridodecanoate
12	23.188	6.33	$C_{39}H_{74}O_6$	Dodecanoic Acid, 1,2,3-Propanetriyl Ester
			$C_{47}H_{90}O_6$	Hexadecanoic Acid, 2-[(1-Oxododecyl)Oxy]-1,3-Propanediyl Ester
			$C_{57}H_{10}O_6$	Glyceryl Tridodecanoate
13	23.305	11.81	$C_{55}H_{106}O_6$	Eicosanoic Acid, 2-[(1-Oxohexadecyl)Oxy]-1-[[(1-Oxohexadecyl)Oxy]Methyl]Ethyl Ester (Cas) Glyceryl-2-Eicosanoate-1,3-Dih Exadecanoate
			$C_{47}H_{90}O_6$	Hexadecanoic Acid, 2-[(1-Oxododecyl)Oxy]-1,3-Propanediyl Ester
			$C_{57}H_{10}O_6$	Glyceryl Tridodecanoate
14	23.405	8.33	$C_{39}H_{74}O_6$	Dodecanoic Acid, 1,2,3-Propanetriyl Ester
			$C_{57}H_{10}O_6$	Glyceryl Tridodecanoate
			$C_{47}H_{90}O_6$	Hexadecanoic Acid, 2-[(1-Oxododecyl)Oxy]-1,3-Propanediyl Ester
15	23.575	5.27	$C_{39}H_{74}O_6$	Dodecanoic Acid, 1,2,3-Propanetriyl Ester
			$C_{57}H_{10}O_6$	Glyceryl Tridodecanoate
			$C_{27}H_{52}O_5$	Dodecanoic Acid, 1-(Hydroxymethyl)-1,2-Ethanediyl Ester
16	23.642	4.15	$C_{39}H_{74}O_6$	Dodecanoic Acid, 1,2,3-Propanetriyl Ester
			$C_{57}H_{10}O_6$	Glyceryl Tridodecanoate
			$C_{27}H_{52}O_5$	Dodecanoic Acid, 1-(Hydroxymethyl)-1,2-Ethanediyl Ester
17	23.719	2.23	$C_{39}H_{74}O_6$	Dodecanoic Acid, 1,2,3-Propanetriyl Ester
			$C_{57}H_{10}O_6$	Glyceryl Tridodecanoate
			$C_{51}H_{98}O_6$	Octadecanoic Acid, 3-[(1-Oxododecyl)Oxy]-1,2-Propanediyl Ester
18	23.855	3.92	$C_{47}H_{90}O_6$	Hexadecanoic Acid, 2-[(1-Oxododecyl)Oxy]-1,3-Propanediyl Ester
			$C_{39}H_{74}O_6$	Dodecanoic Acid, 1,2,3-Propanetriyl Ester
			$C_{35}H_{66}O_6$	2-Lauro-1,3-Didecoin

3.6 Proximate Analysis

Water Content: Water content is one of the physical properties that will affect the quality of coffee. The water content of a material needs to be known because it can affect its appearance, texture, and taste and determine the freshness of the material. In addition, the moisture content will affect the shelf life and resistance to microbial attack. The lower the water content of coffee, the higher the resistance of coffee, especially to damage caused by microorganisms (Seninde; Chambers, 2020). The principle of analyzing water content using the thermogravimetric or drying method is to evaporate the water in the material using an oven at 105 °C. Based on Table 8, it can be seen that the water content of original liberica coffee HC1 is 4.302%, and cinnamon HC0 is 9.202%. Meanwhile, the water content of HC2, HC3, and HC4 were 4.305%, 4.410%, and 4.530%, respectively.

Ash Content: Ash content is the amount of inorganic or mineral components a food contains. The high or low ash content illustrates the amount of mineral content contained in a food. The higher the value of the ash content, the higher the mineral content, and vice versa. Ash is an inorganic residue obtained by incineration of organic components in foodstuffs. Determination of ash content in the sample was carried out by direct ashing/dry ashing. The principle of this method is to

oxidize all organic substances at high temperatures, namely 525°C, and then weigh the substances left behind after the ashing process. Table 8 shows that the ash content of original liberica coffee (HC1) is 4.175%, and cinnamon (HC0) is 4.205%. While the ash content of HC2, HC3, and HC4, were 4.240%, 4.254%, and 4.265%, respectively.

Protein Content: Table 8 shows that the original liberica coffee HC1 protein content is 17.61%, and cinnamon HC0 is 3.56%. Meanwhile, the protein levels of HC2, HC3, and HC4 were 17.12%, 16.95%, and 15.88%, respectively. When Coffee is added to Cinnamon with several ratios, the protein content decreases along with the added Cinnamon content. Because the protein content of Cinnamon is lower than Coffee, the addition of Cinnamon can reduce the protein content of Coffee Liberica. Protein plays a role in forming the bitter taste in coffee, so the role of protein in determining the quality of coffee is vast. The lower the protein content, the less bitter the taste.

Table 8: Results of Proximate Analysis.

Sample	Water	% Ash	% Protein	% Fat	Carbohydrate
HC1	4.302	4.175	17.61	10.17	5.940
HC0	9.202	4.205	3.56	1.34	5.184
HC1	4.305	4.240	17.12	10.14	5.400
HC2	4.410	4.254	16.95	9.85	4.752
HC3	4.530	4.265	15.88	9.16	4.320

HC1= Original Liberica Coffee, HC2 = Coffee:Cinnamon (99:1); HC3= Coffee:Cinnamon (97:3); HC4 = Coffee:Cinnamon (95:5), HC0= Cinnamon.

Fat Content: Fat is one of the chemical components in coffee that forms the taste of coffee. Most of the fat content in coffee is found in coffee oil in the endosperm of the coffee green bean, and a small part is in the coffee wax layer, which is the outermost layer of the coffee bean. The wax layer has 5-hydroxytryptamine fatty acids from palmitic, arachidic, behenic, and lignoceric acids [29]. The method used in determining the fat content in coffee is the soxhlet method with the principle of continuous extraction using a constant amount of organic solvent in the presence of back-cooling. Table 8 shows that the fat content of original liberica coffee, HC1 is 10.17%, and cinnamon is 1.34%. Meanwhile, the fat content of HC2, HC3, and HC4 were 10.14%, 9.85%, and 9.16%, respectively.

Carbohydrate Content: This study used quantitative analysis in the form of the Luff school method to determine the carbohydrate content in the sample. The basic principle of the luff schrool method is iodometric because it uses iodide ions as the basis for determining carbohydrate levels. Table 8 shows that the carbohydrate content of original liberica coffee HC1 is 5.940%, and cinnamon is 5.184%. Meanwhile, the levels of carbohydrates HC2, HC3, and HC4 were 5,400%, 4,752%, and 4,320%, respectively (Table 8). The carbohydrate content decreases along with the added Cinnamon content. Because the carbohydrate content of Cinnamon is lower than that of Coffee, the addition of Cinnamon can reduce the carbohydrate content of Coffee.

4 DISCUSSION

4.1 The addition of Cinnamon enhances the Liberica Coffee Sensory Profile

The addition of Cinnamon improves the senses or taste of coffee. The flavours in coffee will affect the sensation of taste and the value of enjoyment when enjoying a cup of coffee. The brewing process causes the volatile components in liberica coffee and cinnamon spices to evaporate so that the aroma of the combination of the two appears. This result is the same as previous research, which showed that herbs' synergetic effect on coffee increases its antioxidant activity and bioactive components (Gobbi et al., 2023). The more components of volatile compounds that dissolve in water during the brewing process, the sharper the aroma will be. Based on Table 1, the results of the ANOVA test showed that the P value <0.05, so there is a significant difference between the HC1, HC2, HC3 and HC4 treatments on sensory Liberica coffee. Duncan's further test was carried out to determine which group was significant. Duncan's further test results showed that there was a significant difference in the HC1 and HC2 (99:1) treatment, HC1 and HC3 had a significant difference, HC1 and HC4 had a significant difference, HC2 and HC3 have significant differences, HC2 (99:1) and HC4 have significant differences as well as HC3 and HC4 there is no real difference. According to the (Specialty Coffee Association of America - SCAA, 2015), the limit of coffee can be categorized as specialty coffee when the final taste score resulting from the cupping test is ≥80.00. Most of the distinctive aromas of coffee are formed during the roasting process and appear during the brewing process (Fadri et al., 2020). Several components, such as carbohydrates, alkaloids, and carboxylic acids, influence the taste of coffee. Carbohydrates are degraded to form glucose, galactose, and mannose, which produce a sweet taste. Alkaloids in the form of caffeine and trigonelline, and chlorogenic acid give a bitter and astringent taste. Meanwhile, carboxylic acids such as malic, citric, acetic, and pyruvic acids give an acidic impression. The combination of sweet, bitter, and sour tastes in coffee gives a distinctive taste which is the main attraction for various coffee products (Seninde; Chambers, 2020).

4.2 The addition of Cinnamon increased the Total Phenol and Total Flavonoid Levels

The results of the ANOVA test showed that the P value <0.05, so there is a significant difference between the HC1,

HC2, HC3, and HC4 treatments on total phenolic levels. Duncan's further test was carried out to determine which group was significant. The results of Duncan's further test showed significant differences from all treatments. The results of the ANOVA test show that the P value <0.05, so there is a significant difference between the HC1, Cinnamon, HC2, HC3, and HC4 treatments on total flavonoid levels. Duncan's further test was carried out to determine which group was significant. The results of Duncan's further test showed significant differences from all treatments.

4.3 Cinnamon lowers Caffeine and Chlorogenic Acid Levels

Based on Table 4, the results of the ANOVA test showed that the P value <0.05, so there was a significant difference between the HC1, HC2, HC3, and HC3 treatments on levels caffeine. Duncan's further test was carried out to determine which group was significant. The results of Duncan's further test showed that there were significant differences from all treatments, HC1, HC2, HC3, and HC4. HC1, HC2, HC3, and HC4 caffeine levels were 0.858%, 0.759%, 0.736% and 0.678%, respectively. The interactions between phenolics and caffeine are intermolecular interactions that combine π-π interactions (π stacking) and hydrogen bonds. The hydrogen atoms in the hydroxyl groups of phenolic compounds tend to form hydrogen bonds with C=O and N in caffeine. The addition of cinnamon, which contains a lot of phenolic compounds, causes strong intermolecular interactions, thereby reducing the caffeine content as the cinnamon content is added. This can be seen in Table 2 shows that the total phenolic content is high in cinnamon. The same result also occurred in the levels of chlorogenic acid, the results of the ANOVA test showed that the P value <0.05, so there was a significant difference between the HC1, HC2, HC3, and HC4 treatments on levels chlorogenic acid. Duncan's further test was carried out to determine which group was significant. The results of Duncan's further test showed that there were significant differences from all treatments, both HC1, HC2, HC3, and HC4. Chlorogenic acid levels HC1, HC2, HC3, and HC4 were 0.858%, 0.759%, 0.736% and 0.678% respectively. In addition, according to (Shahidi; Dissanayaka, 2023), the interaction of chlorogenic acid compounds and proteins can form complexes through hydrogen bonds and hydrophobic and electrostatic interactions. Hydrogen bonding occurs between the peptide bond's oxygen atom and chlorogenic acid's hydroxyl group. Hydrophobic interactions occur between the hydrophobic amino acids and the aromatic ring structure of the chlorogenic acid. In comparison, electrostatic interactions/ionic bonds occur between positively charged protein groups and negatively charged hydroxyl groups of chlorogenic acid. The protein contained in cinnamon can cause reduced levels of chlorogenic acid in coffee due to the strong interaction between protein and chlorogenic acid. Hydrogen bonds, hydrophobic and electrostatic interactions are the main forces forming non-covalent complexes between proteins and chlorogenic acid.

4.4 Proximate Analysis of Liberika-Cinnamon Coffee

When CH0 (Cinnamon) is added to CH1 (Coffe Liberica) in several ratios, the water content increases as the CH0 content is added. Because the water content of CH0 is greater than that of CH11, the addition of Cinnamon can increase the water content of CH1. The results of the water content analysis in cinnamon-flavored coffee have met the quality requirements of ground coffee based on SNI 01-3542-2004, where the water content in ground coffee is a maximum of 7% w/w (SNI, 2014). When Coffee is added to Cinnamon with several ratios, the ash content increases along with the added Cinnamon content. Because the ash content of CH0 is greater than that of CH1, the addition of CH0 can increase the ash content of CH1. The analysis results of ash content analysis in cinnamon-flavored coffee have met the quality requirements of ground coffee based on SNI 01-3542-2004, where the ash content in ground coffee is a maximum of 5% w/w (SNI, 2014). When Cinnamon was added to Coffee with several ratios, the fat content decreased along with the added cinnamon content. Because the fat content of Cinnamon is lower than that of Coffee, the addition of Cinnamon can reduce the fat content of Coffee. The content of carbohydrate compounds in coffee plays a role in forming aroma and sweetness in coffee brewing. Fatty acids and sugars form the sweet taste and distinctive aroma of coffee. Some sugar compounds will caramelize during roasting, giving rise to a sweet taste. Reducing sugars react with amino acids to form aroma and sweet taste compounds through the Maillard reaction (Devi et al., 2021).

4.5 Cinnamon Liberica Coffee Increases % DPPH Inhibition

Based on Table 3, the results of the ANOVA test showed that the P value <0.05, so there was a significant difference between the ascorbic acid, CH1, CH2, CH3, CH4, and Cinnamon treatments. Duncan's further test was carried out to determine which group was significant. The results of Duncan's further test showed that there were significant differences from all treatments CH1, CH2, CH3, and CH4. There is limited information on the interactions of coffee phenolics with those of other commonly paired food matrices in the literature (Erskine et al., 2022). The interaction of robusta coffee and cinnamon has been reported by previous studies (Durak et al., 2014). In the first part, this study focused on how coffee and cinnamon's individual bioactive phenolics interact with each other, with both obtained from extracts and

standardized chemicals for comparison. Second, investigation how these compounds interact during in vitro gastrointestinal digestion and determine their bioavailability. Cinnamon is rich in cinnamic acid and coumarins, providing antioxidant properties and defense against lipoxygenase (LOX) activity and can be used in coffee to improve taste and flavour.

5 CONCLUSIONS

Based on the research that has been done, adding cinnamon to liberica coffee affects liberica coffee sensory, which the coffee panelists like the most spiced coffee. In addition, all spiced coffee formulations contain higher levels of phenolics, flavonoids, antioxidants, and other compounds than the original liberica coffee. Meanwhile, caffeine and chlorogenic acid levels in all formulations of spiced coffee were lower than those of the original liberica coffee.

6 AUTHOR CONTRIBUTIONS

ILT wrote the manuscript and performed the experiment; SM assisted in conducting Research, conducted all statistical analyses; SS conceptualization, reviewed and approved the final version of the work; YY conducted statistical analyses, and ML supervised the experiment and co-worked the manuscript.

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