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Effect of Light, Medium, and Dark Roasting on Antioxidant Activity of Gununghalu Arabica Coffee (Coffea arabica L.)

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Abstract

Coffee is one of the popular drinks for Indonesian people. Coffee consumption in Indonesia has increased very rapidly. The influence of lifestyle and the increasing number of cafes and coffee shops contribute to the increase in coffee consumers. One downstream processing of coffee beans is roasting coffee beans, which consists of light, medium, and dark roasting. This study aimed to determine the antioxidant activity of Gununghalu Arabica Coffee (Coffea arabica L.) with Light Roasting, Medium Roasting, and Dark Roasting Techniques. This research is an experimental study, where the antioxidant activity analysis was carried out using the DPPH method (2,2-diphenyl-1-picrylhydrazyl). Gununghalu Arabica coffee with light, medium, and dark roasting techniques positively containing flavonoids, alkaloids, saponins, tannins, and terpenoids. The results showed that the IC50 value of Gununghalu Arabica coffee for light, medium, and dark roasting was 102.94 ppm, 70.66 ppm, and 87.66 ppm. The test results show that the antioxidant activity of Gununghalu Arabica coffee with light roasting techniques are moderate, while medium and dark roasting techniques are strong. The results of this study are expected to provide implications for the development of coffee processing techniques to have maximum health benefits.

Keywords: Gununghalu arabica coffee, roasting, DPPH, temperature.

1. Introduction

Coffee is one of the commodities in the world that has been cultivated by more than 50 countries. Countries that cultivate coffee plants are spread across the Americas, Africa, and Asia. According to the International Coffee Organization (ICO), Indonesia is one of the countries in Asia that has cultivated coffee plants. Indonesia is ranked 4th in the world as the largest coffee-producing country after Brazil, Vietnam, and Colombia (Nasution, 2018). Based on statistical data from the Directorate General of Plantations, in 2021 the total area of coffee plantations in Indonesia will be 1,249,615 hectares with a total production of 765,415 tonnes. The total area of Arabica coffee plantations in 2020 in Indonesia is 365,490 hectares with a total production of 208,539 tons (Retkute et al., 2021). Coffee production has increased from 2019 to 2020. In 2019 coffee production was 752.51 thousand tons. In 2020 coffee production rose to 762.38 thousand tons, an increase of 1.31% (BPS, 2021).

One of the coffee-producing places consumed by the community is in the highlands of West Bandung. The coffee commodity in Gununghalu District, West Bandung is a leading commodity with a coffee plantation area of 314 Ha with a production of 204.72 tonnes (BPS, 2019). The area of coffee plantations in the West Bandung Regency area is divided into robusta and arabica coffee plantations. Arabica coffee types are more widely grown than robusta coffee. The area of the Robusta coffee plantation is 494 Ha, and the area of the Arabica coffee garden is 2,531 Ha2. Arabica coffee generally has a distinctive aroma and distinctive taste, according to the location where it is grown, this is also what makes Gununghalu arabica coffee in demand by consumers. Gununghalu arabica coffee has a sweet, nutty taste, with dominant acidity but a thin, concentrated taste that can be felt at the end. Due to its quality and popularity, in 2018 Gununghalu arabica coffee received the Silver Gourmet award from the Agency for the Valorization of Agricultural Products (AVPA) Gourmet Products in Paris, France (Muttaqien, 2020).

Coffee is a complex mixture of more than 800 volatile compounds, and the most common are caffeine and chlorogenic acid which have many health benefits. New approaches in epidemiological studies and experimental research show that coffee consumption can help prevent several chronic diseases, including type 2 diabetes mellitus, liver disease (Nieber et al., 2017), cancer and Parkinson's (Muchtaridi et al., 2021). In addition, coffee is useful as an anti-cancer, anti-inflammatory, anti- bacterial, anti-diabetic, and anti-atherosclerotic (ALAsmari et al., 2020).

Chlorogenic acid (CGA) in coffee has been shown to have antiviral activity against viruses. However, the caffeine content in coffee beans can also cause insomnia and stomach irritation, and increase heart rate and respiratory rates (Muchtaridi et al., 2021).

Along with the increase in consumptive nature and changes in people's lifestyles, drinking coffee has become a way of life. The coffee shop creative industry is growing and developing so rapidly and is here to provide choices for how to enjoy coffee through good brewing with new methods (Rahmawati and Tanjung 2020). Coffee producers consistently maintain product quality, always use the latest innovations in a more varied range of coffee drink products (Adiwinata et al., 2021). In the coffee preparation process, the roasting technique is the most well-known and widely used processing method (Endeshaw and Belay 2020).

In general, the roasting technique is divided into three levels, namely light roast with a temperature of 193°C to 199°C, medium roast with a temperature of 204°C and dark roast with a temperature of 213°C to 221°C (Abubakar et al., 2021). The roasting process in coffee is one of the most important parts of the formation of coffee aroma and also has a major influence on the composition of the biologically active compounds in coffee13. Several studies have shown that coffee bean processing techniques by roasting can affect the sensory quality and pH(Abubakar et al., 2021), the content of bioactive compounds, trigonelline, and chlorogenic acid (Bolka and Emire 2020), acrylamide content, nutritional composition, and antioxidant properties, phytochemical and total phenol content (Jung et al., 2021), caffeine content (Hidayat et al., 2023), and volatile compounds in coffee (Alamri et al., 2022).

Based on the above literature, there is no comprehensive study that analyzes the effect of the three roasting techniques on Gununghalu Arabica coffee. Therefore, the purpose of this study was to analyze the antioxidant activity in Gununghalu Arabica coffee (Coffea arabica L.) Light Roasting, Medium Roasting, and Dark Roasting techniques.

2. Material and Methods

2.1. Materials and Instrumentation

Arabica coffee is obtained directly from the Gununghalu, West Bandung, West Java, Indonesia, with the Gayo 1 variety with the long berry type. The materials used in this study included hydrochloric acid, Mg powder, Bouchardat's reagent, 95% ethanol, 1% ferric chloride (Merck), acetic acid anhydrous, aquadest, concentrated H2SO4 (Smartlab), chloroform (Emsure), methanol (Fultime), DPPH. The instrumentation used in this research is roasting machine (WE W600i SE), UV-Vis spectrophotometry (Shimadzu UV1780), and Rotary Evaporator (EM1000/CE).

2.2. Gununghalu Arabica Coffee Preparation

The picked Arabica coffee beans are six months old and have a yellowish-red color, and the entire skin is red. The Arabica coffee processing stage must be processed a maximum of 6 hours after it is reaping as there is no spoilage in the Arabica coffee beans. The first technique is light roasting, were as much as 500 g of coffee beans is prepared. The gas tube is attached to the roasting machine, turn on the fire to start heating the chamber, turn on the switch, and wait until the temperature reaches 150^{o}C for 20 minutes. Periodically check the engine temperature on the temperature indicator, and insert the coffee beans into the chamber. The engine will spin, and the temperature will continue to increase. The coffee beans in the chamber are periodically checked for maturity until there is a first crack sound with a roasting time of about 7 minutes.

The second technique is medium roasting, the coffee beans in the chamber are periodically checked for maturity until there is a first crack sound, and before the second crack with a roasting time of about 8 minutes. The third technique is dark roasting, where the coffee beans in the chamber are periodically checked for maturity until there is a second crack sound with a roasting time of about 10 minutes. After obtaining the appropriate level of maturity, the fire and the chamber drive are turned off, then the coffee beans are removed and cooled before being packaged. The coffee beans that have gone through the roasting process are then ground with a grinder type N600 to become granulated coffee powder. Coffee bean powder is stored in a clean and tightly closed container (Clarke, 2012).

2.3. Determination of Phytochemical Content

Phytochemical compounds identified in the Gununghalu Arabica Coffee are flavonoids (Willstater test), alkaloids (Wagner and Dragendorff test), tannins (color test), saponins (foam test), and terpenoids (Liebermann- Burchad) (Fachriyah et al., 2018; Parbuntari et al., 2018). This identification was conducted to determine the compounds that play a role in antioxidant activity.

2.4. Determination of Antioxidant Activity

As much as 50 mg of Arabica coffee extract resulting from the light roasting, medium roasting, and dark roasting techniques was weighed and then dissolved with methanol into a 50 ml volumetric flask up to the mark. Prepare solutions with concentrations of 20, 40, 60, 80, and 100 ppm from the stock solutions into a 10 ml volumetric flask, and close it with aluminum foil. Added as much as 4 ml of sample to 4 ml of DPPH solution, then homogenized.

Leave it at 25-30°C for 30 minutes. The absorbance was measured at the maximum wavelength using a UV-Vis spectrophotometer. Then calculate the percentage of inhibition (resistance) using equation (1) and IC50 (50% inhibition concentration). Obtain the IC50 value from the line cut between the 50% inhibition and the concentration axis using the linear equation (y=bx+a), where y=50 and x denotes IC (Insanu et al., 2021).

$$\%\ Inhibition = \frac{Control\ absorbance\ -\ sample\ absorbance}{Control\ absorbance}\ \text{X}\ 100\% \quad (1)$$

3. Result and Discussion

3.1. Phytochemical Content of Gununghalu Arabica Coffee

The results of the phytochemical content test in Table 1 show that the Gununghalu Arabica coffee beans produced from the light roasting, medium roasting, and dark roasting techniques contain flavonoid, alkaloid, terpenoid, saponin, and tannin groups compound, these results are consistent with several previous studies (Fatmawati et al., 2021; Meynderth and Noviastuti 2022; Ali et al., 2022; Harahap et al., 2021).

The flavonoid test results indicated the formation of an orange color when the sample reacted with Mg and HCl. Magnesium and hydrochloric acid addition can reduce the benzopyrone in the flavonoid structure, forming the red or orange flavylium salts (Yuniati et al., 2020). The alkaloid test results are the formation of a reddish brown precipitate with Wagner's reagent, and an orange precipitate with Dragendorff reagent indicated as the presence of the complex compound of potassium-alkaloid.

The positive test results for saponins in coffee bean extract from the light roasting, medium roasting, and dark roasting techniques indicate the formation of foam after shaking the extract dissolved in hot water. When shaken, the hydrophilic groups will bind to water, while the hydrophobic groups will bind to air to form foam (Jafriati et al., 2019). The positive tannin test results were indicated by the formation of blackish-green color with 1% FeC reagent. The formation of a color change is due to the tannins forming complex compounds with Fe3+ ions (Setyawaty, 2020). The results of the terpenoid test indicated a dark green color with the addition of acetic anhydrous and the formation of a brown ring at the solution boundary when concentrated H_2SO_4 was added. This is due to the oxidation of terpenoid compounds to form cholestahexaena sulfonic acid (Habibi et al., 2018).

The rich content of phytochemical content makes Arabica coffee have many health benefits as a medicine for various diseases including improving physical performance, burning fat, reducing the risk of stroke, liver, prostate, and colorectal cancer, the risk of Parkinson's disease reducing the risk of type II diabetes, reducing the risk of dementia, protecting the mind, raising the mood, helps us fight depression, and coffee consumers have a lower risk of a heart attack (Wachamo, 2017).

Table 1: Phytochemical content on gununghalu arabica coffee

Phytochemical Content	Methods	Results		
		Light Roasting	Medium Roasting	Dark Roasting
Flavonoids	Willstatter	+	+	+
Alkaloids	Wagner	+	+	+
	Dragendorff	+	+	+
Saponins	Foam test	+	+	+
Tannins	Color test	+	+	+
Terpenoids	Liebermann-Burchad	+	+	+

3.2. Antioxidant Activity of Gununghalu Arabica Coffee

In the analysis of the antioxidant activity of Gununghalu arabica coffee in the light roasting, medium roasting, and dark roasting methods with UV-Visible Spectrophotometry, the maximum wavelength of the DPPH is 515.6 nm, and the absorbance value of the DPPH obtained is 0.661. Analysis of antioxidant activity is done by reacting a sample solution at each concentration with a DPPH solution then the mixture is incubated for 30 minutes at a temperature of 25-30˚C. The antioxidant activity found in the sample results in color changes in the DPPH solution in methanol which is reacted with the sample. The early purple solution turns purple. Radical compounds are purple when reacting with their damper compounds will produce a change in purple intensity to yellow. This color change shows the presence of compounds that are free radicals that reduce DPPH (Acar et al., 2022).

The results of the absorbance of the Arabica Gununghalu coffee in various concentrations with the light roasting, medium roasting, and dark roasting techniques obtained are changed to the percentage of inhibition using equation (1). Based on the inhibition calculation in Figure 1, the greater concentration of the sample, the smaller the absorbance

value, and the greater percentage of inhibition, these results are consistent with several previous studies (Rahmawati et al., 2022; Kurang and Kamengon 2021). The highest antioxidant activity value in the light roasting of Gununghalu Arabica coffee bean with an inhibition percentage of 36.21% with a concentration of 100 ppm solution. The medium roasting technique has an antioxidant activity value of 86.74% with a concentration of 100 ppm solution, and the dark roasting technique has an antioxidant activity value of 68.63% with a concentration of 100 ppm solution.

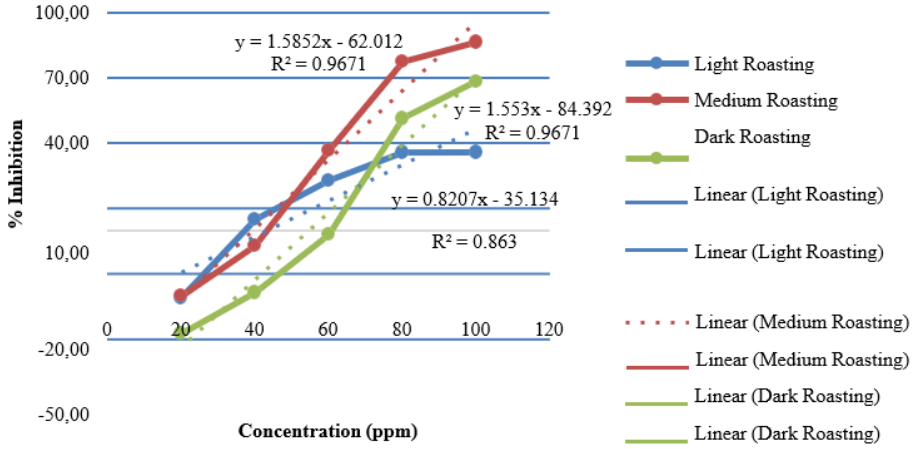

Figure 1: Correlation of inhibition and gununghalu arabica coffee concentration

The linearity equation obtained from the curve in Figure 1 is used to find the concentration of the Gununghalu arabica coffee samples using light roasting, medium roasting, and dark roasting techniques that are effective for reducing DPPH free radicals or IC_{50} values. The IC50 value is the ability to inhibit a substance that is an antioxidant by 50% against the free radical activity (Fokwen et al., 2018).

Table 2: IC_{50} value of Gununghalu Arabica Coffee

Sample	Results		Antioxidant Activity
	Linear Equation	IC50 (μg/ml)	
Light Roasting	y = 0.8207x – 35.134	102.94	Moderate
Medium Roasting	y = 1.5852x – 62.012	70.66	Strong
Dark Roasting	y = 1.553x – 84.392	87.66	Strong

Based on table 2, shows that the IC50 value in all samples has a value above 50. Arabica coffee bean extract using medium roasting and dark roasting techniques has a value below 100 which means it has strong antioxidant properties (IC50 70,66 µg/ml and 87,66 µg/ml). Whereas for Arabica coffee bean extract, the light roasting technique has a value above 100, which means it has moderate antioxidant properties (IC50 102,94 µg/ml). The level of strength of this antioxidant activity is based on the provisions of Molyneux's antioxidant activity (Molyneux, 2004). These results indicate that the antioxidant activity of Gununghalu arabica coffee with medium roasting and dark roasting techniques is higher than with the light roasting method.

The factor causing the difference in antioxidant activity is the temperature during the roasting process. Light roasting is processed at a temperature of 193°C to 199°C, medium roasting at a temperature of 204°C and dark roasting at a temperature of 213°C to 221°C. This shows that the higher the roasting temperature the higher the antioxidant activity. These results are consistent with previous studies that compared the antioxidant activity of Arabica coffee that compared the antioxidant activity of Arabica coffee using hot brewing (85–95°C) and cold brewing (20–25°C) methods. The results obtained are antioxidant activity and phenolic compound content in the hot brew method higher than the cold brew method (Muzykiewicz-Szymańska, et al., 2021). This is due to the content of metabolite compounds that function as antioxidants found in Arabica coffee. Several studies have shown that the flavonoid and quercetin content in Arabica coffee processed using the dark roasting technique is the highest, while the light roasting technique has the lowest flavonoid and quercetin content (Król et al., 2020).

The roasting process also affects the physical and chemical properties of coffee. Factors that have an important influence on the coffee roasting process are roasting time and temperature where these two factors will directly affect the content of water, carbohydrates, protein, and levels of phenolic compounds which then have an impact on the taste of coffee consumed by consumers (Mehaya and Mohammad 2020). In addition, other factors besides temperature and the duration of the roasting process, which is during the extraction process. In accordance with previous studies which stated that the temperature and time of maceration affect the antioxidant activity. The higher the temperature used up to 60°C and the longer the maceration time of up to 36 hours will make it easier for the solvent to damage the cell walls (Quiroz-Reyes et al., 2013).

4. Conclusion

In conclusion, the antioxidant activity of Gununghalu arabica coffee using a light roasting technique was moderate, and the antioxidant activity of Gununghalu arabica coffee using medium roasting and dark roasting techniques was strong. The results of this study are expected to provide implications for the development of coffee processing techniques so that they have maximum health benefits. However, the complete phytochemical content in Gununghalu arabica coffee can provide great health benefits.

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