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CHARACTERISTICS OF GROUND COFFEE QUALITY ON VARIATIONS IN TEMPERATURE AND ROASTING TIME FOR ROBUSTA COFFEE (*Coffea Canephora* PIERRE EX A.FROEHNER) GREEN BEAN

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ABSTRACT

Robusta coffee beans dominate coffee plantations in Indonesia because they have superior properties and are fast-growing. Bogor Regency is one of the largest coffee producers in West Java and was selected to supply robusta coffee for this study. However, the quality of coffee beans still needs to improve. The quality of the coffee beans can be enhanced if the roasting process is carried out at the right temperature and roasting time. This study aims to determine the temperature and duration of roasting the optimum robusta coffee and roasted coffee grounds compared to the quality of branded coffee on the market. Robusta coffee beans roast using a stainless steel skillet with an iron thermometer. The temperature and roasting duration is 170° C, 180° C, and 190° C for 10 and 15 minutes. The robusta ground coffee from Cipanas was analyzed and compared with the branded coffee. Phytochemical tests showed robusta ground coffee samples containing secondary metabolites of alkaloids, flavonoids, saponins, and tannins. The temperature and roasting time of Bogor robusta coffee at 190 °C for 10 minutes gave the best results for several test parameters (moisture content, caffeine levels, pH, coffee content, ash content, and microbial contamination). The quality results obtained are to the requirements set by SNI 01-3542-2004. The quality of roasted ground coffee is the same as branded ground coffee. It is recommended that coffee producers use optimal roasting temperature and duration to improve the quality of their coffee products.

1. INTRODUCTION

Coffee is a plantation crop that plays an essential role as a source of foreign exchange because it has a high economic value among other plantation crops (Sundari et al., 2020). Coffee is one of the primary tropical commodities traded worldwide, contributing to half of the total exports. The popularity and worldwide appeal of coffee are mainly due to its unique taste, supported by historical, traditional, social, and economic factors (Ayelign & Sabally, 2013). Economic value is due to coffee's distinctive taste and characteristics, so it is widely consumed by all levels of society worldwide. As a result, the demand for coffee has increased rapidly yearly. This reason causes coffee to become a trade commodity with the potential to be developed, especially in Indonesia (Siregar et al., 2020). Coffee plantations in Indonesia are dominated by robusta coffee beans, which are superior and overgrown compared to other coffee beans. Most ground coffee production comes from robusta green bean coffee, a green coffee bean of the Robusta type that has removed its epidermis (Henza, 2015). One of the largest coffee producers in Indonesia is Bogor Regency (West Java). The coffee that dominates is the robusta variety, with annual robusta coffee production of 1.3 kg/ha (Health Research and Development Agency, 2000). An essential concern in maintaining the quality of coffee beans is postharvest handling.

Improper postharvest handling resulted in low-quality coffee beans, which affected the development of the final coffee production. One of the postharvest handlings of coffee is roasting. The right temperature and roasting time can determine the quality of coffee beans. Roasting can cause chemical changes and biological activity, and a reaction will form, especially the Maillard reaction, due to the degradation of reducing sugars, amino acids, and chlorogenic acid (Mustika et al., 2022). Previously, research had been carried out on the effect of temperature and roasting time of Robusta coffee which varied using an oven as a roasting medium. Based on the results of this study, the results obtained were that at temperatures over 190 ºC and a roasting time of more than 10 minutes, the quality would decrease (Edvan et al., 2016). The process of temperature and long-time roasting and the interaction of temperature and roasting time significantly impacted caffeine, antioxidant activity, browning index, aroma, and taste (Saloko et al., 2019). Siregar et al. (2020) researched coffee roasting (robusta and arabica) using a stove with stainless steel and clay pans with variations of roasting time of 1, 5, 13, 16, and 20 minutes. The results showed that using stainless steel pans produced a higher yield than clay pots, and the quality of the ground coffee followed the requirements of SNI 01-3542-2004 about quality requirements for ground coffee. So ground coffee has been processed with this processing technique and can be circulated in the market and guaranteed quality and safety. However, in this study, the temperature was not measured at each variation of roasting time. Therefore, it is necessary to research determining variations in temperature and roasting time for robusta green bean coffee using a stove, 170 ºC, 180 ºC, and 190 ºC for 10 minutes and 15 minutes.

2. METHODS

2.1. Materials and Processing of Robusta Green Bean Coffee

The materials used are aluminium foil during the coffee roasting process is intended to reflect heat back onto the coffee beans and prevent heat leaks, distilled water for dissolve the sample, ammonia (NH_4OH) for reagent complex compound in phytochemical test, hydrochloric acid (concentrated HCl) for reagent phytochemical test, buffered peptone water (BPW) for diluent solution microbial contamination, ethanol for sample extractor, ferric chloride ($FeCl_3$) for reagent complex compound in phytochemical, calcium carbonate ($CaCO_3$) for separates caffeine from other compounds, cotton, chloroform ($CHCl_3$) for sample extractor, media Tryptone Soya Agar (TSA) for media in microbiological examination,

Sabouraud Dextrose Agar (SDA) media media in microbiological analysis, Mayer reagent for reagent phytochemical test, Wagner reagent for reagent phytochemical test, Dragendorff reagent for reagent phytochemical test, magnesium ribbon for reagent phytochemical test, the sample of wet robusta coffee beans from Cipanas, Bogor, branded ground coffee, and caffeine standards.

Wet Robusta coffee beans weighing 6 kg are washed with running water. Wet coffee beans are dried in the sun for 14 days, and the epidermis is peeled using a huller (coffee rice/green bean). Robusta green bean of as much as 250 g is roasted on the stove using a stainless steel skillet and an iron thermometer. The roasting temperatures used were 170°C, 180°C, and 190°C for 10 and 15 minutes. The coffee produced comes from samples ground using a blender and then filtered using a 60-mesh filter.

2.2. Phytochemical test

The resulting ground coffee is taken as much as 2 g and added to 100 mL of boiling water (95°C). The ground coffee sample was stirred for 2 minutes, filtered, and then ground coffee extract was obtained.

Alkaloids

1 ml of coffee extract was added to 1 ml of ammonia solution and 1 ml of chloroform and then shaken, then waited for it to separate into two parts. The top of the solution was divided into three parts, and Wagner, Mayer, and Dragendorrf reagents were added. Positive results are indicated by the formation of brown (Wagner), white or yellow (Mayer), and brownish-red (Dragendorff) precipitates. Alkaloids are considered positive if a precipitate occurs or at least two or three of the above tests.

Saponins

1 ml of coffee extract was heated with 2 ml of distilled water using a water bath. The filtrate was shaken vigorously and left for 15 minutes. The formation of stable foam indicated the presence of saponins.

Flavonoids

1 ml of coffee extract is added to ethanol and then heated. The solution is added with a little Mg band and five drops of concentrated HCl from the side of the tube. The formation of orange color indicates the presence of flavonoids.

Tannins

2 ml of distilled water and 1 ml of coffee extract were combined and then heated over a water bath. The filtrate was added with 5% $FeCl_3$. The presence of tannins was indicated by the formation of green, dark blue, or greenish black.

2.3. Moisture Content (SNI 01-2891-1992)

A total of 1-2 g of ground coffee samples were weighed in a porcelain cup that had been dried and found to be empty. The sample was put in the oven for 3 hours at 105 °C and kept in a desiccator for 15 minutes. After that, the sample was weighed again to determine the weight after heating. The moisture content is calculated using the following formula:

$$\text{Moisture content} = \frac{W_1}{W} \times 100\%$$

Information:
W= Weight of a sample before drying (grams)
W1= Loss of weight after drying (grams)

2.4. Caffeine levels

2.4.1. *Preparation of Caffeine Standard Solution*

100 mg of caffeine standard was put into a 1000 mL volumetric flask and adjusted to the mark with distilled water (100 ppm). The standard solution is then pipetted as much as 0; 0.25; 0.5; 1; 2; 3; 4; 5; 7.5; 10 mL into a 50 mL measuring flask and adjusted to the mark with distilled water to obtain a standard solution concentration of 0; 0.5; 1; 2; 4; 6; 8; 10; 15; 20mg/L. The standard solution was measured with a UV-Vis spectrophotometer at the maximum wavelength (250-300 nm). Then a calibration curve was made for the relationship between absorbance and concentration of the standard solution.

Figure 1. Working Standard Solution

2.4.2. *Determination of the Maximum Wavelength of Caffeine*

4 mL of standard caffeine solution with a concentration of 100 ppm and pipetted into a 50 mL volumetric flask, diluted with distilled water up to the marked line, and homogenised. The absorbance of the standard solution was measured with a UV-Vis spectrophotometer at a wavelength of 250 – 300 nm. Aquades was used as a blank test.

Figure 2. Standard Solution

2.4.3 *Caffeine Extraction*

As much as 1 g of ground coffee sample was put into a beaker, added 150 mL of hot water and stirred for 2 minutes. The coffee solution is filtered through a funnel with filter paper into the Erlenmeyer. 1.5 grams of $CaCO_3$ powder and coffee solution were put into a separatory funnel and then extracted with 25 mL of chloroform four times. Take the bottom

layer (chloroform fraction), and evaporate it with a water bath to form a dry extract. The dry extract was put into a 100 mL volumetric flask and diluted with distilled water up to 100 mL. The absorbance of the sample solution was measured at the maximum wavelength (250-300 nm). The calculation of caffeine levels in ground coffee is as follows:

$$\%b/b = \frac{\text{concentration } \left(\frac{\text{mg}}{\text{L}}\right) \times \text{volume sample (L)} \times \text{fp}}{\text{mg sample}} \times 100\%$$

Figure 3. Caffeine Extraction

2.5. Degree of Acidity (pH)

2 g of ground coffee sample dissolved in 150 ml of boiling water. The sample solution was measured with a pH meter. The measurement results were read and measured in 3 repetitions.

2.6. Coffee content (BSN, 2004)

The ground coffee sample was weighed 2 g and put into a 500 mL beaker. Boiling water was added as much as 200 mL and allowed to stand for 1 hour. The sample solution was filtered into a 500 mL volumetric flask and rinsed with hot water until the solution became clear. The solution was allowed to come to room temperature; water was added until it was right at the tera mark. Pipette 50 mL of the solution into a porcelain cup of known weight and then heat it over a water bath until it dries. The cup was put in the oven at 105 ± 2 °C for 2 hours. The sample is cooled in a desiccator and weighed to a constant weight. The formula calculates the value of the Coffee content:

$$\text{Coffee content} = \frac{W_1 \times 500}{W_2 \times 50} \times 100\%$$

Information:
W1 = extract weight (grams)
W2 = Sample weight (grams)
500= Sample dilution volume (mL)
50 = Sampling volume (mL)

2.7. Ash Content (Badan Standardisasi Nasional, 1992)

Ground coffee samples were weighed as much as 2-3 g in a porcelain cup. The sample had been dried, and the empty weight was known. The sample is charred on top of the kiln, and ashes using a furnace at 550 ºC until complete ashing. The ash was ignited in the furnace and stored in a desiccator for 15 minutes. The sample was weighed again to determine the weight after heating. Ash content is calculated using the following formula:

$$\text{Ash content} = \frac{W_1}{W} \times 100\%$$

Information:
W = Sample weight (grams)
W1 = weight of ash (grams)

2.8. Microbial contamination

2.8.1 *Preparation of Buffer Peptone Water (BPW) Diluent Solution*

The diluent solution was prepared by weighing 4.5 g of BPW and then dissolving it in 500 mL of distilled water and stirring over a stirred heater until homogeneous. The homogeneous BPW solution was poured as much as 45 mL into the Erlenmeyer. The BPW solution was poured into Erlenmeyer, and the test tube was plugged with cotton and covered with aluminum foil, then sterilized by autoclaving for 15 minutes at 121 °C.

2.8.2. *Making Tryptone Soya Agar (TSA) Media*

Agar media was prepared by weighing 4 g of TSA and then dissolving it in 100 mL of distilled water, stirring over a heated stirrer until boiling and sterilizing with an autoclave for 15 minutes at 121°C.

2.8.3. *Making Sabouraud Dextrose Agar (SDA) Media*

The agar media was prepared by weighing 6.5 g of SDA and then dissolving it in 100 mL of distilled water, stirring over a heated stirrer until boiling and sterilizing with an autoclave for 15 minutes at 121°C.

2.8.4. *sample Preparation*

The coffee sample was weighed as much as 1 gram and poured into 9 mL BPW solution, shaken until homogeneous, and allowed to stand until the sample settled. Samples were made with various dilutions in a 10^{-2} dilution test tube (for ALT) and up to 10^{-1} dilution (for Mold/Yeast Number Test).

2.8.5. *Total Plate Number Test*

Pipette 1 mL of the sample solution into a petri dish and pour 12 mL of sterile TSA media at 40°C, homogenize and leave until the media solidifies. The petri dish is placed in an incubator at 30-35°C for five days in an inverted position. TSA media was used as a control.

2.8.6 *Testing of Mold Numbers*

Pipette 1 mL of the sample solution into a petri dish and pour 12 mL of sterile SDA media at 40°C, homogenize and leave until the media solidifies. The petri dish is placed in an incubator at 20-25°C for 5-7 days in an inverted position. SDA media was used as a control.

2.8.7. *Calculations*

If the colony is more than 1 :

$$\text{ALT/AK (Colonies/gram)} = \frac{\text{number of colonies}}{\text{v x df}} \text{ x } 100\%$$

If colony 0 :

$$\text{ALT/AK (Colonies/gram)} = \frac{1}{\text{v x df}} \text{ x } 100\%$$

Information:
v = Sample volume in a petri dish
df = dilution factor

3. RESULTS AND DISCUSSION

3.1. Results

3.1.1. *Processing of Robusta Green Bean Coffee*

Robusta wet coffee bean processing is carried out using the dry method. Wet coffee beans that have been dried are peeled using a huller machine. This machine will produce rice or green bean coffee. Rice coffee is a green bean with its epidermis removed (Henza, 2015). This rice coffee will then be carried out in the roasting process. The color of the Robusta coffee beans shown in Figure 4a indicates that the coffee beans need to be appropriately roasted.

Meanwhile, the color of the Robusta coffee beans in Figures 4b, 4c, 4d, 4e, and 4f shows that the resulting color is getting darker and indicates that the coffee beans have been roasted perfectly. The temperature and roasting time affect the color of the coffee beans produced. The higher the temperature and the longer the roasting time, the color of the coffee beans becomes brownish and darker.

(a) (b) (c) (d) (e) (f)

Figure 4. Robusta Coffee Beans After Roasting (a. Temperature 170 °C for 10 minutes; b. Temperature 170 °C for 15 minutes; c. Temperature 180 °C for 10 minutes; d. Temperature 180 °C for 15 minutes; e 190°C for 10 minutes f. 190°C for 15 minutes).

3.1.2. *Phytochemicals*

Robusta ground coffee samples contained secondary metabolites: alkaloids, flavonoids, saponins, and tannins. The following are the results of the phytochemical test (Table 1).

Table 1 Phytochemical results of robusta ground coffee

Sample Name	Parameter					
	Alkaloid			Flavonoid	Saponin	Tanin
	Wagner	Mayer	Dragendorff			
170 °C, 10 minute	+++	+++	-	+	+	++
170 °C, 15 minute	++	++	-	+	+	++
180 °C, 10 minute	++	+	-	+	+	+++
180 °C, 15 minute	++	++	-	+++	++	+++
190 °C, 10 minute	++	+	-	++	++	++
190 °C, 15 minute	++	++	-	+++	+	+++
Brand A	+	+	-	++	+	+++
Brand B	++	+	-	++	++	+++
Without Roast	+++	+	-	+	+	+++

Information :
+++: Very concentrated
++ : Thick
+: Less dense
-: Not detected

3.1.3. *Moisture Content*

The ground coffee moisture content shows that the higher the temperature and the longer the roasting time, the lower the moisture content (Figure 5). The following is the moisture content of ground coffee samples (Figure 5).

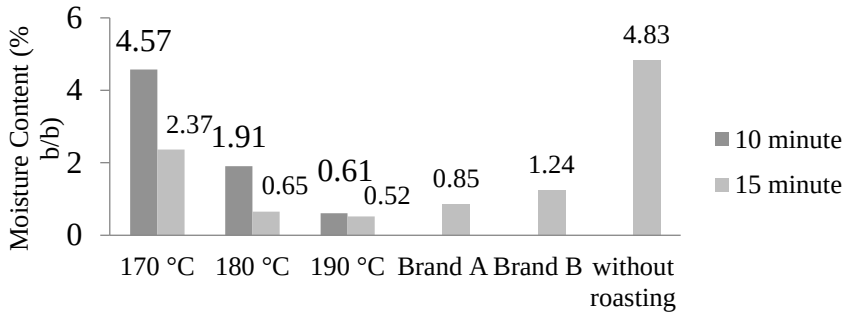

Figure 5 Moisture Content of Ground Coffee

3.1.4. *Caffeine Levels*

The spectrophotometric method can analyze caffeine content in Robusta coffee. From the observations, it can be seen that caffeine is detected in the UV region, namely at a wavelength of 275 nm. The wavelength that produces the highest absorbance value can be seen based on the maximum wavelength. The following are the maximum wavelengths of caffeine (Figure 6). The regression equation obtained from the caffeine standard is y = 0.0498x - 0.0017, with a correlation coefficient of 0.9979. The correlation coefficient value obtained was stated to be suitable for caffeine standards, which was above the minimum limit (of > 0.9900) (AOAC, 2005) (Figure 6).

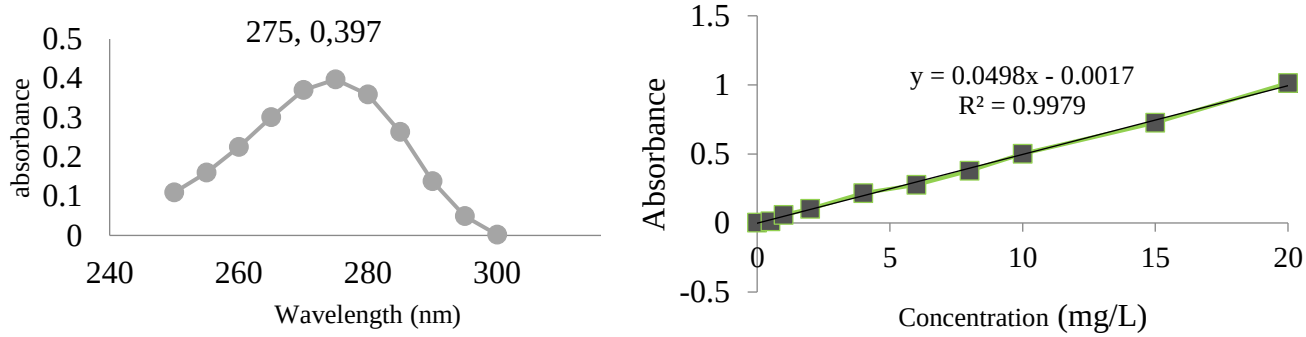

Figure 6 Caffeine Maximum Wavelength and Caffeine Standard Curve

It can be seen that the higher the temperature and the longer the roasting time, the less caffeine content will decrease. The caffeine content of the ground coffee sample can be seen in Figure 7.

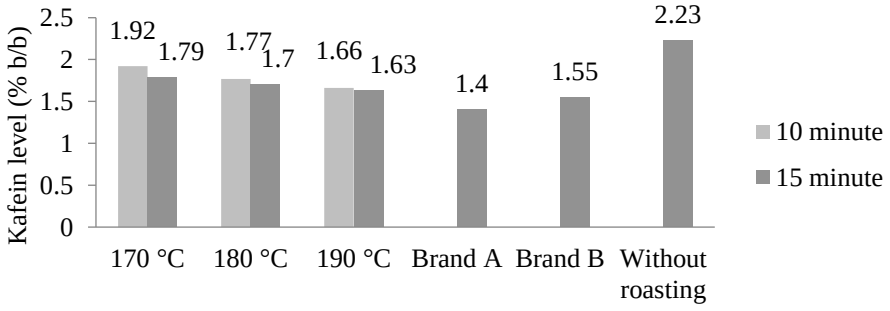

Figure 7 Ground Coffee Caffeine Levels

3.1.5. *Degree of Acidity (pH)*

The pH of ground coffee obtained ranged from 5.02 - 6.58. A green bean has a pH value classified as acidic, namely 5; with increasing temperature and roasting time, the pH gets closer to neutral. In the samples from brands A and B, the resulting pH was similar to that of roasted ground coffee (Figure 8). The following is the pH of ground coffee (Figure 8).

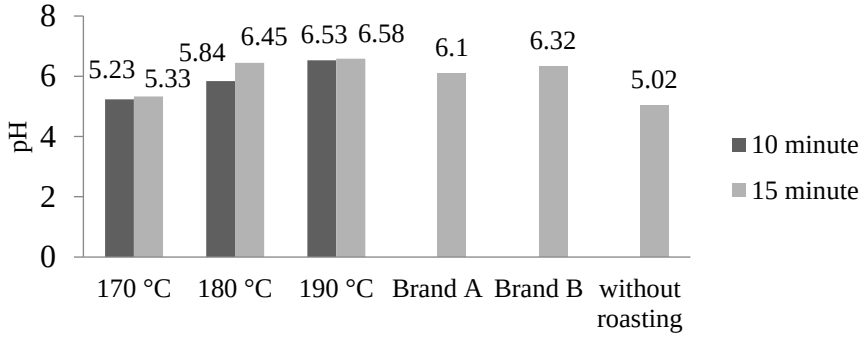

Figure 8 The pH of Ground Coffee

3.1.6. *Coffee Content*

Based on the observations, it was found that ground coffee was roasted at a temperature of 180 °C for 15 minutes, 190 °C for 10 minutes, and 15 minutes. Brand A and B followed SNI 01-3542-2004 with the requirements in the 20 - 36% w/b. The resulting juice content is not included in the requirements for the roasted ground coffee at 170 °C for 10 minutes, 170 °C for 15 minutes, and 180 °C for 10 minutes, and non-roasted samples (green bean). Ground coffee extract levels can be seen in Figure 9.

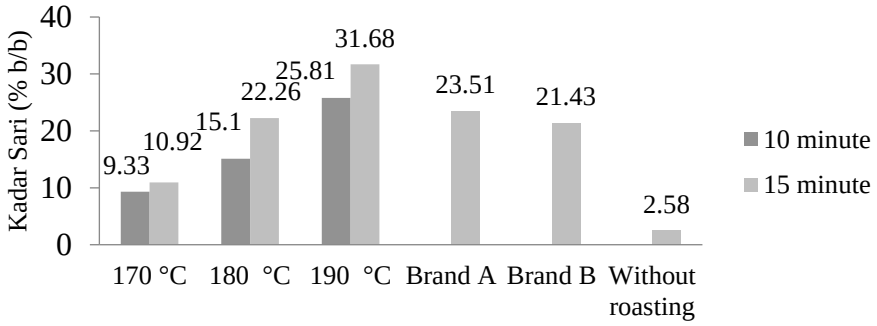

Figure 9 Levels of Ground Coffee Extract

3.1.7. *Ash Content*

The resulting ash content ranges from 3.61-21.81% w/w. Ash content in ground coffee roasting results at 190 °C for 10 minutes and 190 °C for 15 minutes; brands A and B have ash content following SNI 01-3542-2004 with a maximum limit requirement of 5% w/w. In-ground coffee roasting at 170°C for 10 minutes, 170°C for 15 minutes, 180°C for 10 minutes, and 180°C for 15 minutes, and without roasting, the resulting ash content is not included in the requirements. The following is the ash content of robusta ground coffee (Figure 10).

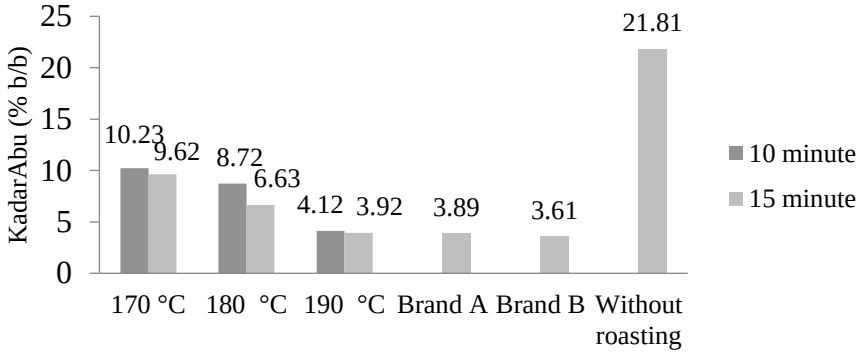

Figure 10 Ash content of ground coffee

3.1.8. *Microbial contamination*

The microbial contamination value was measured using the total plate number and the molding rate. Both values affect the quality of a food sample; the higher the value of both, the worse the food quality. The analysis of microbial contamination showed that the roasted ground coffee, coffee brand A and brand B complied with SNI 01-3542-2004 with the maximum limit requirement of the total plate number of 10^6 and 10^4 colonies/g of mold. The following is the result of microbial contamination of Robusta ground coffee (Table 2).

Table 2 Results of robusta ground coffee microbial contamination

No.	Sample	Microbial Contamination Analysis	Observation Results (colonies)	Yield (colony/g)
1.	Brand A	ALT	0	99,89
		AK	1	9,99
2.	Brand B	ALT	0	99,50
		AK	1	9,95
3.	Without roasting	ALT	TBUD	TBUD
		AK	TBUD	TBUD
4.	170, 10 minute	ALT	88	8230
		AK	19	178
5.	170, 15 minute	ALT	8	751
		AK	13	122
6.	180, 10 minute	ALT	5	500
		AK	11	110
7.	180, 15 minute	ALT	4	386
		AK	14	135
8.	190, 10 minute	ALT	2	190
		AK	10	95
9.	190, 15 minute	ALT	3	295
		AK	11	109

Information:
ALT: Total Plate Number
AK: Mold Number
TBUD: Cannot Be Counted

3.2. Discussion

3.2.1. *Processing of Robusta Green Bean Coffee*

The dry method was chosen because the process is relatively simple. The dry method is done by directly drying the peeled Robusta coffee beans using sunlight for 14 days (Gafar, 2018). The roasting process uses a stainless-steel pan because it is a better conductor of heat than a clay pan. Heat transfer from the heat source (stove) to the pan is faster than from the pan to the ingredients, resulting in faster water evaporation from the ingredients into the air. However, stainless steel pans can cause case hardening, where the material outside (surface) is dry while the inside is still wet (Siregar et al., 2020).

The temperature and roasting time affect the color of the coffee beans. The color of the coffee beans will turn brown and get darker due to the high temperature and roasting time. The higher the temperature and the longer the roasting time, the color of the coffee beans becomes brownish and darker. This condition is because the factors that affect the Maillard reaction are temperature and heating time. The higher the temperature and the longer the roasting time, the easier the Maillard reaction will occur (Herlina, 2022). The Maillard reaction is a non-enzymatic browning reaction that occurs due to a reaction between reducing sugars and free amine groups from amino acids or proteins (Agustina et al., 2019). After roasting, coffee beans are milled using a blender and filtered with a sieve size of 60 mesh. This size was chosen because ground coffee produced at 40 mesh comes from coarse grinding (Edowai, 2019).

3.2.2. *Phytochemicals*

Positive test results on two of the three reagents indicate a sample containing alkaloids (Harborne, 1987). The results of the phytochemical test showed that the higher the temperature and the longer the roasting time, the less the intensity of the resulting color. The results of this qualitative test follow the statement of Panggabean (2019), which states that the decrease in caffeine content after roasting is caused because some of the caffeine will sublimate into caffeine. Caffeine is an alkaloid compound found in coffee that can inhibit the growth of bacteria. The caffeine content in Robusta coffee is 1.6% - 2.4% (Sumantri et al., 2021). The roasted samples and positive brands contain flavonoids. The higher the temperature and the longer the roasting time, the resulting color intensity is almost the same. Flavonoids found in coffee are catechins (Fadhilah et al., 2021). Flavonoids are secondary metabolites that have the potential as antioxidants and positively correlate with diabetes therapy (Shiyan et al., 2017).

Ground coffee samples from roasting and positive brands contain tannins. From the observations, it can be seen that the higher the temperature and the longer the roasting time, the resulting color intensity is almost the same. This result is because chlorogenic acid, included in the class of tannin compounds, has unstable properties at high temperatures (Azizah et al., 2019). Coffee is a rich source of phenolic compounds, especially chlorogenic acids, amino acids, and reducing sugars (Xu et al., 2012). Chlorogenic acid contained in Robusta coffee is around 7-10%, and Chlorogenic acid has high antioxidant activity (Wiranata, 2016). Saponins in robusta coffee are cafestol and kahweol (Azizah et al., 2019). Saponins are surface-active compounds with the same properties as soap so that they can cause foam. Plant saponins work as anti-microbial, inhibiting bacteria and fungi growth (Rabani RS & Fitriani, 2022).

3.2.3. *Moisture content*

The moisture content in the material determines the resistance to attack by microorganisms (Purnamayanti et al., 2017). The lower the moisture content of ground coffee

produced, the higher the ground coffee's durability because it can increase the resistance of ground coffee to damage caused by microorganisms. This result follows the statement of Lestari et al. (2018) that the more significant the temperature difference between the heating medium and the food, the faster the heat transfer to the food and the faster the evaporation of water from the food. Changes in the mass of water will occur when the moisture content in the material has reached a saturated condition, causing the water in the material to change from the liquid phase to vapor (Edvan et al., 2016). The resulting moisture content ranges from 0.52-4.83% w/w. The moisture content produced in all samples according to SNI 01-3542-2004 with a maximum limit of 7% w/w. The moisture content of rice coffee (green bean) is the highest, with a moisture content of 4.83% w/w. This is due to rice coffee (green bean) being dried in the sun for 14 days and immediately milled so that the moisture content in the sample is still high.

3.2.4. *Caffeine Levels*

This study used the spectrophotometric method to analyze caffeine levels because it is more efficient than the HPLC method. The spectrophotometric method was chosen because the concentration of caffeine in Robusta coffee is high, which is in the range of 2.26 g/100 g, higher than in Arabica coffee, which is 1.61 g/100 g (Azizah et al., 2019). This condition follows the statement of Heriana et al. (2023), which states that the decrease in caffeine content after roasting is caused because some of the caffeine will sublimate into caffeine. The caffeine content obtained ranged from 1.40 – 2.23% w/w. Caffeine levels in coffee brands A and B are lower than in the roasted samples due to the method of processing coffee brands that have been added with additional ingredients during roasting, such as rice, sticky rice, and corn, which will cause lower caffeine levels (Yulia et al., 2016).

Caffeine levels were produced in all samples of ground coffee roasted according to SNI 01-3542-2004 with a range of 0.9-2% w/w except for rice coffee (green bean) without roasting treatment a caffeine content of 2.23% b /b. This condition is because green beans are directly milled and not roasted, which causes the level of caffeine in this sample to be still high. This result follows Aulia (2010) that robusta coffee beans produce caffeine levels of 1.5 - 2.5% w/w before roasting. Varieties influence the high and low levels of coffee caffeine. The caffeine content in the Robusta coffee variety after roasting is relatively high, namely 2% w/w (Pradipta & Fibrianto, 2017).

3.2.5. *Degree of Acidity (pH)*

According to Panggabean (2019), the carboxylic acid content in Robusta coffee beans is 1.6%. Types of carboxylic acids in coffee beans include formic acid, acetic acid, citric acid, pyruvic acid, lactic acid, malic acid, and quinic acid. Acids that form sour taste components are acetic acid, malic acid, citric acid, and phosphoric acid. The acids contained in coffee affect the degree of acidity.

This decrease in acidity is due to the evaporation of some acids when the coffee is roasted. This condition follows Gafar (2018) that coffee beans naturally contain volatile compounds such as aldehydes, furfural, ketones, alcohols, esters, formic acid, and acetic acid, which have volatile properties. Changing the pH value can monitor chemical changes in coffee beans during roasting. The longer and higher the roasting temperature, the number of free H+ ions in the brew is significantly reduced (Sulistyowati, 2002).

3.2.6. *Coffee Content*

Ground coffee extract content shows the substance dissolved in water during brewing (Edowai, 2019). Substances dissolved in water during brewing affect the taste of brewed

coffee. The coffee content obtained from several treatments showed that the higher the temperature and the duration of roasting, the higher the coffee content in ground coffee. The higher the temperature and duration of roasting, the higher the value of ground coffee content. Extract content is closely related to particle size and surface area. The substance dissolving in water during brewing will increase if the surface area is expansive. A good taste will be related to the coffee's finer grind. The finer the grind, the better the taste produced from the brew. According to Gloess et al. (2014), the finer the coffee particles, the easier it is to remove the ground coffee components.

Samples from roasting with coffee content are not included in the requirements because the water used has a temperature of less than 95 °C. This result can cause the coffee's components not completely to dissolve in water, so the coffee content in Robusta ground coffee is low and does not meet the requirements. This condition relates to solubility factors: temperature, time, and surface area. Temperature and extraction time are factors that affect the extraction rate. The extraction rate will increase as the extraction temperature increases in the extraction process. In addition, the length of contact with the solvent will increase the solubility of the material to be extracted. After that, the extraction speed also increases (Ramadhan & Phaza, 2013). Reducing the particle size aims to expand the material's surface to accelerate the solvent's penetration into the extraction material (Tambun et al., 2016).

3.2.7. *Ash Content*

Ash content shows the amount of material contained in a material (Gafar, 2018). The material content in coffee can be elements needed by plants for growth. This result is because the ashing process is imperfect, so not all samples become ashes. According to Estiasih and Ahmadi (2011), the characteristics of perfect ashing can be seen from the process of ashing the sample until it is grey to white and free from residual samples that are not burned. This condition can still cause high ash content in the treatment sample.

Ash content in Robusta ground coffee decreased with higher temperature and roasting time. According to Aisah et al. (2021), the ash content increases because the longer the time and the higher the drying temperature, the more water will evaporate from the material. Samples with high moisture content will evaporate more water. Erni et al. (2018) that the ash content depends on the type of material, the method of ashing, and the time and temperature used for drying. The longer the time, the higher the drying temperature will increase the ash content because the water from the material is high. The high ash content in green beans is caused by not roasting, so the impurities present in the samples are still high. According to Palungan et al. (2018), differences in coffee ash content are caused by several factors, including coffee quality. High ash content indicates the quality of food that is less clean (Edowai, 2019).

3.2.8. *Microbial contamination*

Green bean (without roasting) has the highest microbial contamination results because both ALT and AK have results that cannot be calculated. This result is because green beans (without roasting) are not roasted, so the resulting moisture content is still high at 4.83% w/w. This condition causes the results of microbial contamination to be still high. Purnamayanti et al. (2017) state that the moisture content in the material determines the resistance to attack by microorganisms. The results of microbial contamination for samples brand B, ALT, and AK had the best results compared to those for brand A and roasted ground coffee. The results of microbial contamination were better in samples from brand A and brand B compared to roasted ground coffee. Ground coffee at 190 °C for 10 minutes was the best microbial contamination because ALT and AK produced the lowest number of colonies, namely 190 colonies/g and 95 colonies/g, compared to other roasting samples. Ground coffee roasted at

190°C for 15 minutes experienced more colonies than at 190°C for 10 minutes. This result is due to the less sterile coffee packaging process, which allows the growth of microorganisms on ground coffee which causes the number of colonies to increase.

The growth of mold on food ingredients and traditional medicinal raw materials can reduce the quality of food or traditional medicines to produce toxins that are harmful to the human body. Certain types of mold can produce toxins, namely mycotoxins. Mycotoxins are secondary metabolites of molds that can cause toxic effects on humans and animals. One example is the aflatoxin produced by Aspergillus flavus. Aspergillus is saprophytic in soil and can contaminate essential commodities such as rice, cassava, nuts, and spices. Aflatoxin is one of the most toxic natural substances (Kusnadi & Putri, 2020).

4. CONCLUSION

The temperature and roasting time of Bogor robusta coffee at 190 °C for 10 minutes gave the best results for several test parameters (moisture content, caffeine levels, pH, coffee content, ash content, and microbial contamination). The quality results obtained are to the requirements set by SNI 01-3542-2004. The quality of roasted ground coffee is the same as branded ground coffee. It is recommended that coffee producers use optimal roasting temperature and duration to improve the quality of their coffee products.

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