

## Physicochemical and sensory analysis of mangrove seed coffee (*Sonneratia ovata*) compare with robusta coffee from Indonesian origin

Suryono, M. and \*Sumartini

College of Fishery Harvest Processing, Politeknik Kelautan dan Perikanan Dumai, Dumai 28826 Indonesia

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### Abstract

Coffee is a global drink for millennials. Indonesia is one of the countries with the most significant coffee consumption in the world. The main problem with coffee consumption is the caffeine content, many researchers are looking for alternative coffee drinks that do not contain caffeine, one of which is mangrove fruit seeds. Caffeine can be removed during roasting, but over-roasting produces unwanted sensory impacts on coffee. This study aimed to determine mangrove coffee beans' sensory characteristics and caffeine content to compare with robusta coffee as commercial coffee. In addition, it is also necessary to monitor changes in the properties of the mixture of Robusta coffee beans and mangrove seeds during the roasting process in real-time. The method used was a randomized block design, using two factors, commercial coffee (C) and mangrove seed coffee (M), and 3 test levels, light (L) at 193°C to 199°C, medium (M) at 204°C and dark roast (D) at 213°C to 221°C. Analysis of data using Analysis of variance (ANOVA). Significantly different test results were then tested using Duncan's advanced test. Data processing was carried out using SPSS Version 28 software. The results showed that the sensory characteristics of commercial coffee (Robusta) were preferable to mangrove coffee, but the impact of caffeine could be eliminated by consuming mangrove coffee. The degree of roasting greatly affects coffee's sensory and chemical quality, with the best results obtained in commercial coffee roasted at a medium level (M) at 204°C. The comparison results showed that the characteristics of coffee between commercial coffee (Robusta) and mangrove coffee have phenol content, total acid, and proximate and sensory values close to commercial coffee. However, the caffeine content is not found in mangrove coffee, so coffee connoisseurs can use mangrove coffee because it can be used as an alternative to coffee drinks without giving the effect of caffeine addiction.

## 1. Introduction

Nowadays, drinking coffee has become a lifestyle for the millennial generation, not just a drink to relieve drowsiness. This is reflected in the proliferation of cafes or shops selling drinks made from brewed coffee grounds throughout the archipelago. According to data from the International Coffee Organization (ICO), Indonesia is one of the countries with the most significant coffee consumption in the world. In 2016/2017, Indonesia's coffee consumption reached 4.6 million packs of 60 kg/lb (60 kg), ranking the sixth country with the most significant coffee consumption in the world after Russia. At the same time, the most significant coffee consumption in the world is in countries that are members of the European Union, with a consumption of more than 42.6 million lb (60 kg). During the 2016-2021 period, Indonesia's coffee

consumption is predicted to grow by an average of 8.22% per year. In 2021, the coffee supply was expected to reach 795 thousand tons with a consumption of 370 thousand tons, resulting in a surplus of 425 thousand tons.

Meanwhile, South Sumatra is the largest producer of Robusta coffee in Indonesia. According to data from the Ministry of Agriculture, coffee production in this province reaches 184,168 tons, all of which are Robusta. This production is about a quarter of the national coffee production, reaching 722,461 tons consisting of 528 thousand tons of Robusta and 195,000 tons of Arabica (Ministry of Agriculture, 2019).

During the last few years, there has been an increasing interest in evaluating various mangrove fruits of the *Sonneratia* sp. species regarding their function and

\*Corresponding author.

Email: [tinny.sumardi@gmail.com](mailto:tinny.sumardi@gmail.com)

nutritional value as food ingredients (Sumartini *et al.*, 2020). Fruits are rich in antioxidants that help lower the incidence of degenerative diseases such as cancer, arthritis, and the aging process. In addition to providing nutritional properties, this edible mangrove fruit can also function as a natural antioxidant. Reports on antioxidant activity in mangroves applied to food have been carried out (Sumartini and Ratrinia, 2022). Robusta coffee contains more than 1,000 bioactive substances (Gonzalez *et al.*, 2014). Based on Olechno *et al.* (2021), Robusta coffee dry weight, polysaccharides (50-55% and 37-47%), oligosaccharides (6-8% and 5-7%), lipids (12-18% and 9-13%), proteins (11-13%), chlorogenic acids (5.5-8% and 7-10%), minerals (3-4.2% and 4-4.5%), fatty acids (1.5-2%), caffeine (0.9-1.2% and 1.6-2.4%), trigonelline (1-1.2% and 0.6-0.8%) and free amino acids (2%). Caffeine is one of the unwanted substances in coffee. Approximately 0.3-0.5 mg caffeine/100 g has been reported in decaffeinated roasted coffee (Fujioka and Shibamoto, 2008).

Mangrove ecosystems are distributed throughout the Indonesian Archipelago (Noor *et al.*, 1999), especially along the east coast of Sumatra, the north coast of Java, the west and east coasts of Kalimantan, protected bay landscapes in Sulawesi, small islands in Maluku, and South Coast of Papua. Mangroves grow in muddy coastal landscapes, sheltered bays, deltas, and small islands. During the last few years, there has been an increasing interest in evaluating various mangrove fruits of the *Sonneratia* sp. species regarding their function and nutritional value as food ingredients (Sumartini *et al.*, 2020). Fruits are rich in antioxidants that help lower the incidence of degenerative diseases such as cancer, arthritis, and the ageing process. In addition to providing nutritional properties, this edible mangrove fruit can also function as a natural antioxidant. Reports on antioxidant activity in mangroves applied to food have been carried out (Sumartini and Ratrinia, 2022). Robusta coffee contains more than 1,000 bioactive substances (Gonzales *et al.*, 2014). Based on Olechno *et al.* (2021), Robusta coffee dry weight, polysaccharides (50-55% and 37-47%), oligosaccharides (6-8% and 5-7%), lipids (12-18% and 9-13%), proteins (11-13%), chlorogenic acids (5.5-8% and 7-10%), minerals (3-4.2% and 4-4.5%), fatty acids (1.5-2%), caffeine (0.9-1.2% and 1.6-2.4%), trigonelline (1-1.2% and 0.6-0.8%) and free amino acids (2%). Caffeine is one of the unwanted substances in coffee. Approximately 0.3-0.5 mg caffeine/100 g has been reported in decaffeinated roasted coffee (Fujioka and Shibamoto, 2008).

The choice of robusta coffee beans over Arabica as a comparison is because Robusta coffee has advantages in terms of its characteristics of being disease-resistant and

having the strongest aroma and taste among other types of coffee (Kuswardhani *et al.*, 2019). Robusta are cheaper to grow because they are more resistant to disease. Moreover, it can survive in warmer climates (prefer temperatures between 23°C and 30°C) according to the climate in Indonesia. Robusta also has a higher caffeine content when compared to Arabica (182 mg caffeine/100 g green coffee) than in Arabica green coffee (154 mg caffeine/100 g green coffee) (Caracostea *et al.*, 2021). According to Skowron *et al.* (2016), Robusta coffee extract showed significantly higher antioxidant activity results in the Folin-Ciocalteu test than Arabica extract. Thus, it can be explained that Robusta coffee steeping contains the highest content of chlorogenic acid, caffeine, and antioxidant activity. In addition, the most preferred type of coffee in Indonesia, especially in Sumatra, is Robusta coffee. According to Pane and Khaliqi (2022), North Sumatra coffees have received the Geographical Indication certification compared to other regions in Indonesia. Among the 18 types of speciality coffees, seven types have procured the Geographical Indication certification, and 1 type is in the process of being certified, in which from the most favored by consumers are Sidikalang Robusta Coffee, Sumatera Mandheling Arabica Coffee, Sumatera Simalungun Arabica Coffee, Tanah Karo Arabica Coffee, Sipirok Arabica Coffee, Sumatera Lintong Arabica Coffee, Pulo Samosir Arabica Coffee, and North Tapanuli Arabica Coffee.

According to Reta *et al.* (2017), coffee is widely consumed not only because of its distinctive taste but coffee has antioxidant properties due to its polyphenols and produces perception and brain performance. The main problem with coffee consumption is its caffeine content. When consumed excessively, caffeine can increase muscle fatigue, heart disease risk, and gastric acid secretion (Gonzales and Ramirez, 2014). Based on scientific evidence, moderate caffeine consumption is currently recommended by the EFSA Panel on Dietetic Products, Nutrition and Allergies (NDA) (2015), Food and Drug Administration (FDA, 1959), and Scientific Committee for Food (SCF) (1983) to maintain health by consuming caffeine within safe limits. However, acute toxic effects of caffeine associated with excessive intake may occur. The first studies of caffeine toxicity were carried out in the 19th century, initially with animals (Mulder, 1838) and soon after, with humans (Lehman, 1850) reporting some symptoms after acute oral administration of 2 to 10 g of caffeine. Such poisoning results in 'caffeinism,' which refers to a syndrome characterized by various adverse reactions, for example, restlessness, nervousness, anxiety, irritability, shaking, muscle tremors, insomnia, headache, diuresis, tachycardia, arrhythmias, irregular pulse, increased

frequency, increased respiration and gastrointestinal disturbances (e.g., nausea, vomiting, diarrhea) (James, 1991), especially at doses of about 80 mg/kg body weight (Arnaud *et al.*, 2005). According to Papatungan *et al.* (2017), the weakness of using mangrove fruit other than *Sonneratia* sp. species is that it cannot be consumed directly because of the high tannin content, while *Sonneratia ovata* fruit can be consumed directly. *Sonneratia ovata*, a type of mangrove, is non-toxic, does not require special handling, and can be eaten immediately. Young fruit with a sour taste can be eaten directly and made into syrup.

Caffeine can be reduced during the production of ground coffee, but the roasting and cooling stages require precise controls to avoid overcooking the coffee. Burned coffee beans will taste bitter (Sunarharum *et al.*, 2014). Burnt coffee beans will produce a bitter taste. The ideal roasting process is very complicated because different methods will have other qualities of coffee. The roasting rate is controlled by roasting temperature and time. The distinctive taste and sensory qualities of the world's coffees vary widely due to differences in genetic strain, geographic location, agricultural practices, climate, and variations in the processing methods applied. The desired coffee aroma has developed completely, and the color of the beans when the roasting stage is homogeneous. Therefore, control activities during the roasting process are essential to stop the roasting process properly. This study aimed to determine the sensory characteristics and roasting level of mangrove coffee beans that are important during the roasting process. Control of the roasting process is carried out by creating a method to evaluate the coffee roasting degree in real-time. The roasting process can be assessed, including physical, physicochemical, and chemical composition changes. In addition, it is also necessary to monitor changes in the properties of the mixture of robusta coffee beans and mangrove seeds during the roasting process in real-time.

## 2. Materials and methods

### 2.1 Sample preparation

The Robusta coffee originates from Sumatera (altitude 600-700 m a.s.l) in Indonesia. The coffee beans are picked manually and sorted according to visual maturity, raw (green), half-ripe (yellow-orange), ripe (full red), and mature (red-brown). The material used in the study was Robusta coffee beans harvested from Lubuk Bigau, Kampar, Sumatera. The coffee bean specification matches SNI 2907-2008 (SNI, 2008) on the coffee bean. Coffee bean was classified based on their type and roasting method. At the same time, mangrove seeds (*Sonneratia ovata*) are obtained from Bandar

Bakau, Dumai City, Riau Province. Mangrove fruit seeds are from ripe mangrove fruits, waste from the production of pedada fruit syrup.

Coffee beans are roasted on a medium to dark roast level. The roasting machine (SC 2.5 Kg) is set with an initial temperature of 180°C then, followed by degrees of roasting, a light roast at 193°C to 199°C, a medium roast (M) at 204°C, and dark roast (D) at 213°C to 221°C (Abubakar *et al.*, 2021). Roasting is done for 10 mins. Coffee and mangrove beans were cooled to room temperature, then ground and sieved 60 mesh. Coffee grounds are stored in aluminum foil packaging until further processing (Ni'mah *et al.*, 2021). The equipment used is an analytical balance, oven, Soxhlet, and UV-Vis Spectrometer

### 2.2 *Sonneratia ovata* flour production

The seed of *Sonneratia ovata* was peeled, and then sorting and removing the pistil was carried out. The next step was drying in an oven for 10 hrs (70°C). The fruit flour of *Sonneratia ovata* was blended for 3 mins. Sifting was done to get a soft texture using a sieve (filter size 60 -80 mesh).

#### 2.3.1 Moisture content

Moisture content was measured using the thermogravimetric method referring to The Association of Official Analytical Chemists (AOAC, 2005) method. Two grams of samples were weighed and dried. The cup used in the measurement was dried in an oven (Memmert UN55) at a temperature of 100-105°C. After that, it was cooled in a desiccator and weighed. The sample was heated in the oven for 30 mins, cooled in a desiccator, cooled in the oven for 30 mins, and cooled in a desiccator. The calculation treatment was as follows.

$$\text{WC (\%)} = (\text{Initial weight-final weight})/(\text{final weight}) \times 100\%$$

#### 2.3.2 pH

The pH was determined by a calibrated pH meter with a glass electrode (Starter 5000, OHAUS, USA) for an extract of 2.25 g of ground coffee in 50 mL of water at a temperature of 80°C, which was then brought to room temperature to perform the measurement (Mazzafera, 1999). pH was measured in the solution. A total of 10 g of ground coffee was weighed and placed in an Erlenmeyer flask, added with 100 mL of distilled water at a temperature of 25°C. After adding the water, the content was mixed in an electronic agitator for 30 mins. The contents were placed in a beaker, left to rest for 10 mins, and pH was measured.

### 2.3.3 Phenol content

The phenolic component (total phenol) was tested using thermogravimetry, referring to Purbowati *et al.* (2018) with ethanol modification to the solvent. Gallic acid was used as the standard. This method's principle combines 0.1 mL of the test solution with 2.0 mL of 2% Na<sub>2</sub>CO<sub>3</sub>. After 2 mins, 0.1 mL 50% Folin Ciocalteu reagent was added, and the mixture was incubated for 30 mins at room temperature. After that, the absorbance was measured using a UV-Vis spectrophotometer (UV-VIS AMV11) with a wavelength of 750 nm. A standard curve was created by replacing the sample with various concentrations of the common solution prepared previously.

### 2.3.4 Caffeine content

Caffeine was extracted from 1 g of the sample, dissolved in 150 mL of hot distilled water, and then filtered. The filtrate was taken and put into a separating funnel and was added with 1.5 g of CaCO<sub>3</sub> and extracted four times with 25 mL of chloroform each. The extract was evaporated using a rotary evaporator until the chloroform was evaporated, and the remaining caffeine extract was diluted ten times using distilled water. The solution was then measured for its absorbance using a UV-Vis (UV-VIS AMV11) Spectrophotometer at the maximum wavelength (Fajriana and Fajriwati, 2018).

### 2.3.5 Sensory analysis

Coffee taste testing (cup testing) was done by roasting commercial coffee beans (C) and mangrove (M) at light (L), medium (M), and dark (D) levels and processed into ground coffee according to procedures that refer to Specialty Coffee Association of America (SCAA) standards (2015). The assessment of the sensory attributes of coffee was carried out by three trained panelists, including aroma, flavor, aftertaste, acidity, body, balance, uniformity, sweetness, clean cup, and overall. Panelists assessed each sensory attribute with a score of 6.00 to 6.75 (good), 7.00 to 7.75 (very good), 8.00 to 8.75 (excellent), to 9.00 to 10 (outstanding). The final score was obtained by adding up the scores for each attribute.

## 2.4 Statistical analysis

The research used a factorial randomized block design (RBD) experimental design method with a 5% test level. The variables used in this study were differences in materials (robusta coffee and mangrove seed coffee). The parameters tested were the comparable value, caffeine, pHenolic, pH, and sensory attribute analysis.

## 3. Results and discussion

The choice of Robusta coffee beans over Arabica as a comparison was done because it has advantages in terms of its characteristics of being disease resistant and having the strongest aroma and taste among other types of coffee (Kuswardhani *et al.*, 2019). Robusta is cheaper to grow because they are more resistant to disease and can survive in warmer climates (prefers temperatures between 23°C and 30°C). Sensory attributes are the most critical parameters in coffee production. The purpose of evaluating sensory attributes was to determine the level of consumer acceptance; then, the organoleptic test used panelists (trained panelists) who were considered to have sensitivity and were often used to assess the quality of types of food to measure the shelf life of food products. Aromas and odors in food are reactions from food that can affect consumer preference before enjoying food by smelling the food. The flavor is an attribute of food, drink, and spices, which results from stimulating all the senses when food passes through the food and respiratory tract, especially taste and smell. Taste is a sensation produced by food and other chemical components when stimulating receptors in the sense of taste on the tongue. Food texture results from a material response to physical stimulation when there is contact between the inside of the oral cavity and food (Sari and Yohana, 2015). According to the (SCAA, 2015) standard on the quality of brewing coffee, the sensory attribute parameters of coffee observed include odor, flavor, aftertaste, acidity, balance, clean up, sweetness, and the overall average value. Based on the results shown in Table 1, the general level of consumer preference was for the treatment of commercial coffee roasted at the medium level (MC) with an overall value of 85.41±0.130. Compared to the level of appreciation for coffee on mangrove beans, panelists tend to prefer Robusta coffee. This was possible because Robusta coffee has many aromatic volatile compounds that form aroma and flavor that mangrove coffee does not have. However, based on the literature, mangrove coffee is superior in health because it does not have caffeine-like Robusta coffee. Volatile compounds from green coffee beans decrease with the increasing intensity of roasting conditions. According to Yu *et al.* (2021), the higher the roasting temperature and the longer the roasting time, the higher the 2,20-methylene-bis-furan, guaiacol, and 4-ethyl guaiacol and the lower the furfural concentration. In contrast, the chemical aroma produced by the Maillard reaction increased under higher roasting conditions.

Figure 1 shows mangrove seed coffee powder and *Sonneratia ovata* fruit which produces seeds as raw material for mangrove coffee and mangrove coffee beans that have been roasted and mashed. Mangrove coffee

beans, after grinding, are similar to other commercial coffee beans. The appearance of ground coffee with mangrove seeds shows a reddish-black color, like commercial coffee. Factors that affect the color and appearance of mangrove coffee are the temperature and the length of the roasting of the coffee beans. The results of the sensory attribute parameters of coffee to determine the level of consumer acceptance are shown in Table 1. The results of water content (Figure 2), phenolic content (Figure 3), coffee ash content (Figure 4), pH content (Figure 5), and total acid (Figure 6) in mangrove coffee and commercial coffee roasted using three roasting levels, the caffeine content in mangrove coffee and commercial coffee was shown in Table 2.



Figure 1. Mangrove coffee powder and *Sonneratia ovata*.

### 3.1 Panelist score

The low level of panelists' score preference for Robusta coffee was higher because mangrove coffee beans are unfamiliar to the public's taste. The aromatic components of volatile flavor-forming compounds in mangrove coffee beans are less than in Robusta coffee. The flavor produced in coffee can come from the degradation and formation of chemical compounds resulting from the Maillard reaction, starch degradation, amino acid decomposition, trigonelline degradation, quinic acid, caffeine, chlorogenic acid, and lipids that occur during the roasting process. According

to Saloko *et al.* (2019), the higher the temperature and the roasting time of the coffee, the higher the value of brewing Robusta coffee. The higher the roasting temperature and time will accelerate the degradation and formation of other chemical compounds, such as caffeoyl, produced from caffeine compounds during the roasting process. Caffeine can act as a taste and aroma found in coffee in addition to chlorogenic acid, caffeine, and trigonelline. This was in line with Sunarharum *et al.* (2014) who reported that roasting on taste stems from the degradation and formation or release of various chemical compounds through the Maillard reaction, amino acid degradation, and decomposition trigon in degradation, *quinic acid*, and lipids. The use of high temperatures will accelerate the degradation process and the formation of chemical compounds that will affect the taste of coffee, such as caffeoyl, chlorogenic acid dissolved in water and trigonelline.

Based on the test results in Table 1 on the aroma parameter, the panelists prefer the aroma produced from robusta coffee (C) compared to mangrove seed coffee (M). Robusta coffee may be richer in aroma-forming volatile compounds than mangrove seeds. The volatile compounds in coffee include aldehydes, ketones, furfurals, esters, and alcohol. Meanwhile, when roasted coffee beans also produce a fragrant aroma. It differs from mangrove seeds which tend to have less volatile components than commercial coffee. Few studies have examined the use of mangrove coffee beans as raw material for coffee, so it has yet to be discovered what types of volatile compounds dominate mangrove coffee beans. This result was also shown in the coffee taste parameter, which shows that the panelists' preference for robusta coffee was higher than that for mangrove coffee. This was possible because mangrove coffee still needs to be familiarized with the Indonesian people who usually consume Robusta coffee. Even so, this result is

Table 1. Sensory attribute scores for mangrove coffee (M) and commercial coffee (C).

Sensory Attribute	Mangrove seed coffee (M)			Commercial coffee (C)		
	LM	MM	DM	LC	MC	DC
Odor	7.90±0.105	7.98±0.110	7.88±0.100	7.95±0.116	8.05±0.188	7.90±0.880
Flavor	7.66±0.105	7.80±0.195	7.70±0.120	7.70±0.204	7.99±0.303	7.86±0.278
Aftertaste	7.56±0.220	7.76±0.121	7.50±0.009	7.65±0.262	7.86±0.485	7.66±0.254
Acidity	7.65±0.200	7.85±0.108	7.60±0.220	7.75±0.137	7.95±0.518	7.68±0.024
Body	7.60±0.100	7.90±0.115	7.65±0.205	7.70±0.129	8.00±0.129	7.75±1.374
Uniformity	10.00±0.00	10.00±0.000	10.00±0.000	10.00±0.00	10.00±0.000	10.00±0.00
Balance	7.58±0.132	7.77±0.100	7.62±0.215	7.68±0.165	7.58±0.220	7.78±0.612
Clean cup*	10.00±0.00	10.00±0.00	10.00±0.000	10.00±0.00	10.00±0.000	10.00±0.00
Sweetness*	10.00±0.00	10.00±0.00	10.00±0.000	10.00±0.00	10.00±0.000	10.00±0.00
Overall	7.69±0.124	7.87±0.105	7.72±0.218	7.78±0.160	7.98±0.227	7.68±0.602
Final score**	83.64±0.80	84.93±1.220	83.67±1.330	84.21±0.445	85.41±0.130	84.31±0.100

LM: Light Roasting Mangrove Coffee, MM: Medium Roasting Mangrove Coffee, DM: Dark Roasting Mangrove Coffee, LC: Light Roasting Commercial Coffee, MC: Medium Roasting Commercial Coffee, DC: Dark Roasting Commercial Coffee,

\* The parameters get the maximum score based on cup testing (applies to most other coffees).

\*\* Final score > 80 classified as a specialty class (SCAA, 2015).

insignificant because the panelists can still drink mangrove coffee with a similar acceptability value.

### 3.2 Moisture content

Based on Figure 2, the water content in mangrove coffee or commercial coffee at the same roasting degree treatment showed no significant difference ( $p < 0.05$ ), except for the "Dark" level roasting degree treatment. The longer the roasting time, the less water content will decrease. This was due to the high-temperature treatment during roasting, resulting in water evaporation in the mangrove seeds. The coffee roasting treatment at a light level showed no significant effect ( $p < 0.05$ ); this was possible because, at this temperature, the water content in the coffee beans was still trapped in the material. According to Bolka and Emire (2020), changes in the moisture content of coffee beans are seen during the roasting process. The moisture content of coffee beans roasted using the three types of roasting levels showed a significant difference ( $p < 0.05$ ) between the three roasting degrees and the type of roasting technology. The results ranged from 1.31% to 3.48%, higher for lighter roasts (Light) and lower for darker roasts (Dark). The lowest moisture content was obtained at the unclear roast degree for a longer roasting time. This was due to the loss of more water content due to high temperatures.

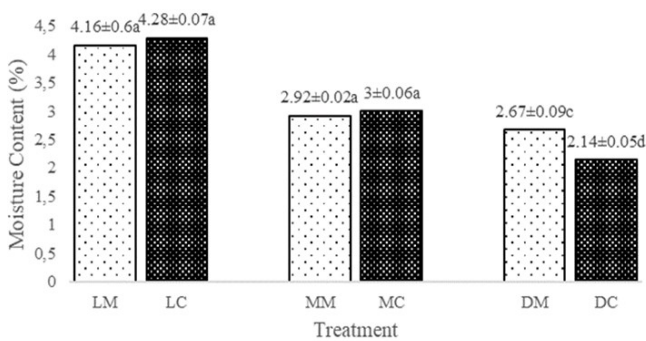


Figure 2. Bar chart of mangrove coffee's moisture content on coffee roasting degree. Values are presented as mean ± SD of triplicates. Values with different alphabets notations are statistically significantly different at the test level  $\alpha = 5\%$ .

### 3.3 Phenol value

Figure 3 shows the results of the phenol value in coffee during roasting. The phenol value during roasting decreased along with the increase in roasting degree. The thermal process can increase the release of phenolic in the extract. A fact that can be explained is that the intracellular extraction in coffee beans increases with the heating process. In addition, Wang *et al.* (2008) found that high temperatures increased the phenolic content due to polysaccharide hydrolysis. In addition, Sharanappa *et al.* (2016) reported that polyphenols from plants are responsible for antioxidant activity. Besides that, it is also essential to consider the effect of heat

treatment on the total phenol content because the thermal degradation results are highly correlated with the value of phenol reduction. Overall, the correlation analysis data revealed that heating for 5 mins resulted in a significant loss of phenolic compounds. Therefore, at a lower temperature, it will further suppress the rate of phenol breakdown. Thermal treatment will cause the dissolution of phenolic compounds and thus cause a decrease in total phenolic content.

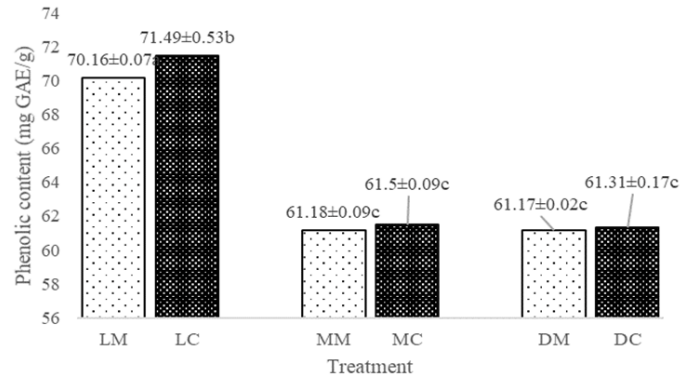


Figure 3. Bar chart of mangrove coffee's phenolic content on coffee roasting degree. Values are presented as mean ± SD of triplicates. Values with different alphabets notations are statistically significantly different at the test level  $\alpha = 5\%$ .

### 3.4 Ash content

Figure 4 shows the ash content of coffee in different roasting treatments. The highest ash content was obtained from coffee with a dark level roasting temperature of 213°C to 221°C in the range of 3.36-4.07% ash content, which means the ash content value was still within the normal range of ash content values. According to Conti *et al.* (2013), the average ash content of Arabica coffee ranges from 2.5-4.5%, while that of Robusta coffee was 4.64%. It is also possible to associate the mineral composition of coffee with nutritional status. According to Muller *et al.* (2013), when the ash content exceeds 5.00%, there may be many impurities in the sample. The value of ash content in mangrove seeds shows lower yields when compared to Robusta coffee

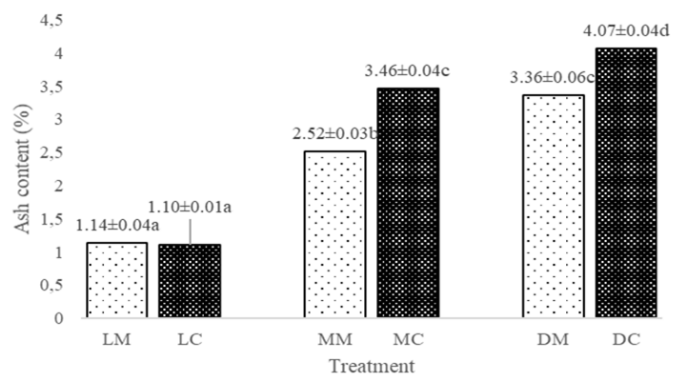


Figure 4. Bar chart of mangrove coffee's ash content on coffee roasting degree. Values are presented as mean ± SD of triplicates. Values with different alphabets notations are statistically significantly different at the test level  $\alpha = 5\%$ .

beans. The mineral component of Robusta coffee beans (commercial) may be higher than that of mangrove coffee beans. According to Pigozzi *et al.* (2018), some samples of roasted coffee contain heavy metals with content above the permissible level. Parameters such as coffee beans' species and origin can contribute to rich metal content variations.

### 3.5 pH value

Figure 5 shows that the pH value of roasting coffee with different levels showed a significant difference ( $P < 0.05$ ). The higher the temperature in the roasting process, the higher the pH value. The taste will be more bitter and reduce consumer preference for the aftertaste parameter (Table 1). Robusta coffee contains a lot of chlorogenic acids. During shorter roasting at lower temperatures, chlorogenic acid may be hydrolyzed, and the concentration of caffeic acid in Robusta coffee beans may increase temporarily.

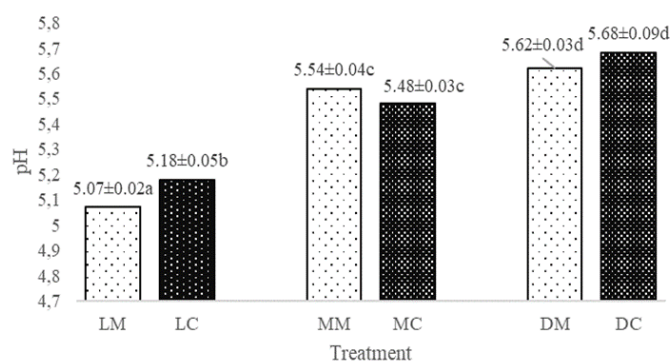


Figure 5. Bar chart of mangrove coffee's pH content on coffee roasting degree. Values are presented as mean $\pm$ SD of triplicates. Values with different alphabets notations are statistically significantly different at the test level  $\alpha = 5\%$ .

On the other hand, the longer the roasting time and the use of higher temperatures, caffeic acid is released from the chlorogenic acid and can be further degraded. There was a significant increase in the concentration of caffeic acid in the roasted coffee beans and a further reduction in the concentration of caffeic acid during the more extended roasting period. The formation of phenolic substances during coffee roasting can also be seen from the concentration of total phenolic compounds. According to Mehaya and Mohammad (2020), gallic and caffeic acids seemed to increase at the beginning of roasting time and decrease afterwards. Gallic acid reached its maximum at 160°C after 30 mins (0.384 mg/g), while caffeic acid reached its maximum at the same temperature after 20 mins. The same trend was observed at 180 and 220°C, but the maximum values were obtained after 20 and 10 mins for gallic and caffeic acids, respectively. This could be because, during roasting, chlorogenic acid slowly degraded to increase caffeic and quinic acids. Also, the increase in gallic acid

may be due to the breakdown of hydrolyzable tannins (glucose esters of gallic acid) into their constituent gallic acid and carbohydrates.

During medium roasting (medium), sucrose and chlorogenic acid are degraded with a longer roasting time, and the organic acid content in coffee will increase. The effect of this acid degradation will raise the pH, so the longer the coffee roasting process, the more the pH value will increase. From the green coffee roasting process to coffee roasted to a maximum temperature of 250°C, they found that pH increased with roasting level or level (Moon *et al.* 2009). The study found that coffee pH was mainly due to the formation of aliphatic acids during roasting, a mechanism that depends on precursor compounds such as sucrose (Ginz *et al.*, 2000).

This study's results indicate a difference in pH between coffee produced from mangroves and Robusta. Judging from the pH value, the pH made by Robusta coffee was higher than that of mangrove coffee beans. Based on the literature, *Sonneratia* fruit tends to be more acidic, a type of mangrove that is non-toxic, does not require special handling, and can be eaten immediately. The pH of ripe mangrove fruit seeds was not much different from that of the fruit in 3.97-4.91. This was in line with the research of Rajis *et al.* (2017) who reported that the pH of *Sonneratia ovata* fruit was 4.91. Young fruit has a sour taste and a high bioactive content, which can be used as an antioxidant. Compared to the pH of Robusta coffee beans, according to Soraya (2013), arabica coffee generally has a lower pH than Robusta coffee. Arabica coffee has a pH of around 4.85-5.15 and Robusta coffee has a pH of 5.25-5.40.

### 3.6 Total acidity

Figure 6 shows that the total acidity of roasted coffee decreases as the degree of roasting increases, similar to the previous research by Bilge (2020). The total acidity of roasted coffee during roasting and different roasting levels indicate that the roasting level can significantly

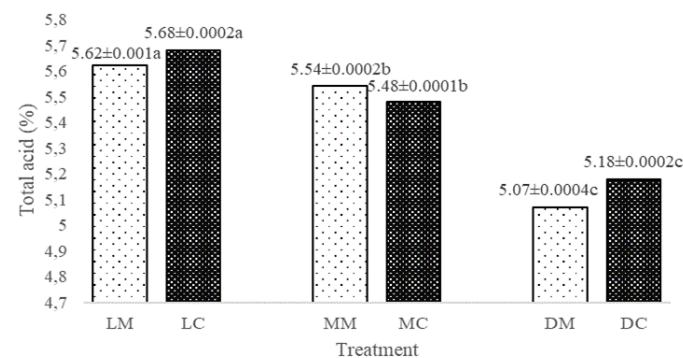


Figure 6. Bar chart of mangrove coffee's total acid content on coffee roasting degree. Values are presented as mean $\pm$ SD of triplicates. Values with different alphabets notations are statistically significantly different at the test level  $\alpha = 5\%$ .

reduce the total acid value, with the initial total acid value being 5.68% to 5.18% in Robusta coffee, while in mangrove coffee, the value was from 5.62% to 5.07%. According to Bolka and Emire (2020), a significant decrease in the trigonelline and total chlorogenic acid content of coffee beans was observed during the roasting process. The coffee beans were roasted at a darker (dark) and reached the most negligible value K.

### 3.7 Caffeine content

Coffee contains an active compound pharmacologically derivative of methylxanthine, caffeine. Caffeine is an alkaloid in coffee beans, tea leaves, and cocoa beans. The difference in the effect of these products may be possible because of the differences in the compounds they contain (Weinberg, 2010). The data in Table 2 showed that the caffeine value in Robusta coffee was 0.836-1.335%, while in mangrove coffee, no caffeine content was detected. The phytochemical compounds' components cause the presence or absence of caffeine levels in foodstuffs. Mangrove seeds naturally do not contain caffeine, unlike coffee beans which naturally contain caffeine. Robusta coffee naturally contains caffeine. According to Gaibor *et al.* (2020), the chemical composition of green coffee was characterized by caffeine in the range of 1.45-2.38%, while the caffeine content in roasted coffee in robusta coffee was in the range of 1.7-4.0%. Coffee beans were roasted on a medium to dark roast level. The roasting machine (SC 2.5 Kg) was set with an initial temperature of 180°C then, followed by degrees of roasting, a light roast at 193°C to 199°C, a medium roast (M) at 204°C, and dark roast (D) at 213°C to 221°C.

## 4. Conclusion

Based on the study results, it was shown that the roasting level had a significant effect on the chemical and sensory characteristics of coffee, both commercial coffee and mangrove coffee. The sensory features of commercial coffee (Robusta) were preferable to those of mangrove coffee, but the impact of caffeine can be eliminated by consuming mangrove coffee. The degree of roasting was based on the sensory and chemical quality of the coffee, with the best results obtained in commercial coffee (Robusta), which was roasted at a

medium level. The comparison results show that the characteristics of coffee between commercial coffee (Robusta) and mangrove coffee have phenol content, total acid, and proximate and sensory values close to commercial coffee. However, the caffeine content was not found in mangrove coffee, so coffee connoisseurs can use mangrove coffee because it can be used as an alternative to coffee drinks without giving the effect of caffeine addiction.

### Conflict of interest

The authors declare no conflict of interest.

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Table 2. Caffeine value in mangrove coffee and commercial coffee (Robusta).

Code	Treatment	Caffeine (%)	Deviation standard
LM	Light-roasting mangrove seed coffee	-	-
LC	Light roasting commercial (Robusta) coffee	0.836	0.03
MM	Medium roasting mangrove seed coffee	-	-
MC	Medium roasting commercial (Robusta coffee)	1.236	0.02
DM	Dark roasting mangrove seed coffee	-	-
DC	Dark roasting commercial (Robusta) coffee	1.335	0.03

-. Not identified/not detected.

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