Quality Characteristics of Merapi Robusta Coffee Products from the Traditional, Semi Modern, and Modern Process

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Abstract. Coffee is widely cultivated because it has a distinctive taste, one of the areas that cultivates Robusta coffee is Sleman Regency. The problem that exists in the home industry of coffee processing in the region is that the roasting process is still carried out in a traditional and semi-modern method and does not yet know the right roasting method and time. This causes the coffee produced to be of low quality and not uniform. This research was conducted using grade A Merapi Robusta green bean coffee, the roasting process was carried out at medium level with a temperature of 180 C. Roasting was carried out by 3 methods, namely traditional, semi-modern, and modern with each roasting time of 20 and 25 min. This study aims to analyze the chemical characteristics and sensory analysis of Merapi Robusta coffee. The test shows that the water content, caffeine content, and coffee extract meet the SNI for ground coffee. On the water content and coffee extract, the method and time of roasting have a significant effect. On the caffeine content, the roasting method had no significant effect, but the roasting time had a significant effect. The coffee that was most preferred by the panelists regarding the attributes of aroma, taste, and aftertaste was the traditional roasting method for 20 min, while the most preferred color attribute was the modern roasting method for 25 min. The results of the metal contamination test showed that no lead (Pb), cadmium (Cd), and ochratoxin were found in the three best samples.

Keywords: Chemical characteristic · hedonic test · roasting · robusta coffee · quality

1 Introduction

Indonesia is the fourth largest coffee producer and exporter in the world [1]. Most green coffee beans are produced from two species, namely Arabica (*Coffea arabica*) and robusta (*Coffea canephora*) [2]. The country of Indonesia cultivates more robusta coffee than Arabica coffee because Robusta coffee has good environmental and pest resistance, but Robusta coffee is second-class coffee because it has a more bitter taste, less acid, and high caffeine content than Arabica coffee [3]. Daerah Istimewa Yogyakarta (DIY)

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is one of the producers of coffee commodities in Indonesia. One of the regencies in DIY that produces Robusta coffee is Sleman Regency.

Coffee has a distinctive taste and effect of its freshness on the body causes it to be in great demand by consumers around the world, so it has a fairly high economic value and promises to increase the economy as a source of foreign exchange [4]. The effect of the caffeine content in coffee is also believed to increase a sense of cheerfulness to make people who consume coffee feel more refreshed and energetic [5]. Processing of coffee beans needs to pay attention to various aspects that can maintain the quality of the coffee beans. One of the most important things is during the roasting process, because roasting is the process of forming the taste and aroma of the coffee beans. The quality of coffee beans can be improved if the roasting process is carried out properly [4]. Factors that affect the quality of roasting include the quality of raw materials, roasting method, roasting time and temperature, roasting media, and the amount of raw materials [6]. Roasting is a major factor in determining the quality of coffee drinks compared to other factors [7].

Previous research explained the type and duration of roasting on the quality of Robusta coffee [4]. The update of this study is to explain the quality characteristics of Merapi Robusta coffee products with independent variables, namely the method and roasting time, while the dependent variables or parameters of this study include water content, caffeine content, coffee extract, lead and cadmium metal contamination, octratoxin, and sensory test.

The problem that exists today is that the Tunggak Semi Farmer Group still uses traditional and semi-modern roasting methods. Both methods of roasting still use human power, so they have drawbacks, namely the yield and quality of coffee that is less uniform and the quantity of coffee produced is still limited. In addition, the Tunggak Semi Farmer's group has not found the right roasting method and time to produce quality coffee and uniform results, so it is necessary to compare the roasting method and time to get the best coffee roasting results at the most popular roasting level, namely the medium roast level.

Based on these considerations, it is necessary to conduct research on the roasting process of coffee beans related to the roasting time and method. The purpose of this study was to analyze the chemical characteristics of Merapi Robusta coffee products which were roasted using traditional, semi-modern, and modern methods, as well as to analyze the sensory properties of Merapi Robusta coffee products in the form of color, aroma, taste, and aftertaste which were roasted using traditional, semi-modern, and semi-modern methods, and modern.

2 Material and Methods

2.1 Coffee Samples

The material used in this research is *Greenbean* Robusta Merapi Grade A coffee. *Greenbean* coffee is obtained from the Tunggak Semi Farmers Group, Cangkringan, Sleman. *Greenbean* coffee used is 500 g per sample. The tools used are cauldrons and furnaces, manual roasters whose stirring still uses human power, VNT roasters, thermometers, and grinding machines.

Table 1. Merapi Robusta Coffee Samples

Samples	Information
1	Traditional roasting for 20 min
2	Traditional roasting for 25 min
3	*Semi modern* roasting for 20 min
4	*Semi modern* roasting for 25 min
5	*Modern* roasting for 20 min
6	*Modern* roasting for 25 min

Roasting is divided into 3 methods and each method is carried out with 2 different times, namely 20 and 25 min. The traditional method is carried out using a cauldron and furnace, stirring during roasting still uses human power. The semi-modern method is carried out using a manual machine with engine specifications that are made of aluminum which has a maximum roasting capacity of 2 kg, and the duration of LPG gas fuel is 3 kg. This tool is equipped with a rotating handle and a thermometer. The turning handle on this machine is rotated by hand, so this machine also still uses human power. The modern method is done using a VNT roaster. The specifications of this machine are that it has a maximum capacity of 2.5 kg, has computerized control, and is fueled using LPG gas.

There are 6 samples in this study, namely in Table 1.

2.2 Reference Analysis

The reference used in the water content and coffee extract test in this study was SNI for coffee powder 01-3542-2004. The method used in the coffee extract test is the oven method, the principle of the coffee extract test is coffee extraction. The reference used in the caffeine test is AOAC, Official Methods of Analysis (1990) 930.08. *Caffeine in Roasted Coffee, Chromatographic Spectrophotometric method*. The method used in the test for metal contamination of lead (Pb) and cadmium (Cd) is ICP-MS (Inductively Coupled Plasma Mass Spectrometry), while the method for testing ochratoxin uses the LC-MSMS (Liquid Chromatography Tandem-Mass Spectrometry) method. Sensory test performed using hedonic test. Hedonic test is a test to measure the level of preference for a product. The hedonic test was carried out using a Likert scale. The hedonic test attributes of this research are color, aroma, taste, and *aftertaste.*

2.3 Statistical Analysis

Data analysis of water content, caffeine content, and coffee extract used ANOVA followed by the DMRT test (*Duncan's Multiple Range Test)* at a level of 5%.

The hedonic test was analyzed by carrying out statistical tests using the SPSS version 25 application. The analysis of this study begins with the Kolmogorov-Smirnov method of normality test, because the data is more than 50. The data normality test aims to

Table 2. Test Results with SNI Ground Coffee

No.	Test Criteria	Unit	Results Test	Meet SNI
1.	Water	% w/w	0.13 ± 0.02–0.29 ± 0.01	√
2.	Coffee extract	% w/w	30.70 ± 0.15–36.59 ± 0.02	√
3.	Caffeine (anhydrous)	% w/w	1.32 ± 0.00–1.52 ± 0.01	√
4.	Metal Contaminants			
4.1	Lead (Pb)	mg/kg	Not detected	√

determine whether a data is normally distributed or not. If the data obtained has a significance value > 0.05 (sig. > 0.05), then the data is said to be normally distributed, but if the significance value is < 0.05 (sig. < 0.05), then the data is said to be not normally distributed. In this study, the data were not normally distributed, so it was continued with the Kruskal-Wallis test. The Kruskall Wallis test is used as an alternative to the ANOVA test when the assumption of normality of the data in the ANOVA test is not met [8]. Furthermore, if in the test using the Kruskall Wallis test, the data is still not normally distributed, then a further test is needed, namely the Mann-Whitney test.

The three best results from the analysis of hedonic properties were then carried out with further tests in the form of metal contamination tests, namely the lead (Pb), cadmium (Cd) test, and ochratoxin.

3 Result and Discussion

The test results are compared with SNI 01-3542-2004 regarding ground coffee, which is in Table 2.

Water content is an important component in a food product because it affects the appearance, texture, taste, acceptability, freshness, and shelf life of the product [3]. Caffeine levels must be in accordance with SNI because consuming excessive amounts of caffeine can cause health problems [9]. The number of levels of coffee essence can affect the organoleptic quality of steeping such as aroma, taste, and freshness of coffee [10]. The hedonic test in this study was to determine consumer preferences for Robusta Merapi coffee products. Metal contamination test was carried out in this study to ensure that the consumer's choice of the best Robusta coffee was free from metal contamination.

3.1 Water Content

Information:

1. The same lowercase notation indicates that the samples are not significantly different in different roasting methods with the same length of time with a significance level of p > 0.05

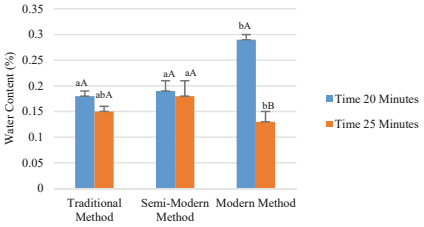

Fig. 1. Water Content of Merapi Robusta Coffee Samples

2. The same capital letter notation shows that the samples are not significantly different at different roasting times with the same method with a significance level of $p > 0.05$

At a roasting time of 20 min, traditional and semi-modern roasting methods showed samples that were not significantly different, traditional and modern methods showed significantly different samples, and semi-modern and modern methods also showed significantly different samples. At a roasting time of 25 min, the traditional roasting method was not significantly different from the modern or semi-modern roasting, but the semi-modern and modern roasting methods were significantly different. In the traditional method and the semi-modern method, the duration of 20 min and 25 min showed no significant difference. While in the modern method, the results of the sample are significantly different at 20 min and 25 min. It can be concluded that the roasting method and the length of the roasting time have a significant effect (Fig. 1).

Roasting method and the length of the roasting time have a significant effect. The more modern the roasting method, the more consistent the roasting results. The longer the roasting time, the lower the water content in the coffee. During the roasting process, the water content decreases due to heat transfer in the roasting machine into the coffee so that the water content in the coffee beans evaporates. [3].

The results of testing the water content of each roasting method are in accordance with the theory that longer roasting results in lower water [6]. Low water content can inhibit the development of organisms in coffee grounds and if the coffee water content is high it can cause a decrease in quality during storage because organisms can grow quickly. The lower the water content in ground coffee, the better the quality of the coffee because it can maintain the quality of the coffee for a longer time. According to the SNI for ground coffee, namely SNI 01-3542-2004, the maximum water content of ground coffee is 7%. The water content of ground coffee in all samples met SNI.

3.2 Caffeine Content

Information:

1. The same lowercase notation indicates that the samples are not significantly different in different roasting methods with the same length of time with a significance level of $p > 0.05$

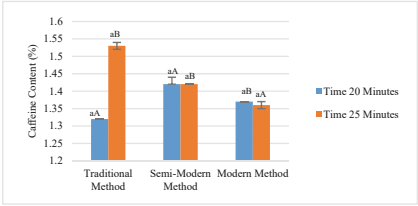

Fig. 2. Caffeine Content of Merapi Robusta Coffee Samples

2. The same capital letter notation shows that the samples are not significantly different at different roasting times with the same method with a significance level of $p > 0.05$

At the roasting time of 20 min, the traditional method with the semi-modern method was not significantly different, the traditional method with the modern method was not significantly different, and the semi-modern method with the modern method was not significantly different. At the roasting time of 25 min, the traditional method with the semi-modern method was not significantly different, the traditional method with the modern method was not significantly different, and the semi-modern method with the modern method was not significantly different. In the traditional roasting method, the length of time from 20 min to 25 min is significantly different. Semi-modern roasting method, the length of time is 20 min with 25 min significantly different. Modern roasting methods, the length of time is 20 min with 25 min significantly different. The results of caffeine content show that different roasting times with the same roasting method have a significant effect (Fig. 2).

The results of testing the caffeine content, namely the roasting method had no significant effect and the roasting time had a significant effect on the caffeine content of coffee. The longer the roasting time and the higher the roasting temperature, the higher the caffeine content, this is presumably due to the decomposition of liquids and acids [11].

According to the SNI for ground coffee, namely SNI 01–3542-2004, the caffeine content of ground coffee is 0.9–2% in the first requirement and 0.45–2% in the second requirement. The results of testing the caffeine content in each roasting method are that all samples meet the requirements of SNI.

3.3 Coffee Extract

Information:

1. The same lowercase notation indicates that the samples are not significantly different in different roasting methods with the same length of time with a significance level of $p > 0.05$
2. The same capital letter notation shows that the samples are not significantly different at different roasting times with the same method with a significance level of $p > 0.05$

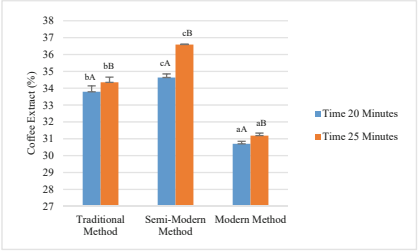

Fig. 3. Coffee Extract of Merapi Robusta Coffee Samples

Coffee extract with a roasting time of 20 min, the traditional method with the semi-modern method was significantly different, the traditional method with the modern method was significantly different, and the semi-modern method with the modern method was significantly different. Coffee extract with a roasting time of 25 min, the traditional method with the semi-modern method was significantly different, the traditional method with the modern method was significantly different, and the semi-modern method with the modern method was significantly different. The coffee extract showed that in the traditional method, the roasting time of 20 min and 25 min was significantly different. The semi-modern method, the roasting time of 20 min with 25 min was significantly different. The modern method, the roasting time of 20 min with 25 min is significantly different. This shows that the roasting method and time significantly affect the yield of coffee extract (Fig. 3).

In this study, the coffee extract content of 25 min of roasting time was higher than 20 min for each roasting method. In previous studies, it was explained that the level of coffee extract was influenced by the roasting level, which was directly proportional to the roasting level. The degree of roasting of coffee is influenced by the length of time and temperature of roasting [12]. The value of coffee essence according to SNI for ground coffee SNI 01–3542-2004 is worth 20–36 in the first requirement and a maximum of 60 in the second requirement, so that the coffee essence value in all samples meets SNI.

3.4 Hedonic Test

The results of the hedonic test analysis in the form of the average preference level of the Merapi Robusta coffee sample can be seen in Table 3.

3.4.1 Color Attribute

The test results on the color attribute are that there is no significant difference between the traditional and modern roasting methods, but they are significantly different from the semi-modern roasting method. This can be caused during semi-modern roasting, the tool is still moved by hand so there is a possibility that the color of the coffee produced is uneven which makes the coffee after grinding look lighter than the results of traditional and modern roasting methods. In traditional roasting, humans still use human power in the roasting process, but when doing traditional roasting methods, researchers can see firsthand the roasting process because the roasting uses a stove and cauldron, while in

Table 3. The Average Preference Level of The Merapi Robusta Coffee Sample

Sample	Attribute			
	Color	Aroma	Taste	Aftertaste
1	5.13 ± 1.33^{a}	5.13 ± 1.33^{a}	4.57 ± 1.50^{b}	4.45 ± 1.58^{a}
2	5.23 ± 1.14^{a}	4.28 ± 1.43^{a}	3.64 ± 1.57^{a}	4.26 ± 1.56^{a}
3	4.26 ± 1.51^{b}	4.53 ± 1.51^{ab}	3.81 ± 1.80^{a}	4.21 ± 1.61^{a}
4	3.74 ± 1.67^{b}	4.04 ± 1.65^{a}	3.47 ± 1.76^{a}	3.92 ± 1.66^{a}
5	5.17 ± 1.25^{a}	4.57 ± 1.47^{ab}	3.62 ± 1.77^{a}	3.57 ± 1.76^{a}
6	5.53 ± 1.43^{a}	4.92 ± 1.58^{a}	3.92 ± 1.79^{a}	3.95 ± 1.79^{a}

Note: The same letter in the same column shows no significant difference at the 5% significance level

semi-traditional roasting it is done in a machine that rotates by hand so that researchers cannot see whether the coffee beans are evenly distributed or not in the roasting process.

3.4.2 Aroma Attribute

The test results obtained that there was a significant difference in the aroma attributes in each sample with the same roasting method. The difference in the aroma of the coffee produced is influenced by several factors, namely the type of coffee, the roasting process, and the brewing method. In this study, the type of coffee and the method of brewing coffee are the same, the difference is the method and length of the roasting process. The longer the roasting, the more charred the coffee will be, so it will affect the aroma of ground coffee. Aroma is a smell that is difficult to measure, causing differences of opinion in assessing quality. This difference of opinion is due to the fact that everyone has a different olfactory ability, although they can distinguish the aroma, but everyone has different preferences [3].

3.4.3 Taste Attribute

The test results on the taste attribute, namely sample 1 was significantly different from the other five samples and between the other five samples was not significantly different. Sample 1 was also the most preferred sample by the panellists on the taste attribute. This is because sample 1 was produced from roasting using the traditional method, in this traditional method the roasting is done using a cauldron and furnace. Roasting in an open area such as this traditional method of roasting can affect the taste of coffee, for example being exposed to smoke from burning firewood [12]. Firewood is used as fuel for the roasting, at the time of roasting there is a flow of hot air, namely the smoke from the firewood which allows it to affect the distinctive taste of coffee than roasting with other methods.

Same roasting method as sample 2, but there is a significant difference between the two. This is influenced because the length of time in roasting has an effect on determining roasting results including taste attributes. The higher temperature and roasting time will

Table 4. The results of the metal contamination

Metal Contamination	Unit	Sample			Limit of Detection
		Sample 1	Sample 3	Sample 6	
Lead (Pb)	mg/kg	Not Detected	Not Detected	Not Detected	0.00025
Cadmium (Cd)	mg/kg	Not Detected	Not Detected	Not Detected	0.0005
Ochratoxin	mg/kg	Not Detected	Not Detected	Not Detected	1.01

accelerate the degradation and formation of caffeol chemical compounds produced from caffeine compounds. Formation of taste and aroma in roasted coffee is influenced by chlorogenic acid, trigonelin, and caffeine [3].

3.4.4 Aftertaste Attribute

The aftertaste attribute in this study was not significantly different in all the samples tested. This is because the type of coffee used is the same, namely Robusta Merapi, because the aftertaste produced by coffee can be different depending on the type of coffee being tested.

3.5 Metal Contaminant

Metal contamination is carried out because metal contamination in food products can be harmful to consumers and the environment due to toxicity [13]. Tests for metal contamination in coffee products are carried out because the metal content can be absorbed and stored in the roots, leaves, and even coffee beans. Heavy metals are a source of pollutants in the food chain, and can end up in human food [14].

Metal contamination test is carried out after the best results from the hedonic test are known. This metal contamination test only uses the three best samples from the hedonic test. The samples used were sample 1, sample 3, and sample 6. The selected metal contamination tests were tests on Lead (Pb), Cadmium (Cd), and Ocratoxin. The results of the metal contamination test can be seen in Table 4.

3.5.1 Lead (Pb)

Lead metal contamination is a public problem in the world because it causes health problems, especially children who are contaminated with metal contamination. Health problems due to metal contamination can be in the form of permanent brain damage, learning disabilities, hearing loss and behavioral disorders while in adults, it is known to cause hypertension, heart disease and adverse effects on the reproductive system [13]. Lead contamination affects human health, so it is hoped that the food or drink consumed is free from lead contamination. Therefore, in this study, a lead contamination test was carried out on the best ground coffee samples.

The lead (Pb) contamination test on samples 1, 3, and 6 showed that all three were not polluted by lead. The limit of detection of lead is 0.00025.

3.5.2 Cadmium (Cd)

Cadmium metal contamination in food is caused by the absorption of cadmium by organic substances that make up the soil and are found in the earth's crust. Cadmium contamination poses a risk to human health when consumed by humans [15]. Healthy food and beverage must be free from cadmium contamination. The Cadmium (Cd) contamination test on samples 1, 3, and 6 showed that all three were not contaminated by cadmium. The limit of detection of cadmium is 0.0005.

3.5.3 Ochratoxin

Ochratoxin A (OTA) is a mycotoxin produced by different Aspergillus and Penicillium fungal species. OTA can be found in food products such as cereals, grains, spices, and even beverages such as beer, wine, and tea. OTA can contaminate coffee beans during storage and transportation. In the food processing process, temperature, and humidity can increase OTA contamination in foodstuffs [16]. Ochratoxin A (OTA) is a mycotoxin with nephrotoxic, teratogenic, carcinogenic and immunotoxic properties that can frequently be found in ground roasted coffee [17]. To reduce the risk of exposure, the European Commission has established a maximum permissible OTA concentration of 5 $\mu g\ kg^{-1}$ in ground roasted coffee [16].

The results of the ochratoxin test in samples 1,3, and 6 were that all three did not contain ochratoxin. The limit of detection of ochratoxin is 1.01.

4 Conclusion

Tests of water content, caffeine content, and coffee extract meet the standards of SNI requirements. In this study, the roasting method and time significantly affected the water content. On the caffeine content, the roasting method had no significant effect and the roasting time had a significant effect. In coffee extract, roasting method and time have a significant effect.Robusta Merapi coffee which was most preferred by panelists related to aroma, taste, and aftertaste attributes was the traditional roasting method for 20 min, while the most preferred color attribute was the modern roasting method for 25 min. In the three best samples, namely samples 1,3, and 6 there was no metal contamination. All three were not contaminated with lead (Pb), cadmium (Cd), and ochratoxin.

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