International Journal on Food, Agriculture, and Natural Resources
Volume 05, Issue 01, Page 95-99
ISSN: 2722-4066
http://www.fanres.org

Original Paper

The Effect of Using Fast Roast and Slow Roast Roasting Techniques on the Chemical and Organoleptic Characteristics of Robusta Coffee Beans (Coffea robusta L.)

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Received: 12 December 2023; Revised: 02 March 2024; Accepted: 23 March 2024
DOI: *https://doi.org/10.46676/ij-fanres.v5i1.261*

***Abstract*— One of the commodities with the highest economic value in the plantation sector in Indonesia is coffee. In 2016 there was a significant difference between the area of robusta and arabica coffee, with the area of robusta coffee being superior. The wide difference between robusta and arabica coffee plantations is because robusta coffee is considered a potential opportunity in developing the community's economy compared to arabica coffee with a particular market. To improve the taste or quality of coffee production, one of the factors is the roasting process. Currently, the demand for coffee production is increasing with the need for maximum quality and taste of coffee beans, so the processing of coffee plants must be very concerned and improved. Therefore this study aims to determine the roasting technique with a roasting machine and its effect on improving the quality and taste of coffee beans that are popular with consumers. This study used a Split Plot Design (SPD) using the basic pattern of a Completely Randomized Design consisting of 2 levels. The first factor is the roasting time as the main plot with four levels. Then the second factor is the roasting temperature with two levels. Each factor was repeated four times so there were 32 experimental units. The results of this study indicate that in the roasting process using slow roast and fast roast techniques, roasting time affects all observation parameters, namely moisture content, pH value, brix value, flavor, aroma, and caffeine. However, the roasting temperature only affects moisture content, brix value, and caffeine.**

Keywords*— Coffee Beans, Fast roast, Roasting, Slow roast

I. INTRODUCTION

Indonesia is one of the fourth coffee bean-producing countries after Brazil, Vietnam, and Colombia [1]. Coffee plants in Indonesia are an essential commodity in the plantation sector, marked by the area of plantation land in 2016 for coffee plants, with an area of 1,233,294 Ha for Arabica and Robusta coffee plants [2]. The value of Indonesia's annual coffee production was 612 thousand tons in 2018 [3]. The coffee land area is intended to increase the production of coffee plants in Indonesia. However, it is not only the area of coffee plantations that is maximized. Improving the quality of coffee beans through several processes, such as using varieties, cultivation techniques, and post-harvest processing, must also be considered.

In order to improve the quality of the production of flavored coffee plants or the quality of coffee plant production is influenced by several factors, namely 30% of the roasting process, 60% of the coffee cultivation process, then 10% from the barista at the time of serving [4]. In improving the quality of coffee beans, one process plays a vital role in maximizing the quality of coffee beans, namely the roasting process. The roasting process is a process for forming the taste and aroma contained in coffee beans to improve the quality and quality of coffee beans using the right temperature and time. The quality of the coffee beans at the roasting time must be considered starting from the uniformity of shape, texture, specific gravity, water content, and other contents that will facilitate the roasting process [5]. Roasting has several levels, namely light roast, medium roast, and dark roast, which roasters use in determining the type of roast to be used on coffee beans.

In the roasting process, there are two techniques that can be used, namely fast roast and slow roast. The fast-roast technique uses high temperatures and uses a long, fast roasting time. Meanwhile, the slow roast technique is a roasting technique using relatively low temperatures and a longer roasting time [6]. The use of these two techniques requires special attention in the roasting process due to the risk of failure during roasting. The use of roasting temperature and roasting time greatly affect the water content of robusta coffee beans [5]. Meanwhile the use of roasting temperature and length of roasting time had an effect on the level of acidity and a strong taste [7]. Therefore research on the use of fastroast and slowroast techniques on the chemical and organoleptic characteristics of Robusta coffee beans was conducted to determine the effect of the two techniques.

II. MATERIALS AND METHODS

A. Time and Location

The research was conducted at the Rangkum Shop, Jl. Lake Toba No. 08, Tegalgede, Sumbersari District, Jember Regency in August - October 2022. The choice of Kedai Rangkum as the location for the research was due to the presence of roasting machine with the Nor-Coffee Roaster 505 brand with a maximum capacity of 1 kg.

B. Tools and Materials

The materials used in this study were Argopuro Krucil robusta coffee beans from Watupanjang Village, Krucil District, Probolinggo, standard caffeine, aquadest, 96% ethanol, chloroform (CHCl3), sodium carbonate (Na2CO3), alcohol, label paper, and filter paper.

The tools used are roasting machines, stationery, test tubes, grinders, measuring cups, volumetric flasks, volume and drip pipettes, funnels, analytical balances, pipette bulbs, stirring rods, beaker glasses, glass funnels, separatory funnels, cups, ovens, desiccators, BUCHI B-81 socket tools as well as UV spectrophotometers, pH meters, and refractometers.

C. Experimental Design

This study used a Split Plot Design using the basic pattern of a Completely Randomized Design consisting of 2 levels. The first factor is the length of roasting time, as the main plot with four levels. Then the second factor is the roasting temperature as a subplot with two levels. Each factor was repeated four times so that in the study, there were 32 experimental units.

I. The first factor is the difference in coffee roasting time consists of 4 levels:
W_1: 5 Minutes
W_2: 8 Minutes
W_3: 11 Minutes
W_4: 14 Minutes

II. The second factor is the difference temperature in coffee roasting which consists of 2 levels:
S_1: 180˚C
S_2: 210˚C

D. Parameters

The parameters in this study were observed with several chemical and organoleptic characteristics as follows:

1. Moisture content was tested using the oven method.
2. Caffeine levels were tested using the Bailey-Andrew Method
3. The Brix value is tested using a refractometer.
4. The pH value is tested using a pH meter.
5. The taste test was tested by the cupping method by 10 panelists.
6. The aroma test was tested using the sense of smell by 10 panelists.

E. Analysis Method

The data obtained were then analyzed using analysis of variance. If there is a significant difference between the treatments then proceed with Duncan's multiple range test at the 5% level.

III. RESULTS AND DISCUSSION

The most crucial processing technique for enhancing color, flavor, and aroma is roasting. From a sensory standpoint, roasting can produce aromatic molecules by a number of events, including the Maillard reaction, the Strecker degradation, the degradation of sugars, and the breakdown of amino acids [8]. The roasting process starts at 120 °C and finishes between 180 and 200 °C. A sequence of events that correspond with the roasting process take place during this very easy operation, causing the green bean to totally alter its structure and release the components that create the coffee in the cup [9].

Fast roast and slow roast have differences in roasting time and temperature. The fast roast method roasts coffee beans at a high temperature but in a shorter time. On the other hand, the slow roast method actually roasts the coffee beans at a low temperature and for a longer time. Development time ranged from 90 in the fast profile to 266 s in the slow roast profile [10]. Development time defined as the duration from the first crack to the unloading of roasted coffee [11]. Fig 1 showed the six important points in coffee roasting process, namely charge, turning point, dry end, first crack, second crack, and drop point [12].

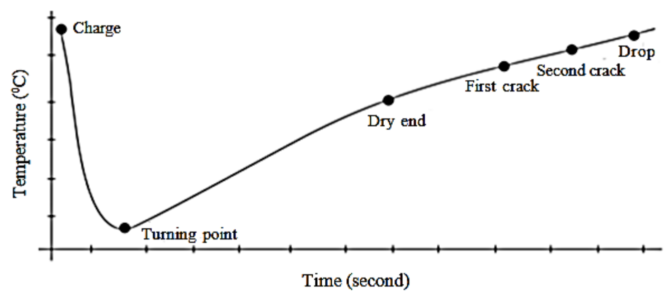

Fig 1. Observation Point During Roasting [12]

Based on Fig 1, the temperature in the drum roaster was kept at a high level during the charge observation point, which occurred right before the green coffee bean was placed inside the roasting drum. The temperature of the drum rapidly decreases after the green beans are added, then increases once more near the turning point. After lowering to its peak at the turning point, the temperature gradually rises to a dry end observation point. The Maillard reaction has begun at this moment. The Maillard reaction has begun, the drying process has significantly slowed down, and the dry end temperature is set at 140 0C. After expanding in volume during roasting, the bean eventually develops what are known as the first and second cracks. The beans entered the development phase as indicated by the first and second cracks. The drop point, or when roasting is complete and roasted coffee beans are released, is the final observation point [12].

A. Water Content

The results of the analysis of variance on the observed variable moisture content of Robusta coffee beans in Table 2 show that the best use of the fast roast technique is the treatment with a roasting temperature of 210°C, a roasting time of 14 minutes (S_2W_4) with a moisture content value of 0.97%. Whereas in the use of the slow roast technique, the best treatment was found in the treatment with a roasting temperature of 180°C, a roasting time of 14 minutes (S_1W_4) with a value of 3.65%.

The data shows that the use of the influence of temperature and length of roasting time has an effect on the water content. The longer roasting time and the roasting temperature used will result in the coffee beans being roasted if it takes too long, which results in a decrease in the quality of the coffee beans [5].

TABLE 1. RESULTS OF THE ANALYSIS OF VARIANCE ON THE VARIABLE MOISTURE CONTENT OF ROBUSTA COFFEE BEANS

Roasting Time	Roasting Temperature	
	S1	S2
W_1	5.58 a	2.78 a
	A	B
W_2	4.6 b	2.68 b
	A	B
W_3	4.55 b	1.83 b
	A	B
W_4	3.65 c	0.97 c
	A	A

Note: Numbers followed by the same letters are not significantly different in Duncan's test at the 5% level. Numbers followed by capital letters (vertical) indicate a simple effect of the temperature factor on the same roasting time. Lowercase letters (horizontal) indicate the simple effect of the long factor of roasting time at the same temperature.

B. pH Value

The data analysis of variance in Table 2 shows that the effect of temperature and length of roasting time on using fast roast and slow roast techniques do not interact. However, the use of long roasting time has a significant effect. Based on Table 2, the roasting time of 5 minutes, 8 minutes, 11 minutes, and 14 minutes can still be consumed. Because the limit value of acidity that humans can consume is not below a value of 4 [13].

Breaking down organic acids causes the acidity level to decrease, but the pH value increases. The level of acidity that occurs in coffee beans is due to volatile substances such as formic acid, acetic acid, ketones, alcohol, and several chemical compounds that have volatile characteristics when subjected to long periods and high temperatures [7].

TABLE II. RESULTS OF THE ANALYSIS OF VARIANCE ON THE OBSERVED VARIABLES ON THE PH VALUE OF ROBUSTA COFFEE BEANS

Treatment	Value
W_1	5.98 a
W_2	5.8 b
W_3	5.75 b
W_4	5,79 b

Note: Numbers followed by the same letter show a significant difference in Duncan's test at the 5% level. Numbers followed by lowercase letters (horizontally) indicate the simple effect of temperature on roasting time.

C. Brix Value

The data analysis of variance in Table 4 shows that the best treatment for the fast roast technique is using a temperature of 210°C for 8 minutes (S_2W_2) with a value of 2.65%. In contrast, the slow roast technique shows that using a temperature of 180°C takes 11 minutes of roasting time (S_1W_3) with a value of 2.475%. The Brix content in Robusta coffee beans is not so high compared to Arabica coffee which is caused by the content of sugars and essential oils in Robusta coffee not too much when hot water is extracted so that the dissolved solids are not so high [14].

TABLE III. RESULTS OF THE ANALYSIS OF VARIANCE ON THE OBSERVATION VARIABLE FOR THE BRIX VALUE OF ROBUSTA COFFEE BEANS

Roasting Time	Roasting Temperature	
	S1	S2
W_1	1.2 b	2.45 a
	B	A
W_2	1.2 b	2.65 a
	B	A
W_3	2.475 a	2.5 a
	A	A
W_4	1.75 ab	2.35 a
	B	A

Note: Numbers followed by the same letter show a significant difference in Duncan's test at the 5% level. Numbers followed by capital letters (vertical) indicate the simple effect of the temperature factor on the same roasting time. Lowercase letters (horizontal) indicate the simple effect of the long roasting time factor at the same temperature.

There is an interaction between the length of roasting time and the roasting temperature because the higher the temperature and the longer it takes the coffee beans to change chemical reactions in the Maillard phase and first crack phase. The Maillard phase has a caramelization process which is the process by which coffee beans undergo the breakdown of sugar into amino acids, which usually occurs at temperatures of 100-190°C. Then the first crack effect that occurs at a temperature of 180-200°C is a caramelization stage derived from sucrose compounds [6]. If this phase takes a long time, it will result in coffee beans experiencing excessive sugar burning, which results in a coffee taste that tends to be bitter.

D. Aroma

Based on the data in Table 5, the analysis of variance regarding aroma shows that the use of the fast roast technique shows the best treatment at 210°C for 5 minutes of roasting time (S_2W_1) with an average value of 3,025 panelists, which means the panelists like the aroma of the treatment. Meanwhile, the slow roast technique showed the best treatment at 180°C for 11 minutes of roasting time (S_1W_3) with the highest average value of 3.45, which means the panelists liked the aroma of the treatment. There is an interaction between temperature and time because, during the roasting process, there is an aroma formation process caused by caffeol and coffee aroma-forming compounds during the Maillard reaction of free amino acid degradation, trigonelline degradation, sugar degradation, and phenolic compound degradation which results in the appearance of a distinctive aroma in roasted and cooled coffee beans [6].

In the roasting process, the longer the time used, the more volatile compounds will evaporate and affect the distinctive aroma of Robusta coffee beans. The oil contained in the coffee beans dissolves many aromatic compounds resulting in periodic evaporation and release when the coffee beans are before or after brewing [7].

TABLE IV. RESULTS OF VARIABLE ANALYSIS OF AROMA OBSERVATION VARIABLES IN ROBUSTA COFFEE BEANS

Roasting Time	Roasting Temperature	
	S1	**S2**
W_1	1.675 b	3.025 a
	B	A
W_2	1.95 b	2.5 a
	B	A
W_3	3.45 a	2.575 a
	A	B
W_4	1.105 b	2.4 a
	B	A

Note: Numbers followed by the same letter show a significant difference in Duncan's test at the 5% level. Numbers followed by capital letters (vertical) indicate the simple effect of the temperature factor on the same roasting time. Lower case letters (horizontal) indicate the simple effect of the long factor of roasting time at the same temperature.

E. Taste

Based on the data in Table 5, the analysis of variance regarding flavors shows the best treatment using the fast roast technique, namely the temperature treatment of 210℃, 5 minutes of roasting time (S_2W_1), with an average value of 2,575. Whereas in the slow roast technique, the highest average value was found in the temperature treatment of 180°C for 11 minutes of roasting time (S_1W_3), namely 2,775. The panelists gave such an assessment because brewed coffee beans have a complex taste. The complexity in question is sourness, sweetness, and a balanced level of bitterness. The resulting flavor comes from several compounds, such as carbohydrates which are degraded into glucose, volatiles, alkaloids, and chlorogenic acid, which form sweet, sour, and fruity flavors in coffee beans [15]. Therefore, using high temperatures with less than optimal time will make the burning of compounds in coffee beans less than optimal.

TABLE V. RESULTS OF THE ANALYSIS OF VARIANCE ON THE OBSERVATION VARIABLE FOR ROBUSTA COFFEE BEAN FLAVOR

Roasting Time	Roasting Temperature	
	S1	**S2**
W1	1.525 b	2.575 a
	B	A
W2	1.6 b	2.275 a
	B	A
W3	2.775 a	1.9 a
	A	B
W4	1.875 ab	1.825 a
	A	A

Note: Numbers followed by the same letters are not significantly different in Duncan's test at the 5% level. Numbers followed by capital letters (vertical) indicate the simple effect of the temperature factor on the same roasting time. Lower case letters (horizontal) indicate the simple effect of the long factor of roasting time at the same temperature.

F. Caffeine Content

Based on the data in Table 6, the analysis of variance shows that the best treatment is the use of the fast roast technique, which is the temperature treatment of 210°C, the duration of roasting time is 14 minutes (S_2W_4) with a value of 3.95%. While using the slow roast technique, the best treatment was used, namely at 180°C, 14 minutes of roasting time (S_1W_4), with a value of 3.71%. The caffeine content in coffee beans is affected by the use of roasting temperature and the length of roasting time.

TABLE VI. RESULTS OF THE ANALYSIS OF VARIANCE ON THE OBSERVATION VARIABLE CAFFEINE CONTENT (%) OF ROBUSTA COFFEE BEANS

Roasting Time	Roasting Temperature	
	S1	**S2**
W1	3,18 ± 0,127 b	3,88 ± 0,14 a
	B	A
W2	3,34 ± 0,064 b	3,90 ± 0,035 a
	B	A
W3	3,66 ± 0,042 a	3,93 ± 0,042 a
	A	B
W4	3,71 ± 0,042 ab	3,95 ± 0,049 a
	B	C

Note: Numbers followed by the same letters are not significantly different in Duncan's test at the 5% level. Numbers followed by capital letters (vertical) indicate a simple effect of the temperature factor on the same roasting time. Lower case letters (horizontal) indicate the simple effect of the long factor of roasting time at the same temperature.

The higher the temperature and the longer the time will result in a high caffeine content [16]. Coffee beans' caffeine content can be influenced by several factors, such as biological conditions and chemical reaction processes that occur during post-harvest processing, that coffee beans obtain significantly affects the caffeine content [6].

CONCLUSIONS

Based on the research that has been done, the different roasting times and roasting temperatures in the use of slow roast and fast roast roasting techniques interact with the moisture content, brix value, taste, aroma, and caffeine content. Roasting time affects all observation parameters: moisture content, pH value, brix value, taste, aroma, and caffeine. However, the roasting temperature affects the parameters of moisture content, brix value, and caffeine only.

In using the fast roast roasting technique, the best treatment was at a temperature of 210℃ for 8 minutes of roasting time (S2W2) for the brix value and water content. Meanwhile, using the slow roast roasting technique, the best treatment was 180°C, roasting time was 11 minutes (S1W3) for water content, taste, aroma, and brix value.

Based on this research, it is necessary to carry out further research regarding the use of fast roast and slow roast techniques by using different roasting times and temperatures and using coffee bean varieties other than robusta to determine the effectiveness of using fast roast and slow roast techniques.

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