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Research Article

The Effect Of Exselsa Coffee Roasting Temperature And Time On The Physicochemical And Sensory Properties Of Coffee Powder

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Abstract
This study aims to obtain the best combination of temperature and roasting time in processing excelsa coffee beans on the quality of the coffee powder produced. The research design used RAK which was arranged by factorial two factors, namely roasting temperatures of 190°C, 200°C, 210°C and roasting times of 10, 15, 20 minutes, so that 9 treatment combinations were obtained, 3 replications. The result data were analyzed statistically with the ANOVA test, followed by the BNJ test, the best quality coffee powder was produced at a temperature and time of 210°C 15 minutes, namely yield 84.70%, water content 1.85%, ash content 3.95%, caffeine content 6,88%, organoleptic characteristics, aroma 3.97 (strong), acidity 3.43 (slightly sour), body/mouthfeel 3.70 (thick), color 3.97 (black), and consumer preferences 3.70 (like).

***Keywords*:** Exselsa coffee beans, coffee powder, specification

1. Introduction

Coffee is a kind of drink that comes from the processing and extraction of coffee plant seeds. Coffee is the second most traded commodity in the world after oil, in terms of production world coffee reaches 7 million tons per year. Coffee is the most popular drink by the wider community, including Indonesia from various backgrounds and ages. Coffee is the most consumed drink after mineral water coffee has a fairly high economic value (Fatoni, 2015).

The most important quality of coffee powder is flavor (aroma and taste) because it affects consumer preferences. The flavor will be formed during the coffee production process, especially during roasting. According to Mulato et al. (2006), the roasting process is the stage of forming the distinctive aroma and taste of coffee from inside the coffee beans by heat treatment. Roasting plays an important role in the results of brewing coffee, several factors need to be considered during roasting, including the roasting machine, temperature, and roasting time (Panggabean, 2011).

Excelsa coffee, which taxonomically belongs to the Liberica group (Coffea liberica) but is different from arabica coffee (Coffea arabica) and robusta (Coffea canephora) (Jambi Province Plantation Office and Puslitkoka, 2013). Exselsa coffee has a more bitter taste than Liberika coffee, its presence is still rare in Indonesia but has the potential to develop because of its unique taste and people's liking. A type of coffee can be distinguished by looking at the shape of the beans.

The advantages of excelsa coffee are that it has resistance to leaf rust disease, has the adaptability to a wider climate and this type of coffee can last a long time. The weaknesses of this type of coffee are that the production is very low, has an acidic taste, and the formation of the coffee fruit is relatively slow (Afliana, 2018).

The quality of coffee beans can be improved if the roasting process is carried out at the right temperature and roasting time to get the water content and acidity level in accordance with the standards SNI 01-2983-1992 (Indonesian National Standard, 1992) and SNI 01-3542-2004 (Indonesian National Standard, 2004). The roasting process is the process of forming the taste and smell of coffee beans. During the roasting process, the factors that must be considered are the temperature and roasting time and the stirring is carried out until the end of the process so that the heat is distributed evenly over the coffee beans. Currently, there is still little data on how the proper roasting process is to produce quality coffee products. Information regarding roasting temperature and time causing a decrease in quality due to overroasting is still very limited, so research on roasting temperature and time needs to be carried out.

2. Methods

2.a Time and Site

This research was conducted at the Food Technology Laboratory, Faculty of Agriculture, Universitas Tanjungpura. This research was carried out for ± 6 months.

2.b Materials and Tools

The materials used in this study were Excelsa coffee beans purchased online in the form of green beans, the chemicals used were distilled water, KOH (Potassium Hydroxide) solution, hydrochloric acid (HCl) 0.01 N, lead II acetate (Pb(CH3COO) 2 2 M, 3 M sulfuric acid (H2SO4), ethanol, and caffeine powder. The tools used in this study included electric roasting machines, electric grinders, and sieves to obtain the desired coffee powder. The tools used for analysis included analytical scales, a porcelain cup, a desiccator, a spectrophotometer, a furnace, a test tube, a test tube rack, a suction flask, a volume pipette, a beaker, Erlenmeyer, a 40 mesh sieve. Tools used for sensory tests are coffee cups, label paper, tasting booths, stationery, sensory test paper, and a camera.

2.c Research Design

The research design used a randomized block design (RBD) which was arranged by factorial two factors, namely roasting temperature (p) and roasting time (w). Based on these two factors, 9 combinations were obtained, 3 repetitions. Treatment factors performed include:

Factor I Temperature:	Factor II Time:
p1 = 190°C	w1 = 10 Minutes
p2 = 200°C	w2 = 15 Minutes
p3 = 210°C	w3 = 20 Minutes

2.d Work procedures

2.d.1 Preparation of Coffee Beans (Exselsa)

Excelsa-type coffee beans are purchased in the form of green beans with guaranteed quality and authenticity. The coffee beans are then sorted to select the best coffee beans.

2.d.2 Preparation of the Roasting Machine

Before doing the roasting, heat the electric roaster for 10 minutes using a temperature of 200oC so that the heat is evenly distributed.

2.d.3 Roasting

After heating, input the coffee beans into the roasting machine, and adjust the temperature according to the treatment.

2.d.4 Cooling the Roasted Beans

The cooling process of roasted coffee beans is carried out by transferring the coffee beans to a tray and then aerating them before grinding. This aims to prevent further heating if the coffee beans are still in the coffee roaster.

2.d.5 Milling

The grinding process is carried out using an electric grinder to grind the coffee beans to obtain coffee powder. In the milling process, coffee beans that have been roasted according to the treatment are ground until smooth.

2.d.6 Process Sieving

Sieving aims to uniform the size of the coffee bean powder. The sieving process carried out in this study is using a sieve.

2e. Data analysis

The research data were analyzed statistically using the F test (ANOVA) with a test level of 5%, if it had a significant effect then it was continued with the Honest Significant Difference (BNJ) test with a level of 5%. Data from hedonic quality test results were analyzed using the Friedman method. Determination of the best treatment is done by comparing the values in each treatment through the Effectiveness Index test using the method (De Garmo et al., 1984)

3. Results and Discussion

3. a Yield

Yield is an important value in product manufacture, yield is expressed as a percentage of the weight of the final product per weight of processed material (Hartanti et al., 2003).

Table 1. Yield Percentage at Different Temperatures

Temperature (^{0}C)	Yield (%)
190	87,98^c ± 4,01
200	86,70^b ± 4,67
210	84,77^a ± 6,22
BNJ 5% = 1,26	

Table 2. Yield Percentage at Different Time

Time (Minutes)	Yield (%)
10	88,28^b ± 3,29
15	86,08^a ± 6,00
20	85,09^a ± 5,33
BNJ 5% = 1,26	

The results showed that there was a significant effect of temperature and time on the yield. The highest yield of excelsa coffee to temperature was found in the 190^{0}C treatment, namely 87.98%, while the lowest yield was found in the 210^{0}C temperature treatment, namely 84.77%. The highest yield value of excelsa coffee was found in the 10-minute treatment, namely 88.28%, while the lowest yield was found in the 20-minute treatment, namely 85.09%. Supported by Yusianto et al. (2013) showed that the average yield of coffee from the domestic market ranged from 80.4% to 91.4%.

The BNJ test results show that the higher the temperature and the longer the roasting time, the lower the yield of Excelsa coffee. It is suspected that there is greater evaporation of water during the process of roasting Excelsa coffee beans, the hotter the temperature, the wider the surface of the coffee so that the free water evaporates easily. This is in accordance with the statement of Sivetz and Foote (1979) that the yield is also affected by the weight loss of coffee beans during roasting, the longer the roasting time the yield will be smaller. This is presumably due to the pyrolysis process which causes the evaporation of water and volatile compounds that are formed so that the higher the temperature and roasting time, the lower the yield.

Woodman et al. (1967) stated that the shrinkage value is highly dependent on temperature and roasting time, the longer the roasting process and the higher the temperature used, the higher the shrinkage. According to Purnamayanti et al. (2017), roasting losses occur due to water evaporation and pyrolysis of organic materials generally ranging from 10% to 25%.

3. b Water Content

Stating that the water content in foodstuffs also determines the freshness and durability of these foodstuffs, high water content makes it easy for bacteria, molds, and yeast to multiply so that changes will occur in food ingredients (Sandjaja, 2009).

Table 3. Moisture Content at Different Temperatures

Temperature (^{0}C)	Moisture Content (%)
190	$2,48^b \pm 2,35$
200	$1,94^a \pm 1,51$
210	$1,79^a \pm 1,25$
Tabel BNJ 5% = 0,26	

Table 4. Moisture Content at Different Time

Time (Minutes)	Moisture Content (%)
10	$2,66^c \pm 1,82$
15	$2,00^b \pm 0,69$
20	$1,54^a \pm 0,74$
Tabel BNJ 5% = 0,26	

The results showed that there was a significant effect of temperature and time on water content. The highest water content value of Excelsa coffee with respect to temperature was found in the 190^{0}C treatment which was 2.48%, while the lowest water content was found in the 210^{0}C temperature treatment which was 1.79%. The highest water content value of Excelsa coffee over time was found in the 10-minute treatment, namely 2.66%, while the lowest water content was found in the 20-minute treatment, namely 1.54%.

The BNJ test results showed that the higher the temperature and roasting time, the water content of the Excelsa coffee decreased. It is suspected that during the roasting process water evaporation from the ingredients into the air can reduce the water content in Excelsa coffee. This is in line with research by Yusdiali, (2013) which states that the temperature and duration of roasting greatly affect the water content, the higher the temperature and roasting time, the amount of water in the evaporating material.

Research by Agustina et al. (2019) showed that the higher the temperature and roasting time, the higher the decrease in water content. Sivetz and Foote (1973), stated that at the beginning of the process, the available heat energy in the roasting chamber is used to evaporate water.

3. c Ash Content

Ash content is an inorganic substance left over from the combustion of a food ingredient, ash content is the number of minerals present in the material, where the minerals found in coffee are potassium, potassium, calcium, magnesium, and non-metallic minerals, namely phosphorus and sulfur (Clarke and Macrae, 1985).

Table 5. Ash Content at Different Temperatures

Temperature (^{0}C)	Ash Content (%)
190	$3,55^a \pm 0,55$

Temperature (^{0}C)	Ash Content (%)
200	3,73^a ± 0,25
210	3,83^a ± 0,46

Table 6. Ash Content at Different Time

Time (Minutes)	Ash Content (%)
10	3,65^a ± 0,29
15	3,71^a ± 0,90
20	3,76^a ±0,37

The results showed that there was no significant effect of temperature and time on ash content. The lowest ash content value of Excelsa coffee with respect to temperature was found in the 190^{0}C temperature treatment which was 3.55%, while the highest water content was found in the 210^{0}C temperature treatment which was 3.83%. The lowest ash content value of excelsa coffee with respect to time was found in the 10-minute temperature treatment which was 3.65%, while the highest ash content was found in the 20-minute temperature treatment which was 3.76%.

According to SNI 01-3542-2004, the maximum ash content of ground coffee is 5%. In this study, the ash content of the coffee powder obtained met the SNI standards. As well as in line with research. In a study by Edvan et al (2016), the longer the roasting time causes the ash content in roasted coffee beans to increase, this is due to the high mineral content so the ash content increases. This opinion is supported by the research of Lubis (2008) that high ash content is closely related to mineral content which is found in coffee beans where the ash content depends on the type of material, method of ashing, time, and temperature used. The determination of ash content is closely related to the mineral content contained in a material, and the purity and cleanliness of a material produced (Sudarmadji, 1997). Ash content is a mineral component that does not evaporate in the process of burning or irradiating organic compounds. According to Harris and Karmas (1989), an increase in temperature and appropriate time in a roasting process does not result in mineral damage.

3. d Caffeine Levels

Caffeine is one of the alkaloid compounds naturally found in coffee beans which acts as a refreshing and non-alcoholic stimulant compound in the form of crystals, tastes bitter, and dissolves easily in water (Arwangga et al., 2016).

Table 7. Caffeine Levels at Different Temperatures

Temperature (^{0}C)	Caffeine Levels (%)
190	19,80^c ± 1,63
200	13,72^b ± 2,09
210	8,72^a ± 1,59
Tabel BNJ 5% = 1,89	

Table 8. Caffeine Levels at Different Time

Time (Minutes)	Caffeine Levels (%)
10	21,20^c ± 1,75
15	13,11^b ± 2,12
20	7,93^a ± 1,68
Tabel BNJ 5% = 1,89	

The results showed that there was a significant effect of temperature and time on caffeine levels. The lowest caffeine content value of Excelsa coffee with respect to temperature was found in the 210^{0}C treatment, namely 8.72%, while the highest caffeine content was found in the 190^{0}C temperature treatment, namely 19.80%. The lowest caffeine content value of Excelsa coffee over time was found in the 20-minute temperature treatment which was 7.93%, while the highest caffeine content was found in the 10-minute temperature treatment which was 21.20%.

The BNJ test results showed that the higher the temperature and roasting time, the caffeine content of Excelsa coffee decreased. Allegedly because the roasting process can affect the levels of caffeine in coffee beans. The longer the time and the higher the roasting temperature, the less or less the caffeine content in the coffee beans will be.

This is the same as the chemical properties of caffeine, where caffeine will melt at 236°C and boil at 178°C in the atmosphere (Mumin, 2006). Coffee beans roasted in a light way have a higher caffeine content than coffee beans roasted in a dark way (Kurnia, 2018). This research is also supported by research conducted by Suwarsa et al. (2018) and research conducted by Fajriana et al. (2018), which proved that caffeine levels would decrease in the coffee roasting process using high temperatures.

3. e Organoleptic Test

Organoleptic testing has an important role in implementing quality. Organoleptic testing is referred to as sensory assessment or sensory assessment that utilizes the five human senses. There are five types of sensory modalities namely sight, smell, touch, hearing, and taste. Liliyana (2012), said the purpose of the organoleptic test was to find out whether a commodity or certain sensory properties were acceptable to the public. Organoleptic quality is product quality that can only be assessed or assessed by sensing processes which include color, aroma, taste, and texture.

The organoleptic test in this study used the hedonic test method with the aim of knowing the value of aroma quality, acidity, body/mouthfeel, color, and preferences of Excelsa coffee. For quality assessment or analysis of the sensory properties of a commodity, panelists act as instruments or tools. Tests were carried out by 30 semi-trained panelists. The hedonic test results obtained were then processed using the Friedman test to find out whether Excelsa coffee had a significant or not significant effect on temperature and roasting time.

Table 9. Summary of Organoleptic Test Result

T (^{0}C)	t (minutes)	Average				
		Odor ± SD	Acidity ± SD	Body/mouthfeel ± SD	Color ± SD	Preferences ± SD
190	10	2,30± 0,47	2,67 ± 0,48	2,70 ± 0,70	2,43 ± 0,50	2,83 ± 0,70
	15	2,77 ± 0,57	2,90 ± 0,40	2,97 ± 0,61	2,70 ± 0,53	3,07 ± 0,64
	20	3,20 ± 0,76	2,90 ± 0,55	2,97 ± 0,56	3,17 ± 0,65	3,27 ± 0,52
200	10	3,13 ± 0,63	3,20 ± 0,61	3,43 ± 0,68	3,33 ± 0,61	3,43 ± 0,73
	15	3,57 ± 0,68	3,27 ± 0,64	3,50 ± 0,51	3,70 ± 0,47	3,63 ± 0,67
	20	3,70 ± 0,75	3,27 ± 0,58	3,40 ± 0,67	3,80 ± 0,48	3,57 ± 0,73
210	10	3,73 ± 0,83	3,43 ± 0,73	3,50 ± 0,63	3,70 ± 0,65	3,63 ± 0,81
	15	3,97 ± 0,89	3,43 ± 0,77	3,70 ± 0,75	3,97 ± 0,49	3,70 ± 0,75
	20	4,07 ± 0,78	3,53 ± 0,68	3,77 ± 0,68	4,13 ± 0,57	3,77 ± 0,82
Asymp.Sig.		0,00	0,00	0,00	0,00	0,00

Information: *Asymp. Sig* < 0,05 so it has a real effect.

3. e. 1 Smell

The smell is a quality trait that very quickly gives an impression to consumers because the smell is a factor that greatly influences consumer acceptance of a product (Tobri, 2006). The

longer the roasting, the more volatile compounds will evaporate which will affect the aroma of ground coffee (Punamamayanti, 2017).

The Friedman test results (α = 0.05) (Appendix 15) show that the Asymp. Sig < 0.05 so that it can be seen that the aroma in the Excelsa coffee brew has a significant effect on the temperature and roasting time. Based on the results of the organoleptic test of Excelsa coffee, the aroma value was obtained between 2.30-4.07 (less like to really like). The lowest value was found at 190°C 10 minutes, namely 2.30 (did not like it), while the highest value was found at 210°C 20 minutes, namely 4.07 (very like it).

The higher the temperature and the longer the roasting time, the stronger the distinctive aroma of Excelsa coffee will be. Allegedly because the phenolic and volatile compounds present in the Excelsa coffee beans will come out to form an aroma when the Maillard and caramelization reactions occur. This is supported by (Sivetz, 1972) saying the aroma of coffee appears

As a result of volatile compounds captured by the human sense of smell, volatile compounds that affect the aroma of roasted coffee are formed from Maillard reactions or non-enzymatic browning reactions, sugar degradation, and degradation of phenolic compounds, the longer the roasting, the more volatile compounds that evaporate so that it will affect the aroma coffee powder.

According to Tranggono and Sutardi (1989), the formation of aroma occurs due to a caramelization reaction, this caramelization reaction gives rise to a distinctive aroma, known as caramel aroma. According to Safitri et al. (2019), during roasting, a pyrolysis process occurs which causes oxidation, reduction, hydrolysis, polymerization, decarboxylation, and other chemical changes which form compounds that determine the aroma and taste of brewed coffee grounds.

3. e. 2 Acidity

Every coffee product contains acids that will affect the degree of acidity, aroma, and taste of the coffee product. Types of acids in coffee beans include acetic acid, formic acid, tamarind lactic, malic acid, pyruvic acid, quinic acid, and citric acid (Panggabean, 2011).

The Friedman test results (α = 0.05) (Appendix 16) show that the Asymp. Sig < 0.05 so that it can be seen that the acidity of the Excelsa coffee brew has a significant effect on the temperature and roasting time. Based on the results of the organoleptic test of Exselsa coffee, the value for acidity was between 2.67-3.53 (less like to like). The lowest value was found at 190°C 10 minutes, namely 2.67 (did not like it) while the highest value was found at 210°C 20 minutes, namely 3.53 (liked).

The higher the temperature and the longer the roasting time, the acidity of the Excelsa coffee will increase. It is suspected that this decrease in acidity is caused by the evaporation of acidic substances such as chlorogenic acid in coffee beans and black glutinous rice. This is in line with research conducted by Sari (2001) which states that the taste of coffee is affected by the results of the degradation of several compounds such as carbohydrates, alkaloids, collagenic acids, volatile compounds, and trigonelline.

The higher the temperature and the longer the roasting time, the compound will heat up faster, so the atoms move harder and break chemical bonds, this is what causes coffee from acid to become bitter (Punamamayanti, 2017).

3. e. 3 *Body/ Mouthfeel*

Body/mouthfeel is the sensation received by the senses of taste in the form of a thick, thick, soft or smooth taste. Testing the thickness of the coffee aims to detect the sensation of the thickness of the coffee that is felt by the surface of the tongue when it is sipped, if the thickness is thick, the value that will be given is greater. In the mouth, the body is often described as the smoothness and depth of coffee that is felt on the surface of the tongue. The more concentrated (thick) the coffee is, the higher the value will be.

The Friedman test results (α = 0.05) (Appendix 17) show that the Asymp. Sig < 0.05 so that it can be seen that the body/mouthfeel in the brewed Excelsa coffee has a significant effect on

the temperature and roasting time. Based on the results of the organoleptic test of Exselsa coffee, the value for body/mouthfeel was between 2.70-3.77 (less like to like). The highest value is at 210°C 20 minutes, namely 3.77 (likes), while the lowest value is at 190°C 10 minutes, namely 2.70 (fewer likes).

The higher the temperature and the longer the roasting time, the higher the body of the Excelsa coffee. It is suspected that the lipid compounds during the pyrolysis process are broken down to produce oil in the coffee beans which results in a higher body of excelsa coffee. This is in accordance with the statement (Calligaris et al., 2009) that a high breakdown of lipid compounds will produce more coffee oil and affect the level of coffee viscosity. The thicker the coffee, the consumer will like the coffee because this will affect the strong taste of the coffee (Panggabean, 2001).

Mulato et al. (2006) stated that the higher the temperature used, the body in coffee will increase because fat, complex carbohydrates-, and alkaloid compounds are increasingly formed. The body sensation is caused by the presence of lipid compounds, carbohydrates, and polysaccharides dissolved in the coffee solution

3. e. 4 Color

Color is a parameter that can be tested directly by the panelists' sense of sight (Shofiati et al., 2014). Even though it has the desired taste, if it has a color that does not match what consumers want, then the acceptance power will be low. The color changes from green to cinnamon brown and then black with an oily surface.

The Friedman test results ($\alpha = 0.05$) (Appendix 18) show that the Asymp. Sig < 0.05 so that it can be seen that the aroma in the Excelsa coffee brew has a significant effect on the temperature and roasting time. Based on the results of the Excelsea coffee organoleptic test, the value for color was obtained between 2.43-4.13 (less like to really like). The highest value is at 210°C 20 minutes, namely 4.13 (very like), while the lowest value is at 190°C 10 minutes, namely 2.43 (less like).

The higher the temperature and the longer the roasting time, the darker the color of the Excel coffee will be. Allegedly because it is influenced by the fast propagation of heat in the roasting medium the Millard reaction occurs which forms volatile compounds, the caramelization of carbohydrates, and the formation of CO2 as a result of oxidation during roasting. This is in accordance with Sari's statement (2018), the factors that affect the color of the resulting brewed coffee, namely due to the process of caramelization of sugar which causes a dark brown color to appear. Other factors that affect the color of ground coffee are the roasting and grinding processes and the level of maturity when harvesting coffee (Ditjenbun, 2012).

3. e. 5 Preferences

Based on the results of the organoleptic test of Excelsa coffee, the value for preferences was obtained between 2.83-3.77 (less like to like). The highest value is at 210°C 20 minutes, namely 3.77 (likes), while the lowest value is at 190°C 10 minutes, namely 2.83 (fewer likes).

The Friedman test results ($\alpha = 0.05$) (Appendix 19) show that the Asymp. Sig < 0.05 so that it can be seen that the preference for brewing Excelsa coffee has a significant effect on the temperature and roasting time.

Panelists prefer coffee with a roasting temperature of 210°C 20 minutes, a strong aroma, less acidic, a very thick body, and black color. While the roasting temperature was 190°C for 10 minutes, the panelists didn't like it because at that temperature the coffee still tended to have a weak, sour, thick, and not black aroma. The combination of bitter, sweet, and sour tastes, the resulting distinctive aroma is thought to be due to the presence of substances such as chlorogenic acid, phenols, reducing sugars, and carbohydrates present in coffee beans.

4. Conclusion

Based on the results of this study, it can be concluded that the temperature and roasting time of Excelsa coffee beans has a significant effect on yield, water content, caffeine content,

aroma, acidity, body/mouthfeel, color, and preferences. Exselsa coffee processing produces the best quality coffee at a combination of temperature and roasting time of 210°C for 15 minutes. The quality of the coffee produced was 84.70% yield, 1.85% water content, 3.95% ash content, 6.88% caffeine content, organoleptic characteristics, namely aroma 3.97 (likes), acidity 3.43 (likes), body/mouth feel 3.70 (likes)), color 3.97 (likes), and preferences 3.70 (likes).

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