Accepted: 31/08/2023, Revised: 19/10/2023, Published: 31/10/2023

EFFECT OF FERMENTATION TIME AND ROASTING TEMPERATURE ON THE SENSORY, CHEMICAL, AND PHYSICAL CHARACTERICTICS OF WINE COFFEE ROBUSTA TIRTOYUDO

Jaya Mahar Maligan*, Nathania Zefanya Anggono

Department of Food Science and Biotechnology, Faculty of Agricultural Technology, Universitas Brawijaya
Veteran Street, Malang, 65145, East Java Indonesia
*Corresponding author, Email: jm.maligan@gmail.com

ABSTRACT

The purpose of this study was to determine the effect and results of the best treatment of the factors of fermentation time and roasting temperature, and to determine the physical and chemical quality characteristics of the resulting Robusta Tirtoyudo wine coffee. The experimental design used is Factorial Randomized Group Design and data will be analyzed with ANOVA. The results showed that fermentation time and roasting temperature had a significant effect on fragrance, flavor, acidity, body, and overall attributes. Fermentation time also affects the aftertaste, while the interaction between the two treatment factors significantly affects flavor, body, and overall. Roasted beans had a normal aroma, taste, and color, moisture content below 7%, and ash content below 5%. The best wine coffee was obtained from a 30 days fermentation - medium roast (150˚C), which had an ash alkalinity 62.16 ml NaOH/100g, coffee extract 12.61%, caffeine 4.23% and cupping score 83.30 (specialty).

Keywords: Cupping test, Fermentation, Roasting, Wine coffee

INTRODUCTION

Based on data from Badan Pusat Statistik Kabupaten Malang (2019), the amount of Robusta coffee production in Tirtoyudo District was 2031 tons in 2018. Tirtoyudo Robusta coffee planting is carried out at an altitude around 400 - 800 mdpl, where according to Elfariyanti et al. (2020), planting coffee at a low altitude can cause the production of secondary metabolites increase, which can affect the quality of the coffee flavor. Based on the research by Maligan et al (2022), the total score of cupping test is 75.38. which shows that Robusta Tirtoyudo coffee processed naturally by Alir Coffee is not yet included in the specialty coffee category and has a flavor characteristics of cocoa, caramel, burn, and peanut. The burn flavor is a form of defect. To avoid these flavor defects, one of them can be done by making a wine coffee.

Wine coffee is a form of coffee that has gone through a fermentation process on the cherry fruit which will have an aroma and taste like wine. According to some farmers, the price of wine coffee is higher than coffee in general because the process is not easy and takes a long time (Zulkarnain *et al*., 2020). Based on Ramadhan's research (2021), the fermentation time and roasting temperature had a significant effect on several attributes in the cupping test and it was found that a fermentation period of 30 days with a roasting temperature of 220˚C produced the most optimum Arjuna Arabica wine coffee flavor. In addition, the cupping test score obtained is 86,66 which indicates that Arjuna Arabica wine coffee is included in the specialty coffee category. The purpose of this study was to determine the effect and results of the best treatment of the factors of fermentation time and roasting temperature, and to determine the sensory, physical and chemical quality characteristics of Robusta Tirtoyudo wine coffee.

METHODOLOGY

Materials

The materials used were dark red Robusta Tirtoyudo coffee cherries, roasted bean Robusta Tirtoyudo natural, roasted bean Arabica Arjuna Honey to Red, wine coffee Arabica, wine coffee Robusta obtained from Alir Coffee Malang, mineral water, granulated sugar, citric acid, caffeine powder, MSG, palm sugar essence, caramel essence, chocolate essence, peanut essence obtained from Sensoflavo Kit, 3% H_2O_2 solution, 0.5N HCl solution, 0.5N NaOH solution, PP (Phenolphthalein) indicator, Pb acetate, PbO, absolute ethanol, methanol, caffeine standard, distilled water, and filter paper.

Tools

Several tools that were used in this study were a roasting machine with specifications of 5 kg capacity; local brand Malang; and LPG heating source, cupping cup, cupping spoon, cupping form, coffee grinder machine, analytical balance, huller machine, petri dish, iron spatula, crucible, electric oven, furnace, burette, 250 ml erlenmeyer flask, 10 ml measuring pipette, 500 ml beaker glass, electric stove, 500 ml volumetric flask, funnel, 50 ml measuring pipette, drip pipette, desiccator, HPLC, test tube, 50 µl syringe, membrane filter, vacuum filter, 10 kg plastic bag, 25 kg gunny sack, ballpoint, kettle, paper cup, 1 L plastic bottle, 1 kg standing pouch, questionnaire for panelist selection, basic taste test form, basic aroma test form, threshold test form, and raffia rope.

Research Design

The research design used for this research is RAKF (Randomized Group Factorial Design) consisting of two factors, where factor I is the fermentation time, which is 10. 20. 30. and 40 days. Meanwhile, factor II is roasting temperature with 3 levels, which are light (130 °C), medium (150 °C), and dark (160 °C), so that there are 12 treatments in total. Repetitions were carried out 5 times in the cupping test, where 5 different cups were used in each test. Meanwhile, the chemical and physical tests were repeated twice and the cupping test.

Research Stages

The research was divided into three stages which are trained panelist selection, making green beans, and making roasted beans of Tirtoyudo Robusta coffee wine. The trained panelist selection process consists of panelist recruitment, basic flavor and aroma test, threshold test, coffee sensory vocabulary, and intensity test. The process of making green beans begins with soaking the coffee cherries, draining the water, and drying. Next, the coffee cherries are put into plastic for fermentation at room temperature from 10 – 40 days. After the fermentation process is complete, final drying and hulling is carried out to produce green beans wine coffee. The process of making roasted beans is done by roasting green beans for 10 minutes, tempering for 5 minutes and resting for at least 24 hours.

Analysis Procedure

Analysis of the physical quality of green beans wine coffee will be carried out based on the applicable regulations in SNI 2907-2008 regarding coffee beans. The test includes the determination of live insects, foul-smelling and moldy beans, moisture content, defect value and coffee impurities. Quality analysis of roasted beans is conducted based on SNI 3542-2004 regulations regarding ground coffee. Tests carried out include testing color, aroma, taste, water content, ash content, and for organoleptic test cupping tests will be carried out according to the SCA rules. For testing color, taste, aroma, moisture content, ash content is carried out based on SNI 2891-1992 regarding how to test food and beverages. Analysis of the best roasted beans wine coffee will be carried out based on SNI 3542-2004 regulations regarding ground coffee, where the test will include ash, coffee extract, and caffeine.

The data analysis process will be carried out through Minitab 18 software using ANOVA (Analysis of Variance) with a confidence level of 95%. The further test will be carried

out if there is a real influence between the observed factors on the response, where the BNT or Fisher 5% further test is used. Meanwhile, the 5% BNJ or Tukey further test will be carried out if there is an interaction between the observed factors. For the basic taste and aroma test data, panelists who pass to the next stage are panelists who score above 80. As for the threshold test results, the data obtained will be analyzed using the BET (Best Estimation Threshold) method with Microsoft Excel software to obtain the panelist threshold aroma. The results of the intensity test will be analyzed with Minitab software using Pearson correlation and paired T-test. The best treatment will be determined through the total score of the cupping test, which will show the results of wine coffee with the best quality.

RESULT AND DISCUSSION

Trained Panelist Selection Results

a. Panelist Recruitment

The panelist recruitment process was carried out by distributing questionnaires, where the total number of candidate panelists who filled out the questionnaire was 26 people. Based on the information obtained from the questionnaire results, it was found that 61.54% of the candidate panelists were male and the remaining 38.46% were female. Candidate panelists will then take part in the selection and training stage, which is in accordance with the requirements that have been made. So, it can be said that all panelist candidates have stated that they are willing to take part in the selection and training stages. The results of the general characteristics of all candidate panelists can be seen in Table 1.

Table 1. Results of Panelist Characteristics

No	Characteristic	Result
1	Gender	16 males dan 10 females
2	Age	18 – 22 years old
3	Job	Student
4	Domicile	Malang

Description: data is the result of all 26 candidates.

b. Basic Flavor and Aroma Test

The basic flavor and aroma testing process is conducted at the same time, where the test begins with the basic flavors. In this test, each panelist will be presented with 10 solutions representing 5 basic flavors, namely sweet, salty, umami, bitter, and sour, and each of these flavors consists of 2 different concentrations. Meanwhile, the basic aroma test is carried out by smelling the essence that represents the basic aroma in coffee, including palm sugar, caramel, chocolate, and nuts. Panelists who can continue to the next stage, namely training, are panelists who get the correct score of more than or equal to 80%. Based on the testing and data processing that has been done, it is found that there are 15 panelists who can continue to the training stage and 11 others who cannot.

c. Threshold Test

Threshold test was conducted on five basic flavors, which are sweet, sour, salty, umami, and bitter. Based on the results of the tests that have been done, it is found that for samples with a sweet taste both in each panelist and as a whole, the minimum concentration needed to give the impression of sweetness is 5 g/L. In samples with sour taste, it shows that individual panelists have different thresholds with a concentration range of 0.1 g/L to 0.4 g/L, while panelists as a whole can detect sour taste at the lowest concentration of 0.1 g/L. Samples with salty taste showed that individual panelists had different thresholds with a concentration range of 1 g/L to 1.5 g/L and as a group, panelists could detect the presence of salty taste at a minimum concentration of 1.1 g/L. In samples with umami flavor, it shows that individual panelists have different thresholds with a concentration range of 0.1 g/L to 0.2 g/L. While overall, panelists can detect the presence of umami flavor at a minimum concentration of 0.1 g/L. In samples with bitter taste, it shows that individual panelists have different

thresholds with a concentration range of 0.1 g/L to 0.4 g/L. While overall, panelists can detect the presence of umami flavor at a minimum concentration of 0.2 g/L. The results of the threshold test can be seen in Table 2.

Table 2. Threshold Test Result

Solution	Individual BET	Group BET
Sugar	0.5	0.5
Citric Acid	0.01 – 0.04	0.01
Salt	0.10 – 0.15	0.11
MSG	0.01 – 0.02	0.01
Caffeine	0.01 – 0.04	0.02

Description: data is the result of calculation by BET method ASTM E679

d. Coffee Sensory Vocabulary Training

The panelist training process is conducted to introduce various flavors that are commonly found in coffee. The training was conducted using a cupping test based on SCA rules. In this process, 3 different types of coffee samples were used, including Arjuna honey to red Arabica coffee, Robusta wine coffee, and Arabica wine coffee. Based on the results of the coffee flavor vocabulary discussion training with the cupping test, it can be concluded that overall the panelists were able to detect the various flavors present in the test coffee samples. The overall cupping test results can be seen in Table 3.

Table 3. Cupping Test Result

Sample	Aroma	Flavor	Acidity	Body
Arabika Arjuna Honey to Red	Nutty, chocolate, fruity	-	Thin to medium	Thin to medium
Wine Robusta	fruity	Brown sugar, chocolate	Thin to Medium	Thin to medium
Wine Arabika	Nutty, chocolate, fruity	Winey, savory, citrus, tea	Medium	Thin to medium

e. Coffee Sensory Attribute Intensity Training

Attribute intensity evaluation consists of three main parts, namely aroma, flavor, and body. Based on the analysis that has been done, it is found that all PCC values show results of more than 0.514 so that panelists can be considered consistent as a group. As for all p-value results, all data show values above 0.05 so that it can be stated that panelists have been consistent on the intensity of nutty, citrus, and chocolate aroma attributes; sour, bitter, sweet, and salty flavor attributes; and body attributes with milk and CMC solutions. The results of the intensity test can be seen in Table 4.

Table 4. Intensity Test Result

Attribute	PCC	*P-value*
	Aroma	
Nutty	0.613	0.500
Citrus	0.823	0.994
Chocolate	0.619	0.758
	Flavor	
Sour	0.808	0.997
Bitter	0.878	0.996
Sweet	0.823	0.932
Salty	0.948	1.000
	Body	
Milk	0.979	1.000
CMC	0.814	1.000

Description:

1. Data is the result of 2 repetitions, which includes 15 panelists

Quality Analysis Results of Green Beans Wine Coffee Robusta Tirtoyudo

All green beans tested have met the specified standards. For testing live insects and aromas beans, all samples did not contain live insects and did not smell of rot or mold. As for quality classification, all samples are included in quality 2 because they have a range of defect values of 12.30 to 17.3. Based on the analysis that has been done, it is found that generally the defects found in green beans of Robusta Tirtoyudo coffee wine are black beans, brown beans, coffee skins of various sizes, horn skins, broken beans, hollow beans, and spotted beans. The fermentation process can affect water content. According to research conducted by Thalia et al. (2018), the longer the fermentation, the water content in green beans will decrease. This is due to the increase in temperature that occurs during the fermentation process, where the activity of microbes will also increase and cause enzyme activity to become more active, so that the mucus on the seeds will decrease and the pores on the seeds become more open. The more open pores will cause water evaporation and decrease the water content of the seeds. The test results can be seen in Table 5.

Table 5. Quality Testing Results of Green Beans Wine Coffee

Sample	Criteria	Unit	Result
Green Beans wine coffee Robusta Tirtoyudo 10 days fermentation	Water content	% mass fraction	11.353 ± 0.205
	Dirt content	% mass fraction	0.42
Green beans wine coffee Robusta Tirtoyudo 20 days fermentation	Water content	% mass fraction	10.855 ± 0.181
	Dirt content	% mass fraction	0.38
Green beans wine coffee Robusta Tirtoyudo 30 days fermentation	Water content	% mass fraction	10.754 ± 0.063
	Dirt content	% mass fraction	0.33
Green beans wine coffee Robusta Tirtoyudo 30 days fermentation	Water content	% mass fraction	10.653 ± 0.880
	Dirt content	% mass fraction	0.25

Description:
1. Data is the average of 2 repetitions and the number after ± is the standard deviation.

Research Results of Roasted Beans Wine Coffee Robusta Tirtoyudo

a. Cupping Test

Cupping test is one of the tests that can be done to determine whether a coffee sample tested is included in the specialty coffee type. The effect of fermentation time, roasting temperature, and the interaction between the two can be seen in Table 6, Table 7. and Table 8.

Table 6. Effect of Fermentation Time on Various Attributes

Fermentation Time	Average ± SD					
	Fragrance	Flavor	Aftertaste	Acidity	Body	Overall
10 days	7.79 ± 0.26^{c}	7.52 ± 0.26^{c}	7.64 ± 0.27^{a}	7.47 ± 0.19^{b}	7.93 ± 0.22^{b}	7.70 ± 0.22^{c}
20 days	7.93 ± 0.22^{b}	7.69 ± 0.23^{b}	7.60 ± 0.27^{a}	7.66 ± 0.21^{a}	7.79 ± 0.22^{c}	7.83 ± 0.23^{b}
30 days	8.03 ± 0.24^{a}	7.82 ± 0.24^{a}	7.68 ± 0.33^{a}	7.74 ± 0.26^{a}	8.03 ± 0.24^{a}	8.03 ± 0.21^{a}
40 days	7.79 ± 0.21^{c}	7.61 ± 0.22^{b}	7.39 ± 0.37^{b}	7.44 ± 0.23^{b}	7.78 ± 0.25^{c}	7.76 ± 0.25^{bc}

Description:
1. Data is the average score of 15 panelists and the number after ± is the standard deviation.
2. Different notations indicate significant differences (α = 0.05)

Table 7. Effect of Roasting Temperature on Various Attributes

Roasting Temperature	Average ± SD				
	Fragrance	Flavor	Acidity	Body	Overall
Light Roast (130˚C)	7.88 ± 0.25^{b}	7.70 ± 0.21^{a}	7.59 ± 0.23^{b}	7.84 ± 0.22^{b}	7.88 ± 0.23^{a}
Medium Roast (150˚C)	8.01 ± 0.22^{a}	7.76 ± 0.24^{a}	7.69 ± 0.26^{a}	8.01 ± 0.23^{a}	7.90 ± 0.25^{a}
Dark Roast (160˚C)	7.76 ± 0.24^{c}	7.52 ± 0.27^{b}	7.45 ± 0.21^{c}	7.80 ± 0.26^{b}	7.70 ± 0.25^{b}

Description:
1. Data is the average score of 15 panelists and the number after ± is the standard deviation.
2. Different notations indicate significant differences (α = 0.05)

Table 8. Effect of Interaction of Fermentation Time with Roasting Temperature on Various Attributes

Fermentation Time	Roasting Temperature	Average ± SD		
		Flavor	**Body**	**Overall**
10 Days	*Light Roast* (130˚C)	7.68 ± 0.20^{abcd}	7.80 ± 0.19^{bcd}	7.80 ± 0.19^{bcd}
	Medium Roast (150˚C)	7.58 ± 0.18^{bcd}	7.98 ± 0.22^{ab}	7.75 ± 0.21^{cde}
	Dark Roast (160˚C)	7.30 ± 0.24^{e}	8.02 ± 0.20^{ab}	7.55 ± 0.19^{e}
20 Days	*Light Roast* (130˚C)	7.77 ± 0.20^{abc}	7.78 ± 0.21^{bcd}	7.93 ± 0.22^{bcd}
	Medium Roast (150˚C)	7.80 ± 0.19^{ab}	7.90 ± 0.18^{bc}	7.80 ± 0.22^{bcd}
	Dark Roast (160˚C)	7.52 ± 0.20^{cde}	7.70 ± 0.22^{cd}	7.75 ± 0.21^{cde}
30 Days	*Light Roast* (130˚C)	7.78 ± 0.21^{ab}	7.98 ± 0.20^{ab}	8.00 ± 0.21^{ab}
	Medium Roast (150˚C)	7.90 ± 0.28^{a}	8.22 ± 0.21^{a}	8.15 ± 0.18^{a}
	Dark Roast (160˚C)	7.77 ± 0.22^{abc}	7.90 ± 0.18^{bc}	7.93 ± 0.20^{abc}
40 Days	*Light Roast* (130˚C)	7.58 ± 0.18^{bcd}	7.78 ± 0.21^{bcd}	7.77 ± 0.22$_{bcde}$
	Medium Roast (150˚C)	7.75 ± 0.21^{abcd}	7.95 ± 0.19^{b}	7.92 ± 0.20^{abc}
	Dark Roast (160˚C)	7.50 ± 0.21^{de}	7.60 ± 0.21^{d}	7.58 ± 0.20^{e}

Description:
1. Data is the average score of 15 panelists and the number after ± is the standard deviation.
2. Different notations indicate significant differences (α = 0.05)

Fragrance

The treatment of fermentation time and roasting temperature had a significant effect on fragrance attributes. The aroma profiles produced are chocolate, nutty, savory, earthy, fruity, roast, herbs. The highest aroma value was produced from the 30-days fermentation process with a medium roast profile. During the fermentation process, there will be the formation of volatile compounds caused by the decomposition of carbohydrate and protein compounds into reducing sugars, organic acids, lipids, and amino acids where all of these compounds play a role in the formation of coffee brewing aroma (Purnamayanti *et al*., 2017). Volatile compounds that affect the aroma of coffee are caused by the Maillard reaction or non-enzymatic browning, free amino acid degradation, trigonelline degradation, sugar degradation, and phenolic degradation. Maillard reaction itself is an influential process in the formation of coffee aroma due to the presence of several compounds produced such as pyrroles, furanones, pyrazines, thiols, thiophenes, and pyridines (Wiraputra *et al*., 2020).

Flavor

The treatment of fermentation time, roasting temperature, and the interaction between the two had a significant effect on flavor attributes. The resulting flavor profiles are earthy, fruity, nutty, spices,and roasty. The highest flavor value resulted from the 30 day fermentation process with a medium roast profile. This is due to the fermentation process that can produce various precursor compounds, which will be activated during roasting and will affect the flavor of the brewed coffee (Poerwanty and Nildayanti, 2021). In the fermentation process, chemical reactions will occur that play a role in the formation of flavor precursors in coffee, including organic acids, amino acids, and reducing sugars (Poerwanty and Nildayanti, 2021). The sweet taste that arises in the brew can be caused by the medium roast process, which is due to the carbonation of the sugar contained in the coffee beans (Kinasih *et al*., 2021).

Aftertaste

The treatment of fermentation time significantly affects the aftertaste attribute. The highest aftertaste value is in the sample with a fermentation time of 30 days. The process of protein degradation will also occur during fermentation, where the longer the fermentation, the protein will be broken down into oligopeptide, dipeptide, and then will become amino acids (Larassati *et al*., 2021). In addition, microbes during the fermentation process will produce

several metabolites in the form of precursors such as aldehyde compounds, organic acids, and esters that play a role in flavor formation (Wiraputra *et al*., 2020). Other changes can also occur during the fermentation process, where carbohydrates will break down into reducing sugars such as glucose and fructose due to the activity of the enzyme carbohydrase. Carbohydrates will also break down into various organic acids such as lactic acid and acetic acid (Lin, 2010).

Acidity

The treatment of fermentation time and roasting temperature significantly affected the acidity attribute. The highest acidity value resulted from a 30 day fermentation process with a medium roast profile. Various types of acids from the carboxylic group such as quinic acid, acetic acid, oxalic acid, lactic acid, formic acid, citric acid, and malic acid are acids formed due to the fermentation and roasting processes carried out, which will increase the sour taste of the brew (Aditya et al., 2016). During the roasting process, some of the acid content contained in coffee will evaporate, where some of these acids are chlorogenic acid and carboxylic acid (Purnamayanti *et al.,* 2017).

Body

The treatment of fermentation time, roasting temperature, and the interaction between the two had a significant effect on body attributes. The highest body value was produced from the fermentation process for 30 days with a medium roast profile. According to Wibowo et al. (2021), fermentation can cause protein hydrolysis, where the protein content in coffee beans will decrease. Dehydration in roasting can cause coffee beans to crack and become more brittle, thus facilitating the process of extracting coffee from coffee beans, so that the resulting body will be higher. The interaction between treatments is significantly different due to the fermentation process that can produce various precursor compounds, where these precursor compounds will be activated during roasting and will affect the body results of coffee brewing (Poerwanty and Nildayanti, 2021).

Overall

The interaction between fermentation time and roasting temperature showed a significant effect on the overall attribute. The highest overall value resulted from a 30 day fermentation process with a medium roast profile. The length of fermentation can affect overalls due to changes in taste, aroma, and color that occur during the fermentation process, where the starch in the coffee beans will degrade into glucose so that it can affect the enjoyment of coffee (Aini *et al*., 2021). In the roasting process, the temperature used, whether light roast, medium roast, or dark roast, can affect the characteristics of the coffee produced (Murad *et al*., 2020). The interaction between treatments is significantly different due to the fermentation process that can produce various precursor compounds, where these precursor compounds will be activated during roasting and will affect the overall results of coffee brewing (Poerwanty and Nildayanti, 2021).

b. Analysis of Roasted Beans Quality

Quality testing of roasted beans is based on SNI 3542-2004 regulations regarding ground coffee. For testing color, taste, aroma, moisture content, ash content is done based on SNI 2891-1992 on how to test food and beverages. The test results of moisture content and ash content can be seen in Table 9.

Aroma, Taste, and Color

Aroma, taste, and color test is done based on the rules in SNI 3542-2004 regarding ground coffee, where for how to test these conditions refers to SNI 2891-1992 regarding how to test food and beverages, in the state of the sample for all types of food and beverages. The test is carried out by checking the sample organoleptically both on color, smell, and taste. Based on the research that has been done, it is found that the 12 samples tested have aroma, taste, and color that are in normal conditions.

Water Content

The interaction between the treatment of fermentation time and roasting temperature shows a significant effect on water content, where the longer the fermentation is done and the higher the roasting profile used, the resulting water content will tend to be lower. Based on the results of the study, it was found that the sample with the lowest water content was at a fermentation time of 30 days with a dark roast profile. This is because in fermentation itself, water evaporation will occur due to the opening of pores in the coffee beans. Meanwhile, in the roasting process, water evaporation will also occur due to heat transfer in the beans, so that the water content in the coffee beans will decrease (Bahroni *et al*., 2019).

Ash Content

The interaction between fermentation time and roasting temperature showed a significant effect on ash content, where the longer the fermentation, the lower the ash content, while the higher the roasting profile used, the higher the ash content. Based on the results of the study, it was found that the sample with the lowest moisture content was at the fermentation time of 10 days with a dark roast profile. During fermentation, various minerals will dissolve into water and fat and come out during the drying process, so the ash content will decrease. Meanwhile, in the roasting process, the dry matter in the coffee beans will be affected by the process that occurs, so that the ash content will increase (Bahroni *et al*., 2019).

Table 9. Effect of the Interaction of Fermentation Time with Roasting Temperature on the Value of Water Content and Ash Content

Fermentation Time	Roasting Temperature	Average ± SD	
		Water Content	Ash Content
10 Days	*Light Roast* (130˚C)	4.89 ± 0.05^{a}	4.47 ± 0.27^{abcd}
	Medium Roast (150˚C)	4.79 ± 0.26^{a}	4.68 ± 0.12^{ab}
	Dark Roast (160˚C)	4.60 ± 0.16^{a}	4.85 ± 0.09^{a}
20 Days	*Light Roast* (130˚C)	4.86 ± 0.16^{a}	4.57 ± 0.09^{abc}
	Medium Roast (150˚C)	4.61 ± 0.22^{a}	3.92 ± 0.08^{cdefg}
	Dark Roast (160˚C)	4.54 ± 0.16^{a}	4.31 ± 0.03^{abcde}
30 Days	*Light Roast* (130˚C)	3.62 ± 0.05^{b}	3.36 ± 0.04^{gh}
	Medium Roast (150˚C)	3.31 ± 0.19^{bc}	3.77 ± 0.01^{efgh}
	Dark Roast (160˚C)	2.60 ± 0.17^{d}	4.15 ± 0.11^{bcdef}
40 Days	*Light Roast* (130˚C)	3.22 ± 0.17^{bc}	3.19 ± 0.23^{h}
	Medium Roast (150˚C)	3.23 ± 0.32^{bc}	3.53 ± 0.46^{fgh}
	Dark Roast (160˚C)	2.90 ± 0.14^{cd}	3.83 ± 0.15^{defgh}

Description:
1. Data is the average water content value of 2 repetitions and the number after ± is the standard deviation.
2. Different notations indicate significant differences (α = 0.05)

c. Best Roasted Beans Wine Coffee Analysis Results

The best treatment of the samples tested can be determined by looking at the highest total score from the cupping test results. Based on the data calculations that have been carried out, it is found that the best treatment is found in the coffee wine sample with a fermentation time of 30 days and the roasting temperature is at a medium level, namely 150˚C. The roasting process was carried out for 10 minutes with a tempering time of 5 minutes and the roasted beans were rested for 24 hours before the cupping test. The results of all cupping test samples can be seen in the table below.

Table 10. Cupping Test Score Result of All Samples

Fermentation Time	Roasting Temperature	Cupping Test Score
10 Days	*Light Roast* (130˚C)	81.13
	Medium Roast (150˚C)	81.47
	Dark Roast (160˚C)	80.78
20 Days	*Light Roast* (130˚C)	82.05
	Medium Roast (150˚C)	82.50
	Dark Roast (160˚C)	81.12
30 Days	*Light Roast* (130˚C)	82.40
	Medium Roast (150˚C)	83.30*
	Dark Roast (160˚C)	81.67
40 Days	*Light Roast* (130˚C)	80.68
	Medium Roast (150˚C)	81.70
	Dark Roast (160˚C)	80.42

Description:
1. Data is the total score of 15 panelists
2. The sign (*) indicates the best treatment result

Ash Alkalinity and Coffee Extract

Ash alkalinity and coffee extract test refers to the SNI 2004 method regarding ground coffee. Based on the research that has been done, the results show that the ash alkalinity of the Robusta Tirtoyudo coffee wine sample has met the standards by SNI because it is within the existing standard range, that is 62.16 which meets the standard requirements I and II. As for the coffee extract, the Robusta Tirtoyudo wine coffee sample also meets the standards set by SNI because it is within the standard range, where the level is 12.61. The coffee extract has met the standard requirements II in SNI. The results of testing the alkalinity of ash and coffee extract can be seen in Table 11.

Table 11. Ash Alkalinity and Coffee Extract Value of Wine Coffee

Ash Alkalinity (ml NaOH/100g)	Coffee Extract (%)
62.16 ± 3.17	12.61 ± 0.04

Description:
1. Data is the average of 2 repetitions and the number after ± is the standard deviation.

Caffeine

Caffeine test was done on the best treatment results and naturally processed Robusta Tirtoyudo coffee. Based on the test results, it was found that there was a decrease in caffeine levels from the natural process to wine. Saccharomyces cerevisiae and proteolytic bacteria such as LAB (*Leuconostoc mesenteroides* and *Lactobacillus plantarum*) during fermentation will produce proteolytic enzymes (protease enzymes) that will enter the cytoplasm, so that later the caffeine in the coffee will be broken down. The mucus layer that has been lost during the fermentation process will facilitate the entry of these proteolytic enzymes (Hindah *et al*., 2022). In this regard, coffee beans that have lost the mucus layer will interact more easily with various microbes in the environment where the fermentation process is carried out. As a result, the process of caffeine reduction will tend to occur more easily (Aini *et al.,* 2021). The results of the caffeine test can be seen in Table 12.

Table 12**.** Caffeine Content of Wine Coffee and Natural Processed Samples

Sample	Caffeine Content (%)
Wine Coffee	4.23 ± 0.01
Natural	5,07 ± 0.00

Description:
1. Data is the average of 2 repetitions and the number after ± is the standard deviation.

CONCLUSIONS

Fermentation time significantly affects the attributes of fragrance, flavor, aftertaste, acidity, body, and overall while roasting temperature significantly affects the attributes of fragrance/aroma, flavor, acidity, body, and overall. The interaction between the factors of fermentation time and roasting temperature significantly affects the attributes of flavor, body, and overall. The results of physical and chemical quality testing of green beans showed the absence of live insects, foul-smelling beans and mold, moisture content below 12.5%, dirt content below 0.5 and included in quality classification 2. The results of testing the quality of roasted beans showed normal aroma, taste, and color, moisture content below 7%, and ash content below 5%. The best Robusta Tirtoyudo Wine Coffee was obtained from the fermentation treatment for 30 days with a medium roast profile (150 °C), where the cupping test score obtained was 83.30 so that it could be categorized as specialty coffee and had an ash alkalinity value of 62.16 ml NaOH/100g, coffee extract 12.61%, and caffeine 4.23%.

REFERENCES

Aditya, I. W., Nocianitri, K. A., Yusasrini, N. L. A. (2016). Kajian Kandungan Kafein Kopi Bubuk, Nilai pH dan Karakteristik Aroma dan Rasa Seduhan Kopi Jantan (Peaberry coffee) dan Betina (Flat beans coffee) Jenis Arabika dan Robusta. Jurnal Ilmu Dan Teknologi Pangan (Itepa), 5(1), 1–12.

Aini, A. F., Saripah, Manfaati R., Daysyadi T. (2021). Pengaruh pengupasan dan lama waktu fermentasi terhadap kadar kafein, nilai pH, dan kadar etanol biji kopi arabika hasil fermentasi. Prosiding The 12th Industrial Research Workshop and National Seminar, 12. 145–150.

Badan Pusat Statistik Kabupaten Malang. (2019). Luas dan Produksi Kopi Robusta Rakyat Menurut Kecamatan Di Kabupaten Malang.

Badan Standardisasi Nasional. (2004). Kopi Bubuk. https://aksessni.bsn.go.id/viewsni/baca/2750.

Badan Standardisasi Nasional. 2008. Biji Kopi. https://akses-sni.bsn.go.id/viewsni/baca/3560.

Bahroni, W., Barus, J., Studi, P., Hasil, T., & Kopi, B. (2019). Pengaruh Lama Fermentasi dan Lama Pengeringan Terhadap Mutu Bubuk Kopi. *Wahana Inovasi: Jurnal Penelitian dan Pengabdian Masyarakat UISU,* 8(2), 111-115.

Elfariyanti, Silviana E, Santika M. (2020). Analisis Kandungan Kafein Pada Kopi Seduhan Warung Kopi Di Kota Banda Aceh. *Lantanida Journal*, 8(1), 1.

Hindah, N. P., Munandar, K. (2022). Pengaruh Lama Waktu Fermentasi Terhadap Kadar Kafein dan Nilai Ph Kopi Robusta. Thesis Universitas Muhammadiyah Jember, 1–9.

Kinasih A, Winarsih S, Anis SE. (2021). Sensori Kopi Arabica Dan Robusta Menggunakan Teknik Brewing Berbeda. *Jurnal Teknologi Pangan Dan Hasil Pertanian,* 16(2), 1–11. http://journals.usm.ac.id/index.php/jtphp

Larassati, D. P., Kustyawati, M., E., Sartika D. (2021). Efek Fermentasi Basah Menggunakan Kultur Saccharomyces cerevisiae Terhadap Sifat Kimia dan Sensori Kopi Robusta (*Coffea canephora*). *Jurnal Teknik Pertanian Lampung,* 10(4), 449–458.

Lin, C. C. (2010). Approach of Improving Coffee Industry in Taiwan Promote Quality of Coffee Bean by Fermentation. The Journal of International Management Studies 5(1): 154 - 159.

Maligan, J. M., Wibowo, A. T. E., Anggono, N. Z., Kosasih, S. U., Putra, Y. K. (2022). Pengujian Karakteristik Sensori Kopi Robusta. Prosiding Seminar Nasional Instiper, 299–305.

Murad, Sukmawaty, Sabani R, Ansar, Kurniawan H. (2020). Introduksi Tentang Pasca Panen Dan Pengolahan Kopi Pada Industri Rumah Tangga Guna Meningkatkan Nilai Tambah di Kecamatan Tanjung Kabupaten Lombok Utara. *Jurnal Ilmiah Abdi Mas TPB*, 2(1): 28–35. 10.29303/amtpb.v2i1.38

Poerwanti H, Nildayanti. (2021). Pengaruh Suhu Dan Lama Fermentasi Kopi Terhadap Kadar

Kafein. Agroplantae: Jurnal Ilmiah Terapan Budidaya dan Pengelolaan Tanaman Pertanian dan Perkebunan, 10(2): 124–130. https://doi.org/10.51978/agro.v10i2.293

Purnamayanti, P., Gunadnya, I., & Arda, G. (2017). Pengaruh Suhu dan Lama Penyangraian terhadap Karakteristik Fisik dan Mutu Sensori Kopi Arabika (Coffea Arabica L). *Jurnal BETA (Biosistem Dan Teknik Pertanian), 5*(2), 39-48.

Ramadhan, R. L. (2021). Pengaruh Lama Fermentasi dan Suhu Roasting Terhadap Kualitas Organoleptik Produk Kopi Wine Arabika (*Coffea arabica*) Arjuno. Skripsi. Fakultas Teknologi Pertanian, Universitas Brawijaya.

SCA. (2021). Cupping Protocols. https://sca.coffee/research/protocols-best-practices.

Thalia, Tia. Ersan. Delvitasari, Febrina. Maryanti, (2018). Pengaruh fermentasi S. cerevisiae terhadap mutu kopi robusta. Agritrop, 18(1), 60-77.

Wibowo N A, Mangunwardoyo W, Santoso TRIJ. (2021). Effect of Fermentation on Sensory Quality of Liberica Coffee Beans Inoculated with Bacteria from Saliva Arctictis binturong Raffles , 1821. *Biodiversitas Journal of Biological Diversity*, 22(9), 3922–3928. https://doi.org/10.13057/biodiv/d220938

Wiraputra D, Adrianto R, Jyoti MD. (2020). Pengaruh lama waktu fermentasi dalam fermentasi kopi robusta (*Coffea canephora*). 5, 13–22.

Zulkarnain, Fazari N, Widyawati, Bagio, Ertika Y. (2020). Keputusan konsumen dalam pembelian wine coffee di na coffee banda aceh. Teknologi Pertanian 6(1): 101–110.