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The Physical and Organoleptic Characteristics Comparison of Arabica and Robusta Coffee in the Gayo Plateau by Wet Processing Method

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Abstract Coffee is one of the most popular drink globally. Wet processing is a common method that enhances coffee quality and raises its market value compared to other methods. This study examines the effects of wet processing on the physical and organoleptic characteristics of Arabica and Robusta coffee. Wet processing involves fruit skin removal, fermentation (48 and 72 hours), washing, drying, and parchment skin removal. Physical analyses included bean weight, yield, sorting, and impurity levels. Organoleptic characteristics were assessed using a hedonic test involving 21 panelists. The results revealed that Arabica coffee fermented for 72 hours exhibited superior physical traits, with an average bean weight of 0.240 g, a yield of 16.50%, and impurity levels of 4.3%. Organoleptic tests indicated Arabica coffee fermented for 72 hours received the highest overall scores, particularly in aroma and body. ANOVA analysis at a 5% significance level showed no significant differences in color and body across samples, while aroma, taste, and overall scores demonstrated significant differences. These findings suggest that fermentation duration significantly impacts both the physical and sensory qualities of coffee, with Arabica coffee processed for 72 hours yielding the best results. Future research should explore additional sensory attributes and chemical analyses to further validate these findings.

Keywords Physical Characteristics; Organoleptic; Arabica Coffee; Robusta Coffee; Wet Processing

INTRODUCTION

The agriculture, forestry, and fisheries sectors play a significant role in Indonesia's economy, contributing around 13.70% to the national GDP in 2020. Among these, the plantation subsector holds substantial potential (Nurhidayah, 2022). Coffee is a traditional plantation commodity cultivated for its vital economic role as a source of foreign exchange, employment, and income for coffee farmers and other stakeholders involved in cultivation, processing, and marketing (Wardana et al., 2023).

Coffee is one of the most widely consumed beverages globally, appreciated for its flavor and various benefits to societal development (Edowai, 2019). Arabica coffee accounts for 70% of global coffee consumption, while Robusta accounts for 26% (Wiyono, 2019). Coffee production has steadily increased over the years, with successful agribusiness development requiring support from stakeholders across production, processing, and marketing. Efforts to enhance productivity and coffee quality continue to ensure Indonesia remains competitive in the global market (Dani & Andayani, 2020).

As the world's leading producer of Arabica coffee and the second-largest producer of Robusta coffee after Vietnam, Indonesia produces approximately 700,000 tons of coffee annually, with 80% of Robusta and 90% of Arabica exported. Coffee quality is determined by observable and measurable characteristics, assessed based on SNI 01-2907-2008 standards (Winarno & Indah, 2020). Aceh Province, a major coffee production hub, produces

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Page : 35-45
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76,386 tons of Arabica and Robusta annually, with Bener Meriah Regency leading production at 25,068 tons of Arabica and 1,157 tons of Robusta in 2022 (BPS Aceh, 2023).

Typically, Arabica and Robusta coffees are processed differently; Arabica is processed using the wet method, while Robusta uses the dry method. Traditional (farmer-level) and modern (estate-level) processing methods result in variations in coffee quality (Wiyono, 2019). Wet processing is widely used because it produces higher-quality coffee that commands premium market prices, despite higher production costs, which are offset by better returns. Coffee processed through the wet (full wash) method is of superior quality compared to other methods (Febriyansyah et al., 2020).

Arabica coffee is superior to Robusta, cultivated at altitudes between 1,000 and 2,100 meters above sea level, with higher elevations enhancing flavor. Arabica is primarily grown in Sumatra and Java but is vulnerable to diseases when planted at lower altitudes. Consumers prefer Arabica for its distinct flavor and quality (Mukhlishah et al., 2020). Arabica (*Coffea arabica*) is favored for its desirable flavor and commands higher market prices, while processed Arabica coffee powder must meet SNI standards through optimal production (Siregar et al., 2020). In contrast, Robusta, regarded as secondary to Arabica, has a more bitter and slightly acidic taste with a higher caffeine content, and a nutty aroma before roasting, while Arabica is more acidic with citrus and fruity notes (Kinasih et al., 2021).

This study aims to compare the physical and organoleptic characteristics of Arabica and Robusta coffee cultivated in the Gayo Plateau using the wet processing method. By examining these key attributes, the research seeks to provide insights into how processing methods influence coffee quality and flavor, highlighting the potential of coffee from this region to meet global market demands.

METHOD

This study was conducted in Bener Meriah Regency, with coffee bean sampling carried out in Wih Pesam, Bener Meriah Regency. The physical and organoleptic characteristics were tested in the Coffee Laboratory of the Faculty of Agriculture, Universitas Gajah Putih.

The equipment used in this study included a pulper machine, huller machine, roasting machine, grinder, basin, digital scale, gas stove, bucket, burlap sack, spoon, coffee cup, small plate, sieve, tray, plastic packaging, stationery, and camera. The materials used consisted of Arabica coffee cherries, Robusta coffee cherries, water, paper, label paper, and tissue. This study utilized two types of coffee, Arabica and Robusta, with coffee cherries harvested from smallholder coffee plantations in Bener Meriah, Central Aceh. Only red cherries, commonly referred to as "red cherry," were used in this study.

Preparation and Sorting of Arabica and Robusta Coffee

Each coffee sample was harvested in quantities of 20 kg. Arabica coffee cherries (*Coffea arabica*) were harvested at an altitude of 1,200 meters above sea level, while Robusta coffee cherries (*Coffea canephora*) were harvested at an altitude of 800 meters above sea level. After harvesting the red coffee cherries, the next step was the sorting process (using the flotation method) by separating the red cherries based on their density. The purpose of this process was to separate healthy red cherries from those affected by pests, as well as to remove green cherries, black cherries, and any debris.

Proceeding of 4th International Conference on Research and Development (ICORAD)
Vol. 3 No. 2 (2024)
Page : 35-45
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Wet Processing (Full Wash) for Arabica and Robusta Coffee

In this study, both Arabica and Robusta coffee were processed using the wet processing method (full wash). The steps are as follows:

1. Pulping (Removing Coffee Cherries' Outer Skin)
   This step involves separating the outer skin (epicarp) and mucilage (mesocarp) from the coffee beans using a pulper machine. Water is introduced into the pulper cylinder along with the cherries to facilitate peeling. After pulping, the beans, still covered with mucilage and parchment skin, are soaked in water to dissolve any remaining mucilage.
2. Fermentation and Washing
   Fermentation is carried out to remove the mucilage layer by soaking the coffee beans in water for 48 or 72 hours at ambient temperatures (25–30°C). This step helps break down the sugars and pectins in the mucilage, promoting optimal fermentation. Proper fermentation enhances flavor by reducing bitterness and creating a mild taste. The process concludes when the mucilage completely dissolves, leaving the parchment layer clean. Beans are then thoroughly washed for about two hours to remove any remaining residue.
3. Drying
   Beans are sun-dried to reduce their moisture content from 60–65% to a maximum of 12%, taking approximately two weeks. Accurate drying is crucial to avoid issues such as excessive weight loss from overdrying or mold growth from insufficient drying.
4. Hulling (Removing Parchment Layer)
   After drying, the beans are tempered for a day to reduce their temperature and prevent damage during hulling. Using a hulling machine, the parchment and silver skin are removed from the coffee beans. The processed green beans are then graded based on size and quality.

Physical Characteristics Analysis

The physical analysis is conducted on coffee beans and ground coffee to evaluate their quality using human sensory perception, guided by the SNI 01-2907-2008 standard. The organoleptic analysis involves evaluating brewed coffee using a hedonic method.

1. Bean Weight Analysis (SNI 2008)
   The weight per bean is calculated by weighing 100 grams of dried coffee beans (green beans) after processing and counting the total number of beans (performed in triplicate). The weight per bean is determined using the formula:
   Bean Weight = 100 grams green bean / Total number of green beans per 100 grams
2. Yield Analysis (SNI 2008)
   The yield is assessed by comparing the weight of the green beans produced with the weight of the initial coffee cherries. The yield percentage is calculated (in triplicate) using the formula:
   % Yield = Weight of green beans / Weight of coffee cherries × 100%
3. Green Bean Sorting (SNI 2008)
   Green beans are weighed and sieved to determine their particle size. The beans that pass through the sieve are collected, weighed with 0.01-gram precision, and stored for defect and impurity analysis. The fraction of passing coffee is calculated (in triplicate) using the formula:
   % Mass Fraction = Weight of coffee passing sieve / Total green bean weight × 100%
4. Impurity Content and Defect Value of Coffee Beans (SNI 2008)

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For this test, 100 grams of green beans are sorted by physically separating defective beans and impurities. Defect values are assessed, ensuring that if a single bean has multiple defects, only the most severe defect is considered. The classification of defect values is performed according to the ISO 10470:2004 standard, which serves as the reference to determine compliance with SNI 01-2907-2008. The impurity content is calculated (in triplicate) using the formula:

% Impurity Content = Weight of impurities / Total green bean weight × 100%

Organoleptic Characteristics Analysis

The organoleptic test is conducted to determine panelists' preferences (hedonic evaluation) for the product. This assessment involves 20 untrained panelists and is repeated three times. The coffee organoleptic test, or cupping test, follows the guidelines of the Specialty Coffee Association of America (SCAA) with the following procedure:

1. Prepare roasted coffee beans at 135°C for 45 minutes.
2. Weigh 8 grams of roasted coffee beans into each cupping glass.
3. Grind the coffee beans for each cupping glass using a grinder set to 20 mesh size. Perform "dry sniffing" to evaluate the coffee's fragrance before brewing.
4. Brew the coffee grounds with 150 mL of hot water and let them sit for 4 minutes. Stir the surface of the coffee solution while bringing the nose close to the cupping glass to evaluate the aroma during the "break." Skim off the foam from the surface using a spoon.
5. Once the coffee cools to 70–73°C, it is ready for analysis or tasting by slurping.

The evaluation uses a hedonic test. Panelists rate the overall acceptance of the product on a scale of 1 (strongly dislike), 2 (dislike), 3 (slightly dislike), 4 (neutral), 5 (slightly like), 6 (like), and 7 (strongly like).

Data Collection Method

The data collection method employed in this research involves a literature review. This technique relies on secondary data to support the research process by gathering information from journals and prior scientific studies. The purpose of this method is to uncover facts and understand the conceptual methods used in similar studies.

Data Analysis Method

The data analysis in this study utilizes both qualitative and quantitative methods. The qualitative analysis involves describing the results of the organoleptic tests on Arabica and Robusta coffee for all treatments. The quantitative analysis employs Analysis of Variance (ANOVA) by examining the calculated F-value.

RESULTS AND DISCUSSION

The Effect of Wet Processing (Full Wash) on Physical Characteristics

The wet processing method (full wash) involves significant use of water and includes several stages: pulping (removal of skin and pulp), fermentation and washing, drying, and hulling (removal of parchment and silverskin).

1. Pulping

   The initial stage of the wet processing (full wash) method is pulping, which involves removing the outer skin of coffee beans using a pulping machine, or pulper. The performance of the pulping machine depends on several factors, including the ripeness of the cherries, the uniformity of their size, the amount of process water used, and the gap

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Page : 35-45
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between the rotor and the stator. The pulping process can influence the size and weight of the coffee beans produced.

Research findings indicate that Arabica coffee parchment obtained during the pulping process is cleaner than Robusta coffee parchment. This is because Arabica cherries used in the process are larger in size and have thinner skins compared to Robusta cherries. The thinner skin of Arabica cherries allows for easier and more efficient peeling. This finding is consistent with research by Kembaren & Muchsin (2021), which states that Robusta cherries are relatively harder to peel than Arabica cherries due to their tougher skin and lower mucilage content. To achieve uniform peeling results, Robusta cherries require repeated pulping with more water compared to Arabica cherries. This is one of the reasons why Arabica coffee is generally of higher quality in terms of processing.

2. Fermentation and Washing

   The next stage is fermentation, where Arabica and Robusta coffee beans are soaked for 48 hours and 72 hours, respectively. The water is replaced every 6 hours to remove the mucilage layer attached to the beans.

   Research has shown that during fermentation, Arabica mucilage is less viscous, less sticky, and sweeter, whereas Robusta mucilage is thicker, stickier, and has a bland taste. During the fermentation process, the breakdown of coffee fruit mucilage compounds is facilitated by microorganisms originating from the coffee skin, mucilage, and parchment. These microorganisms, rich in pectin and sugar, serve as a nutrient source, enhancing the unique flavor profile of the coffee (Mutiara et al., 2023).

   The research findings demonstrate that the fermentation and washing processes have a significant impact on the flavor and aroma of coffee beans. The fermentation stage can result in changes to the final taste and aroma profile, while the washing process helps remove residual mucilage, reducing its negative impact on the flavor profile. These processes contribute to developing a cleaner and more distinct flavor profile, as well as a more complex aroma.

3. Drying

   Drying the coffee beans after fermentation and washing affects their moisture content. Maintaining the appropriate moisture level is crucial for preserving the quality of coffee beans during storage. The drying process also influences physical characteristics such as the density and weight of the beans.

   Research has shown that the drying process reduces the water content within the coffee parchment. The weight of Arabica coffee parchment decreased from 6 kg to 2.2 kg, while Robusta parchment weight decreased from 8 kg to 2.8 kg. Manual drying was carried out for 7 days to achieve a moisture content of 12%.

4. Hulling

   The hulling stage involves removing the outer layers that remain attached to the coffee beans after drying. This process can influence physical characteristics such as density and the final weight of the coffee beans. Hulling also helps reveal the unique flavor characteristics of the coffee. Using a coffee huller machine can reduce the percentage of defective beans. Broken beans lower the market value of coffee, as they result in uneven roasting during the roasting process (Al-Rosyid & Komarayanti, 2021).

The wet processing method, which includes stages such as pulping, fermentation and washing, drying, and hulling, has a significant impact on the physical and organoleptic characteristics of Arabica and Robusta coffee beans. Each processing stage plays an important role in shaping the final quality of coffee beans, leading to visible changes in size,

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Vol. 3 No. 2 (2024)
Page : 35-45
ISSN:2828-4925
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weight, density, color, flavor, aroma, acidity, and balance. This aligns with research conducted by Jaljala et al. (2022), which found that the wet processing method (full wash) experiences the greatest yield loss during the drying process. Based on research findings, the weight loss during the drying process is more significant for Robusta coffee than for Arabica coffee.

Comparison of Physical characteristics

a. Analysis of Bean Weight

The weight per bean is determined by dividing the total number of beans in 100 grams of green beans processed using the wet processing (full wash) method, subjected to fermentation times of 48 hours and 72 hours. The study found the following respective weights, starting from the heaviest: 0.240 grams (Arabica beans fermented for 72 hours), 0.224 grams (Robusta beans fermented for 72 hours), 0.213 grams (Arabica beans fermented for 48 hours), and 0.169 grams (Robusta beans fermented for 48 hours). Detailed results can be seen in Figure .

A study by Winarno & Indah (2020) also revealed that processing methods influence the weight of coffee beans. Beans processed with the wet method had the lowest weight at 0.167 grams. The average bean weight by processing method was, in descending order: 0.186 grams (dry processing), 0.184 grams (semi-wet processing), 0.175 grams (honey processing), and 0.167 grams (wet processing).

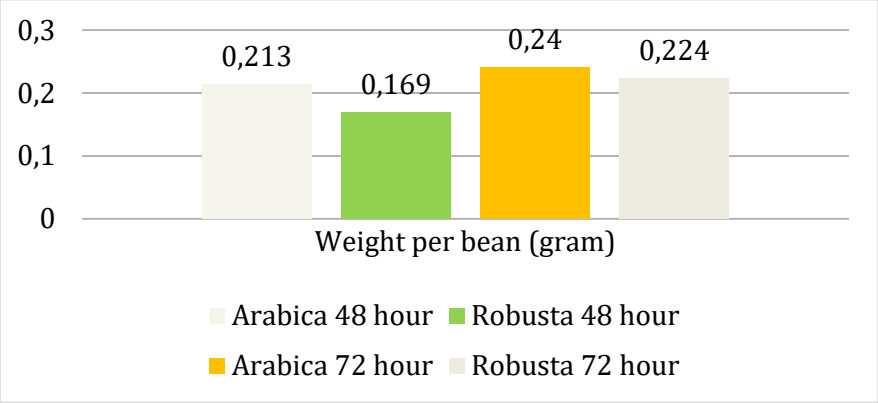

Figure 1: Bean weight of Arabica and Robusta coffee

From Figure 1, it can be concluded that wet processing and fermentation time significantly affect bean weight. Additionally, the coffee variety also impacts the final result. This aligns with the findings of Kinasih et al. (2021), which showed that Arabica beans had a higher weight of 0.175 grams compared to Robusta beans at 0.14 grams. Differences in bean weight are attributed to environmental factors such as altitude, rainfall, and light intensity, as well as the processing method used.

b. Yield Testing

Yield, or weight loss, is the ratio (in percentage) of coffee beans before processing (red cherry) to beans after wet processing and fermentation for 48 and 72 hours (green beans). The average yields of Arabica and Robusta beans processed using the wet method are presented in Figure 2.

Proceeding of 4th International Conference on Research and Development (ICORAD)
Vol. 3 No. 2 (2024)
Page : 35-45
ISSN:2828-4925
DOI: 10.47841/icorad.v3i2.276

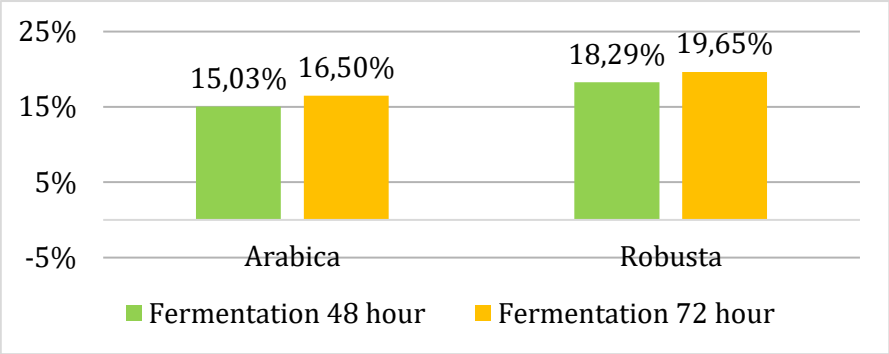

Figure 2: Yield of Arabica and Robusta coffee

The results show a significant effect of processing on the yields of Arabica and Robusta coffee. The highest yield was observed in Robusta beans fermented for 72 hours, and the lowest in Arabica beans fermented for 48 hours. As shown in Figure 2, longer fermentation times in wet processing increase coffee yield.

Fermentation treatments significantly impact coffee yields; higher-quality coffee results in better yields. Yield differences are influenced by the evaporation of substances within the beans during processing (Nurhidayah, 2022). Research by Kinasih et al. (2021) found that the highest yield was from Arabica coffee at 0.991%, while Robusta yielded 0.965%. Yield differences are influenced by the evaporation of compounds and environmental factors such as altitude, rainfall, and light intensity, which affect coffee plant growth. According to factory data, Robusta is grown at altitudes below 1,000 meters above sea level with hot climates and limited water, while Arabica is cultivated in mountainous areas at altitudes of 1,000–2,000 meters above sea level, with temperatures ranging from 14–24°C. Higher yields indicate better coffee quality.

c. Sorting of Green Beans (gram)

Sorting green beans involves separating them based on characteristics such as size, shape, density, surface properties, and color to determine the grade. The mass fraction is calculated as the ratio of the weight of beans that pass through a 5 mm sieve to the initial weight of green beans. Uniform green beans, free from impurities and with minimal defects, command higher market prices. For consumers, uniform bean size and cleanliness are critical quality factors. These attributes influence the roasting process, as uniform beans ensure even roasting, leading to better-quality coffee (Mawardi et al., 2020).

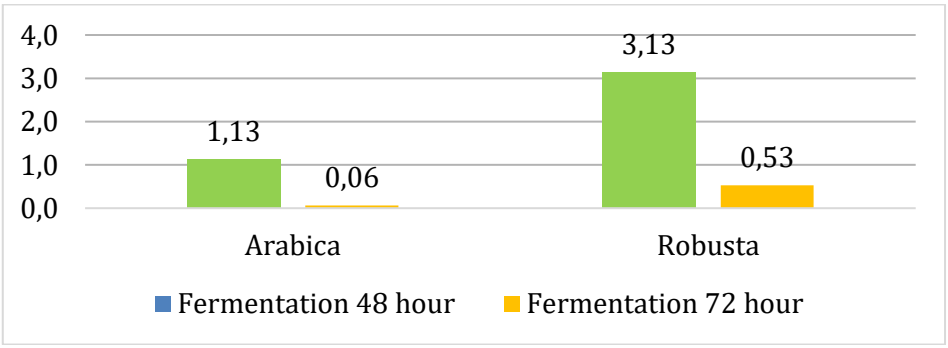

Figure 3: Sorting of green beans (Arabica and Robusta coffee)

d. Impurity Level (%) and Defect count (beans)

This study found that Robusta coffee had higher impurity levels and defect counts

Proceeding of 4th International Conference on Research and Development (ICORAD)
Vol. 3 No. 2 (2024)
Page : 35-45
ISSN:2828-4925
DOI: 10.47841/icorad.v3i2.276

compared to Arabica coffee. Detailed results are shown in Figure 4.

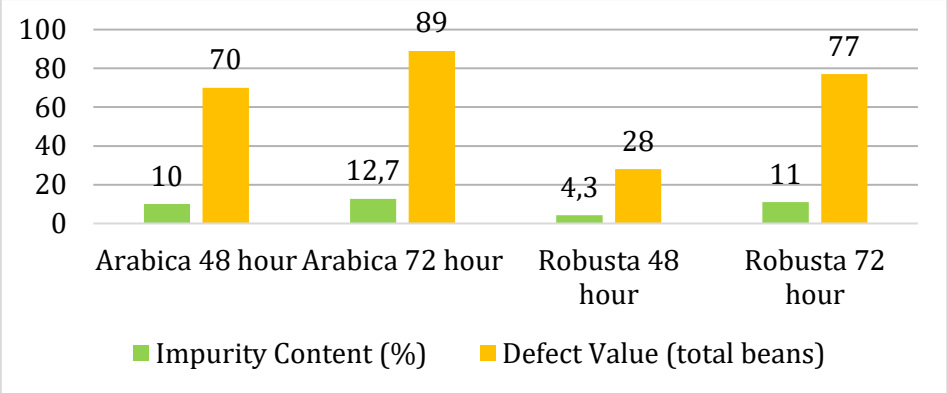

Figure 4: Impurity level and defect count of Arabica and Robusta coffee

From Figure 4, the highest impurity levels and defect counts were observed in Robusta coffee fermented for 48 hours and Arabica coffee fermented for 72 hours. According to Winarno & Indah (2020), Arabica coffee has lower defect levels than Robusta. Physical defects in coffee beans include black beans, partially black beans, and cracked beans. Bean perforation is caused by insect activity, such as the coffee berry borer (Hypothenemus hampei Ferr), which creates holes in the beans. Cracked beans result from improper hulling machine settings. Other defect categories include contamination with foreign matter not associated with coffee.

Comparison of Organoleptic Characteristics Based on Hedonic Evaluation

The organoleptic evaluation was conducted on brewed coffee powder processed with the wet method (full wash) and fermentation times of 48 and 72 hours. Data collection was carried out using a hedonic scale (1–7) for attributes such as color, texture, aroma, taste, and overall evaluation based on SNI 01-2891-1992.

Table 1: Hedonic evaluation results of Arabica and Robusta coffee

No	Organoleptic Attribute	Wet Processing (Full Wash) Fermentation Time			
		48 hours		72 hours	
		Arabica Coffee	Robusta Coffee	Arabica Coffee	Robusta Coffee
1	Color	5.71	5.48	5.67	5.19
2	*Body*	5.33	5.05	5.57	4.81
3	Aroma	5.62	4.81	5.71	4.95
4	Taste	4.87	4.11	4.85	3.89
5	**Overall Score**	**5.71**	**4.95**	**6.14**	**4.67**

Proceeding of 4th International Conference on Research and Development (ICORAD)
Vol. 3 No. 2 (2024)
Page : 35-45
ISSN:2828-4925
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The results indicate that Arabica coffee fermented for 72 hours had the highest score (6.14).

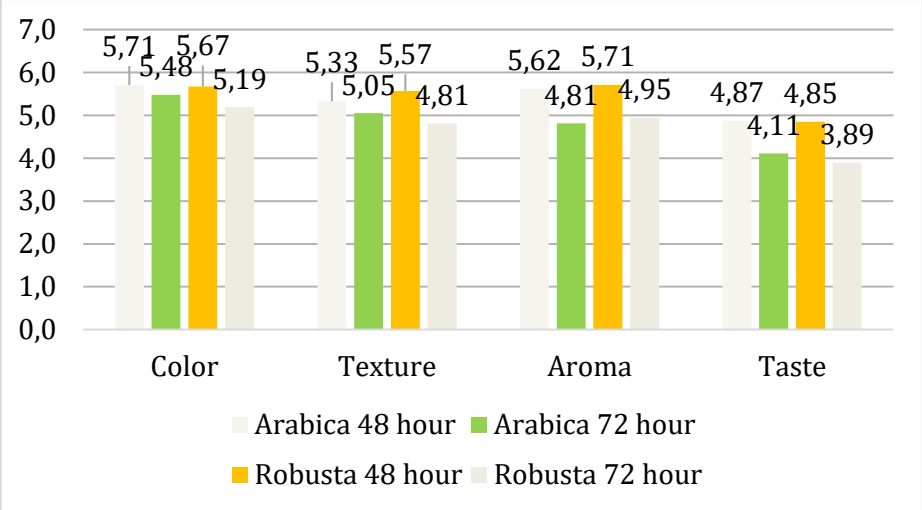

Figure 5: Organoleptic evaluation results of Arabica and Robusta coffee

Panelists preferred the color of Arabica coffee fermented for 48 hours (score: 5.71), the body of Arabica coffee fermented for 72 hours (score: 5.57), and the aroma of Arabica coffee fermented for 72 hours (score: 5.71). The taste most favored by panelists was Arabica coffee fermented for 48 hours (score: 4.87).

Processing methods influence coffee flavor, as they alter the taste and aroma profiles. Wet processing (full wash) results in cleaner flavors and smoother body. According to Mutiara et al. (2023), the full wash method enhances flavors with light, fruity, and acidic characteristics, while dry processing produces a fuller body, diverse fruity notes, and lower acidity.

Comparison of Organoleptic Characteristics Based on Organoleptic Assessment

According to the organoleptic test results for Arabica and Robusta coffee with 48-hour and 72-hour fermentation treatments, it was observed that longer fermentation or soaking times result in a smoother body.

Table 2: ANOVA of Organoleptic Assessment

Source of Variation	DoF	SS	MS	$F_{calculated}$	F_{table}
Color					
Within treatments	3	0.81	0.27	0.20	2.76
Within treatments (error)	80	105.43	1.32		
Total	**83**	**106.24**			
Aroma					
Within treatments	3	21.08	7.03	4.59	2.76
Within treatments (error)	80	122.48	1.53		
Total	**83**	**143.56**			
Taste					
Within treatments	3	32.67	10.89	4.29	2.76
Within treatments (error)	80	203.14	2.54		

Proceeding of 4th International Conference on Research and Development (ICORAD)
Vol. 3 No. 2 (2024)
Page : 35-45
ISSN:2828-4925
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Source of Variation	DoF	SS	MS	$F_{calculated}$	F_{table}
Total	**83**	**235.81**			
Body					
Within treatments	3	6.70	2.23	1.70	2.76
Within treatments (error)	80	104.86	1.31		
Total	**83**	**111.56**			
Overall					
Within treatments	3	29.27	9.76	5.43	2.76
Within treatments (error)	80	143.71	1.80		
Total	**83**	**172.99**			

From Table 2, the $F_{calculated}$ and F_{table} values for color, aroma, taste, body, and overall are as follows: 0.20 < 2.76; 4.59 > 2.76; 4.29 > 2.76; 1.70 < 2.76; and 5.43 > 2.76, respectively. If the $F_{calculated}$ value is greater than the F_{table} value, it indicates that there are differences among the samples, meaning the samples are distinct. Conversely, if the $F_{calculated}$ value is smaller than the F_{table} value, it means there are no differences in the panelists' evaluations of a specific attribute, indicating the samples are similar. As the $F_{calculated}$ value for the overall attribute is greater than the F_{table} value at a 5% (0.05) significance level, it can be concluded that there is a significant difference in the overall evaluation of coffee samples. Hence, the overall scores for all samples are statistically different.

CONCLUSION

The conclusions of this study are as follows:

1. There is an effect of wet processing with different fermentation durations on the physical characteristics of Arabica and Robusta coffee. Based on the results for weight per bean, yield, impurity content, and defect value, the best result is Arabica coffee fermented for 72 hours, while the lowest result is Robusta coffee fermented for 48 hours.
2. The organoleptic characteristics of Arabica and Robusta coffee processed using wet processing methods, based on the results of hedonic tests, show that the color preferred by the panelists is Arabica coffee fermented for 48 hours, with a score of 5.71. The body preferred by the panelists is Arabica coffee fermented for 72 hours, with a score of 5.57. The aroma preferred by the panelists is Arabica coffee fermented for 72 hours, with a score of 5.71. The taste preferred by the panelists is Arabica coffee fermented for 48 hours, with a score of 4.87. Overall, Arabica coffee fermented for 72 hours is preferred compared to other coffees.
3. The organoleptic characteristics of Arabica and Robusta coffee fermented for 48 hours and 72 hours, based on the ANOVA results at a significance level of 5% (0.05) with an F table value of 2.76, show F calculated values for color (0.20), aroma (4.59), taste (4.29), body (1.70), and overall score (5.43). The panelists' evaluation of all coffee samples indicates no differences in color and body, while there are significant differences in aroma, taste, and overall score.

Suggestions for future research include conducting studies using the wet processing method with the same material but more comprehensive (detailed) organoleptic attributes and further testing by analyzing the chemical content. Additionally, organoleptic tests should involve trained panelists.

Proceeding of 4th International Conference on Research and Development (ICORAD)
Vol. 3 No. 2 (2024)
Page : 35-45
ISSN:2828-4925
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