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Analysis of the Arabica Green Bean Coffee Production Process Using the Natural Anaerobic Method

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A B S T R A C T

The natural anaerobic method has become an innovative post-harvest processing technique that can improve the physical quality and market value of specialty Arabica coffee. This study aimed to analyze the production process, yield, and physical quality characteristics of Arabica green coffee processed using the natural anaerobic method at the Koerintji Barokah Bersama Cooperative in Kerinci Regency. The results showed that the total yield of green beans was 14.43%, with an average input of 308.33 kg of coffee cherries resulting in an output of 44.50kg. Based on the sieve-based bean size test results, most green beans were classified as medium in size, indicating good bean size uniformity. The green beans produced have met SNI quality standards, indicated by the absence of live insects or odor defects. The average moisture content of 10.57%, the dirt content of 0.16%, and the bean defect value of 9.18 indicate that the coffee beans fall within quality category I. Overall, the natural anaerobic method produces Arabica green coffee beans with optimal yield, relatively uniform bean size, and good physical quality.

Contribution to Sustainable Development Goals (SDGs):

SDG 1: No Poverty
SDG 8: Decent Work and Economic Growth
SDG 9: Industry, Innovation, and Infrastructure
SDG 12: Responsible Consumption and Production
SDG 15: Life on Land

1. INTRODUCTION

1.1. *Research Background*

Coffee is a strategic plantation commodity that plays a vital role in global trade and contributes significantly to the national economy. Indonesia is one of the world's largest coffee producers, with relatively stable production levels in recent years [1] [2]. In the context of global competition, coffee competitiveness is determined not only by production volume but also by consistent quality and the efficiency of post-harvest processes that produce standardized products.

Kerinci Regency, Jambi Province, is one of the leading Arabica coffee production centers, with agroclimatic conditions conducive to cultivating high-quality coffee. Kerinci Arabica coffee has distinctive sensory characteristics, including balanced acidity, floral aroma, and a strong body [3]. Post-harvest processing practices at the farmer and processing-unit levels still exhibit quality variations and limitations in process control, contributing to inconsistent final product quality [4].

Post-harvest processing is a critical stage that determines the physical and sensory characteristics of green coffee beans. Each stage of the process, from Cherry selection, fermentation, drying, hulling, sorting, and grading, contributes to changes in the material's properties and determines the final product's quality. The natural anaerobic method has emerged as an innovative approach to coffee processing, using fermentation under oxygen-depleted conditions without peeling the fruit. This process encourages the formation of complex fermentation metabolites that influence the coffee's flavor profile [5][6].

Yield is used as a quantitative indicator in assessing the efficiency of raw material conversion from cherry coffee to green beans. The yield value indicates the percentage of the final result obtained from a certain amount of raw material and illustrates the effectiveness of each process stage. Variations in yield during milling, fermentation, drying, and hulling are influenced by the condition of the raw material and the operational parameters used [7] [8]. Interpretation of the yield value requires consideration of its relationship to product quality, as quantitative efficiency does not always align with the quality of the results [9].

Green coffee bean quality is a key parameter in determining product viability in the market, particularly in the specialty coffee segment. Quality assessment is based on standard parameters, such as moisture content, bean defect rate, cleanliness, and bean size, in accordance with Indonesian National Standards [10]. Process control at each stage plays a crucial role in maintaining quality consistency and minimizing bean defects and quality degradation during storage.

Studies on coffee processing have focused primarily on sensory aspects or the final product. Analysis linking the contribution of each process stage to yield and quality in an integrated manner is still limited, particularly in the application of natural anaerobic methods at the processing unit level.

1.2. Research Objective

This research analyzes yield at each stage of the green Arabica coffee bean production process and evaluates product quality against applicable standards. This approach provides insight into the relationship between process stages, production efficiency, and product quality in a coffee processing system.

2. MATERIALS AND METHODS

2.1. Location and Time of Research

The research was conducted at the Koerintji Berokah Bersama Cooperative in Jernih Jaya Village, Kerinci Regency, Jambi, which is one of the centers of quality Arabica coffee production and a pioneer in marketing Kerinci Arabica Coffee, having successfully exported 15.5 tons of green coffee beans to *Belgium* in 2020 [11]. The research location was chosen because this factory has a complete production scale and processing process from post-harvest to *green beans*. The research was conducted in November 2025 - January 2026.

2.2. Tools and Materials

The materials used in this study include red coffee cherries (*Arabica), fermentation and washing processes, and supporting materials such as 60-kg* jute sacks, hermetic plastic as a packaging lining, labels, and seals for product identification.

The tools used in this research consist of a bucket or water tank, fermentation tub or pool, solar dryer dome, digital moisture tester, huller machine, sutton, grader or sieve machine, sorting table with lights, analytical scales, cups, label paper and stationery, and a camera phone for documenting the research process.

2.3. Research Implementation

This research employed a quantitative descriptive approach with a case study method in an Arabica coffee processing unit that implements the natural anaerobic method. The data used consisted of primary data obtained through direct observation at each stage of the production process, as well as secondary data derived from production records and supporting literature. Purposive sampling was used to select processing units that consistently implement methods and have a comprehensive data recording system.

2.3.1. Analysis of Production Process and Yield

The natural anaerobic production process of green Arabica coffee beans was observed from the Cherry selection stage to packaging. The stages analyzed included cherry selection, anaerobic fermentation, drying, hulling, sorting, grading, and packaging.

Yield is calculated at each stage of the process by comparing the output weight to the input weight from the previous stage. This analysis aims to assess the efficiency of converting cherry coffee into green beans and to identify the stages that contribute most to weight loss. Observations are made by recording the weight of the material at each stage of the process to obtain partial and total yield values.

2.3.2. Green bean quality analysis

2.3.2.1. General Quality Analysis of Green Beans

Analysis of the physical quality of green beans is carried out using standard parameters, including the presence of live insects, mold or a rotten odor, water content, and dirt content.

Live insect inspection was carried out visually on coffee samples. Odor testing is performed organoleptically to detect the presence of mold or a rotten odor. Water content was measured several times using a digital moisture tester and then averaged. Impurity content was determined by manually removing foreign matter, such as soil, stones, or other debris, and then weighing the sample to calculate the percentage.

2.3.2.2. Special Quality Analysis of Green Beans

Special quality analysis is carried out through seed size testing and determining defect values. Determination of seed size is done using a graduated sieve with a certain diameter to group seeds based on size. Samples that passed the sieve were weighed to determine the seed size distribution.

Defect scores are determined by manually separating defective beans from the sample and then calculating them according to applicable defect-scoring criteria. This analysis aims to determine the quality of green Arabica coffee beans based on the number of defects found.

3. RESULTS AND DISCUSSION

3.1. Analysis of Production Process and Yield

Yield analysis was conducted to determine the efficiency of converting raw cherry coffee into green beans at each stage of the processing process. Measurements were made by comparing the material's weight before and after each stage to assess the contribution of each process to changes in material weight. The average value and yield at each stage of the production process are presented in Table 1.

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Table 1. Average value and yield at each stage of the production process

Stage	Mean ± SD (kg)	Yield (%)
Coffee cherries	308.33 ± 17.04	
Cherry selection	301.33 ± 16.62	97.73
Fermentation	286.47 ± 17.65	95.06
Drying	94.47 ± 6.31	32.98
Hulling	48.57 ± 2.35	51.4
Sorting and Grading	44.5 ± 1.85	91.62
Packaging	44.5 ± 1.85	100

Source: Primary Data (2026)

Yield analysis was conducted to determine the efficiency of converting raw cherry coffee into green beans at each stage of the processing process. Yield values were calculated from the material weights before and after processing at each stage.

1. The cherry selection stage produced a yield of 97.73%, with a reduction in material weight from 308.33kg to 301.33 kg, which shows that this process functions as a density-based initial sorting to separate coffee cherries based on their level of ripeness and quality so that weight loss is relatively small and most of the material components are maintained [7]. The cherry selection process is shown in Figure 1.

Fig. 1. Cherry selection.

2. The anaerobic fermentation stage produced a yield of 95.06%, with the weight of the material reduced from 301.33kg to 286.47 kg, which indicates that fermentation was carried out without peeling the fruit skin so that the mass of the material was still maintained, while the weight reduction occurred due to the activity of microorganisms and the formation of fermentation metabolites that affect the characteristics of the coffee [5]. The Anaerobic fermentation process is shown in Figure 2.

Fig. 2. Anaerobic fermentation.

3. The drying stage produced a yield of 32.98%, with a weight reduction from 286.47kg to 94.4 kg, which indicates a significant weight loss due to evaporation of water content until it reaches a safe storage condition, where drying plays an important role in maintaining quality stability and preventing damage during storage [9]. The drying process is shown in Figure 3.

Fig. 3. Drying.

4. The hulling stage produces a yield of 51.40%, with the weight of the material reduced from 94.47kg to 48.57kg, which is caused by the separation of dry skin from the coffee beans so that green beans are obtained

as the main product, where improper hulling process settings can cause mechanical damage to the beans and affect the yield and quality [12]. The Huling process is shown in Figure 4.

Fig. 4. Hulling.

5. The sorting and grading stage produced a yield of 91.62%, with the weight of the material reduced from 48.57kg to 44.50kg, which was caused by the separation of defective seeds, impurities, and seeds that did not meet size standards, thereby increasing the uniformity of physical quality and the quality of the final product [13]. The sorting and grading process is shown in Figure 5.

Fig. 5. Sorting and grading.

6. The packaging stage produces a yield that is close to 100% because there is no significant change in weight, considering that this process only involves moving green beans into packaging, but still plays a role in maintaining coffee quality by protecting the product from contamination and changes in environmental conditions during storage [14]. The packaging process is shown in Figure 6.

Fig. 6. Packaging.

Arabica coffee processing using the natural anaerobic method shows a decrease in material weight at each stage of the production process. This weight reduction results from the separation of fruit parts, the evaporation of water, and the release of non-bean components during processing. Observations show that an average input of 308.33 kg of cherry coffee yields 44.50kg of green beans, with a total yield of 14.43%. The yield at each stage of the process varies. The threshing stage produces a relatively high yield because it separates coffee cherries solely by density, without altering the beans' main components. In the anaerobic fermentation stage, the weight change is relatively small because the process occurs without peeling the skin, so most of the fruit's mass is retained.

The greatest weight loss occurs during the drying stage. This process helps reduce the seeds' moisture content to a stable level, resulting in significant mass loss. This phenomenon aligns with [9], which states that drying is a critical stage in determining weight loss due to water evaporation during the process. Yield variations during the drying stage are also influenced by drying intensity, material layer thickness, and environmental conditions. The hulling stage shows a decrease in weight due to the separation of the dry skin (husk) from the coffee beans, so that green beans are obtained. The yield at this stage is influenced by the machine's efficiency and the material's dryness. The sorting and grading stage results in additional weight loss due to the separation of defective beans and impurities, so that only quality beans are retained as the final product.

The total yield of 14.43% indicates a level of raw material conversion that is generally consistent with the characteristics of coffee processing using the natural anaerobic method. Yield is influenced by the quality of the raw materials, the ripeness of the fruit, and process control at each stage. Interpretation of yield cannot be separated from the quality aspect, because quantitative efficiency does not always align with the quality of the resulting product [8].

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3.2. Green Bean Quality Analysis

3.2.1. General Quality Analysis of Green Beans

Green bean quality analysis is conducted to evaluate the physical quality of the produced coffee beans against applicable standard parameters. Testing includes general and specific quality parameters, including the presence of live insects, foul-smelling and/or moldy beans, moisture content, and dirt content. The results of the green bean quality testing for Arabica coffee are presented in Table 2.

Table 2. General Quality Standard Results for Green Beans (SNI 01-2907-2008)

Characteristics	Quality standards	Mean ± SD (%)
Live insects	There isn't any	Not detected
The seeds smell rotten and/or moldy.	There isn't any	Not detected
Water content	<12.5%	10.57 ± 0.42
Impurity levels	<0.5%	0.15 ± 0.05

Source: Primary Data (2026)

General green bean quality standards are analyzed to ensure that the coffee beans produced meet nationally established quality requirements. Based on the test results, the green beans produced were free of live insects, foul odor, or mold, thus meeting one of the main criteria in coffee quality standards. This condition indicates that the post-harvest processing, particularly the fermentation and drying stages, has been carried out properly, thereby preventing biological contamination that could reduce coffee quality [10].

The average moisture content was 10.57%, indicating that the green beans were within the safe storage moisture range, below the maximum limit of 12.5% set by applicable standards. Appropriate moisture content is very important for maintaining the stability of coffee bean quality during storage, because too high a moisture content can promote the growth of microorganisms, while too low a moisture content can reduce the sensory quality of coffee [8] [10].

The dirt content of 0.16% also indicates that the green beans are clean and remain below the maximum limit of 0.5%. The low dirt content indicates that the sorting process and post-harvest handling have been carried out optimally, minimizing contamination from foreign objects such as soil, stones, or skin residue [10].

3.2.2. Special Quality Analysis of Green Beans

The results of the coffee bean size test using the sieving method are presented in Table 3. This test was conducted to determine the size distribution of green beans and the degree of uniformity in bean size resulting from processing. Determining bean size is a crucial parameter for evaluating the physical quality of coffee because it influences the roasting process and the final product.
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Table 3. Determination of Sieve Passing (SNI 01-2907-2008)

Sieve Size (mm)	Mean ± SD (g)
6.5	9.00 ± 5.29
6	285.33 ± 7.37
5	5.67 ± 2.08

Description: SD = Standard Deviation
Source: Primary Data (2026)

Based on the results in Table 3, the majority of green Arabica coffee beans were declared to be medium in size, namely passing the 6.5 mm diameter sieve and not passing the 6 mm diameter sieve. This indicates that the resulting coffee beans have a fairly good level of size uniformity and are in accordance with the established quality classification. Relatively uniform bean size will provide a more even heat distribution during the roasting process, resulting in a more consistent flavor profile [15].

The dominance of medium size in green beans indicates that the processing process, from Cherry selection to sorting and grading, has been running well in maintaining the physical uniformity of the coffee beans. This uniformity of bean size is also influenced by the quality of the raw materials, especially the fruit's ripeness and the coffee plants' growing conditions, which help determine the size and density of the beans produced [7].

Determining bean size through this sieving method is in accordance with SNI 01-2907-2008, where medium size refers to beans that pass a 6.5 mm diameter sieve but not a 6 mm diameter sieve. This size classification is used to determine the quality and uniformity of coffee beans for marketing [10].

The results of testing the defect value of coffee beans in accordance with SNI 01-2907-2008 are presented in Table 4. This test was carried out to determine the number and types of defects in green beans, as a basis for assessing the quality of the resulting Arabica coffee.

Table 4. Determination of Defect Value (SNI 01-2907-2008)

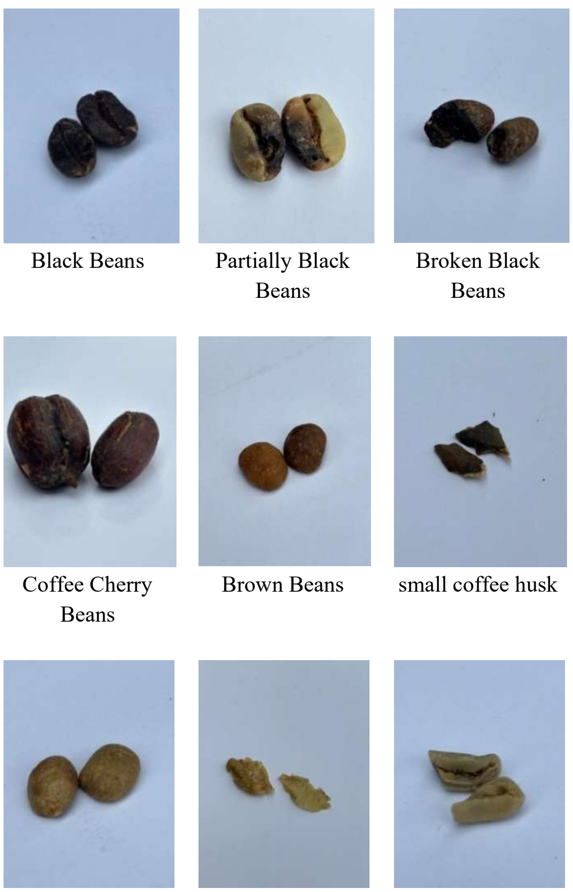
No	**Type of Defect**	**Defect Value**	**Mean±SD**
1	1 Black Beans	1	0.67±0.58
2	1 Partially Black Beans	½	1.50±0.50
3	1 Broken Black Beans	½	0.83±0.58
4	1 Coffee Cherry Beans	1	1.00±1.00
5	1 Brown Beans	¼	0.58±0.14
6	1 large coffee husk	1	0.67±1.15
7	1 small coffee husk	1/5	0.07±0.12
8	1 horn seed	½	1.50±0.87
9	1 medium-sized horn skin	1/5	0.13±0.23
10	1 small horn skin	1/10	0.03±0.06
11	1 broken bean	1/5	0.73±0.31
12	1 Immature Beans	1/5	1.00±0.87
13	1 Beans with One Hole	1/10	0.27±0.06
14	1 seed has more than 1 hole	1/5	0.20±0.00
	Total Defect Value		9.18±3.68

Description: SD = Standard Deviation
Source: Primary Data (2026)\

Based on the results in Table 4, the average defect value was 9.18, indicating that the green Arabica coffee beans produced fell within quality category I, as they were below the maximum defect limit of 11 set by the established standards. This value indicates that the level of physical damage to the beans was relatively low so that the quality of the coffee beans produced was classified as good [10].

The dominant types of defects found include partially black beans, horny beans, and young beans, which are generally related to the fruit's ripeness at harvest and to post-harvest processing conditions. The presence of these defects indicates that, even though the process has been running well, there are still variations in the quality of the raw materials used. The ripeness of coffee cherries at harvest is known to influence both the physical quality of the beans and the number of defects [7].

Defects such as broken and hollow beans were also found in relatively small numbers and were likely caused by mechanical factors during processing, such as at the hulling stage or during post-harvest handling. Inappropriate processing can increase physical damage to the beans and affect the final quality of the coffee. The low defect value indicates that the sorting, grading, and post-harvest handling processes have been carried out effectively, resulting in green Arabica coffee beans with high physical quality and in accordance with applicable standards [12]. The defect bean is shown in Figure 7.



Black Beans | Partially Black Beans | Broken Black Beans
Coffee Cherry Beans | Brown Beans | small coffee husk
horn seed | medium-sized horn skin | broken beans

Immature Beans | Beans with One Hole | Beans with More than One Hole

Fig. 7. Defect bean.

The results of the defect assessment in this study are in line with the concept that the physical quality of green beans is not only assessed visually, but is directly related to the morphological parameters of the beans, such as shape, size, color, and surface damage.

1. Black Beans
   Black beans are coffee beans that undergo excessive fermentation or decay, causing a dark black color. This defect negatively affects sensory quality by producing bitter and burnt flavors and is classified as a major defect in coffee grading standards [16].
2. Partially Black Beans
   Partially black coffee beans are those with black discoloration on part of the surface due to partial damage during fermentation. This defect reduces sensory quality and affects flavor balance, although less severely than fully black beans [16].
3. Broken Black Beans
   Broken black beans are defective beans that exhibit both discoloration and physical damage from mechanical pressure during processing. Physical damage accelerates oxidation and reduces coffee quality [17].
4. Coffee Cherry Beans
   Coffee cherry beans are coffee fruits that remain unpeeled due to incomplete pulping. This defect causes uneven roasting and inconsistent bean maturity and is categorized as a major defect in coffee grading [16].
5. Brown Beans
   Brown beans result from incomplete fermentation and appear brownish. This defect contributes to an imbalance in acidity and reduced flavor complexity in coffee [18].
6. Coffee Husk
   Coffee husk refers to the outer skin fragments that remain after processing. Their presence indicates suboptimal cleaning and sorting and may reduce product cleanliness and quality [19].
7. Horn Beans
   Horn beans are coffee beans still covered by the endocarp due to incomplete hulling. This defect affects heat transfer during roasting and reduces roasting uniformity [16].
8. Medium Horn Skin
   Medium horn skin refers to the endocarp fragments that remain after hulling. This defect reflects inefficient processing and reduces the visual quality and homogeneity of coffee beans [20].
9. Broken Beans
   Broken beans are coffee beans that are physically damaged during processing or transportation. This defect increases susceptibility to oxidation and decreases sensory quality [17].

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10. Immature Beans
    Immature beans originate from coffee cherries harvested before optimal ripeness. These beans have low density and underdeveloped flavor compounds, resulting in poor sensory quality [18].
11. Beans with One Hole
    Beans with one hole are damaged by attacks from the coffee berry borer. The defect affects bean structure and reduces the physical and sensory quality of coffee [16].
12. Beans with More than One Hole
    Beans with more than one hole indicate severe pest damage. This defect causes greater deterioration in quality and significantly lowers the sensory quality of coffee [17].

Determining the defect value of green coffee beans not only serves as a visual grading system but also serves as a scientific indicator directly related to the physical characteristics, morphology of the beans, and final sensory quality. Coffee beans with defects such as black beans, broken beans, holes, and discoloration have different surface structures and internal densities than normal beans, resulting in different thermal responses. These differences affect the formation of volatile compounds that contribute to the coffee aroma and can reduce the consistency of the brew [17].

4. CONCLUSION

The application of the natural anaerobic method in the production of green Arabica coffee beans resulted in a total yield of 14.43%, with an average input of 308.33 kg of cherry coffee to 44.50kg of green beans, where the largest weight loss occurred during the drying stage. From the quality aspect, the green beans have met SNI standards with no live insects or rotten odors or molds found and a water content of 10.57% , a dirt content of 0.16%. The distribution of bean sizes is dominated by medium sizes indicating good uniformity, and a defect value of 9.18 indicates that the coffee is included in the quality category I. This method can produce coffee with good physical quality, although consistency in quality still needs to be improved through control of raw materials and post-harvest processes.

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