

Analysis Of Added Value Of Arabica Coffee Processing At PT. Dete kopi Kintamani, Bali

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Abstract

Coffee processing plays a crucial role in generating added value, significantly contributing to producers' income. This study analyses the value added from processing Arabica red cherry coffee into green beans using three methods: Full Wash, Honey Process, and Natural Process. at PT. Dete Kopi in Kintamani, Bali. The Hayami method was employed to quantify the added value based on output conversion, input cost, and profitability. Data were collected through interviews, field observations, and document analysis. The results revealed that the Natural Process yielded the highest added value, amounting to IDR 11,846 per kilogram (40.85%), followed by the Honey Process at IDR 8,673/kg (33.36%), and Full Wash at IDR 8,556/kg (32.91%). Key factors influencing value creation included raw material quality, weather conditions, availability of drying space, labor, production costs, capacity, and processing techniques. This study underscores the importance of optimizing processing methods to enhance the economic value of.

Keywords: Arabica coffee, added value, coffee processing, Hayami method, production process.

INTRODUCTION

Coffee is one of the main commodities with high economic value in both global and domestic markets. Based on data from the Foreign Agricultural Service (USDA) in December 2024, Indonesia is ranked fourth as the world's largest coffee producer with production reaching around 654 thousand tons. Coffee is a globally significant export

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commodity, second only to petroleum Ariyanti et al., (2019). Arabica Coffee (*Coffea arabica*) is known to have distinctive taste qualities, moderate acidity, complex aroma, and lower caffeine content than Robusta coffee Abdulmajid (2014). According to the data Bali Central Statistics Agency (2024) Coffee is one of the leading products from Bali. One of the famous types of Arabica coffee is Kintamani coffee, which has gained wide recognition and has become the prima donna in Bali. PT. Dete Kopi is a company engaged in the production and marketing of high-quality local coffee. They not only serve as coffee processors, but also as partners for farmers to help improve the quality and selling price of their coffee products. The processing process at PT. Dete Kopi uses several methods, such as *Full Wash*, *Honey Process*, dan *natural*.

Research by Priantara et al., (2016) found that the processing of red coffee logs into HS coffee produced an added value of Rp 9. 918/kg. Furthermore, from HS coffee to Ose coffee, it produces an added value of IDR 40. 749/kg, and from Ose coffee to ground coffee reaches Rp 118. 057/kg. Other research by (Puryanto, 2021) shows that the added value for Arabica coffee processed by the *Full Washed* and *Natural* Included in the high category (more than 40%).

Coffee processing plays an important role in the coffee value chain, which can provide added value for farmers and industry players. According to Sons (2022) The Hayami method is an analytical approach used to calculate the added value of the processing of agricultural products, including coffee. This method focuses on calculating costs and revenues at each stage of processing and provides an overview of the output value and productivity of the production process. The Hayami method was chosen in this study because of its effectiveness in analyzing the distribution of added value in detail at each stage of production, so as to provide a clear understanding of the efficiency and profits obtained by business actors.

In the analysis of added value using the Hayami method, there are three main groups of calculations, namely, the calculation of output, input, and price, which measures the number of products produced, the resources used, and the selling price. Calculation of income and profit to analyze the income earned and the profit achieved from product processing. Factor of production compensation calculation calculates the contribution and rewards to the factors of production involved, such as labor and capital Hidayat et al., (2012).

Some of the factors that affect the added value in Arabica coffee processing are market price fluctuations, climate change, and limited access to technology are the main challenges for farmers to increase their yields Son, F, (2022). Therefore, an in-depth analysis of the processing process and added value is needed so that farmers can adapt to market needs and improve their welfare. The purpose of this study is to calculate the added value of each stage of Arabica coffee processing with the *Full Wash*, honey



process and *Natural* and identifying factors that affect the added value in Arabica coffee processing at PT. Dete Kopi.

LITERATURE REVIEW

PT. Dete Kopi

PT. Dete Kopi is a company engaged in the production, processing, and marketing of Arabica coffee located in Belantih Village, Kintamani District, Bangli Regency, Bali. The company, which was established in 2021, focuses on processing red cherry coffee beans into green beans using three methods, namely Full Wash, Honey Process, and Natural Process. Raw materials are obtained from local farmers as well as plantations owned by the company. Operational activities are carried out by 10 employees with a daily and wholesale wage system. The selling price of the product varies according to the processing method, namely IDR 130,000/kg for Full Wash and Honey Process, and IDR 145,000/kg for Natural Process.

Coffee

Coffee (*Coffea sp.*) is a plant of the family *Rubiaceae* and the genus *Coffea*, which can grow up to 6–7 meters with the characteristic of paired oval leaves (Yokawati & Wachjar, 2019). In Indonesia, the types of coffee that are widely cultivated are Arabica and Robusta (Indrawanto et al., 2010). Arabica coffee has a more complex taste and lower caffeine content than Robusta, so the price is relatively higher. On the other hand, Robusta has better resistance to diseases such as leaf rust (Rahardjo, 2012).

Added Value

Added value is an increase in the value of a commodity due to the process of processing, storing, or distribution (Hamidi & Elida, 2018; Maimun, 2009). Added value can be calculated through two approaches, namely added value during the production process and added value during the marketing process (Hayami et al., 1987). In the context of processing business, added value shows a large appreciation for the use of production factors such as labor, capital, and management (Suhendar, 2002). Hayami et al. (1987) put forward two groups of factors that affect added value, namely technical factors (quality of raw materials, production capacity, labor, and technology) and market factors (selling prices, raw material prices, labor wages, and other inputs supporting production). Kodrat et al. (2019) developed a value-added formula by considering production capacity (K), amount of raw materials (B), labor (T), wages (U), product price (H), raw material price (h), and other inputs (L). Other inputs such as fuel, additives, and packaging also affect added value (Rizqiah & Setiawan, 2014; Amar et al., 2016; Sriwana et al., 2022).



Arabica Coffee Processing

Arabica coffee processing is a series of post-harvest activities that determine the quality and selling value of coffee. The processing stages include harvesting, sorting, peeling, fermentation, washing, drying, hornskin peeling, final sorting, and storage. The selection of ripe fruits is key to producing high-quality seeds. Fermentation removes mucus, while drying aims to reduce moisture content by up to $\pm 12\%$ before storage.

There are three main processing methods:

1. Full Wash

Removes all mucus with intensive water use. Taste characteristics: clean, bright, and have a clear acidity.

2. Honey Process

The skin of the fruit is peeled, but the mucus is still left to stick to it when drying. Taste characteristics: sweet, thicker body, seed color tends to be darker.

3. Natural Process

Coffee fruits are dried whole before peeling. Taste characteristics: fruity, sometimes resembling wine, with the risk of mold if drying is less than optimal.

Different processing methods will produce different taste profiles and affect the selling price and added value of coffee products.

Factors Affecting Added Value

The added value in coffee processing is influenced by technical and market factors. The quality of raw materials, processing methods, and post-harvest management greatly determine the final value of the product. The research of Yosifani et al. (2021) concluded that technical factors include production capacity, the amount of raw materials, and labor, while market factors include selling prices, labor wages, raw material prices, and additional inputs.

1. Technical Factors

- a. Production Capacity: Higher capacity can lower the cost per unit thereby increasing added value.
- b. Quantity and Quality of Raw Materials: High-quality raw materials improve output and cost efficiency.
- c. Labor: Skilled labor improves efficiency, minimizes errors, and produces quality products.

2. Market Factors

- a. Product Selling Price: The higher the selling price, the greater the added value obtained.
- b. Labor Wages: High wages increase production costs, but low wages can lower



productivity.

- c. Raw Material Prices: An increase in the price of raw materials can lower profit margins.
- d. Other Additional Costs: Such as fuel, packaging, and production supporting materials.

The biggest challenges in Arabica coffee processing are market price fluctuations, climate change, and limited access to technology. Previous research, such as Priantara et al. (2016), is still limited to one processing method and does not consider important variables such as production costs, consumer preferences, and social impact on farmers. Therefore, more comprehensive research is needed to address these challenges.

RESEARCH METHODS

This research was carried out at PT. Dete Kopi, which is located in Belantih Village, Kintamani District, Bangli Regency. The research period lasted, from April to June 2025. The research stage begins with data collection by means of direct observation and interviews with the company (employees and owners) as well as conducting a literature study on value-added analysis. To analyze the factors that affect the added value in the Arabica coffee processing process, a qualitative analysis method is used through interviews and observations. This approach is used to understand factors that cannot be measured with numbers, but have an effect on the added value in the Arabica coffee processing process at PT. Dete Kopi. The added value analysis was carried out using the Hayami method to calculate the added value of each stage of the Arabica coffee processing process. There are three parts of calculating added value with the Hayami method, namely:

1. *Outputs, Inputs and Prices*

In this section, the number of outputs and inputs used and the prices set for all elements of coffee processing are calculated, including:

- a. Total output or product (kg)
- b. Amount of raw materials used (kg)
- c. Number of Workforce
- d. Conversion Factors =
$$\frac{\text{Total output produced}}{\text{The amount of raw materials used}}$$
- e. Labor coefficient =
$$\frac{\text{Number of Workforce}}{\text{The amount of raw materials used.}}$$
- f. Output price (Rp/kg)
- g. Total Workforce (Rp)



2. Income and Profits

- (1)
..... (2)

In this section, the calculation and analysis of the income and profits of each element of coffee processing are carried out, including:

- a. Price of raw materials used (Rp)
b. Other input contribution (Rp)
c. Output value = Conversion Factor x Output price(3)
d. Added Value = Output value - Contribution of other inputs -
Price of raw materials used.....(4)
e. Value-added ratio (%) = $\frac{\text{Added Value}}{\text{Output Value}} \times 100\%$(5)
f. Labor compensation = Labor coefficient x Labor wage(6)
g. Labor share = $\frac{\text{Employee Benefits}}{\text{Added Value}} \times 100\%$ (7)
h. Advantage = Added value - Labor compensation(8)
i. Profit level = $\frac{\text{Benefitd}}{\text{Added Value}} \times 100\%$(9)

3. Remuneration

In this section, the calculation and analysis of the large remuneration received by each element of coffee processing is carried out, including:

- a. Margin = Output value - Raw material price..... (10)
b. Percentage of the workforce = $\frac{\text{Employee Benefits}}{\text{Margin}} \times 100\%$ (11)
c. Other inputs = $\frac{\text{Other Input Contributions}}{\text{Margin}} \times 100\%$ (12)
d. Owner advantages = $\frac{\text{Benefits}}{\text{Margin}} \times 100\%$ (13)

The procedure for calculating added value by the Hayami method can be seen in Table 1.

Table 1. Value-added calculation procedure

No.	Outputs, Inputs, and Prices	Symbol
1	Total Output (kg/production process)	a
2	Raw Material Input (kg/production process)	b
3	Labor Input (HOK/kg)	c
4	Conversion Factor (kg output/kg of raw materials)	d = a/b



5	Labor Coefficient	$e = c/b$
6	Output Price (Rp/kg)	F
7	Average Labor Wage (Rp/HOK)	g
Income and Profits		
8	Raw Material Input Price (Rp/kg)	h
9	Other Input Contribution (Rp/kg)	i
10	Output Value (Rp/kg)	$j = d \times f$
11	Added Value (Rp/kg)	$k = j - h - i$
	Value-Added Ratio (%)	$i\% = k/d \times 100\%$
12	Labor Income (Rp/production process)	$m = e \times g$
	Labor Share (%)	$n\% = m/k \times 100\%$
13	Profit (Rp/kg)	$o = k - m$
	Profit Rate (%)	$p\% = o/d \times 100\%$
Remuneration to Production Factor		
14	Margin (Rp/kg)	$q = j - h$
	Percentage of Labor (%)	$r\% = m/q \times 100\%$
	Other Inputs (%)	$s\% = l/Q \times 100\%$
	Owner Profit (%)	$t\% = o/q \times 100\%$

RESULTS AND DISCUSSION

General Company Announcements

PT. Dete Kopi was founded in 2021 as a company that focuses on the production, processing, and marketing of Kintamani Arabica coffee with premium quality. This company gets raw materials from local farmers in Belantih Village as well as from independently managed coffee plantations. PT. Dete Kopi employs 10 workers, both permanent and wholesale workers, with a daily wage system and wages per work unit. In carrying out its operations, the company establishes close partnerships with local farmers through a cooperative model that focuses on improving the quality of raw materials and the implementation of sustainable agricultural practices.

The processing process at PT. Dete Kopi uses several methods, such as *Full Wash*, *Honey Process*, and *natural*. The selling price of the green beans produced varies, which is around IDR 130,000 per kilogram for coffee processed using the Full Wash and Honey Process methods, and IDR 145,000 per kilogram for the Natural Process method. This price difference reflects the added value and unique taste characteristics that result from each processing method.



Calculation of the Added Value of the Arabica Coffee Processing Process at PT. Dete Kopi

The calculation of added value is carried out to find out how much economic benefit is obtained from the coffee bean processing process using three different methods, namely *Full Wash* (FW), *Honey Process* (HP), and *Natural Process* (NP). Added value is calculated from the difference between the output value (the selling price of the final product) and the total input cost during the production process, such as the cost of raw materials, labor, energy, packaging, transportation, and tool depreciation. The greater the added value produced, the higher the level of efficiency and profit of the processing activity (Santi & Dewi, 2025). The results of the calculation of the added value of the three coffee processing methods can be seen in Table 2 below.

Table 2. Calculation of the Added Value of Arabica Coffee at PT. Dete Kopi

No	Outputs, Inputs, and Prices	FW Results	HP Results	NP Results
1	Total Output (kg/production process)	200	200	200
2	Raw Material Input (kg/production process)	1.000	1000	1000
3	Labor Input (HOK/kg)	5	5	5
4	Conversion Factor (kg output/kg of raw materials)	0,2	0,2	0,2
5	Labor Coefficient	0,005	0,005	0,005
6	Output Price (Rp/kg)	130000	130000	145000
7	Average Labor Wage (Rp/HOK)	90000	90000	90000
8	Raw Material Input Price (Rp/kg)	16000	16000	16000
9	Other Input Contribution (Rp/kg)	1444	1327	1154
10	Output Value (Rp/kg)	26000	26000	29000
11	Added Value (Rp/kg)	8556	8673	11846
	Value-Added Ratio (%)	32,91%	33,36%	40,85%
12	Labor Income (Rp/production process)	450	450	450
	Labor Share (%)	5,26%	5,19%	3,80%
13	Profit (Rp/kg)	8106	8223	11396
	Profit Rate (%)	31,18%	31,63%	39,30%
14	Margin (Rp/kg)	10000	10000	13000
	Percentage of Labor (%)	4,50%	4,50%	3,46%



Other Inputs (%)	14,44%	13,27%	8,87%
Owner Profit (%)	81,06%	82,23%	87,66%

Source : Processed data (2025)

Based on the calculation results, the three processing methods *Full Wash* (FW), *Honey Process* (HP), and *Natural Process* (NP) produce 200 kg of green beans from 1,000 kg of cherries, so that the conversion factor remains 0.2. This means that every 1 kg of cherries produces only 0.2 kg of green beans. The level of labor use is also the same, which is 0.005 HOK/kg, because the entire process uses a relatively similar number of workers and workload. *Natural Process* is the method with the highest output price, which is IDR 145,000/kg. Meanwhile, *Full Wash* and *Honey Process* are still at IDR 130,000/kg. The price of the three raw materials is the same, which is IDR 16,000/kg, but the cost of other inputs is not the same, *Full Wash* costs IDR 1,444/kg, *Honey Process* IDR 1,327/kg, while *Natural Process* is the smallest IDR 1,154/kg. The added value obtained, with the *Natural Process* method is IDR 11,846/kg with an added value ratio of 40.85%. Furthermore, the *Honey Process* method obtained an added value of IDR 8,673/kg with an added value ratio of 33.36%. Then for the *Full Wash* method, it produces an added value of IDR 8,556/kg with an added value ratio of 32.91%. The income received by the workforce to process coffee fruits into green bean coffee products using the *Natural Process* method, *Honey Process* *Full Wash* is the same each of which is Rp 450/kg per production. The profits produced by *Natural Process* are the largest, which is IDR 11,396/kg, compared to *Full Wash* IDR 8,106/kg and *Honey Process* IDR 8,223/kg. The profit rate of *Natural Process* reached 39.30%, higher than *Full Wash* and *Honey Process* which were only around 31%.

Based on the analysis of the value of this tamabah, a margin was obtained from the processing of green bean coffee products. The margin obtained by *Natural Process* is IDR 13,000/kg, while the *Full Wash* and *Honey Process* methods are at IDR 10,000/kg. The margin for labor in *Natural Process* has the smallest percentage of labor at 3.46%, in contrast to *Full Wash* and *Honey Process* which are both 4.50%. Other input contributions to *Natural Process* were also the lowest, namely 8.87%, *Honey Process* by 13.27% and *Full Wash* by 14.44%. The owner of PT. Dete coffee received a profit of 87.66% for *Natural Process*, *Full Wash* 81.06% and *Honey Process* 82.23% respectively. According to Hubies, (1987) in Situmeang et al., (2022) if the size of the added value ratio <15%, then it is included in the category of low added value, if the amount of added value ratio is 15-40%, then it is included in the category of medium added value, and if the size of the added value ratio is > 40%, then it is included in the category of high added value. Based on these categories, the added value at PT. Dete Coffee in green bean coffee products with the *Natural Process* method is included in the category of high value-

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added ratio, while *Full Wash* and *Honey Process* are included in the category of medium value-added ratio.

1. Comparison of Added Value with Journals

As a reinforcement of the research results, a comparison of added value with several other research results that have similar topics was carried out. The purpose of this comparison is to see if the added value generated through *the Full Wash*, *Honey Process*, and *Natural Process* methods at the research site has similarities or differences with the results of the research in other areas. Through this comparison, it can also be known how much efficiency and profit is generated from each coffee processing method. The results of the comparison of added value with other studies can be seen in Table 3 below.

Table 1. Table Comparison with other studies

Processing Method		Full Wash	Honey Process	Natural Process
Dete Kopi Kintamani	Rp/kg	8.556	8.673	11.846
	%	32,91	33,36	40,85
(Wibowo & Palupi, 2022)	Rp/kg	9.380	9.709	10.158
	%	52,58	52,96	54,40
(Mufidah & Ariyani, 2024)	Rp/kg	15.430	12.656,67	15.550,67
	%	57,15	52,37	57,45
(Bima Kurnia, 2024)	Rp/kg	8.623		
	%	41,45		
(Rizkiawan et al., 2023)	Rp/kg	23.700		
	%	59,25		

In the *Full Wash* method, Dete Kopi produces a conversion factor of 0.2, which is actually much lower than other studies in the range of 0.7–0.8 (Bima & Y Simatupang, 2024), (Wibowo & Palupi, 2022). The difference of about 0.5–0.6 occurs because the shrinkage of the raw materials of *the Full Wash* Dete Coffee process is larger, especially due to the long washing and fermentation stage. The labor coefficient is only 0.005 HOK/kg, far below the results of other studies which reached 0.02–0.05 HOK/kg. The difference of 0.015–0.045 HOK/kg is likely to arise because the production process at Dete Kopi is more efficient or is done in a larger capacity. In terms of price, Full Wash green beans at Dete Kopi are sold at IDR 130,000/kg, higher than other studies that recorded IDR 60,000–100,000/kg (Rizkiawan et al., 2023), (Wibowo & Palupi, 2022). The

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difference is IDR 30,000–70,000/kg and this can happen due to different quality standards, consumer demand, or branding. The labor wage is Rp90,000/HOK, slightly higher than other studies (Rp60,000–80,000/HOK). Meanwhile, raw materials at Dete Kopi are priced at Rp16,000/kg, while other studies are in the range of Rp8,000–12,000/kg, showing differences in cherry quality or local market conditions.

In the *Honey Process* method, the conversion factor in Dete Kopi remains at 0.2, while other studies show a value of 0.7–0.75 (Wibowo & Palupi, 2022) (Mufidah & Ariyani, 2024). There is a difference of about 0.5, which is most likely to arise because the drying process at Dete Kopi is longer and the rate of shrinkage of raw materials is higher. The labor coefficient of *Honey Process* in Dete Kopi (0.005 HOK/kg) is also still lower than other studies (0.02–0.04 HOK/kg). The difference of 0.015–0.035 HOK/kg shows that the division of labor and process management at Dete Kopi is more efficient. The output price of *Honey Process* at Dete Kopi is IDR 130,000/kg, while other studies recorded IDR 70,000–120,000/kg (Mufidah & Ariyani, 2024). This means that the price difference reaches IDR 10,000–60,000/kg, which can be influenced by differences in quality or the market. The labor wage of Rp90,000/HOK is also slightly higher than other studies (Rp60,000–80,000/HOK). The price of raw materials at Dete Kopi is Rp16,000/kg, while other studies have found that the price of raw materials is in the range of Rp8,000–12,000/kg.

In the *Natural Process method*, the conversion factor in Dete Kopi is also in the range of 0.2, while other studies are in the range of 0.78–0.8 (Mufidah & Ariyani, 2024) (Wibowo & Palupi, 2022). The difference is quite large, around 0.58–0.6. This can happen because *Natural Process* is highly dependent on weather and drying management, so the rate of shrinkage of raw materials in Dete Kopi is higher. The labor coefficient remained 0.005 HOK/kg, lower than other studies that reached 0.02–0.05 HOK/kg. The difference of 0.015–0.045 HOK/kg indicates that the scale of Dete Kopi production is larger or the process is more effective. For output prices, *Natural Process* at Dete Kopi is the highest at IDR 145,000/kg, while other journals recorded IDR 60,000–120,000/kg (Wibowo & Palupi, 2022). The difference is Rp25,000–85,000/kg, influenced by quality standards and market differences. The labor wage is Rp90,000/HOK, again higher than other studies (Rp60,000–80,000/HOK). The price of raw materials for Dete Kopi is Rp16,000/kg, still higher than other studies (Rp8,000–12,000/kg).

2. Factors that affect Added Value at Dete Kopi

The added value generated from the processing activities of a product is greatly influenced by various factors, both in terms of production costs and the quality of processed products. Some of the factors that play an important role include the price of raw materials, labor costs, production process efficiency, technology application, and the



selling price of the final product. If the price of raw materials increases, the total production cost will also increase and have an impact on reducing the added value obtained (Wibowo & Palupi, 2022). On the other hand, the use of more efficient and modern processing technology can improve the quality and productivity of processed products, so that the added value produced becomes higher (Santi & Dewi, 2025). Therefore, increased added value can be achieved through effective cost management, the use of appropriate technology, and the improvement of the quality of the raw materials used. Based on the results of direct observations in the field and interviews with owners and employees, the main factors that affect added value are the quality of raw materials, weather and environmental conditions, limited drying areas, human resources, production costs and production capacity as well as production processes.

Factors that affect the added value of coffee processing at PT. Dete Kopi Kintamani needs to get attention in the form of quality improvement and maintenance. Factors that still need to be improved include improving drying facilities, more economical water management for the Full Wash method, and training of the workforce to be more skilled in maintaining the cleanliness and thickness of the mucus layer in the Honey Process method. Meanwhile, some aspects that have gone well and need to be maintained are the selection of high-quality raw materials, the accuracy of workers in the process of sorting red coffee berries, a closed drying house (Green House) is also a solution to maintain the quality of coffee beans in the Natural Process method so that it is not affected by the weather, as well as the application of fermentation and drying procedures that are in accordance with the company's quality standards (Wibowo & Palupi, 2022).

CONCLUSION

Conclusion

Based on the results of the research that has been conducted, it can be concluded as follows:

1. This study demonstrates that different coffee processing methods significantly influence the value-added outcomes in Arabica coffee production. The Natural Process generate the highest added value at IDR 11,846/kg (40.85%) and the highest owner's profit margin of 87.66%, primarily due to lower production costs and minimal water usage. In contrast, the Full Wash and Honey Process methods resulted in added values of IDR 8,556/kg (32.91%) and IDR 8,673/kg (33.36%), with profit margins of 81.06% and 82.23%, respectively. These disparities are attributed to variations in input costs, labor intensity, and resource consumption across processing methods.
2. Key determinants of added value include the quality of raw materials, environmental and weather conditions, limitations in postharvest infrastructure such as drying space,

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human resource capacity, and overall production efficiency. These findings highlight the strategic importance of process optimization and resource management in enhancing the economic outcomes of coffee agribusiness.

Suggestion

Based on the results of the research that has been conducted, the suggestions that can be given are as follows:

1. The Full Wash method should be optimized to align with both local and export market requirements. This includes enhancing efficiency, reducing input costs, and improving processing consistency.
2. The Honey and Natural Process methods are recommended for further development as specialty coffee variants. This should be supported by continuous training programs to ensure quality consistency and improve production cost management.
3. Investment in semi modern postharvest infrastructure, particularly for drying, is critical. Expanding drying areas and adopting weather-resilient drying technologies will help reduce quality degradation caused by climate variability.
4. Water resource management strategies should be improved, especially for water intensive methods such as Full Wash, to increase environmental sustainability and cost effectiveness.

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