Post Harvest Added Value of Arabica Coffee and Its Determining Factors

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ABSTRACT

BACKGROUND AND OBJECTIVES
Farmers in Bulukerto Village generally sell their coffee in red or semi-dried pods to middlemen. As a result, they receive a much lower price than if they sold it as green or roasted beans. Farmers also lack understanding of standard post-harvest processing techniques and have not optimally utilized coffee processing tools and machinery. Low selling price, limited post-harvest knowledge, dependence on middlemen, and minimal use of technology are the main challenges faced by coffee farmers. The added value of coffee products is largely determined by post-harvest processing, whether through dry (natural) or wet (semi-washed and full-washed) processing. This study aims to analyze the added value and yield of Arabica coffee in Rekesan, Bulukerto Village, Batu City, East Java, and identify the determining factors.

METHODS:
Data were collected from all Arabica coffee farmers belonging to a forest farmer group in Bulukerto Village, who implemented three post-harvest handling methods for harvested coffee beans. The population consisted of 20 farmers. Coffee bean yield was calculated using the applicable standard formula, and the added value of coffee beans was analyzed using the Hayami method. Meanwhile, factors influencing added value through the Cobb-Douglas production function approach were analyzed using a multiple linear regression model.

FINDINGS:
The study revealed that coffee bean yield and added value varied depending on the post-harvest handling methods employed by farmers. The highest yield and added value were achieved through the natural method. Factors influencing added value also varied depending on the post-harvest handling practices employed by farmers. The number of coffee beans significantly influenced added value, although the relationship was different for the full washed method.

CONCLUSION:
Natural post-harvest handling produces high yields and added value, but is less popular with consumers. Therefore, an in-depth study of consumer preferences for these coffee beans is necessary. The full washed method requires significantly more labor, but this factor does not significantly impact added value. A limitation of this study is that it does not differentiate coffee beans by plant age, so future researchers could explore this factor.

Keywords: Added value; Arabica coffee; Fully washed; Natural; Semi-washed

INTRODUCTION

The majority of farmers in Bulukerto Village still sell their coffee in the form of red or semi-dried beans to middlemen. Therefore, they receive a very low price compared to selling green or roasted beans. The very short marketing chain and dependence on capital from middlemen means farmers lack bargaining power in determining prices. Farmers' lack of understanding of standard post-harvest processing techniques, such as the full wash, semi-wash, or natural process, also significantly impacts the taste and price of Arabica coffee. Meanwhile, coffee processing tools and machinery, such as pulpers and hullers, are still limited at the farmer level or have not been optimally utilized to create added value. Farmers process coffee beans traditionally using very rudimentary equipment. Low selling price, limited post-harvest knowledge, dependence on middlemen, and minimal use of technology are the main challenges faced by coffee farmers.

However, various local coffees such as Gayo, Mandailing, and Toraja have been recognized globally, demonstrating Indonesia's great potential in the international coffee market (1). If optimized, this realization will impact its trade balance (2)(3). The amount of added value of coffee is greatly influenced by post-harvest processes, which involve full washed, semi-washed, and natural (4). Processing methods such as full washed and natural processes produce different flavor characteristics because they impact the resulting physicochemical characteristics (5)(6). The wet process tends to produce a clean flavor with bright acidity, while the dry process emphasizes the sweetness and complexity of the fruit (7). In Bulukerto Village, farmers have developed Arabica coffee cultivation which dominates up to 80% of the coffee population on the slopes of Mount Arjuno, thanks to the cool climate and altitude above 1,000 meters (8).

Optimal post-harvest handling not only improves the taste (9) but also the competitiveness of coffee in the global market. However, some farmers face obstacles such as lack of knowledge and capital in this process (10). According to (11) the altitude of the region will also determine the yield of coffee beans. Therefore, analyzing the added value and identifying factors that influence coffee production are important to increase the efficiency and profits of farmers and support the sustainability of Indonesian coffee exports. This study compares the added value and yield of coffee cherries using the semi-washed and full-washed methods, which have never been studied before, as well as the determinants of added value.

Although many people have studied the added value of coffee, this study provides a more specific picture of the socio-economic characteristics of farmers in Bulukerto Village, which is a buffer zone for tourism in Batu City. The novelty of this study also lies in the combination of value-added analysis (Hayami method), with testing factors such as the number of coffee beans, other input costs, labor input, farmer age, and the number of coffee trees that specifically affect the added value of coffee, and compared according to three post-harvest processing methods used by farmers. This study aims to analyze 1) the yield of Arabica coffee in each post-harvest method (natural, full washed, and semi-washed) used by farmers, 2) the added value of Arabica coffee in each post-harvest method, 3) the determining factors of the added value of Arabica coffee.

RESEARCH METHOD

Farmers harvest coffee beans and then process them using three methods: natural, semi-washed, and fully washed. This post-harvest processing produces green Arabica coffee beans, allowing for accurate yield analysis. Furthermore, based on farm-level price information, the added value can be calculated using the Hayami method. Determinants of Arabica coffee added value, namely the number of coffee beans, other input costs, labor input, farmer age, and number of coffee trees, are also analyzed using a regression model. The framework is presented in Figure 1.
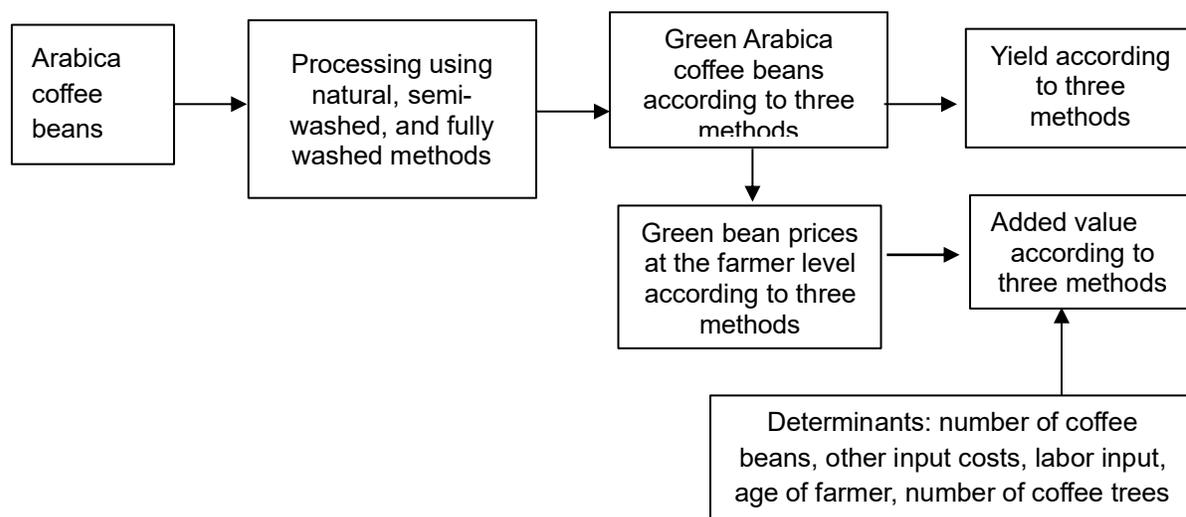

Figure 1. Research Framework

Bulukerto Village, Bumiaji District, Batu City, East Java, was chosen as the research location because this area, located on the slopes of Mount Arjuno, is a producer of superior Arabica coffee. The coffee plantations in this area are managed by the local community, who are members of the Forest Farmers Group (FFG), and are supported by post-harvest facilities and complete roasting equipment.

The population in this study was all Arabica coffee farmers who are members of the KTH and carry out post-harvest processing of Arabica coffee using natural, semi-washed, and full-washed methods. This process takes 15-25 days, depending on the method used, to produce green beans from cherry beans. Due to the limited population size of 20 people, we used a census, where all coffee farmers were selected as respondents.

Primary data was collected through interviews with farmers. This data collection method used a structured questionnaire that was first tested for validity and reliability with five coffee farmers. Furthermore, researchers also observed farmers' post-harvest processing of Arabica coffee beans.

Objective 1 analysis of Arabica coffee yield for each post-harvest method (natural, fully washed, and semi-washed) used the calculation (number of green beans/number of cherry

beans) x 100%. Objective 2 analysis of Arabica coffee added value for each post-harvest method used the Hayami method. Meanwhile, objective 3 analysis of the determining factors of Arabica coffee added value used a multiple regression model. The regression model is formulated as a Cobb Dougas production function: $Yi = X_1{}^{b_1} X_2{}^{b_2} X_3{}^{b_3} X_4{}^{b_4} X_5{}^{b_5} X_6{}^{b_6}$, where Y_i = value added according to natural, semi-washed, full-washed methods (i=1,2,3), X_1 = number of coffee beans, X_2 = other input costs, X_3 = labor input, X_4 = farmer age, X_5 = number of coffee trees. This data is processed using SPSS 26 software.

RESULTS AND DISCUSSION
Arabica Coffee Bean Yield based on the Post Harvest Method

The hamlet of Rekesan, located in Bulukerto Village, Batu City, is a center for Arabica coffee. The Batu City Government has mandated the cultivation of this type of coffee to improve the economic value of the local community and for environmental conservation purposes, namely to prevent flooding and landslides. This area is part of the Arjuno Mountain hillside, neighboring Batu City, Malang Regency, and Pasuruan Regency, and is managed by the Raden Soerjo Forest Park. According to (12), these mountainsides have complex forests that are used as protected forest areas, research areas, and production forests for agriculture, including Arabica coffee, which dominates the area. The shade will affect the nutrients in the surrounding soil. Farmers in Rekesan Hamlet produce high-quality Arabica coffee on the slopes of Mount Arjuno with additional shading from apple, pine, and mahogany trees (8).

Coffee farmers generally process coffee beans using three methods: natural, semi-washed, and full-washed. The choice of method will determine the yield, as shown in Table 1.

Table 1. Arabica Coffee Yield Based on Post-Harvest Methods

No	Post-harvest method	Yiled (%)	Average (%)
1	Natural	18.11 – 25	20.78
2	Semi washed	17.5 – 20	18.99
3	Full washed	16.96 – 19.13	18/20

Source: Primary data 2025

The results of the study show that the post-harvest yield of Arabica coffee using the natural method has the highest value of 20.78%. The natural process involves drying whole red coffee cherries for 34 days without removing the skin, followed by hulling using a huller machine to produce green beans. The semi-washed method has an average yield of 18.99%, where the process involves removing the skin of the fruit, partially cleaning the mucilage, and drying for 15 days before sorting. The full washed method, with an average yield of 18.20%, involves additional fermentation for 12-16 hours after washing to thoroughly clean the parchment skin. Compared to the other two methods, natural produces the highest yield because the substances in the fruit skin are absorbed into the beans during drying, while semi washed and full washed produce lower

yields due to higher levels of cleaning. Thus, farmers in Bulukerto Village use all three methods in processing the coffee beans harvested from their farms due to their different selling prices and processing technologies. This differs from the findings (13) that coffee farmers in Ethiopia prefer to use the natural processing method due to a shortage of capital.

Coffee yields in this region are higher than those in the study (14) because farmers use organic fertilizer from goat manure, which enriches the soil with nutrients. Farmers in this village also practice selective harvesting by picking only perfectly ripe coffee cherries (red picking). This technique contributes to the quality and quantity of coffee. Study (9) confirms the findings of this research that natural methods generally produce higher yields than semi-washed and full-washed methods, mainly because the unpeeled process allows for the absorption of substances from the coffee cherries. Organic cultivation and attention to the ripeness of the coffee cherries are important factors that support successful harvesting with high yields in Rekesan Hamlet. However, (15) found that soaking coffee beans reduces defects, improves quality classification, and maintains balanced acidity.

Added Value of Arabica Coffee Beans based on the Hayami Method

Processing Arabica coffee using the natural method provides an added value of Rp.13,603/kg, with an added value ratio of 48.20%. This means that 48.20% of the value of coffee output is the result of processing cherries beans into green beans (see Table 2).

Table 2. Post-harvest Added Value of Arabica Coffee using the Hayami Method

No.	Variable	Notation	Post-harvest method		
			Natural	semi washed	Full washed
I. Output, input and price					
1	Total product output (kg/production process)	A	24.85	30.58	57.40
2	Raw material input (kg/production process)	B	122.9	162.55	314.35
3	Labor input (HOK/production process)	C	1.15	1.9	22.55
4	Conversion factor (kg output/1kg raw material)	D =A/B	0.2022	0.1881	0.1826
5	Labor coefficient (HOK/kg raw material)	E = C/B	0.00935	0.01168	0.07173
6	Output price (IDR/kg)	F	141,250	110,750	121,000
7	Average labor wage (Rp/Production Process)	G	80,000	80,000	80,000
II. Revenue and profit					
8	Raw material input price (IDR/kg)	H	10,000	10,000	10,000
9	Other input contributions (IDR/kg)	I	240.85	228.45	140.15
10	Output value (IDR/Kg)	J = D x F	28,560.75	20,832.08	22,094.6
11	Added value (IDR/Kg)	K = J- H- I	18,319.90	10,603.63	11,954.45
	Added value ratio (%)	L = K/J x100%	64.14	50.90	54.11
12	Labor income (IDR/Kg)	M = E x G	748	934.4	648.8
	Labor share (%)	N=M/Kx100%	2.62	4.49	2.94
13	Profit (IDR/Kg)	O = K – M	17,571.90	9,669.23	11,305.65
	Profit margin (%)	P= O/K x 100%	95.92	91.19	94.57
III. Remuneration for production factors					
14	Margin (IDR/Kg)	Q = J – H	18,560.75	10,832.08	12,082.5
15	Labor income (%)	R= M/Qx100%	4.03	8.63	5.37
16	Contribution of other inputs (%)	S=1/Qx100%	1.30	17.00	1.16
17	Entrepreneur's profit (%)	T=O/Qx100%	94.67	89.26	93.57

Source: Primary data 2025

Labor income in this process is IDR 724.8/kg, with labor share of value added at 2.53%. The post-harvest added value of Arabica coffee using the natural method from raw materials sourced from farmers in Rekesan, Bulukerto Village, reached IDR 18,305.775/kg, calculated from an output value of IDR 28,546.625/kg, minus the input price of raw materials of IDR 10,000 and other input contributions of IDR 240.85. The value-added ratio for the natural method reached 64.13%, falling into the high value-added category (>40%), indicating a positive impact on Arabica coffee processing in line with the research results (16).

The ratio of added value to output value of 54.08% is classified as high (above 40%), meaning that the full washed post-harvest process provides positive added value, although it is lower than the natural method. Process efficiency through the use of equipment such as pulpers and hullers will increase added value, although it requires additional operational costs, thereby strengthening the economic benefits of Arabica coffee post-harvest in Rekesan, Bulukerto Village. These findings are similar to the results in (17)(14), but higher than the added value of Arabica coffee in the coffee processing business unit in Badung City (18). Meanwhile, (19) found that there was no difference in added value according to the processing method. In addition to different natural conditions, this difference stems from the processing methods used, which also vary.

The value-added ratio to output value in this method reaches 50.90%, which falls into the high category (>40%), confirming that the post-harvest process of Arabica coffee using the semi-washed method provides positive added value. Although the added value is smaller than that of the natural method, the semi-washed method still provides significant economic benefits for farmers in Bulukerto Village, with process efficiency supported by the use of tools such as pulpers and hullers. According to (20), the quality of coffee produced can be influenced by proper harvesting and post-harvesting processes, resulting in good quality ground coffee. (21) also found that variations in processing methods and the duration of coffee fruit fermentation affect the moisture content, protein content, caffeine content, lipid content, and total acid content. Farmers generally sell their harvest in the form of wet beans at a much lower price (10).

Determinants of Arabica Coffee Value Added

The influence of the number of coffee beans, other input costs (fuel and transportation costs), labor input, farmer age, and number of coffee trees on the value added of post-harvest processing of coffee beans begins with proving the fulfillment of the classical assumptions presented in Table 3.

The data collected for all variables in the regression model proved to be normally distributed for all three post-harvest methods based on asymp.sig.2-tailed > 0.05. All variables also showed no multicollinearity, as evidenced by VIF, 10 and tolerance >0.10, while there was no heteroscedasticity, as indicated by the significance of each variable to the absolute residual dependent variable >0.05 as a result of the Glejser test. Thus, the regression model is suitable for analyzing the data in this study.

Table 3. Results of Classical Assumption Tests for Regression Models Based on Coffee Post-Harvest Methods

No	Variable	Natural			Semi washed			Full washed		
		Tolerance	VIF	Sig	Tolerance	VIF	Sig	Tolerance	VIF	Sig
1	Number of coffee beans	0.101	9.879	0.644	0.140	7.123	0.356	0.490	2.041	0.333
2	Other input costs	0.559	1.789	0.856	0.489	2.043	0.106	0.645	1.549	0.464
3	Labor input	0.229	4.365	0.711	0.253	3.952	0.637	0.575	1.740	0.947
4	Farmer age	0.824	1.214	0.507	0.934	1.071	0.348	0.815	1.226	0.095
5	Number of coffee trees	0.135	7.387	0.706	0.265	3.776	0.772	0.378	2.642	0.579
Asymp. Sig. (2-tailed)		0.101			0.051			0.054		

Source: Primary data 2025

The further analysis is to identify how the number of coffee beans, other input costs, labor input, farmer age, and number of coffee trees determine the added value of coffee according to the three post-harvest methods. The results of this analysis are listed in Table 4.

Table 4. Factors Determining the Added Value of Coffee Beans Based on Post-Harvest Methods

No	Variable	Natural		Semi washed		Full washed	
		Regression Coefficient	Sig.	Regression Coefficient	Sig.	Regression Coefficient	Sig.
1	Number of coffee beans	-0.096	0.002**	-0.077	0.008**	0.068	0.003**
2	Other input costs	-0.015	0.470	0.019	0.473	-0.017	0.498
3	Labor input	-0.154	0.000**	-0.210	0.000**	-0.033	0.468
4	Farmer age	-0.006	0.784	0.098	0.002**	-0.090	0.000**
5	Number of coffee trees	0.006	0.755	-0.021	0.218	-0.027	0.110
Sig. F		0.003		0.000		0.000	
R square		0.833		0.832		0.743	

Source: Primary data 2025

Coefficient of determination shows that the variables comprising the regression model have contributed to 74.3%-83.3% of the variation in coffee added value, which also indicates that the model is relevant for analyzing the determinants of coffee bean added value. Simultaneously, the various variables studied had a highly significant effect on the added value of coffee beans, whether dried using the natural, semi-washed, or full-washed methods.

Partially, an interesting phenomenon was found regarding the influence of the five factors on the added value of coffee beans. **First,** the number of coffee beans (kg) and labor input (man-days) had a highly significant effect on the added value of coffee beans dried using the natural method, while other inputs, such as the age of the farmer and the number of coffee trees, had no significant effect. **Second**, the amount of coffee beans (kg), labor input (man-days) and farmer

age have a highly significant effect on the added value of coffee beans dried using the semi-washed method, while other inputs and the number of coffee trees have no significant effect. **Third**, the amount of coffee beans (kg) and the age of the farmer (years) have a highly significant effect on the added value of coffee beans dried using the full washed method, while other inputs, labor input, and the number of coffee trees do not have a significant effect.

Many coffee beans used have a significant effect on the added value of coffee beans with all three methods, with a negative direction for the natural and semi-washed methods. Meanwhile, the direction of the relationship between these two variables in the full washed method is positive. The negative effect of coffee beans on the natural and semi-washed methods shows that improvements in raw material quality are not matched by proportional increases in product sales value, thereby reducing added value. Conversely, in the full washed method, better raw material quality can significantly increase the selling price, thereby having a positive impact on added value. This can happen because the natural and semi-washed methods are relatively simpler and lower in cost. If the coffee beans used are of high quality, the cost of raw materials increases significantly, but the increase in selling price is not proportional to the increase in raw material costs. According to (22), most farmers who harvest red coffee cherries prefer to sell coffee beans and cherries because they need cash and high prices.

Labor intensity has a highly significant and negative effect on the added value of coffee beans using the natural and semi-washed methods, while this variable has no significant effect on the full-washed method. Excessive labor input in the natural and semi-washed methods causes cost inefficiencies that reduce added value, whereas in the full washed method, the role of labor is relatively small because the process is more dependent on technology and processing standards, so its effect on added value is not significant. According to (23) the added value of primary processing is 30%, while labor income from primary processing is 69%.

Farmers' age has a significant and positive effect on the added value of coffee beans using the semi-washed method and a negative effect on the full-washed method, while it has no significant effect on the natural method. Farmers' age has a positive and significant effect on added value using the semi-washed method, indicating that the older the farmer, the higher the added value produced. Conversely, in the full washed method, the age of farmers has a negative and significant effect, indicating that an increase in the age of farmers actually reduces added value. The positive effect of the age of farmers on the semi-washed method is due to their increasing experience and skills in coffee processing, thereby improving product efficiency and quality. Conversely, in the full washed method, which requires mastery of technology and high precision, older farmers tend to be less adaptive to innovation and new technology, thus negatively impacting added value. As for the natural method, the relatively simple processing process means that the age of farmers does not have a significant effect on added value.

Other input costs (fuel and transportation costs) did not have a significant effect on the added value of coffee beans using the three methods in different directions. Fuel and transportation costs accounted for a relatively small proportion of total production costs, so fluctuations did not have a real impact on the formation of added value. In addition, these costs tended to be fixed and did not directly affect the quality or selling price of the product, so their effect on added value was not significant.

Number of coffee trees also did not significantly affect the added value of coffee beans with the three methods in different directions. An increase in the number of coffee trees had a greater effect on production volume than on improving product quality and selling price. In addition, added value was more determined by post-harvest process efficiency, raw material quality, and processing methods, so that variations in the number of coffee trees had no real impact on added value formation. According to (24), dry processing produces the highest caffeine content (1.25%), while full washing processing increases phenolics (68.05 mg GAE/g), sugar (3.89%), and acidity (0.036%). Processing choices significantly shape functional and sensory quality, so these findings provide practical guidance for optimizing processing to meet the demand for specialty coffee and increase farmers' income.

CONCLUSION

Arabica coffee yields in Bulukerto Village vary depending on the method chosen by farmers, with the highest to lowest being natural, full washed, and semi washed methods. Added value obtained according to post-harvest methods also varies in the same order, namely natural, full washed, and semi-washed methods. Meanwhile, the determining factors for added value according to post-harvest processing methods also vary. In the natural method, the number of coffee beans and labor input have a significant effect on added value, while other input costs, farmer age, and number of coffee trees have no significant effect. In the semi-washed method, the number of coffee beans, other input costs, and the age of the farmer have a significant effect on added value, while labor input and the number of coffee trees do not have a significant effect. In the full washed method, the number of coffee beans and the age of the farmer have a significant effect on added value, while labor input, other input costs, and the number of coffee trees do not have a significant effect.

RECOMMENDATIONS

Finding of this study can be applied at the farmer level where farmers need to improve the processing of Arabica coffee beans using the natural method so that they are more preferred by consumers because they have the highest yield and added value compared to other methods. Further research should examine in greater depth farmers' perceptions of why they use all three methods or prefer one method over the others. The government, through agricultural extension workers, can provide training to improve farmers' skills in post-harvest handling of coffee beans, thereby improving the quality of coffee beans processed using the natural method. Further research needs to differentiate between the ages of coffee trees, as their production varies, resulting in different yields and added value. In addition, research also needs to be expanded to include farmers who are not members of forest farmer groups to analyze the role of farmer institutions in coffee bean yields and added value. Determining factors also need to be differentiated according to internal and external farmer factors so that extension workers and the government can facilitate farmers' needs in creating added value for coffee, which is one of Indonesia's strategic commodities.

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