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The Effectiveness of Inversion In Drying Arabika Coffee Manually and Mechanically In East Java, Indonesia

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ABSTRACT
Post-harvest coffee processing such as drying can affect the effectiveness of the processing process, which in turn will affect the quality of the coffee beans. The process involves male and female workers who have different techniques and working times. The study aimed to compare the effectiveness of manual and mechanized coffee drying and the effect of worker gender on manual drying. The study was conducted from August to November 2023 in East Java, Indonesia. The sampling method used a drying floor of 4 floors with a drying floor area of 490 m2 and time measurements were carried out 4 times repeating each reversal method. The results showed that mechanical reversal was more efficient with an average time of 19.48 minutes compared to the manual method. The gender of the workers showed a significant effect on the reversal of coffee drying and the reversal method affected the weight loss of arabica coffee.

INTRODUCTION

Coffee is a plantation commodity that is widely cultivated in Indonesia and is one of the plantation commodities that has a high enough economic value so that it has an important role in the Indonesian economy. In 2022, coffee production in Indonesia reached 794.8 thousand tons, an increase of 1.1% compared to the previous year (BPS 2022). There are two types of coffee that are widely cultivated in Indonesia, namely Arabica coffee and robusta coffee (Rahardjo, 2012). According to Arlius et al. (2017) Arabica coffee is one of the types of coffee that has the best taste so that it becomes a superior commodity that has a relatively high value in the world market. The superior quality contained in Arabica coffee makes Arabica coffee have a high export value. In 2022, there was an increase in coffee exports by 12.92% compared to the previous year (BPS 2022).

In coffee cultivation there are several aspects that must be considered such as nurseries, maintenance and harvesting, in addition to these aspects one of the stages that must be considered is post-harvest processing of coffee. In the coffee processing process, attention must be paid to and done appropriately to get good quality coffee beans (Dian et al., 2024). In coffee processing, there are 2 processing methods, namely wet processing (wet process) and dry processing (dry process). Wet coffee processing is more widely used by large companies. One of the stages in the coffee processing process is the drying process. The drying process is important in coffee processing to produce maximum coffee quality (Pratama, 2022). The coffee drying process is carried out by drying the coffee beans on the drying floor that is directly in the sun. The drying floor has a convex surface with a slope of 5-10o (Sobriyanto, 2014).

Reversals in coffee drying are usually done using manual tools. Technological developments have made the innovation of making a turning machine. In the process of reversing coffee drying can be done using two methods, namely manual and mechanical

(Martha, 2024). Manual reversal uses the help of a shovel made of wood, while mechanical uses a reversing machine operated by 2 workers. The process of manually reversing is carried out by male and female workers, while in the field it is shown that the drying process is dominated by male workers (Ngaku & Kaleka, 2024).

In the process of drying arabica coffee, the weight of the arabica coffee beans is weighed. The weighing process is carried out using blek made of zinc which is then weighed using a scale. The weighing process begins with grinding using a mini gerbush machine to remove the horn skin on the coffee (Tika, 2022). The weighing process aims to determine the decrease in the moisture content contained in sun-dried Arabica coffee. Drying aims to reduce the level of moisture content contained in coffee beans. The drying process is carried out until the resulting moisture content reaches 10-12% (Sumitro, 2024). The study aims to compare the effectiveness of reversal in the manual and mechanical coffee drying process and the influence of worker gender on manual coffee reversal.

Previous research has examined the impact of post-harvest coffee handling on bean quality and productivity. Santoso and Egra (2018) found that drying methods significantly influence the moisture content and sensory attributes of Arabica and Robusta coffee. Similarly, Andayani et al. (2023) emphasized the role of sorting and drying practices in enhancing coffee bean quality, suggesting that mechanization can reduce labor costs and increase consistency. However, these studies did not focus specifically on the gender dynamics involved in manual drying or direct time-efficiency comparisons between manual and mechanical turning.

Drying is a crucial post-harvest step that determines the final quality and market value of coffee beans. In East Java, many smallholder farmers still rely on traditional manual turning methods that vary in efficiency. As the demand for high-quality Arabica coffee increases, optimizing the drying process becomes critical. Delays or inefficiencies in drying can result in mold growth, uneven fermentation, and economic losses. Therefore, improving the drying process by evaluating mechanical methods and understanding labor dynamics, including gender roles, is urgently needed to ensure product quality and enhance farmers' competitiveness in local and global markets.

Despite advancements in coffee processing, there is a limited body of literature that simultaneously examines the comparative efficiency of manual and mechanical turning methods and the influence of worker gender on drying performance. Most studies focus either on mechanization benefits or on drying outcomes without integrating labor variables such as age, gender, or experience. This gap limits the understanding of how human factors interact with technological interventions in coffee drying.

This study offers a unique contribution by evaluating the effectiveness of manual versus mechanical coffee drying methods while incorporating the gender dimension of labor efficiency. It not only compares processing time and weight loss during drying but also analyzes how male and female workers perform in manual turning tasks. This integrated approach brings new insights into labor productivity and technological adoption in coffee post-harvest processing.

This research aims to assess the effectiveness of manual and mechanical turning methods in Arabica coffee drying and to examine the influence of worker gender on manual turning efficiency. The results are expected to guide farmers and plantation managers in selecting appropriate drying methods to optimize labor usage and maintain coffee bean quality. By identifying time-saving techniques and understanding gender-related labor performance, the study offers practical recommendations for improving post-harvest coffee handling in East Java and similar agricultural contexts.

RESEARCH METHOD

The research activities were carried out from August to November 2023. The research activities were carried out at Java Coffee Estate located in Kalisat Jamit Village, Ijen District, Bondowoso Regency, East Java Province. The research was carried out by collecting data on the length of the coffee reversal process at Java Coffe Estate. Measurements are carried out on 2 reversal methods, namely manual and mechanical. The reversal process is carried out every 1-2 hours. Coffee reversal is done manually with the help of a tool in the form of a shovel made of wood, while mechanical reversal uses the help of a turning machine operated directly by two workers. Observations are made for each reversal process manually or mechanically, furthermore, the data is processed to compare the time needed to work on the reversal process manually and mechanically. In the manual reversal process, workers' personal data was collected which included age and work experience, and the data was then processed to determine the influence of *gender* on the length of time the reversal process was carried out in the coffee drying process. In the drying process, there are stages of weighing coffee beans. The data from the steering wheel weighing was processed to determine the rate of coffee weight loss which was used to determine the moisture content contained in the coffee beans when it was drying.

Observation and Data Collection

The data obtained is in the form of primary data and secondary data. Primary data was obtained by direct observation in the field when he was a freelance daily employee, foreman companion and assistant assistant. Observation and collection of primary data were carried out on several parameters which include:

a. The duration of the work, is carried out in the following ways:
    1. Determine the drying floor used as a sample. The criteria for the drying floor used is 490 m2 with a drying capacity of 11,956 kg for market coffee.
    2. Calculate the time required for manual and mechanical reversal work in one clothesline floor using *a stopwatch*. Observations were carried out 4 times in each method so that a total of 16 data was obtained.
    3. Observations are made every 1-2 hours during the reversal process
b. Gender, age and work experience were conducted by interviewing workers who reversed the manual drying of coffee with a sample of 8 workers including 4 men and 4 women.
c. Coffee weight loss is collected from coffee weighing carried out during drying. Weighing is carried out at 8.30 am every day.

RESULTS AND DISCUSSION

Reversal Efficiency in Manual and Mechanical Coffee Drying

Observations were made to measure the time needed by manual and mechanical workers to perform coffee reversals. The manual reversal process uses a tool in the form of a shovel (Figure 1a), while mechanical reversal uses a reversing machine operated by a worker (Figure 1b).

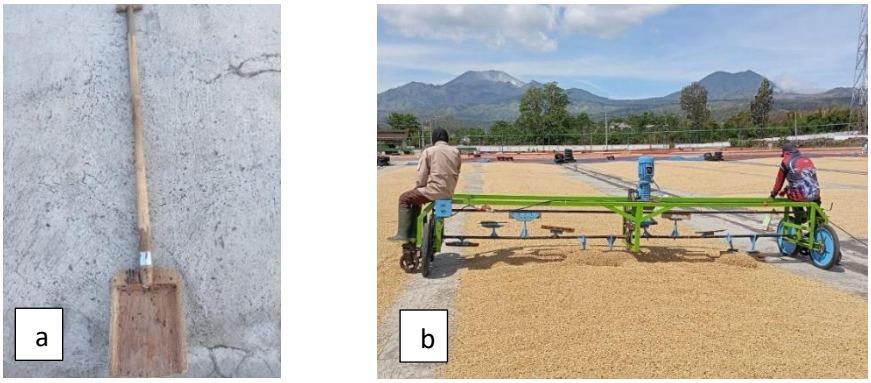

Figure 1 Turning tool (a) Shovel used for manual reversal (b) Machines used for mechanical reversal

Based on the results of observation of reversals in coffee drying, it can be seen that the average time for manual processing takes 54.39 minutes, while mechanically it only takes 19.48 minutes (Table 1). Manual and mechanical reversal work has a considerable difference of 34.51 minutes. The test results in table 6 show that manual and mechanical reversals show noticeably different results from reversal times (Surianti et al., 2020).

Based on the length of work, the use of a turning machine is more efficient than manual coffee reversal. This is because the processing time of the coffee reversal required mechanically is three times faster than manually (Asni, 2015). During the manual reversal process, workers only use an auxiliary in the form of a shovel, where the reversal speed of each worker varies so that it is inconsistent, while in mechanical reversal, a machine with the speed used is more consistent so that the time required is not far between floors. The use of a turning machine reduces the time it takes to flip coffee beans compared to manual reversal and allows for faster and more consistent processing. The use of a turning machine is able to cut the need for labor in the drying room so that it saves more costs incurred to pay workers (Andayani et al., 2023).

Table 1 Manual coffee reversal processing time

Method	Processing Time (minutes)
Manual	54,39
Mechanical	19,48
P < Value	0.000n

Information:
n : real difference

The Influence of Gender on the Duration of Manual Reversal

In the process of manually reversing coffee, workers' personal data is collected which includes age and work experience. The sample of workers used was workers who did manual reversals on 4 floors of clotheslines. The number of manual workers used as a sample was 8 people. The sample of workers taken was 4 female workers and 4 male workers. In the youngest female worker at the age of 29 and the oldest at the age of 35, while in the youngest male worker at the age of 27 and the oldest at the age of 42. The lowest and longest work experience is found in male workers with 9 years and 20 years of work experience (Santoso & Egra, 2018).

The reversal process in manual coffee drying is carried out by male workers (Figure 2a) and female workers (Figure 2b). The number of workers in the drying section at the time

of the harvest is 60-70 people, which are dominated by male workers. The workers who are in the drying room do not always work on the reversal section. The T-test is used to determine the influence of independent variables on whether or not the dependent variable adapts significantly. If the significance level value is < 0.05, then the variable has a significant effect (Setiawan et al., 2022).

Based on the test results, it was found that gender has a real influence on the length of reversal work. The processing time required for reversals by male workers averaged 52.17 minutes while the time required by female workers for reversals averaged 57.01 minutes (Table 2). It can be known that male workers are faster in reversing than female workers. The speed of the reversal can affect the time it takes each worker. Male workers have stronger physical strength and endurance compared to female workers so that in the reversal process they can do it faster. Taking this into account, the workers who are in the drying are dominated by male workers (Budi et al., 2020).

Figure 2 Manual reversal worker (a) Male worker (b) Worker Woman

Table 2 Average manual reversals by *gender*

Gender	Average Length of Operation (minutes)
Man	52,17
Woman	57,01
P < Value	0.000n

Information:
n : real difference

The Effectiveness of Manual and Mechanical Coffee Drying Reversal on Coffee Weight Loss

At the Java Coffee Estate Plantation, the calculation of the moisture content of coffee in drying is carried out by weighing the weight of coffee beans. Before weighing the coffee, a mini grinding process is carried out. This grinding process is carried out for weighing, putting coffee into a blek made of zinc (Figure 3), before weighing the coffee, the grinding process is carried out which is then weighed using a scale. Weighing is carried out once a day at the same time, namely at 8.30 WIB.

Figure 3 Blek coffee weighing place

Weighing the rate of coffee weight loss carried out during drying on reversal manually and mechanically. Weighing is carried out every day until the moisture content is reached in accordance with the Company's SOPs. In the Java Coffee Estate Garden, the maximum moisture content for the coffee to be dried in the sun is 12%. The weighing process is carried out to make it easier to determine the amount of moisture contained in the dried coffee. If after weighing the weight of the coffee reaches 7-7.4 kg, it can be found that the value of the moisture content contained in the coffee is already 11-12%. The level of moisture content contained in coffee is measured using *a green moisture tester* to determine the accuracy of the moisture content contained in coffee. Each weighing is collected to determine the rate of coffee weight loss in drying. The rate of coffee weight loss in manual and mechanical drying can be seen in Table 3.

Table 3 Rate of decline in coffee weight weighing

Weighing	Weight/Spot (kg)	
	Manual	Mechanical
1	0,4	0,1
2	0,8	0,1
3	0,3	0,2
4	0,8	0,1

Based on the results of the comparative test, the results were obtained that the significance value showed that the weight weighing in the coffee reversal had a significant difference (Table 4). The weight loss of coffee beans on manual reversal is faster compared to the weight loss of coffee beans on mechanical reversals. In mechanical reversal, the average rate of coffee weight loss is 0.6 kg per day, while in mechanical reversal, the rate of coffee weight loss is only 0.1 kg per day. This can be caused by manual reversal, workers can directly control the state of the coffee on the drying floor. If the drying of the coffee is not even. Workers can determine the reversal technique used according to the state of the coffee, so that the coffee can dry optimally with sun exposure. The weight of the coffee will reach the target more or less after drying for 18-20 days. Weighing is carried out daily to determine the weight of the coffee when drying and to determine the level of moisture content. Every loss of coffee weight is marked on the drying floor using a flag. The use of flag colors can be seen in Figure 4.

Figure 4 Description of the flag on the drying floor

Table 4 Results of coffee weight loss rates on manual and mechanical reversals

Weighing	Weighing Reduction Result (kg)
Manual	0,6
Mechanical	0,1
P < Value	0.044n

Information:
n : real difference

CONCLUSION

Based on the observation and processing of data for a long time in the reversal process of coffee drying at Java Coffee Estate, it can be concluded that in the process of reversing coffee manually and mechanically, there are significant differences. The use of a turning machine is more efficient than manual. The use of a turning machine can reduce the need for labor in the drying process. In manual drying reversals, it was found that the gender used as a comparison had a real effect on the length of reversal work on coffee drying. Gender variables have a great influence on manual coffee reversals. At the rate of weight loss of coffee beans, manual reversal is more effective than mechanical reversal.

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