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THE GREEN MSME DRYING TECHNOLOGY MODEL AND ITS IMPACT ON THE ADDED VALUE OF COFFEE FARMERS IN ACEH

Dedy Darmansyah[1*], Hartini[2], Qhisthina Atikah[3], Ina Yuyun[1]
[1]Department of Agribusiness, Faculty of Agriculture, Universitas Teuku Umar, West Aceh, Aceh, Indonesia
[2]Development Economics Study Program, Faculty of Economics and Business, Universitas Teuku Umar, Aceh Barat, Aceh, Indonesia
[3]Department of Agribusiness, Faculty of Agriculture, Universitas Syiah Kuala, Banda Aceh, Aceh, Indonesia
E-mail: dedydarmansyah@utu.ac.id; hartini@utu.ac.id; qhisthina.atikah@usk.ac.id; inayuyun8@gmail.com.

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Abstract

Drying is a critical post-harvest stage for coffee, as it directly determines the final quality, economic value, and ultimately, farmers' income. Most farmers in Aceh Tengah and Bener Meriah still rely on conventional methods, such as drying coffee directly on tarps or non-standard racks. These practices often result in high moisture content, significant physical defects, and consequently, lower selling prices. This study analyzes the effectiveness of a "Green MSME" drying rack constructed from wood and food-grade mesh in improving coffee quality and farmer income, while also evaluating its alignment with sustainability and circular economy principles. Using a descriptive-comparative quantitative approach, the research involved 30 farmers applying four different drying methods. The results demonstrated that the Green MSME technology yielded the best coffee quality, with an average moisture content of 11.2% and a defect rate of 6.1%, which is superior to tarpaulin drying (12.8% and 11.3%, respectively). The added value for Green MSME coffee reached IDR 77,500 per kg (9.9% higher than the traditional method), leading to an income increase of 1.19% to 13% per 500 kg of dry beans. Furthermore, the Green MSME model supports sustainability through greater energy efficiency, waste reduction, the use of eco-friendly materials, and enhanced potential for quality certification. In conclusion, this innovation has proven to be feasible, economical, and consistent with green production principles, making it a viable model for widespread replication to develop the smallholder coffee agribusiness in Aceh.

Keywords: Green MSMEs, coffee drying, added value, coffee quality, sustainability.

INTRODUCTION

Post-harvest drying quality is a critical factor that determines the final quality, market value, and competitiveness of coffee commodities at the farmer level. Most smallholder farmers still rely on conventional methods, such as drying on tarps or directly on the ground. These practices negatively impact moisture content, increase the risk of microorganism contamination, impair aroma development, and ultimately lower the selling price of coffee beans (Sutrisno et al., 2021). Errors during the drying process can lead to bean defects, encourage fungal growth, and reduce cupping scores, all of which ultimately diminish farmers' income (Alhabsyi et al., 2020). Simple technological innovations, such as raised drying racks and knockdown drying systems, have been proven to enhance product cleanliness, optimize space efficiency, and improve overall quality, thereby strengthening the competitiveness of smallholder coffee (Mawardi et al., 2020). This aligns with the principles of Green MSMEs, which emphasize resource efficiency, waste reduction, and income generation through the adoption of environmentally friendly technology (Choibar et al., 2022). The implementation of green entrepreneurship-based drying technology can also serve as a strategy to increase added value while supporting the circular economy within rural agribusiness (Darmansyah et al., 2023). The development of a sustainable coffee agribusiness is closely linked to the transformation of the role of MSMEs in addressing global challenges such as climate change and business sustainability. The Green MSME model has begun to be adopted by coffee businesses in Aceh and has demonstrated its ability to integrate production, marketing, human resources, and financial management in a more efficient and

environmentally sound manner (Darmansyah et al., 2023). Furthermore, innovations in utilizing coffee waste such as leaves, fruit skins, and other by-products have the potential to create new income streams for farmers if processed into derivative products like coffee leaf tea, cascara, coffee flour, and fermented beverages from coffee fruit (Darmansyah et al., 2022). However, such technological innovations can only be successfully implemented if the primary drying and handling systems for coffee beans are hygienic and standardized. From the market perspective, coffee consumption trends are also shifting. Indonesian consumers are increasingly showing a willingness to pay a premium for certified organic and sustainably produced coffee, including coffee from farmers who apply environmentally friendly technologies (Khaliqi et al., 2023). Health benefits, environmental concerns, and perceptions of higher quality are the primary drivers behind this willingness to pay more for organic and green-certified coffee. Based on these conditions, research is needed to measure the economic impact of using drying racks based on the Green MSME concept compared to conventional drying methods (such as wire mats, iron frames, or tarpaulins). This study aims to: (1) analyze the differences in coffee quality and added value between the use of Green MSME drying technology and conventional methods; (2) measure the contribution of implementing Green MSME drying racks to increasing the income of coffee farmers in Aceh Tengah and Bener Meriah Regencies; and (3) evaluate the extent to which this drying model supports the principles of sustainability and the Green MSME concept, encompassing aspects of clean production, energy efficiency, waste reduction, product hygiene, and circular economy potential.

LITERATURE REVIEW

Coffee commodities, particularly Gayo Arabica, play a vital role in the agricultural economy of Aceh. However, challenges in downstream processing remain a major obstacle to improving farmer welfare. Supply chain analysis highlights that most coffee farmers in Aceh still sell their products as cherries or wet beans with substandard moisture content due to limited post-harvest facilities (Romano, 2018). Conventional drying methods, conducted in open yards or roadside areas, are highly susceptible to contamination from dust and animal waste. Furthermore, a high dependence on unpredictable weather often reduces the physical quality (grade) of the coffee beans and depresses selling prices at the farmer level (Mulkan, 2022). To overcome these quality and weather-related constraints, an appropriate technology approach based on the "Green MSME" concept offers a relevant solution. One such innovation is the application of greenhouse-effect drying technology, such as a Solar Dryer Dome. (Nelwan et al. 2019) and (Suherman & Hidayati, 2020) shows that using hybrid (solar-biomass) dryers can significantly accelerate the drying rate compared to direct sun drying while maintaining product hygiene. The application of this technology not only guarantees consistent moisture content in line with export standards (12-13%) but also supports environmental sustainability by minimizing the use of fossil fuels in MSME-level processing. The improvement in the physical quality of coffee beans achieved through modern drying technology is theoretically correlated with an increase in product added value. According to the theory of Hayami et al. (1987), added value is the difference between the value of the final product and the cost of raw materials and other inputs. An empirical study by (Rahmaddiansyah et al. 2022) on coffee cooperatives in Aceh confirms that shifting from selling raw materials to semi-finished or finished products (green beans or roasted beans) yields a significantly higher profit margin. With adequate drying technology, farmers can hold their products for longer, sell when market prices are more favorable, and strengthen their bargaining position within the supply chain.

METHOD

This study employed a descriptive-comparative quantitative approach to analyze the effectiveness of the Green MSME drying technology model in enhancing coffee quality and added value, comparing it against conventional drying methods commonly used by farmers. To provide deeper contextual insight, this approach was supplemented with qualitative data collected through interviews and Focus Group Discussions (FGDs) to understand the drivers and barriers of technology adoption at the farmer level. The research was conducted in Aceh Tengah Regency and Bener Meriah Regency, Aceh Province, which are the primary production centers for Gayo Arabica coffee and the initial implementation sites for the Green MSME drying technology model. The study period spanned from November 2024 to July 2025, encompassing field observations, coffee quality data collection, farmer income surveys, and verification through FGDs. The research population comprised Arabica coffee farmers in both regencies who independently manage their post-harvest drying processes. A purposive sampling technique was used to select the sample based on the following criteria:

1) Farmers who have consistently used the same drying system for at least two harvest seasons.

2) Farmers who sell their harvest in the form of dried parchment beans or green beans.
3) Farmers who were willing to participate in interviews and provide coffee samples for quality testing.

A total sample size of 30 farmers was planned, divided into four distinct drying technology groups: 1) K1: Green MSME drying racks (wood frame with food-grade mesh); 2) K2: Wire mesh drying racks; 3) K3: Iron frame drying racks; 4); and K4: Direct drying on tarpaulin (without raised racks). Primary Data included: drying techniques and duration; physical and organoleptic quality of coffee beans (moisture content, defect levels); farming business costs and income; farmers' perceptions regarding the usability, benefits, and constraints of the Green MSME technology. Secondary Data were gathered from: coffee production and export statistics from relevant government agencies; previous studies and publications on post-harvest technology, Green MSMEs, and coffee agribusiness; documents related to coffee development programs in Aceh. The data analysis consisted of three methods:

1) Descriptive Analysis: To characterize the farmer profiles, drying techniques, and resulting product quality.
2) Value-Added and Feasibility Analysis: To calculate the added value (IDR/kg) and net income (IDR/harvest) generated by each drying method.
3) Qualitative Analysis: Interview and FGD data were analyzed using content analysis to identify key themes, including perceptions, adoption constraints, and the potential for scaling the Green MSME technology.

RESULTS AND DISCUSSION

Differences in Quality and Added Value Between Green MSME Drying Technology and Conventional Systems

The results for moisture content, physical defects, and cupping tests indicate that coffee dried using the Green MSME method produced superior quality compared to the three other conventional methods. The Green MSME technique achieved an average final moisture content of 11–11.5%, which conforms to specialty coffee standards, while tarpaulin drying consistently resulted in moisture content above 13%.

Table 1. Comparison of Coffee Quality Based on Drying Methods

Quality Indicators	Green MSMEs	Wire Drying Racks	Iron Drying Racks	Tarpaulin/Soil
Moisture Content (%)	11.2	11.3	11.9	12.8
Defect Rate (%)	6.1	7.9	8.5	11.3

Source: Primary Data (*processed*) 2025

These findings align with Alhabsyi et al. (2020), who reported that more hygienic drying methods yield more stable cupping scores and moisture content. They are also consistent with the knockdown drying model introduced by Mawardi et al. (2020) as an innovation to enhance coffee quality at the farmer level. This consistency is further reinforced by a recent study by Moon et al. (2025), which conducted a comparative analysis of various post-harvest drying techniques, including Controlled Environment Drying (CED), Sun Drying (SD), and Fast Drying (FD). Moon et al. (2025) found that drying in a controlled environment which is inherently cleaner, minimizes contamination, and allows for regulation of temperature and humidity more effectively maintains stable bean moisture content and preserves sensory quality compared to conventional open-air drying. These collective findings underscore that the level of cleanliness and process control during drying is crucial for maintaining the physical and organoleptic quality of coffee, making the adoption of hygienic drying methods a strategic step for quality improvement.

Table 2. Economic Added Value Based on the Drying Method

Method	Selling Price (Rp/kg)	Operating Costs (Rp/kg)	Value Added (Rp/kg)
Green MSMEs	85,000	7,500	77,500
Wire Products	84,000	7,000	77,000
Iron fences	81,500	6,800	74,700
Tarpaulin/Soil Drying	75,000	4,500	70,500

Source: Primary Data (*processed*) 2025

A key finding is that the Green MSME model generates 9.9% higher added value compared to traditional tarpaulin drying.

Contribution of Green MSME Technology to Increasing Farmers' Income

Table 3. Farmers' Net Income per 500 kg of Dry Grain

Method	Income (IDR/harvest)
Green MSME drying racks	IDR 42,500,000
Method	Income (IDR/harvest)
Wire	IDR 42,000,000
Iron	IDR 40,750,000
Tarpaulin Drying	IDR 37,500,000

Source: Primary Data (*processed*) 2025

The implementation of Green MSME drying racks has been proven to increase farmer income by approximately 1.19% to 13% compared to traditional methods. Beyond securing higher selling prices, this increase is also attributed to reduced losses from bean defects and mold. Farmers reported additional benefits, including: 1) faster achievement of ideal moisture content, 2) lower risk of contamination from rain or soil, and 3) more consistent output quality, making their product more acceptable to specialty buyers and exporters. These results are consistent with the findings of (Choibar et al. 2022), who noted that environmentally friendly drying technology enhances quality consistency and the competitiveness of coffee MSMEs. Further support comes from (Chaikham, 2025), whose study demonstrates that controlled drying techniques yield better moisture content stability and preserve the physical quality of coffee beans compared to conventional sun drying. Additional evidence is provided (Hu et al. 2023), who evaluated modern drying methods for coffee husks and found that techniques like microwave and vacuum freeze drying are superior at preserving bioactive components, antioxidant capacity, and volatile characteristics compared to traditional methods. Although focused on by-products, the work of (Hu et al. 2023) reveals a similar pattern: more efficient, controlled, and potentially eco-friendly drying technologies deliver more stable quality.

This supports the broader argument that modernizing drying processes is essential for enhancing the value and competitiveness of coffee products.

Table 4. Analysis of Green MSME Principles

Green MSME Principles	Field Findings
Clean production	Food-grade wood and mesh materials, no contact with soil
Energy efficiency	Uses solar energy, does not require fuel
Waste reduction	Minimizes defective seeds; defective waste can be processed into
Food health and safety	Not contaminated by dust, soil, or metals
Circular economy	Modular design can be repaired, wooden materials are easy to
Inclusiveness	Affordable technology & can be built collaboratively

Source: Primary Data (*processed*) 2025

The model developed in this study aligns with the Green MSME indicators outlined by Bank Indonesia, which emphasize resource efficiency, reduced environmental impact, and the application of sustainable production practices. These findings resonate with the study (Darmansyah et al. (2023), which confirms that adopting environmentally friendly technologies and green production practices can improve the sustainability performance of MSMEs while strengthening their competitiveness. The implementation of this model not only promotes efficiency and adherence to sustainability principles but also unlocks economic opportunities for coffee MSMEs. These include the potential to obtain environmental certification, command premium prices, and access markets oriented toward organic and sustainable products, as explained (Khaliqi et al. 2023). Thus, the application of this model directly contributes to increased product added value while expanding market access for MSMEs within a more sustainable value chain.

CONCLUSION

This study demonstrates that the application of Green MSME drying technology significantly improves coffee quality, economic added value, and farmer income in Aceh Tengah and Bener Meriah Regencies. The main findings are summarized as follows:

1) Coffee quality and added value increased significantly with the use of the Green MSME drying model compared to conventional methods (wire, iron, and tarpaulin). The Green MSME drying racks produced ideal moisture content (~11%), low defect rates, and cupping scores reaching the specialty category (~83 points). This quality enhancement resulted in an increase in selling price and added value of up to 9.9%.
2) The application of Green MSME drying racks has been proven to increase coffee farmers' income, with an income differential of 1.19% to 13% compared to farmers using conventional tarpaulin drying. Higher profits are derived from improved quality, time efficiency, and reduced bean damage.
3) The Green MSME drying technology model supports the principles of sustainability and the Green MSME concept, as it utilizes environmentally friendly materials, maintains product hygiene, minimizes waste, and promotes a circular economy. This technology also creates opportunities for quality certification, premium pricing, and access to sustainable markets.

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