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EFFECT OF HARVEST TIME AND THE DELAYED DRYING PROCESS ON THE QUALITY OF MORINGA LEAVES (MORINGA OLEIFERA)

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ABSTRACT
The quality of food and feed from plant origin is determined from harvest time and handling after harvest. Moringa is a plant that can be used for food and feed. Potential Moringa is reviewed in terms of nutrients so that it is referred to as a superfood and also has very potential as a super feed. This study aims to analyze the nutrient quality of moringa leaves harvested at different harvest times and the delayed handling by drying after harvest. The experimental design used is a randomized complete design with a factorial pattern involving 2 factors. The first factor is the harvest time (morning and evening), and the second is the time before handling, with drying time delays of 0, 2, 4, and 6 hours after harvest. Dry weight, ash levels, crude protein, and fiber are markedly affected by harvest time and delayed handling (delay in drying time). The study concluded that the quality of moringa leaves is maintained at the morning harvest, and the drying process must be done immediately after harvest. The quality of moringa leaves tends to decrease with the delay of the drying process in the afternoon harvest.

KEY WORDS
Soil chemical properties, soil fertility status, andisol, coffee plantation.

Moringa oleifera is one of the most important crops in tropical countries like India and Africa, where it originates. In Indonesia, it is also known as a plant with health benefits and widely used for forage as animal feed, as food for human consumption, as an adsorbent, bioenergetic, industrial, biofertilizer and medicinal plant (Ruíz-Hernández et al., 2022).

The quality of food and feed of plant origin is determined from harvest time and handling after harvest. The agronomic production and post-harvest treatments of the plant parts have been shown to influence the quality of the phytochemicals (Bridgemohan et al., 2020). The time of day for the harvest of the plants, in the morning or evening, will affect the yield in terms of dry weight produced by plants, especially in plants that produce leaves, such as *Moringa oleifera* plants. Moringa leaves and tender pods should be harvested at the coolest time of the day: early morning or late evening (5 – 7 AM and 6 – 8 PM) to minimise moisture loss (Farm Africa, 2019; Goordeen, 2018). The dry weight of the harvest will determine the yield produced by the plant. The process of photosynthesis is sensitive to temperature, particularly in terms of the activation and deactivation of photosynthetic enzymes (Moore et al., 2021), as well as the rate of dry matter accumulation per unit area of leaves (Sinclair & Muchow, 1999). The quality of horticultural products primarily depends on the accumulation of dry materials, which are measured based on dry weight, largely derived from photosynthesis (Inamoto et al., 2016).

Besides harvest time, the production and quality of agricultural crop products are also affected by post-harvest handling. The elements of the post-harvest system include harvest, pre-harvest drying, transportation, post-harvest drying, threshing, processing, and marketing (Grolleaud, 2002). High moisture content in crops at harvest is the main reason for their

deterioration during storage. This moisture promotes the growth of fungi and bacteria, leading to rapid spoilage and a decline in nutrient content (Agha & Al-Mashhadany, 2024).

The various parts of the *Moringa oleifera* plant are typically picked by hand. However, since the flowers, leaves, pods, and seeds are highly perishable, handling them roughly in the field could cause physical damage, leading to secondary infections that can negatively impact the quality and shelf life of the harvested produce (Mohammed & Bridgemohan, 2019). Due to the absence of a proper post-harvest management system, the bulk quantity of moringa gets damaged during handling, transportation, and marketing. Factors during harvesting that can influence postharvest quality include the degree of severity of mechanical damage induced by machines or humans, the accuracy of selecting acceptable rather than unacceptable fruit, the time of day of harvest, and the temperature at harvest (Michailides & Manganaris, 2009; Prusky, 2011).

It's important to handle harvested Moringa leaves quickly to maintain their nutrient quality. Since fresh Moringa leaves do not last long, drying them is the best option for storage. The time between harvesting and drying, as well as the drying process and temperature, all impact the nutrient quality of Moringa. Different methods, drying times, and temperatures can significantly affect the yield and protein content of Moringa. The ideal drying temperature for Moringa leaves is 60°C for 5 hours, resulting in a moisture content of 11.029%, yield of 25.394%, protein of 20.50%, vitamin C of 15.025mg/g, and antioxidant activity of 409.044 mg/g (Setyowatik, 2011). Therefore, the right harvest time and handling after harvest must be known to reduce losses in quality and quantity. In light of this, a research study was conducted to analyze the nutrient content of Moringa leaves (*Moringa oleifera*) concerning harvesting times and delayed drying processes after harvest.

METHODS OF RESEARCH

Moringa leaves were sampled at community gardens with regrowth lasting over 45 days, followed by the drying process. Nutrient content analysis was conducted at the Laboratory of the Faculty of Animal Science, Jambi University, Indonesia.

To harvest Moringa, a machete is used according to the designated harvest times (morning and evening). The leaves are separated from the main branch and then manually stripped from the stalk. Moringa leaves are taken from harvested branches. After that, drying is applied following the treatment. A sample of 100g fresh moringa leaves per treatment is prepared. Drying is done with a food dehydrator that has temperature and time control. The drying temperature applied is 60 °C with a length of 6 hours, modified from (Setyowatik, 2011). Before placing the leaves in the dryer, a sample is weighed fresh. Once dried, the moringa leaves are removed from the food dehydrator and weighed again. Subsequently, the dried leaves are ground into flour for a nutrient content analysis based on proximate analysis.

The research design used is a factorial completely randomized design with two factors. The first factor is the time of harvest, namely: T1 = morning (6-7 am), T2 = afternoon (5-6 pm). The second factor is delayed drying, which consists of D1 = drying directly after harvest (0 hours), D2 = 2 hours delayed drying after harvest, D3 = 4 hours delayed drying after harvest, and D4 = 6 hours delayed drying after harvest. This results in 8 combinations of treatments, each repeated 3 times.

The parameters to be observed in this study are the nutrient qualities of Moringa leaves, which include yield, moisture content, ash content, crude protein, crude fat, and crude fiber (proximate analysis) (AOAC, 1990). The data will be analyzed with an analysis of variance according to the design used. If there is a significant effect between the treatments, then the Duncan Multiple Range Test (Steel & Torrie, 1990) will be followed. The data is running using the R program.

RESULTS AND DISCUSSION

Post-harvest handling is the stage of crop production that occurs after harvest, involving cleaning, selection, packaging, and preservation. Product damage begins once the

plant is harvested, regardless of origin (**Grolleaud, 2002**). Improving harvesting and post-harvest handling practices is essential, as they significantly impact the post-harvest quality and shelf life of crop products (**Clark and Finn, 2008; Lawrence and Melgar, 2018**).

Table 1 shows the nutrient content of Moringa leaves at different harvest times and delayed drying after harvest. The harvest time significantly influences the nutrient quality of Moringa leaves in terms of dry weight, water content, ash content, crude protein, and crude fiber, except for fat content. Morning harvest significantly decreases the dry weight and water content. On the other hand, morning harvest significantly increases the ash, crude protein, and crude fiber content of Moringa leaves. Additionally, delays in the drying process after harvest also affect the nutritional quality of Moringa leaves, specifically in terms of dry weight, water content, ash content, crude protein, but not crude fiber, and crude fat content. The delayed drying process significantly increases the dry weight. Meanwhile, it decreases the water, ash, crude protein, and crude fiber content.

Table 1 – The nutrient content of Moringa leaves with different harvest times and delayed drying time after harvest

Treatment	Dry weight (%)	Water content (%)	Ash (%)	Crude protein (%)	Crude fiber (%)	Crude fat (%)
Harvest Time						
Morning	24,438^{b}	4,012^{b}	9,048^{a}	23,478^{a}	12,340^{b}	11,249
Evening	28,613^{a}	4,523^{a}	8,439^{b}	22,025^{b}	9,694^{a}	10,979
p	0,000	0,007	0,000	0,001	0,007	0,618
Delayed drying after harvest						
0 h	25,600^{c}	4,483^{a}	9,054^{a}	27,510^{a}	11,576	11,258
2 h	25,597^{c}	4,466^{a}	8,513^{b}	21,355^{b}	11,023	11,143
4 h	26,425^{b}	3,892^{b}	8,639^{b}	21,074^{b}	10,655	11,144
6 h	28,482^{a}	4,227^{ab}	8,768^{b}	21,067^{b}	10,813	10,911
p	0,000	0,076	0,000	0,000	0,753	0,619

Different superscripts in the same column showed a significant difference at ($p<0.05$).

The morning harvest produces a lower percentage of (yield) dry weight and moisture content than the evening harvest. However, ash levels, crude protein, fiber, and fat content increased during the morning harvest. The morning harvest is crucial because it occurs during the coldest part of the day, allowing for lower temperatures and respiration rates (Florkowski et al., 2009). Net photosynthesis is initially low in the morning but increases with greater solar radiation and then decreases in the middle and evening of the day (Koyama & Takemoto, 2014). Photosynthate is the substrate of respiration, so increased photosynthate will increase respiration, producing energy for plant growth and ultimately leading to higher crop yields (Lestari et al., 2006). Sangeetha et al. (2017) found that harvest time also significantly impacts the weight of moringa fruit, with morning-harvested pods showing a minimum weight (10.37%) after nine days of storage under room conditions. Moringa leaves are prone to moisture loss from the sun, so harvesting them in the early morning or late evening is recommended to avoid the sun and heat. However, harvesting early in the morning is also advisable to allow enough time to complete subsequent processing steps, which should be carried out simultaneously (Krah et al., 2021).

Moringa has a very short shelf life, and loss of nutritional quality can occur due to poor post-harvest handling. Various food preparation methods also affect moringa's nutrition and functional quality (Sangeetha et al., 2017). Delaying the drying process reduces the overall quality of moringa leaves compared to those dried immediately after harvesting. Storing fresh crops for long periods often involves handling techniques that can stress the tissue. Stress can be caused by extreme temperatures, drying, microbial invasion, gaseous atmosphere, light, and mechanical handling (Shewfelta et al., 2014). Harvesting leads to the loss of water and sugar as storage time increases while essential processes such as respiration and transpiration continue (Zerbini, 2008; Robert et al., 2020). After harvest, water loss from fresh fruits and vegetables is primarily driven by transpiration and respiration. Transpiration is recognized as the most significant process contributing to this water loss (Xanthopoulos et al., 2017). The quality of post-harvest is greatly influenced by harvesting and handling practices (Lawrence and Melgar, 2018). Drying at 50°C for 16 hours retains most nutrients

and phytochemicals in moringa leaves, except for vitamin C. A mild heating and drying process can be achieved using ordinary household facilities, such as stoves, providing a simple and effective way for long-term preservation (Yang et al., 2006).

The interaction between the time of harvest and the delayed drying process was significantly shown in dry weight, ash and crude protein content.

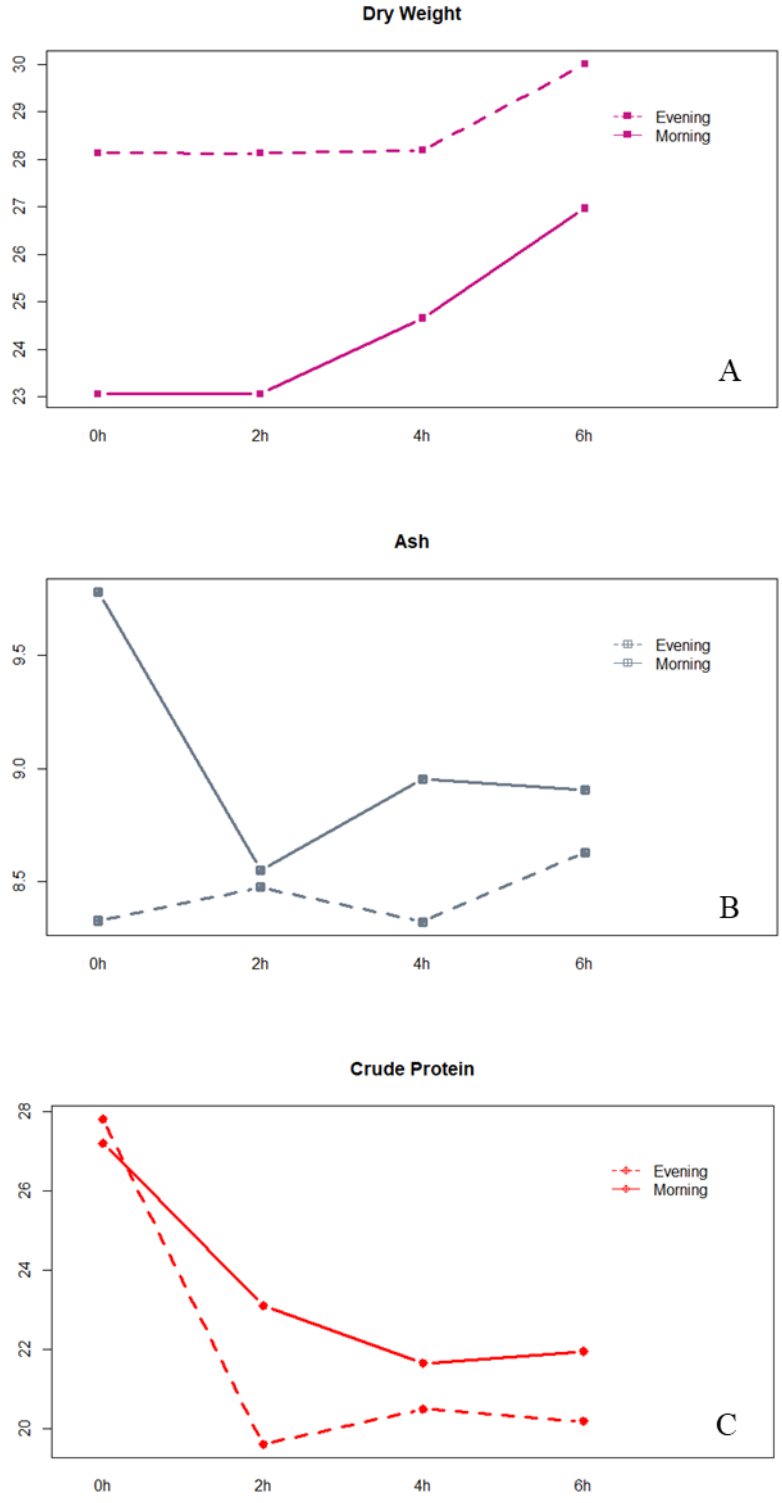

Figure 1 (a, b, c) – Visualization of the interaction between harvest time and delay drying time after harvest

Visualizing interactions (Fig. 1 a, b, c) between harvest time (morning and evening) with delays in drying time after harvest generally shows a decrease in the quality of moringa leaves harvested in the afternoon with late drying. A significant decrease was shown in ash and crude protein content by longer delays in the drying process. Dry weight of Moringa showed an increase in evening harvest with late drying. Harvest time is determined by the maturity level of the plant and weather conditions (Kiaya, 2014). An important characteristic of perishable post-harvest products is the continued metabolic function of the harvested part. Its metabolism differs from that of a parent plant that grows in its original environment. Harvesting and handling products interfere with or remove some essential ingredients used to grow, such as water supply and mineral nutrients from the soil, carbon, and energy from photosynthesis. This causes post-harvest products to experience varying levels of stress. Therefore, it is usually considered potentially injurious to any plant system (El-Ramady et al., 2015). Respiration generates heat, causing an increase in temperature within the product. This increase can lead to regressive processes such as water loss, wilting, and the growth of microorganisms. The respiration rate is used as an indicator to determine the shelf life of fresh produce, as higher respiration rates accelerate the product's deterioration (Ryal and Lipton, 1972).

CONCLUSION

The quality of moringa leaves is higher when harvested in the morning. To maintain the quality of the leaves, it is crucial to begin drying immediately after harvesting. If there is a delay in drying the leaves after an afternoon harvest, their quality is likely to decline.

Post-harvest handling primarily focuses on food products to prevent deterioration in quality. Unfortunately, post-harvest handling for fodder crops is often overlooked. Therefore, further research should be conducted on various feed crops to assess the impact of post-harvest handling on their quality.

REFERENCES

1. Bridgemohan P, Goordeen A, Mohammed M and Bridgemohan R S H. 2020. Review of the agroecology, phytochemistry, postharvest technology, and utilization of moringa (Moringa oleifera Lam.) Journal of Horticulture and Postharvest Research 3(2), 311-332
2. Clark J R and Finn C E. 2014. Blackberry cultivation in the world. Rev. Bras. Frutic. 36(1): 46–57.
3. El-Ramady H R, Domokos-Szabolcsy E, Abdalla N A, Taha H S, and Fári M. 2015. Postharvest Management of Fruits and Vegetables Storage. Springer International Publishing Switzerland. In: E. Lichtfouse (ed.), 2015. Sustainable Agriculture Reviews. 15, p 65-150
4. Farm Africa. 2019. Trainer`s guide for Production, Harvest, Post-Harvest Handling, and Value Addition for Moringa in Tanzania. Retrieved from https://www.farmafrica.org/downloads/2020/advancing-youth-trainers-guide-for-moringa-value-chain-in-tanzaniav2.pdf. Accessed September 25, 2022.
5. Florkowski W J, Shewfelt R L, Brueckner B, Prussia S E. 2014. Postharvest Handling A Systems Approach. Third Ed. Academic Press. Elsevier Inc.
6. Goordeen A. 2018. Postharvest quality attributes of fresh-cut moringa pods. Final Year Project, Department of Food Production, Faculty of Food and Agriculture, University of the West Indies.
7. Grolleaud, M. 2002. Post-harvest Losses: Discovering the Full Story. Overview of the Phenomena of Losses during the Post-harvest System. Retrieved from http//www.foa.org/docrep/004/ac 301e/AC301e.htm.
8. Inamoto, K., K. Nagasuga, T. Yano., & H. Yamazak. 2016. The effect of day and night temperature on the dry matter accumulation of oriental hybrid Lily “Siberia” as the relate to the photosynthetic and respiratory characteristic. JARQ 50 (2), 143-152. http://www.jircas.affrc.go.jp.

9. Kiaya, V. 20014. Post-harvest losses and strategies to reduce them. Technical paper. Action Contre la Faim (ACF). France.
10. Koyama, K. and S. Takemoto. 2014. Morning reduction of photosynthetic capacity before midday depression. Scientific Reports 4:4389. DOI: 10.1038/srep04389. https://www.nature.com/articles/srep04389.pdf
11. Krah,C. Y., Sutrisno, D. Krisnadi, Samsudin. 2022. Effect of harvest and postharvest handling on quality of Moringa leaf powder. IOP Conf. Series: Earth and Environmental Science. doi:10.1088/1755-1315/1038/1/012074
12. Lawrence B., J. C. Melgar. 2018. Harvest, handling, and storage recommendations for improving postharvest quality of blackberry cultivars. Hort. Technology 28(5), 578-583.
13. Lestari G. W., Solichatun, Sugiyarto. 2008. Growth, chlorophyll content, and respiration rate of Garut plants (Maranta arundinacea L.) after administration of gibberelligelic acid (GA3). The growth, chlorophyll content and respiration rate of arrowroot (Maranta arundinacea L.) after Giberelic Acid (GA3) treatment. Biotechnology 5 (1): 1-9.
14. Mohammed, M., & Bridgemohan, P. 2019. Postharvest handling and utilization of exotic plants. In: Mohammed, M. Workshop on Production and Postproduction Recommendations for Tropical Exotic Fruits and Vegetables, Trinidad, 10, 2019.
15. Moore, C. E., K. Meacham-Hensold, P. Lemonnier, R. A. Slattery, C. Benjamin, C. J. Bernacchi, T. Lawson, A. P. Cavanagh, ed. R. Hancock. 2021. The effect of increasing temperature on crop photosynthesis: from enzymes to ecosystems. Journal of Experimental Botany, Vol. 72, No. 8 pp. 2822–2844. doi:10.1093/jxb/erab090
16. Michailides, TJ and GA Manganaris. 2009. Harvesting and handling effects on postharvest decay. Stewart Postharvest Review, 2:3.
17. Prusky, D. 2011. Reduction of the incidence of postharvest quality losses, and future prospects. Food Sec. 3, 463–474 https://doi.org/10.1007/s12571-011-0147-y
18. Ruíz-Hernández, R., M. Hernández-Rodríguez, R. G. Cruz-Monterrosa, M. Díaz-Ramírez, C. G. Martínez-García, A. García-Martínez, and A. A. Rayas-Amor. 2022. Moringa oleifera Lam.: A review of environmental and management factors that influence the nutritional content of leaves. Tropical and Subtropical Agroecosystems 25.
19. Ryall, A. L. and Lipton, W. J. 1972. Handling, Transportation, and Storage of Fruits and Vegetables, Vol. I: Vegetables and Melons. AVI Pub., Westport, Connecticut.
20. Robert L, Alemayehu A, Umezuruike LO. 2020. Water loss of fresh fruit: Influencing preharvest, harvest and postharvest factors. Scientia Horticulturae, 272.
21. Sangeetha V., V. Swaminathan, A. Beanlah, A. Rajkumar, & K. Venkatesan. 2017. Effect of time of harvest, method of harvest, and prepackaging calcium chloride treatments on shelf life and quality of moringa (Moringa oleifera) cv. PKM. International Journal Current Microbiology and Applied Science, 6(4), 212-221.
22. Setyowatik A. T. 2011. Effect of Temperature and Drying Length on Vitamin A and Vitamin C Levels and Antioxidant Activity of Moringa Leaf Flour (Moringa oleifera Lam). Thesis. Food Technology Study Program, Faculty of Industrial Technology, National Development University "Veteran" of East Java.
23. Shewfelta, R. L., S. E. Prussiaa and S. A. Sparks. 2014. Challenges in handling fresh fruits and vegetables. In: Post Harvest Handling: A System Approach. 3rd Eds. Ed. Florkowski W. J., R. L. Shewfelta, B. Brueckner, S. E. Prussia. (2014). Elsevier Inc.
24. Sinclair, T.R. and R.C. Muchow. 1999. Radiation use efficiency. Advances in Agronomy 65: 215-265.
25. Xanthopoulos G T, Charalampos G. Templalexis, Nikolaos P. Aleiferis, Diamanto I. Lentzou. 2017. The contribution of transpiration and respiration in water loss of perishable agricultural products: The case of pears. Biosystems Engineering, 158: 76-85. https://doi.org/10.1016/j.biosystemseng.2017.03.011.
26. Yang, R. Y., L. C. Chang, J. C. Hsu, B. B. C. Weng, M. C. Palada, M. L. Chadha, V. Levasseur. 2006. Nutritional and functional properties of moringa leaves − from germplasm, to plant, to food, to health. Am. Chem. Soc. 1–17.
27. Zerbini, P.E. 2008. Managing maturity and ripening in the fruit production chain for improved flavour. Acta Hort (ISHS).804:63-70.