Journal of Recent Trends in Agriculture and Natural Science
Volume 2, Issue 3, Pages 1-7, 2026 (July-September)
ISSN (online): 3139-1494
DOI: https://doi.org/10.47001/JRTANS/2026.203001
Available Online at https://jrtans.com

Effects of Drying Methods on Nutrient Contents of Moringaoleifera Leaves: A Comprehensive Review

[1]Murugavel M, [2]Kirubakaran V, [3]Nandhakumar D

[1,2,3]PGP College of Agricultural Sciences (PGPCAS), Namakkal, Tamilnadu, India

Abstract: Moringaoleifera Lam., commonly known as the "miracle tree," is a highly nutritious vegetable with immense potential for combating malnutrition, particularly in tropical and subtropical regions. However, its high moisture content renders fresh leaves highly perishable, necessitating preservation through drying. This review synthesizes current scientific evidence on the effects of various drying methods—shade drying, sun drying, solar drying, and oven drying—on the proximate and mineral nutrient contents of Moringaoleifera leaves. Evidence from a comprehensive study conducted at Usmanu Danfodiyo University, Sokoto, demonstrates that shade drying is the most effective method for preserving protein (28.50%), potassium (5800.00 mg/kg), sodium (142.50 mg/kg), magnesium (1.03 mg/kg), and phosphorus (3.30 mg/kg), while solar drying achieved the lowest moisture content (2.67%) and highest ash (12.00%) and carbohydrate (71.67%) retention. Research further confirms that shade drying produces the lowest lipid content (2.33%), enhancing storage stability by reducing rancidity risk. Emerging evidence indicates that sun drying and oven drying are more effective at preserving phenolic compounds and flavonoids, whereas shade drying is superior for retaining antioxidant activity and certain organic acids such as acetic and butyric acids. These findings underscore that no single drying method optimally preserves all nutrients; the choice of method depends on the target compound and intended use. This review recommends shade drying for general nutrient preservation and nutritional supplementation, while recognizing that sun and oven drying may be advantageous for preserving specific bioactive compounds. Future research should focus on optimizing drying protocols to balance nutrient retention with practical feasibility for smallholder farmers and commercial producers.

Keywords: Moringaoleifera, drying methods, nutrient retention, shade drying, proximate composition, mineral content.

1. Introduction

Moringaoleifera Lam., commonly referred to simply as "moringa," belongs to the Kingdom Plantae, Order Brassicales, FamilyMoringaceae, Genus Moringa, and Species Moringaoleifera. Native to the Indian subcontinent, it has become naturalized in tropical and subtropical areas worldwide and is the most widely cultivated species of its genus. The plant is described as a fast-growing, drought-resistant crop that can survive in less fertile soil, making it particularly valuable for cultivation in semi-arid regions. In Nigeria, moringa trees are well naturalized in the northern parts, where the leaves are popularly known as "zogala" and widely consumed by the populace (Pallavi and Dipika, 2010).

Moringa is often called the "miracle tree" due to its exceptional nutritional and medicinal value, with leaves being a rich source of vitamins, minerals, and bioactive compounds. The leaves contain essential nutrients and disease-preventing compounds, making the plant a potential food-based strategy for combatting nutrient deficiencies. However, fresh moringa leaves are highly perishable because of their high-water content, which results in rapid deterioration within approximately 2 to 3 days. Therefore, the food industry faces challenges with preservation, packaging, transportation, distribution, and extending shelf life without compromising nutrient content.

Drying is one of the most commonly used methods for preserving vegetables, particularly in regions where refrigeration is not readily available. Various drying techniques, including sun drying, shade drying, solar drying, oven drying, and air drying, are employed to reduce moisture content and extend shelf life. However, different drying methods affect the nutritional content of vegetable leaves differently, with heat-based methods often leading to degradation of essential bioactive compounds. Understanding the impact of various drying techniques on nutrient retention is crucial for ensuring that consumers receive maximum health benefits

Journal of Recent Trends in Agriculture and Natural Science
Volume 2, Issue 3, Pages 1-7, 2026 (July-September)
ISSN (online): 3139-1494
DOI: https://doi.org/10.47001/JRTANS/2026.203001
Available Online at https://jrtans.com

from dried moringa products.

This review synthesizes current scientific evidence on the effects of drying methods on the nutrient contents of Moringaoleifera leaves, drawing on research from Nigeria and other regions. It examines the proximate composition and mineral content of leaves subjected to different drying techniques and provides recommendations for optimal preservation methods.

2. Drying Methods and Their Effects on Proximate Composition

2.1 Overview of Drying Methods

Several drying methods are commonly employed for preserving moringa leaves, each with distinct characteristics and effects on nutrient retention:

Sun Drying: Leaves are spread on a surface and exposed to direct sunlight, typically for 7 to 72 hours, depending on environmental conditions. This method is cost-effective and widely used in developing countries but exposes leaves to high and often fluctuating temperatures.

Shade Drying: Leaves are arranged on drying frames in a dimly lit, well-ventilated area, avoiding direct exposure to sunlight, typically for 2 to 5 days (120 hours). This method uses lower temperatures and protects leaves from direct UV radiation.

Solar Drying: Leaves are dried in a solar dryer, which captures and concentrates solar energy to accelerate moisture removal, achieving the lowest moisture content (2.67%) among traditional methods.

Oven Drying: Leaves are placed in an oven at controlled temperatures (30°C to 60°C) for 6 to 24 hours. This method allows precise temperature control but may cause degradation of heat-sensitive nutrients.

Air Drying: Leaves are dried at room temperature with good air circulation, resulting in better nutrient retention compared to oven and sun drying methods.

Novel Drying Technologies: Emerging methods such as radio frequency (RF) drying and freeze drying offer superior nutrient retention but may be less accessible in developing regions.

Figure 1: Farming field of Moringa tree

Journal of Recent Trends in Agriculture and Natural Science
Volume 2, Issue 3, Pages 1-7, 2026 (July-September)
ISSN (online): 3139-1494
DOI: https://doi.org/10.47001/JRTANS/2026.203001
Available Online at https://jrtans.com

2.2 Effects on Moisture Content

Moisture content is a critical parameter affecting shelf life and microbial stability of dried moringa leaves. Research demonstrates that solar drying achieves the lowest moisture content (2.67%), followed by oven drying (5.67%), sun drying (8.50%), and shade drying (13.67%). The low moisture content achieved by solar drying makes it most effective for long-term preservation, as moisture provides an enabling environment for microorganism growth and autolytic enzyme activity.

Figure 1: Moringa Leaf Powder Making Process

In a study conducted in the Arba Minch region of Ethiopia, straw mulching with full irrigation reduced watermelon water consumption, demonstrating that drying efficiency can be influenced by pre-harvest conditions. However, for moringa leaves, the choice of drying method primarily determines final moisture content and subsequent preservation quality.

Figure 2: Dried Moringa Leaf Powder

Journal of Recent Trends in Agriculture and Natural Science
Volume 2, Issue 3, Pages 1-7, 2026 (July-September)
ISSN (online): 3139-1494
DOI: https://doi.org/10.47001/JRTANS/2026.203001
Available Online at https://jrtans.com

2.3 Effects on Crude Protein Content

Protein content is one of the most important nutritional attributes of moringa leaves, making them valuable for combating protein-energy malnutrition. Research consistently demonstrates that shade drying is superior for protein retention. A comparative study on four drying methods found that shade drying produced the highest crude protein content (28.50%), significantly higher than sun drying (14.30%), oven drying (6.80%), and solar drying (3.20%).

Similarly, a study from the University of Limpopo found that air drying resulted in significantly high crude protein content (32.71%), compared to oven drying (31.3%) and sun drying (21.01%). The lower protein values for solar and oven drying suggest that macro-nutrient values decrease when dried under heat, consistent with the assertion that heat reduces nutrient values of vegetables. The decrease in protein upon heat drying may be attributed to denaturation and the instability of protein bonds.

2.4 Effects on Lipid (Fat) Content

Lipid content in moringa leaves is relatively low, consistent with their classification as "heart-friendly food" (Pallavi and Dipika, 2010). Research shows that shade drying produces the lowest lipid content (2.33%), while solar drying (6.00%) and sun drying (6.50%) yield significantly higher values. The lower lipid content in shade-dried samples enhances storage life by reducing the chance of developing rancid flavor.

The higher lipid contents in solar and sun-dried treatments cannot be considered advantageous, as moringa leaves are not a significant source of fat-soluble vitamins in most diets. The low lipid content in green leafy vegetables is consistent with their reputation as heart-healthy foods.

2.5 Effects on Fiber and Carbohydrate Content

Crude fiber content varies significantly with drying method. Oven drying produces the highest fiber content (10.50%), followed by solar drying (7.17%), while shade drying (3.00%) and sun drying (3.00%) produce the lowest values. The higher fiber content in solar and oven dried treatments may be due to dehydration and concentration of dry matter. Fiber has a useful role in providing roughage that aids digestion (Lisa, 1997).

Carbohydrate content is highest in solar drying (71.67%), followed by oven drying (68.37%), sun drying (67.03%), and lowest in shade drying (56.50%). The higher carbohydrate content in solar-dried leaves makes them a good source of energy for humans and animals.

2.6 Effects on Ash Content

Ash content indicates the total mineral content of the leaves. Solar drying produces the highest ash content (12.00%), followed by oven drying (9.50%), shade drying (9.33%), and sun drying (9.17%). The higher ash composition in solar-dried leaves may indicate higher mineral elemental composition. Air drying has also been shown to retain high ash content (12.30%), comparable to solar drying.

3. Mineral Retention Under Different Drying Methods

3.1 Potassium

Potassium is an essential macromineral that plays a crucial role in maintaining fluid balance, nerve transmission, and muscle contraction. Research demonstrates that shade drying is most effective for preserving potassium. A comparative study found potassium content of 5800.00 mg/kg in shade-dried leaves, significantly higher than oven dried (3800.00 mg/kg), solar dried (3500.00 mg/kg), and sun dried (3000.00 mg/kg) treatments.

Air drying also demonstrated superior potassium retention (1.87%) compared to oven drying (1.59%) and sun drying (1.55%).

Journal of Recent Trends in Agriculture and Natural Science
Volume 2, Issue 3, Pages 1-7, 2026 (July-September)
ISSN (online): 3139-1494
DOI: https://doi.org/10.47001/JRTANS/2026.203001
Available Online at https://jrtans.com

The higher potassium retention in shade and air-dried leaves suggests that heat exposure during sun, solar, and oven drying may cause potassium loss.

3.2 Calcium and Phosphorus

Calcium and phosphorus are essential minerals for bone health, blood clotting, and nervous function. Solar drying achieves the highest calcium content (1.83 mg/kg), followed by oven drying (1.10 mg/kg), sun drying (0.97 mg/kg), and shade drying (0.77 mg/kg). This pattern suggests that calcium is better preserved under higher-temperature drying methods, possibly due to reduced leaching.

For phosphorus, shade drying produces the highest content (3.30 mg/kg), followed by solar drying (3.20 mg/kg), sun drying (3.13 mg/kg), and oven drying (3.10 mg/kg). The higher calcium and phosphorus in dried leaves compared to fresh samples indicates that drying generally improves mineral content through concentration.

3.3 Magnesium and Sodium

Magnesium is essential for energy production, muscle and nerve function, and bone health. Shade drying (1.03 mg/kg) and sun drying (1.03 mg/kg) are equally effective for preserving magnesium, while oven drying (0.73 mg/kg) and solar drying (0.40 mg/kg) yield significantly lower levels.

For sodium, shade drying produces the highest content (142.50 mg/kg), while solar drying (120.00 mg/kg), oven drying (125.00 mg/kg), and sun drying (125.83 mg/kg) are statistically similar and lower than shade-dried samples. The higher sodium retention in shade-dried leaves indicates that lower-temperature drying minimizes sodium loss.

3.4 Bioactive Compound Retention

Emerging research has also examined the effects of drying methods on bioactive compounds, including phenolic compounds, flavonoids, and organic acids. A recent study on moringa aqueous extract revealed that oven drying and shade drying significantly maintained higher levels of total phenolic compounds compared to sun drying, with oven drying showing the highest retention. For total flavonoids, shade drying showed the highest values, followed by oven drying, both significantly higher than sun drying.

For specific organic acids, shade drying was most effective for preserving acetic acid (2.11%) and butyric acid (0.85%), while sun drying was most effective for preserving salicin (39.4%) and glycine (5.84%). Sun drying also showed the highest antioxidant activity, suggesting that direct sunlight may play a positive role in maintaining or increasing antioxidant compounds.

These findings demonstrate that the optimal drying method depends on the specific bioactive compound of interest, highlighting the importance of selecting appropriate drying techniques based on the target application.

4. Factors Influencing Nutrient Retention During Drying

4.1 Temperature Effects

Temperature is the most critical factor affecting nutrient retention during drying. The intensity of heat applied due to the efficiency of dryers is commensurate with the decrease in protein content. Heat drying causes degradation of proteins through denaturation, while it can lead to the loss of vitamins such as Vitamin E. For example, sun drying (7.512 ± 0.350 mg/kg) and oven drying (7.550 ± 1.547 mg/kg) resulted in a decrease in Vitamin E content compared to room drying. Higher temperatures generally accelerate drying and reduce moisture content, but at the cost of nutrient loss. Oven drying at 60°C achieved rapid drying but resulted in significant protein loss, while oven drying at 30°C achieved better nutrient retention while still providing controlled drying conditions. The optimal temperature balancing moisture removal and nutrient retention is typically 30-45°C for moringa leaves.

Journal of Recent Trends in Agriculture and Natural Science
Volume 2, Issue 3, Pages 1-7, 2026 (July-September)
ISSN (online): 3139-1494
DOI: https://doi.org/10.47001/JRTANS/2026.203001
Available Online at https://jrtans.com

4.2 Duration of Drying

The duration of drying also influences nutrient retention. Shade drying takes longer (up to 120 hours) but preserves nutrients better due to lower temperatures. Sun drying and oven drying at 60°C achieve complete moisture loss within 24 hours but may cause greater nutrient degradation. The trade-off between drying time and nutrient retention is a key consideration when selecting drying methods.

4.3 Environmental Factors

Environmental factors, including humidity, light exposure, and air circulation, influence drying efficiency and nutrient retention. Sun drying exposes leaves to direct UV radiation, which can degrade heat-sensitive and light-sensitive compounds. Shade drying protects leaves from UV radiation but takes longer, potentially allowing enzymatic degradation to occur. Solar drying provides controlled conditions that accelerate moisture removal while protecting leaves from direct UV exposure.

4.4 Genetic and Pre-Harvest Factors

Nutrient composition of moringa leaves also varies with genotype, maturity stage, and growing conditions. Significant genotypic variation has been observed in nutritional composition, with PKM 1, PKM 2, PM 1, and Jodhpur Local identified as promising candidates for nutritional enhancement. The leaf stalk color (white, green, red) slightly affects characteristics, with typical high protein, dietary fiber, and ash content. These factors interact with drying methods to determine final nutrient content.

5. Conclusion

This review has examined the effects of drying methods on the nutrient contents of Moringaoleifera leaves, synthesizing evidence from studies conducted in Nigeria and other regions. The findings demonstrate that drying generally improves the nutrient contents of moringa leaves by concentrating nutrients and reducing moisture that promotes microbial growth. However, different drying methods produce significantly different nutrient profiles. Shade drying is most effective for preserving protein (28.50%), potassium (5800.00 mg/kg), sodium (142.50 mg/kg), magnesium (1.03 mg/kg), and phosphorus (3.30 mg/kg), while also producing the lowest lipid content (2.33%), which enhances storage stability. Solar drying achieves the lowest moisture content (2.67%) and highest ash (12.00%) and carbohydrate (71.67%) contents, making it most effective for long-term preservation. Oven drying produces the highest fiber content (10.50%), while sun drying offers an intermediate profile. Emerging evidence indicates that sun and oven drying are more effective at preserving phenolic compounds and flavonoids, whereas shade drying is superior for retaining antioxidant activity and organic acids such as acetic and butyric acids. The choice of drying method should therefore be guided by the intended use of the dried leaves, with shade drying recommended for nutritional supplementation where protein and mineral preservation is paramount, and sun or oven drying preferred for preserving specific bioactive compounds. Future research should focus on optimizing drying protocols to balance nutrient retention with practical feasibility, particularly for smallholder farmers in developing countries, and exploring emerging technologies such as radio frequency and freeze drying for commercial applications.

REFERENCES

[1] Mahamane, M., Amadou, I., & Aboubacar, M. R. M. (2025). Effect of Drying Methods on Nutritional and Antioxidant Properties of Organic Moringaoleifera Leaves From the Sahel. Journal of Food Processing and Preservation, 2025, 1994240.

[2] Sokombela, A., & Eiasu, B. K. (2024). Drying alters the proximate nutrient composition of Moringaoleifera leaves. ActaHorticulturae, 1407, 121-128.

[3] Attri, V., & Kumar, V. (2025). Nutritional Characterization of Leaf Powder of Introduced Moringaoleifera Lam. Genotypes in the Lower Shiwalik Hills of the Western Himalays, India.Indian Journal of Agroforestry, 27(3).

[4] Ogunyemi, O. A., et al. (2025). Effect of drying conditions on the preservation of selected bioactive compounds in Moringaoleifera aqueous extract: acetic acid, butyric acid, γ-aminobutyric acid, salicin, and glycine. BMC Plant Biology, 25, 1432.

[5] Raphela, M. N., & Bopape-Mabapa, M. P. (2024). Influence of drying methods on the nutritional composition of moringa

Volume 2, Issue 3, Pages 1-7, 2026 (July-September)
ISSN (online): 3139-1494
DOI: https://doi.org/10.47001/JRTANS/2026.203001
Available Online at https://jrtans.com

(Moringaoleifera) leaves. M.Sc. Thesis, University of Limpopo.
[6] Adebayo, F. O., & Abdus-Salaam, R. B. (2022). Comparative assessment of dried Moringa leaves of Nigerian ecotype. African Journal of Food, Agriculture, Nutrition and Development, 22(6), 20721-20736.
[7] Effects of Drying Methods on Nutrient Contents of Moringaoleifera (Lam.) Leaves. (2019). Usmanu Danfodiyo University Sokoto.
[8] Sokombela, A., & Eiasu, B. K. (2024). Drying alters the proximate nutrient composition of Moringaoleifera leaves. Acta Horticulturae, 1407, 121-128.
[9] Impact of different drying techniques on Moringaoleifera leaves as a sustainable tea alternative. (2025). Discover Chemistry, 2, 6.
[10] Fidyasaria, A., Estiasih, T., Wulan, S. N., & Khatib, A. (2024). The physicochemical, functional, and pasting properties of Moringaoleifera leaf powder from different leaf stalk colors. CyTA - Journal of Food, 22(1), 2402062.
[11] Förster, N., et al. (2019). Effects of harvest techniques and drying methods on the stability of glucosinolates in Moringaoleifera leaves during post-harvest. Scientia Horticulturae, 246, 998-1004.

Citation of this Article:

Murugavel M, Kirubakaran V, & Nandhakumar D. (2026). Effects of Drying Methods on Nutrient Contents of Moringaoleifera Leaves: A Comprehensive Review. *Journal of Recent Trends in Agriculture and Natural Sciences.* 2(3), 1-7. Article DOI: https://doi.org/10.47001/JRTANS/2026.203001

***** End of the Article *****