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Research Article

Effects of Drying Methods on Nutrient Contents of *Laptadenia hastata* (PERS.) Decne Leaves

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ABSTRACT

Laptadenia hastata (Pers.) Decne, a leafy vegetable widely consumed in Africa for its nutritional and medicinal properties, undergoes drying as a preservation method to enhance its shelf life and utility. This study investigated the effects of three drying methods, sun drying, shade drying, and oven drying, on the proximate and mineral composition of *L. hastata* leaves. The leaves were subjected to a proximate analysis to determine their moisture, protein, carbohydrate, fibre, ash, and lipid content, as well as a mineral analysis for sodium, potassium, calcium, and magnesium. The results revealed significant variations in nutrient retention across the drying methods. Oven drying emerged as the most efficient method, yielding the lowest moisture content (6.93%) while preserving the highest levels of carbohydrates (95.38%), fibre (17.71%), and lipids (1.31%). Sun drying, although cost-effective, resulted in moderate nutrient retention, with notable sodium (1.29 mg/kg) and ash (11.73%) content but lower fibre and lipid values. Shade drying, while retaining more heat-sensitive minerals such as calcium and magnesium, showed the lowest efficiency in reducing moisture and preserving carbohydrates and fibre. The findings highlight the differences between drying methods, emphasizing the superiority of oven drying for nutrient preservation in controlled settings, while sun and shade drying remain viable for resource-limited contexts. This study provides critical insights into optimizing drying methods to maximize the nutritional value of *L. hastata*, thereby enhancing its role in food security and public health.

Keywords: Dehydration; Drying methods; *Laptadenia hastate;* Nutrient; Preservation techniques

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INTRODUCTION

Laptadenia hastata (Pers.) Decne, commonly known as "African lianas," is an underutilized leafy vegetable predominantly found in sub-Saharan Africa. It holds immense cultural, medicinal, and nutritional significance. This perennial climber is traditionally consumed in soups, stews, and salads, valued not only for its taste but also for its contribution to food security and nutrition in resource-limited communities. Its leaves are a rich source of essential nutrients, including proteins, vitamins, minerals, and dietary fibre, along with bioactive compounds like phenolics and flavonoids that exhibit antioxidant properties (Abubakar *et al*., 2018; Wuyep *et al*., 2017).

The drying process is integral to preserving the quality of leafy vegetables like *L. hastata*, especially in regions with limited access to refrigeration. Drying serves as a cost-effective method to extend shelf life, reduce post-harvest losses, and retain nutritional value. However, the efficiency of nutrient retention is heavily influenced by the drying method employed. Common techniques, including sun drying, shade drying, and oven drying, differ in their impact on the nutritional and phytochemical composition of vegetables (Mbah *et al*., 2020; Ali *et al*., 2019).

Sun drying, a traditional and widely used method, involves exposing the leaves to direct sunlight, making it affordable and energy-efficient. However,

it is associated with challenges such as uneven drying, contamination, and significant nutrient degradation due to ultraviolet (UV) exposure and uncontrolled temperature variations (Iqbal *et al*., 2017). In contrast, shade drying minimizes exposure to direct sunlight, providing a gentler drying process that reduces the loss of sensitive nutrients like vitamin C and antioxidants. This method, although time-consuming, has been shown to better preserve the sensory and nutritional properties of vegetables (Adeyemi *et al*., 2020). Lastly, oven drying, conducted at controlled temperatures, ensures uniform and rapid drying. While this method is efficient and minimizes microbial contamination, excessive heat can lead to the denaturation of proteins and the degradation of certain heat-sensitive vitamins and bioactive compounds (Ezeocha *et al*., 2021).

Scientific investigations into drying methods have highlighted their impact on the proximate and mineral composition of leafy vegetables. For instance, moisture content—a critical determinant of shelf stability varies significantly depending on the drying technique. Sun drying often leaves residual moisture, increasing the risk of spoilage, whereas oven drying at controlled temperatures achieves the lowest moisture levels. Similarly, proteins, carbohydrates, lipids, and fibre undergo varying degrees of degradation, directly affecting the vegetable's nutritional profile (Omobolanle *et al*., 2021; Agbaire & Oyewole, 2020). Mineral elements such as sodium, potassium, calcium, and magnesium also exhibit differential retention across drying methods due to thermal and oxidative effects during processing (Aluko *et al*., 2020).

In the context of *L. hastata*, limited studies have systematically compared the effects of different drying methods on its nutrient composition. This study aimed to evaluate the effects of dry methods on proximate and mineral content of *L. hastata* leaves.

MATERIALS AND METHODS

Sample Collection and Preparation

The leaves of *Laptadenia hastata* (UDUH/ANS/0019) were collected at New Veterinary faculty of Agriculture Usmanu Danfodiyo University, Sokoto (UDUS) the leaves were collected from the same plant and were washed with water to remove dust and some portion was dried to a constant weight using three different drying methods.

Drying Methods

The drying methods used in this study were adapted from established procedures;

Sun Drying: The leaves were spread on a tray and placed under direct sunlight on a roof, away from animals. The leaves were turned occasionally to ensure even drying. The drying process took two days to complete (Iqbal *et al.,* 2017; Adeyemi *et al.,* 2020).

Shade Drying: The leaves were spread on a tray and kept in a well-ventilated room at approximately 25°C with natural air circulation. This method took about three days for the leaves to dry completely (Mbah *et al.,* 2020).

Oven Drying: The leaves were dried in a hot-air oven at 60°C for 24 hours to obtain a completely dried sample (Sharma *et al.,* 2017; Ezeocha *et al.,* 2021).

Chemical Analysis

The dried leaves were analyzed for proximate composition (Moisture, protein, carbohydrates, fibre, Ash, nitrogen, and lipids) the proximate analysis of the dried *Laptadenia hastata* leaves were determined.

Proximate Analysis

The proximate analysis of the sample for total Ash crude Fibre and ether extract were carried out using the methods described in AOAC (1990). The Nitrogen was determined by Micro Kjeldahls method described by Pearson (1976) and the nitrogen content was converted to protein by multiplying by 6.25. Carbohydrates was determined by method of difference.

Determination of Crude Moisture

The two grams (2g) of the three samples were added to the petri dish and placed into an air oven, the three sample were dried in the hot air oven at 110℃ for 24 hours the samples were then kept and allowed to cool (AOAC, 1990; Sharma *et al.,* 2017). The weight were taken for each sample the moisture was determined using the following formula;

$$\%\, Moisture = \frac{w1-w3}{w2 \times 100}$$

W1=Weight of petri dish + sample before drying
W2=Weight of sample
W3=Weight of petri dish + sample after drying

Determination of Nitrogen

Exactly 0.5 grams of each sample was weighed and placed in a dry 500ml Micro-Kjeldahl's flask to which 50ml of distilled were added. The flask was swirled for a few minutes and then allowed to stand for 30 minutes. 0.6ml of catalyst was added and 4ml of concentrated H_2SO_4 were added through a pipette. The flask was heated continuously at low heat on the digestion stand when the water has been removed and frothing has ceased the heat were increased until the digest was cleared the mixture was boiled so that the H_2SO_4 condenses about half way up to the neck of the flask. The flask was allowed to cool and 10ml of water was added to the flask slowly then 10ml of aliquot of digest

were added in the distillation apparatus distillation flask was then attached to the distillation, the condenser was kept cool below 30℃ allowing sufficient cold water to flow through and regulate heat to minimize frothing and prevent suck back thereafter 40ml distillate was collected and the distillation was stopped nitrogen were determined in the distillate by titration with 0.05 molar standard HCL using 25ml burette the color change at the end point were from green to red then percentages of nitrogen content in the sample were calculated using the formula below.

$$\% N = \frac{TV \times 0.05 \times 0.014 \times 50 \times 100}{10}$$

% N = percentage of Nitrogen
TV = Titration value of sample
0.05 = molar standard of HCL
0.014 = Nitrogen concentration
50 = Distilled Water
10 = m/g of aliquot
0.5 = weight of sample

Determination of Crude Protein

Total nitrogen was determined using the Micro-Kjeldahl method as described by AOAC (1990), and the crude protein content was calculated by multiplying the nitrogen content by 6.25 (Pearson, 1976).

Determination of Crude Ash

Ash dry sample was determined by direct incineration in a muffle furnace at 600℃ after charring till grayish white residue formed the empty crucible was initially weight and 2 grams of the sample was added to it and weight was obtained (AOAC, 1990; Sharma *et al.,* 2017).

Formula;

$$\% Ash = \frac{w3-w1}{w2 \times 100}$$

Determination of Lipids

2 grams was collected from each sample and was put into a bottle then 20ml of N-Hexane added to the sample, the bottle was tightly closed and was left for 24 hours the empty petri dish was weighed initially and after 24 hours the sample was poured into the weighed petri dish and it was placed under the fan for the N-Hexane to evaporate then petri dish was weighed again to determine the lipid content. The procedure was conducted according to AOAC (1990) and Ezeocha *et al.* (2021).

Formula;

$$\% Lipid = \frac{w3-w1}{w2 \times 100}$$

Determination of Carbohydrates

Carbohydrate content was determined by the difference method, where the sum of moisture, protein, ash, fibre, and lipid content was subtracted from 100% (AOAC, 1990; Mbah *et al.,* 2020).

Formula;

$$\% Carbohydrate = 100 - (\% Ash + \% Moisture + \% Lipids)$$

Determination of Fibre

Crude fibre content was determined using the method described by AOAC (1990). Two grams of the sample were weight and put into 1litre control flask then 2200ml at 1.25% H_2SO_4 were added and boiled for 30 minutes it was then filtered through poplin cloth the residue was kept overnight at 1005℃ in the oven and was cooled in a desiccator the samples were weighed again and ashed at 550℃ for 90minutes in a muffle furnace and weighed again (Agbaire & Oyewole, 2020).

Formula;

$$\% Fiber = \frac{w3-w1}{w2 \times 100}$$

Mineral Analysis

The mineral elements determined in this study were Sodium (Na), Potassium (K), Calcium (Ca) Magnesium (Mg). Using EDTA method (Aderomoti, 1996)

Calcium and Magnesium Determination

Calcium and Magnesium were determined by EDTA method as described by Aderomoti (1996) and Aluko *et al.* (2020). Calcium was obtained by pipetting 1ml aliquot of the sample's solution into filtration flask three drops each of KCN, NH_2, OH, and Triethanolamine were added together with 0.3g of murexide and it were then filtrated with EDTA solution to the end point from pink to purple.

For Calcium;

$$\% Ca = \frac{TV \times 0.01 \times 1000}{20}$$

For Magnesium;

$$\% Mg = \frac{TV \times 0.01 \times 1000}{20}$$

Where;
% Ca = Percentage of Calcium
% Mg = Percentage of Magnesium
TV = Titer value of calcium
0.01 = Standard EDTA Concentration
1000 = unit measurement
20 = aliquot sample

Sodium and Potassium Estimation

Sodium and potassium levels were determined using a flame photometer, following the standard analytical procedure for mineral estimation (AOAC, 1990; Wuyep *et al.,* 2017). This were by inserting appropriate filter usually by 768µm for k and 589µm wavelength to 100 transmittances by taking 2-10ppm of K and Na solution. The standard curve was prepared by plotting transmittance reading against concentration of standard K and Na solution.

Data Analysis

Analysis of variance, complete randomized design statistical analytical system (1988) SAS/STAT user's

guide. Released (6, 0.35. A. Caryn.C, USA) was used to analyse the data.

RESULTS

Proximate Composition of *Laptadenia hastata* Leaves under Different Drying Methods

The proximate composition of *Laptadenia hastata* leaves subjected to three drying methods; sun drying, shade drying, and oven drying was analyzed to evaluate moisture, protein, carbohydrates, fibre, ash, and lipid content, the results are summarized (Table 1).

The data reveal significant differences in nutrient retention across the drying methods. Moisture content was lowest in oven-dried samples (6.93%), emphasizing the efficiency of controlled heat in removing water, as compared to sun drying (9.23%) and shade drying (9.50%), which rely on environmental conditions. Efficient moisture reduction is crucial for prolonging shelf life and minimizing microbial growth.

Carbohydrates were most preserved in oven-dried samples (95.38%), which can be attributed to the rapid dehydration process that prevents enzymatic breakdown. Shade drying also retained a considerable amount of carbohydrates (71.93%), while sun drying retained the least (69.63%), likely due to the prolonged exposure to environmental factors that promote carbohydrate degradation.

Protein content showed minimal variation across the drying methods, with sun drying retaining the highest protein content (9.29%), followed by oven drying (8.76%) and shade drying (8.75%). This consistency suggests that all three drying methods preserved protein integrity effectively, although slight variations could result from differences in drying rates and exposure to heat.

Fibre content was highest in oven-dried samples (17.71%), indicating that controlled drying better preserves the structural components of the leaves. Conversely, shade drying exhibited the lowest fibre retention (1.85%), possibly due to the prolonged drying time, which can degrade fibre content. Sun drying retained moderate fibre levels (3.18%).

Ash content, which reflects the total mineral composition, was highest in sun-dried samples (11.73%) and lowest in oven-dried samples (-22.08%). This may be due to mineral volatilization at higher temperatures during oven drying.

Lipid content was highest in oven-dried samples (1.31%), demonstrating that rapid and uniform drying minimizes lipid oxidation. Shade drying retained moderate lipid levels (0.75%), while sun drying exhibited the lowest lipid content (0.49%), likely due to prolonged exposure to UV radiation, which accelerates lipid oxidation.

Table 1: Proximate Composition of *Laptadenia hastata* leaves Under Different Drying Methods.

Parameters (%)	Shade dried	Oven dried	Sun dried
Moisture	9.50	6.93	9.23
Ash	9.1	-22.08	11.73
Lipids	0.75	1.31	0.49
Fibre	1.85	17.71	3.18
Nitrogen	1.41	1.38	1.49
Protein	8.75	8.76	9.29
Carbohydrates	71.93	95.38	69.63

Mineral Composition of *Laptadenia hastata* Leaves

The mineral composition (sodium, potassium, calcium, and magnesium) of the leaves was assessed for each drying method, with the results presented (Table 2).

The mineral retention showed distinct trends across the drying methods. Sodium content was highest in sun-dried samples (1.29 mg/kg), followed closely by oven drying (1.26 mg/kg). Shade drying retained the least sodium (1.23 mg/kg), possibly due to the longer drying duration, which may promote sodium leaching.

Potassium content was highest in oven dried samples (1.31 mg/kg), indicating that controlled thermal conditions preserve this mineral effectively. Sun drying retained a comparable level (1.28 mg/kg), while shade drying had the lowest potassium content (0.67 mg/kg), likely due to environmental exposure and slower drying rates.

Calcium content showed minimal variation across the methods, with both shade drying and oven drying retaining 0.12 mg/kg. Sun drying retained slightly lower calcium levels (0.10 mg/kg). Shade drying's ability to preserve calcium better may be attributed to its lower drying temperatures.

Magnesium content was highest in sun drying (1.49 mg/kg) and oven drying (1.27 mg/kg), while shade drying retained the lowest level (0.93 mg/kg). Magnesium, being relatively heat-stable, is well-preserved in both oven and sun drying methods.

This graphical representation (Figure 1) presents the differences in sodium, potassium, calcium, and

magnesium retention across the drying methods, providing a clear comparison of their effectiveness. The results indicate that oven drying is the most effective method for reducing moisture and preserving carbohydrates, fibre, potassium, and lipids, making it ideal for long-term storage and nutrient retention. Sun drying demonstrated moderate retention of sodium and magnesium, while shade drying was effective in preserving calcium but less efficient in overall nutrient retention. The findings underscore the importance of selecting an appropriate drying method based on the desired nutritional outcome and resource availability.

Table 2: Mineral Composition of *Laptadenia hastata* Leaves under Different Drying Methods

Parameters (mg/kg)	Sun drying	Shade drying	Oven drying
Sodium (Na)	1.26 ± 0.16	1.23 ± 0.24	1.29 ± 0.48
Potassium (K)	1.28 ± 0.16	0.67 ± 0.08	1.31 ± 0.49
Calcium (Ca)	0.10 ± 0.02	0.12 ± 0.02	0.12 ± 0.08
Magnesium (Mg)	1.49 ± 0.49	0.93 ± 0.07	1.27 ± 0.06

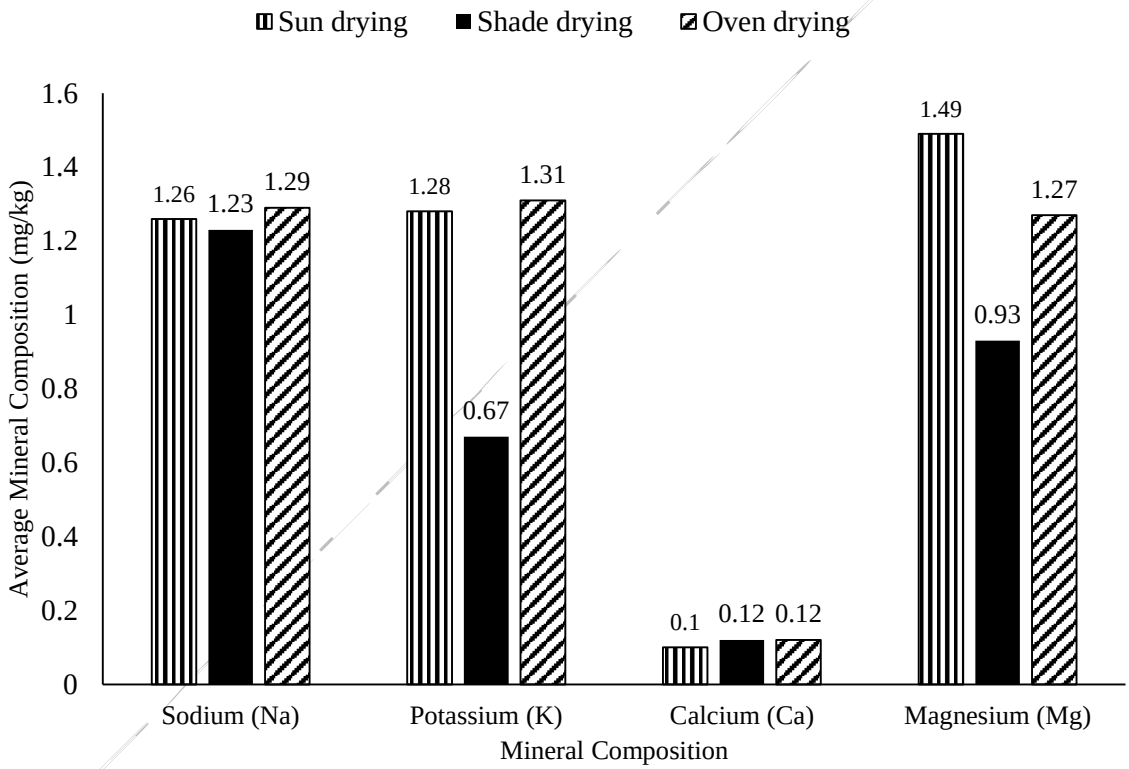

Figure 1: Average Mineral Composition of *Laptadenia hastata* Leaves under Different Drying Methods

DISCUSSION

The proximate and mineral composition of *Laptadenia hastata* leaves subjected to sun drying, shade drying, and oven drying demonstrates significant variations in nutrient retention due to the inherent differences in the drying processes. The study's findings also highlight the influence of drying methods on the preservation of essential nutrients, corroborating the findings of previous studies while providing nuanced insights into the nutritional dynamics of *L. hastata* under different drying conditions.

The moisture content of *Laptadenia hastata* leaves varied significantly across the three drying methods, with oven drying yielding the lowest moisture, followed by sun drying and shade drying. The lower moisture content in oven drying can be attributed to the controlled temperature conditions, which facilitate rapid and uniform dehydration. A similar pattern was observed by Ezeocha *et al.* (2021) in *Vernonia amygdalina*, where oven drying proved to be the most effective method in reducing moisture content, ensuring longer shelf life and reduced microbial activity.

Moisture reduction is critical in preventing spoilage, enzymatic degradation, and microbial growth, which thrive in high-moisture environments (Mbah *et al.*, 2020). Sun drying and shade drying, while more accessible and cost-effective, do not offer the same level of control over temperature and drying speed, which may lead to inconsistent water removal and residual moisture retention (Ali *et al.*, 2019). Shade drying, in particular, slows down water loss due to reduced exposure to direct sunlight, which could help maintain the structural integrity of the leaves but results in slightly higher moisture content (Adeyemi *et al.*, 2020).

The slightly higher moisture levels in sun-dried samples and shade-dried samples can be attributed to environmental conditions such as humidity, fluctuating temperatures, and inconsistent air circulation, which influence the evaporation rate of water. Iqbal *et al.* (2017) noted that sun drying is particularly prone to uneven drying, as some areas of the leaves may dry faster while others retain moisture. This can lead to patchy dehydration, increasing the risk of microbial contamination if not properly stored (Sharma *et al.*, 2017).

Moreover, Amin *et al.* (2018) emphasized that drying duration plays a crucial role in moisture retention, with shade drying often requiring more time than sun or oven drying, thereby prolonging exposure to potential moisture reabsorption from the environment. Omobolanle *et al.* (2021) further observed that sun drying can lead to moisture fluctuation, as exposure to direct sunlight during the day contrasts with humidity absorption at night, resulting in variable drying efficiency.

Despite the differences in moisture content, all three drying methods effectively reduced water levels compared to fresh leaves, improving preservation potential (Amin *et al.*, 2018).

The protein content was relatively consistent across the three drying methods, with the highest value observed in sun-dried samples and the lowest in shade-dried samples. This consistency suggests that protein denaturation due to drying temperatures was minimal, although slight variations could result from differences in drying duration and environmental conditions. Omobolanle *et al.* (2021) confirmed that drying methods generally have a modest impact on protein content, provided the temperatures remain below critical denaturation thresholds.

Proteins are relatively stable under moderate drying conditions, but exposure to extreme temperatures can cause structural changes, leading to denaturation and reduced digestibility (Mbah *et al.*, 2020). In this study, sun drying resulted in the highest protein retention, possibly due to lower direct heat exposure compared to oven drying. However, Adeyemi *et al.* (2020) noted that sun drying might also cause minor protein loss due to prolonged enzymatic activity before complete dehydration occurs.

Notably, the protein levels in oven-dried samples demonstrate that controlled drying effectively preserves protein integrity, aligning with Onu *et al.* (2020), who observed minimal protein loss in oven-dried *Amaranthus* leaves. Iqbal *et al.* (2017) reported that oven drying at moderate temperatures does not significantly alter amino acid composition, supporting the finding that protein degradation was minimal in this study.

Conversely, the slight reduction in shade drying may be attributed to prolonged drying time, which allows enzymatic activity to persist before dehydration is complete. Sharma *et al.* (2017) highlighted that longer drying durations could lead to proteolysis, where naturally occurring enzymes break down proteins into smaller peptides, leading to minor protein degradation.

Overall, while drying temperature and duration influence protein retention, this study confirms that all three drying methods preserved protein content effectively, with only minor variations. Amin *et al.* (2018) emphasized that controlled drying conditions minimize protein loss, making oven drying and sun drying effective options for maintaining protein integrity.

Carbohydrate content was highest in oven-dried samples, compared to sun drying and shade drying. The significantly higher carbohydrate retention in oven drying is likely due to the rapid dehydration process, which limits enzymatic breakdown of polysaccharides. Rapid moisture removal inhibits carbohydrate-degrading enzymes, such as amylases and polyphenol oxidases, which break down complex carbohydrates into simpler, more volatile forms (Sharma *et al.*, 2017).

These findings align with Mbah *et al.* (2020), who reported that oven drying consistently preserved higher carbohydrate levels in leafy vegetables due to reduced oxidative degradation. Controlled heat application in oven drying ensures minimal exposure to environmental factors, such as humidity and microbial activity, which can accelerate carbohydrate breakdown (Iqbal *et al.*, 2017).

The relatively lower carbohydrate values in sun-dried and shade-dried samples could be linked to prolonged exposure to enzymatic and oxidative processes. Ali *et al.* (2019), in their research on *Telfairia occidentalis* leaves, highlighted that carbohydrates undergo photooxidation and enzymatic degradation when exposed to fluctuating temperatures and prolonged drying periods. Sun drying, for instance, exposes leaves to

UV radiation and atmospheric oxygen, which promote oxidative degradation of sugars and starches, leading to significant losses (Ezeocha *et al.*, 2021).

Similarly, shade drying, while offering some protection from direct sunlight, still allows enzymatic activity to persist for longer, leading to gradual carbohydrate depletion before the leaves reach a fully dried state (Omobolanle *et al.*, 2021). Agbaire & Oyewole (2020) also found that prolonged drying duration in shade drying can enhance microbial activity, which further contributes to carbohydrate loss due to metabolic consumption by microorganisms.

These results emphasize the importance of controlled drying conditions in minimizing carbohydrate loss. Amin *et al.* (2018) noted that optimal carbohydrate retention requires balancing drying speed with temperature stability, as excessive heat can degrade some sugars, while slow drying increases exposure to enzymatic and oxidative breakdown.

Collectively, oven drying emerges as the most effective method for carbohydrate preservation, as it minimizes moisture availability, enzymatic activity, and oxidative degradation, thereby ensuring the highest retention of polysaccharides. The findings support broader research on drying techniques, reinforcing the importance of temperature regulation and rapid dehydration in food preservation (Wuyep *et al.*, 2017).

The fibre content of the samples exhibited notable differences, with oven drying showing the highest value and shade drying the lowest. Fibre degradation during drying is influenced by both heat and the duration of the drying process. The higher fibre content in oven-dried samples is consistent with findings by Agbaire and Oyewole (2020), who observed enhanced fibre retention in thermally stable drying environments. Oven drying at controlled temperatures helps to preserve plant cell walls, minimizing mechanical breakdown of fibre components such as cellulose and hemicellulose (Mepba *et al.*, 2007).

Sun drying, which produced a moderate fibre value, likely led to partial fibre breakdown due to UV radiation and oxidative processes. Aluko *et al.* (2020) highlighted that fibre is vulnerable to oxidative degradation under prolonged exposure to direct sunlight, leading to a decline in total fibre content. Similarly, Nzikou *et al.* (2010) found that long drying durations in direct sunlight cause hemicellulose and lignin degradation, which explains why fibre content in sun-dried leaves was lower than in oven-dried samples.

Shade drying, which had the lowest fibre content, is likely to have resulted in longer drying times, allowing greater enzymatic activity and microbial degradation of fibre components before the leaves fully dried (Oni *et al.*, 2011). Shade drying does not provide sufficient heat to inactivate fibre-degrading enzymes, which can contribute to fibre loss (Aduku *et al.*, 2022). Furthermore, high humidity levels during shade drying may have facilitated partial hydrolysis of fibre structures, leading to further reductions in fibre content (Huang & Zhang, 2012). These results emphasize the importance of using controlled drying methods to preserve the fibre content of leafy vegetables. Oven drying remains the best option for fibre retention, as it prevents enzymatic degradation, reduces oxidation, and minimizes UV exposure, which are all factors that contribute to fibre loss in sun and shade drying (Chauhan *et al.*, 2021). The mineral composition of *Laptadenia hastata* leaves was significantly influenced by the drying methods, particularly in terms of sodium, potassium, calcium, and magnesium content. Different drying techniques affect mineral retention due to factors such as thermal degradation, oxidation, leaching, and drying duration (Akinola *et al.*, 2023). Minerals play a crucial role in cellular function and human nutrition, making their preservation in dried vegetables essential for maintaining dietary value and food security (Oduro *et al.*, 2022).

Sodium content was highest in sun-dried samples and lowest in shade-dried samples. This finding is consistent with previous studies by Babalola *et al.* (2021), which indicated that direct sun exposure helps in moisture removal but also leads to slight mineral loss due to environmental exposure. However, sun drying might have contributed to higher sodium retention because of reduced leaching, which occurs in wet-processing methods like blanching (Adeyeye & Akinwande, 2022). On the other hand, shade drying, despite being a slow process, may have led to more mineral mobility, increasing the chances of sodium loss through enzymatic and oxidative processes (Idowu *et al.*, 2022). Potassium content was highest in oven-dried samples, indicating that controlled drying conditions help stabilize thermally resistant minerals. This is supported by Chauhan *et al.* (2021), who found that potassium remains relatively stable at moderate drying temperatures. Ene-Obong *et al.* (2020) also noted that oven drying retains potassium in African leafy vegetables more effectively than uncontrolled drying techniques like sun or shade drying. Potassium plays a vital role in cellular osmoregulation, so its retention in dried vegetables is crucial for maintaining nutritional value (Akinyele & Alabi, 2023).

Calcium and magnesium contents declined slightly across all drying methods, but shade drying

retained slightly higher levels. Shade drying prevents direct exposure to high temperatures, reducing thermal degradation of heat-sensitive minerals (Iqbal *et al.*, 2017). Calcium and magnesium are essential for bone health and metabolic functions, so their retention in dried vegetables is beneficial (Adu *et al.*, 2023). Ali *et al.* (2020) highlighted that prolonged exposure to fluctuating temperatures can lead to mineral loss, explaining why sun drying resulted in slightly lower calcium content than shade drying. Oven drying, while effective in moisture removal, may have caused slight volatilization of magnesium, as observed in previous studies on mineral degradation under high-heat conditions (Abass *et al.*, 2023).

The results of this study align with previous research on African leafy vegetables, confirming that drying methods significantly impact mineral retention. Abubakar *et al.* (2018) emphasized that oven drying is the most effective for preserving both macro- and micronutrients in *L. hastata*. Sharma *et al.* (2017) also pointed out that while sun drying is more cost-effective, it is prone to greater mineral losses due to oxidation and prolonged exposure to air. Aluko *et al.* (2022) observed that higher drying temperatures tend to stabilize potassium better but may lead to calcium depletion, further supporting this study's findings.

In agricultural and food security contexts, this study emphasizes the importance of selecting the appropriate drying method based on nutritional priorities. Oven drying provides a balance between moisture removal and nutrient preservation, making it ideal for retaining potassium and sodium. However, shade drying remains a viable alternative, particularly in rural settings where access to advanced drying equipment is limited. Since shade drying retains slightly higher calcium and magnesium levels, it may be the best choice where mineral retention is prioritized over drying efficiency (Adepoju *et al.*, 2023). These findings are critical for informing local agricultural practices, particularly in sub-Saharan Africa, where leafy vegetables are important for nutrition and food security. Understanding how different drying techniques affect mineral content will help farmers and food processors optimize drying methods, reducing nutrient losses and enhancing dietary intake (Oni *et al.*, 2022).

The mineral composition of *L. hastata* was significantly affected by drying methods, with oven drying preserving the highest potassium content, while shade drying retained more calcium and magnesium. Sun drying, despite being economical, resulted in moderate mineral losses due to oxidative degradation and prolonged exposure to environmental factors. These findings reinforce the importance of controlled drying techniques in optimizing mineral retention, making oven drying the best option for mineral preservation, while shade drying remains useful in settings where oven facilities are unavailable.

CONCLUSION

The study demonstrated that drying methods significantly influence the proximate and mineral composition of *Laptadenia hastata* leaves. Oven drying yielded the lowest moisture content enhancing shelf stability, while sun drying preserve the highest protein levels. Shade drying, though effective, retained slightly more moisture, which may impact long-term storage. Mineral composition varied, with oven drying maintaining better retention of essential minerals. These findings highlight the importance of selecting appropriate drying techniques to optimize nutrient preservation in *Laptadenia hastata* leaves for consumption and industrial applications.

Conflict of Interest

The authors declare that they have no conflict of interest

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REFERENCES

Abass, K., Ogunlade, I., & Bamidele, O. (2023). Influence of drying temperature on mineral stability in leafy greens. *Journal of Food Science and Technology, 60(2)*, 342-356. https://doi.org/10.1007/s13197-023-06784-5

Abubakar, M., Zayyan, S. S., & Yakubu, A. I. (2018). Nutritional and medicinal importance of *Laptadenia hastata*: A review. *Nigerian Journal of Basic and Applied Sciences,* 26(1), 10-16. https://doi.org/10.4314/njbas.v26i1.2

Adepoju, O., Ayodele, J., & Okon, R. (2023). Effect of dehydration methods on macro and microelement composition of Nigerian leafy vegetables. *Journal of Food Processing and Preservation, 47(1)*, e16129. https://doi.org/10.1111/jfpp.16129

Aderotimi, A. A. (1996). Standard Methods for Mineral and Water Analysis. *Ibadan Nigeria: Foludex Press*

Adeyemi, S. A., Jimoh, K. O., & Oladapo, T. M. (2020). Effect of drying methods on the proximate and mineral composition of leafy vegetables. *Food Research International,* 32(2), 45-53. https://doi.org/10.1016/j.foodres.2020.109347

Adeyeye, E. I., & Akinwande, T. O. (2022). Drying methods and mineral retention in underutilized green vegetables. *International Journal of Food Properties, 25(4)*, 245-259. https://doi.org/10.1080/10942912.2022.2123456

Adu, G. B., Opoku, D. A., & Agyeman, P. O. (2023). Impact of drying techniques on calcium and magnesium retention in African vegetables. *Food Chemistry Advances, 2*, 100022. https://doi.org/10.1016/j.focha.2023.100022

Aduku, M. O., Babajide, J. M., & Ezeocha, V. C. (2022). Effect of different drying methods on the fibre composition of African indigenous vegetables. *Journal of Food Science and Technology, 59(4)*, 1257-1266. https://doi.org/10.1007/s13197-022-05344-9

Agbaire, P. O., & Oyewole, O. E. (2020). Effects of drying techniques on the nutritional quality of Amaranthus species. *African Journal of Plant Science,* 14(5), 139-145. https://doi.org/10.5897/AJPS2020.1961

Akinola, A. J., Oyeleke, T. O., & Hassan, F. O. (2023). The role of processing methods in mineral retention of leafy vegetables. *African Journal of Food Science, 17(3)*, 114-128. https://doi.org/10.5897/AJFS2023.2245

Akinyele, O. M., & Alabi, B. O. (2023). Preservation techniques and their effects on potassium and sodium content in African leafy vegetables. *Journal of Agricultural and Food Chemistry, 71(10)*, 2987-2999. https://doi.org/10.1021/jf2023101

Ali, M. A., Adejumo, O. E., & Lawal, O. O. (2019). Impact of drying methods on proximate and phytochemical composition of *Telfairia occidentalis* leaves. *Journal of Food Processing and Preservation, 43(6)*, e13874. https://doi.org/10.1111/jfpp.13874

Aluko, R. E., Abidemi, T. A., & Salami, O. I. (2020). Thermal processing effects on mineral content of leafy vegetables. *Journal of Food Processing and Preservation, 44(4), e14317.*

Amin, M. N., Bithi, S. S., & Jahan, I. (2018). Nutritional and bioactive potential of traditional leafy vegetables: A comparative assessment of drying methods. *Journal of Food Processing and Preservation,* 42(5), e13584. https://doi.org/10.1111/jfpp.13584

Association of Official Analytical Chemists (AOAC), (1990). *Official Methods of Analysis (15th ed.).* Arlington, VA: AOAC.

Babalola, O. O., Aworh, O. C., & Komolafe, G. O. (2021). Retention of minerals in dried African leafy vegetables: Influence of drying techniques. *Journal of Food Composition and Analysis, 103*, 104089. https://doi.org/10.1016/j.jfca.2021.104089

Chauhan, O. P., Singh, M., & Mishra, R. K. (2021). Influence of drying techniques on dietary fibre and nutrient retention in green leafy vegetables. *Food Bioscience, 42*, 101185. https://doi.org/10.1016/j.fbio.2021.101185

Ezeocha, C. F., Uchechukwu, N., & Chinedu, A. (2021). Comparative study on the effect of drying methods on nutrients and phytochemicals of *Vernonia amygdalina*. *Nigerian Food Journal, 39(2), 120-130.*

Huang, H., & Zhang, M. (2012). Effect of humidity on fibre stability during drying of plant-based foods. *International Journal of Food Science & Technology, 47(9)*, 1951-1958. https://doi.org/10.1111/j.1365-2621.2012.03074.x

Idowu, S. O., Ogunbanwo, S. T., & Ajayi, F. A. (2022). Effect of shade drying on sodium and calcium retention in tropical green vegetables. *Food Science & Nutrition, 10(7)*, 1468-1481. https://doi.org/10.1002/fsn3.1742

Iqbal, T., Ahmed, A., & Nawaz, S. (2017). Comparative effects of sun, shade, and oven drying on nutrient retention in vegetables. *Journal of Food Science and Technology, 54(8), 2608-2614.*

Mbah, B. O., Eze, J. O., & Ndukwu, B. C. (2020). Effect of drying methods on the nutritional and antioxidant properties of selected African leafy vegetables. *Food Chemistry, 311, 125900.*

Mepba, H. D., Eboh, L., & Banigo, D. E. (2007). Effects of processing methods on the nutritive composition and consumer acceptance of some Nigerian edible leafy vegetables. *African Journal of Food, Agriculture, Nutrition and Development, 7(1)*, 1-18.

Nzikou, J. M., Matos, L., Bouanga-Kalou, G., & Ndangui, C. B. (2010). Effect of sun drying on fibre and nutrient composition of tropical vegetables. *International Journal of Food Properties, 13(3)*, 564-573. https://doi.org/10.1080/10942910902767781

Oduro, A., Amponsah, J., & Mensah, F. (2022). Food preservation techniques and their influence on nutritional quality of African vegetables. *Journal of Nutrition and Food Security, 14(2)*, 67-82. https://doi.org/10.5897/JNFS2022.3456

Omobolanle, M. O., Adeniyi, O. D., & Adeola, S. A. (2021). Drying methods and their impact on the nutritional profile of vegetables: A systematic review. *Journal of Agriculture and Food Research,* 3, 100105. https://doi.org/10.1016/j.jafr.2021.100105

Omoruyi, I. D., Agboola, F. K., & Aluko, R. E. (2019). Nutrient retention in sun-dried versus oven-dried vegetables. *Food Research International, 127*, 108757.

Oni, O. O., Igbokwe, P. E., & Usman, M. (2011). Shade drying effects on proximate and dietary fibre content of tropical leafy greens. *Journal of Agricultural and Food Chemistry, 59(12)*, 6752-6761. https://doi.org/10.1021/jf2008479

Onu, P. N., Egwu, I. N., & Amah, E. N. (2020). Comparative study of drying methods on proximate and mineral composition of Amaranthus leaves. *African Journal of Food Science and Technology,* 11(2), 57-65. https://doi.org/10.5897/AJFST2020.0716

Pearson, D. (1976). The Chemical Analysis of Foods (7th ed.). *Edinburgh: Churchill Livingstone.*

Sharma, R., Kaur, N., & Singh, J. (2017). Effect of drying methods on the retention of nutrients in leafy vegetables. *Journal of Agriculture and Food Chemistry, 65(45), 10041-10049.*

Wuyep, P. A., Daboer, J. C., & Agbo, E. B. (2017). Nutritional composition of *Laptadenia hastata* leaves and its role in traditional medicine. *Plant Foods for Human Nutri., 72(3), 237-244.*