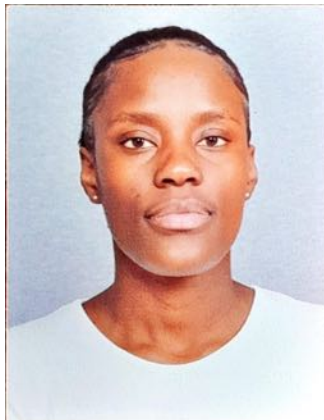


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INFLUENCE OF DRYING METHODS ON THE NUTRITIONAL COMPOSITION OF MORINGA (*Moringa oleifera*) LEAVES

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ABSTRACT

Moringa (Moringa oleifera), a nutrient-rich tree, has great potential for nutrition, health, and prevention. Moringa leaves have the potential to improve macronutrient intake and alleviate malnutrition issues significantly, moreover, when dried and crushed into a powder, contain higher nutrient contents than when the leaves are fresh. The fresh Moringa leaves tend to lose quality over time due to their short shelf life, which is approximately 2 to 3 days. Therefore, this study explored various drying methods to find the best way to preserve Moringa's nutrients and extend its shelf life. Moringa leaf samples were harvested during the summer season from (December 2022 to March 2023) and taken to the University of Limpopo plant production laboratory for drying treatments in a Completely Randomized Design (CRD) experiment: sun (1), shade (2), oven at 30°C (3), and oven at 60°C (4) drying methods to determine the best method for nutrient preservation. The experiment had 5 replications for each treatment to ensure precise and validated results. Standard methods were used to analyse the leaf nutrients, and one-way Analysis of variance (ANOVA) was used to analyse and interpret the data. The findings from the analysis of dry Moringa leaves revealed a significant difference ($p \leq 0.05$) among the drying methods in moisture, fat, ash, magnesium (Mg), phosphorous (P), potassium (K), and calcium (Ca). The contents of iron (Fe) at 94.5 mg, ash at 12.17 %, fat at 8.10% and phosphorous (P) at 0.32 % were found statistically significant from samples dried in the oven at 30°C. The sun-drying method showed a statistically significant potassium (K) content of 1.43% and achieved the lowest moisture level at 5.88%. However, there were no significant differences among the drying methods in protein, zinc (Zn), or sodium (Na) contents. Sun-drying and oven-drying at 60 °C were the fastest techniques, with leaves reaching their final moisture content after 72 and 48 hours, respectively. Overall, the findings indicate that drying methods significantly influence nutrient preservation in Moringa leaves. Oven-drying at 30 °C is recommended for producing high-quality dried leaves with optimal nutrient retention.

Key words: *Moringa oleifera*, minerals, leaf nutritional composition, drying methods

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INTRODUCTION

Moringa (*Moringa oleifera*) is one of the most unusual plants containing minerals with therapeutic properties, which are not found in most of known plants [1]. One of the advantages is that Moringa leaves have ability to end hunger and malnutrition through availability of nutritious dry leaves during off-seasons for consumption as vegetables [1]. The need to meet nutritional requirements through adequate food supplies and proper selection of diet has been a basic determinant of stability and progress [2]. According to Govender *et al.* [3], most South African communities are affected by a lack of balanced diets, manifested as malnutrition, with poverty being the primary cause. This leads to a greater demand for nutritious foods such as Moringa that is affordable and widely available to eradicate this poverty [4]. There are many edible and pleasant plant foods, however, extraordinarily little is consumed as part of the daily diet primarily due to their unavailability throughout the year [2]. Moringa, also known as the miracle tree is the most cultivated species in the Moringaceae family. This tree has the potential to enhance nutrition, improve food security and nurture rural development [5]. It is an edible tree having medicinal and nutritional qualities as well as one of the promising crops which could contribute to an increased intake of micronutrients in rural communities. Moringa is a nutrient-rich food that can enhance human nutrition when added to meals like spinach, porridge, or rice, providing essential minerals, fiber, and proteins. In addition, the leaves are commonly dried before grinding into a powder for enrichment and supplementary purposes, especially in complementary infant feeds [6].

Moringa leaves can be consumed year-round, which can contribute to the enhancement of households with nutritious diets. However, research indicated that harvested Moringa leaves' nutritional and physical quality can be significantly and rapidly degraded before consumption [6]. This is primarily because, at high moisture content, there are high microbial, enzymatic, and physiological activities causing Moringa leaves to be susceptible to rapid deterioration [7]. On the other hand, inappropriate processing methods and conditions can also destroy the nutritional content of the Moringa leaves. Therefore, these highly perishable leaves require proper processing techniques to reduce the risk of contamination and to prevent post-harvest losses thus prolonging their shelf-life [6].

Drying is one of the most frequent processing procedures used to extend shelf life and to prepare Moringa leaves for use as an ingredient in food and beverage [7, 8]. This process involves the use of different temperature regimes which could affect the nutritional value of Moringa leaves and it is essential since the moisture at harvest in Moringa leaves is high [9]. Several studies reported various drying methods for Moringa leaves, including traditional methods used in most rural communities of South Africa, involving sun drying and shade drying [10,11].



Moreover, dry leaves of Moringa have been reported to have a higher shelf-life and more nutritional content than fresh leaves [1, 7, 12]. An appropriate drying method must not affect active nutrients and must reduce the moisture to the achievable level [7]. However, improper preparations may significantly result in a delayed drying period, infection of the leaves which are associated with loss of nutrients and low-quality leaves for market [12]. One of the goals of drying leaves is to reduce the differences in colour and aroma during dehydration [13]. The use of appropriate drying methods on Moringa leaves will encourage farmers to adopt them as the most adequate food processing methods to retain high nutrition, improving nutrient intake and fighting food insecurity.

MATERIALS AND METHODS

Experimental procedure

Moringa leaves were harvested from the University of Limpopo Syferkuil Experimental Farm, from a trial established in 2016. The harvesting took place during the summer season (December 2022 - March 2023), using pairs of shears to cut the leaves from a height of 30 cm to 1 m above the ground at the coolest time of the day to avoid moisture loss and spoilage. Samples were taken to the University of Limpopo Plant Production laboratory, where the treatments were laid out in a Complete Randomized Design: sun (1), shade (2), oven at 30°C (3), and oven at 60°C (4) drying methods, each replicated five times for precision and validation of the results.

Harvested leaves were washed in running tap water to remove unwanted particles on the surface of the leaves. The leaves were removed and placed on a paper towel for the removal of excess water, then divided into a sample of portions of 350 g per spread in a tray for the actual drying process according to the treatments. The moisture content for all samples in each treatment was measured each day until constant weight was reached. The accepted percentage of moisture should be less than 10%. To be certain that the Moringa samples were completely dried, the moisture content was calculated according to the formula below.

$$\%MC = \frac{\text{initial weight of samples (g)} - \text{final weight of samples (g)}}{\text{The intial weight of samples (g)}} * 100 \dots\dots\dots (1)$$

Drying Procedure

Sun drying: The 350 g potion samples were distributed in a tray and enclosed with a netted cloth to keep back dust and pests whilst subjecting it to direct daylight between 10h00 to 15h00 every day until the moisture was completely removed from the leaves, which took 72 hours (3 days). The average daily temperatures within the



period which Moringa leaves took to completely dry in the sun were 18.5°C, 21°C, and 19°C.

Shade drying: The 350 g portion of samples was distributed in trays and dried until the leaves were completely dried in a well-aerated room where the natural flow of air and standard room temperature of 18.5°C, 18.5°C, 21°C, 19.5°C, and 22°C, was prevalent for leaves to completely dry, which took 120 hours (5 days).

Oven drying 30°C: The 350 g portion samples were distributed in trays and exposed to a constant temperature of 30°C. The temperature in the oven was maintained at 30°C until the leaves were completely dried, which took 144 hours (6 days).

Oven drying at 60°C: The 350 g portion samples were distributed in trays and exposed to a constant temperature of 60°C. The temperature in the oven was maintained at 60°C until the leaves were completely dried, which took 48 hours (2 days).

The dried leaves were ground using an electrical grinder with 0.5mm - 1mm pores into a powder for analysis and packaged into zip-lock bags, where they were labelled.

Determination of Proximate Analysis and elemental analysis

Moisture Content

The moisture content of Moringa samples was checked using a halogen moisture analyser. Three grams of each sample were weighed into an aluminium dish and placed in the automatic halogen moisture analyser. The results were recorded as a percentage.

Nitrogen Content

The Automated Dumas dry combustion method using a LECO CNS 2000 instrument, was the technique used to determine the nitrogen content. Moringa samples were combusted in an induction furnace at 950 to 1050°C in the presence of oxygen to form water, carbon dioxide (CO₂), sulphur dioxide (SO₂), various nitrogen oxides (NO₂), and nitrogen gas (N₂). Carbon dioxide (CO₂) and sulphur dioxide (SO₂) were removed, and the oxygen was removed from the NO₂, through combustion where these gases passed through a column containing copper or Cu-coated granules, NO₂ was reduced to N₂ by reacting with hot copper. Total N₂ was measured using a thermal conductivity detector [14,15]. The nitrogen content of the sample was multiplied by the protein conversion factor (6.25) by Jones [16], to calculate the total crude protein content of the sample.

Ash content

Clean crucibles were dried inside a muffle furnace for two hours at 55°C after which the crucibles were placed in the desiccator to cool. Each crucible was weighed and 3 grams of the Moringa samples were dispensed per crucible and placed in a muffle



oven at 550°C overnight, after which the crucible was weighed, and the ash percentage was calculated [17].

$$\text{Ash content} = \frac{\text{Weight of crucible after ashing}}{\text{weight of crucible before ashing}} \times 100 \dots \dots \dots (2)$$

Fat content

Gas Chromatography-Mass Spectrometry (GC-MS) is a separating technique utilized for the identification and characterization of organic compounds used in the medical, cosmetic, detergent, coatings, and agrochemical industries. Moringa powder sample was processed to extract the fat using hexane to isolate the fat from the sample. The extracted fat was converted into fatty acid methyl esters by reacting with methanol and a catalyst sodium and they were transferred to Gas Chromatography column where they were separated based on their volatility and chemical structure [18]. Fatty acids and other fat components were identified and quantified based on their retention time and molecular weight. The individual fat components were introduced into the mass spectrometer where they were ionized and fragmented. The concentration of each fat component was determined by comparing the area under the curve for each peak in the chromatogram to a calibration curve. The total fat was calculated by summing the concentrations of the individual components [18].

Element Concentrations

The Inductively Coupled Plasma-Optical Emission Spectrometry (ICP-OES) was utilized for the determination of plant elements: phosphorus, potassium, calcium, magnesium, sodium, copper, zinc, iron, manganese and aluminium. This technique depends upon the spontaneous emission of photons from atoms and ions that have been excited in a high temperature (>5000°C) plasma of argon gas. Samples were ashed and then extracted or acid digested using HNO₃/HCl; analytes of interest were present in a solution form [19]. The nebulizer converted the liquid samples into fine mist which was transported into plasma using argon gas. When the sample was introduced to the plasma energy, the component elements (atoms) got excited. When the excited atoms returned to a lower energy level, emission rays (spectrum rays) were released and those that corresponded to the photon wavelength were measured [19]. A calibration curve was generated, and samples emission intensities were compared against the curve to determine elemental concentrations.

Statistical Analysis

Data generated from the proximate and element analysis was subjected to a one-way analysis of variance (ANOVA) using GenStat (2020). The differences between the means were compared for significance at a 5% probability level using the Least Significant Difference (LSD) [20].



RESULTS AND DISCUSSION

Effect of drying methods on moisture content and weight of Moringa leaves

The average initial moisture content was 100% at an initial weight of 350 g for Moringa leaves in all drying methods. The drying was continued till the constant weight achieved and the final moisture contents calculated. The moisture contents were reduced to 23.82%, and 23.01%, for sun and room drying methods. Similarly, for oven at 30°C and 60°C methods, the moisture in Moringa leaves reduced to 22.22%, and 23.04%. The moisture removal was found insignificant among all drying methods; however, the constant weights were significantly different with the room drying method being superior to other investigated methods as shown in Figure 4.

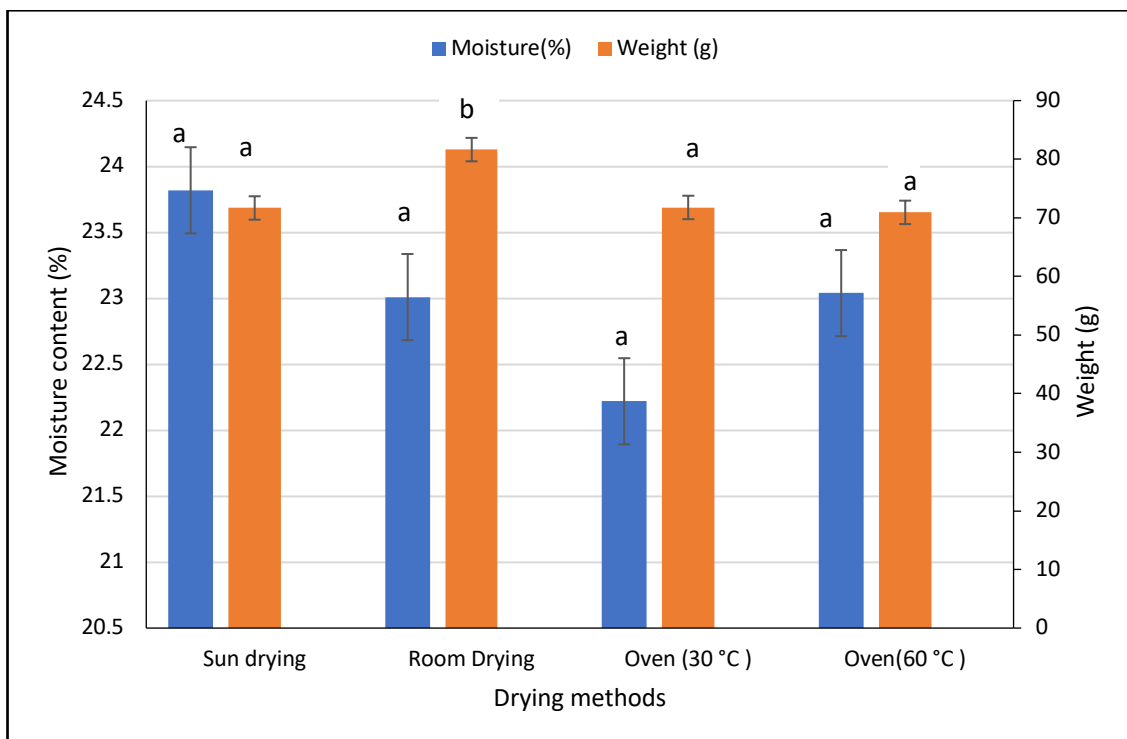


Figure 1: Moringa leaves moisture content and weight as influenced by drying methods

Different letters on columns indicate significantly different ($p \leq 0.05$)

It is recognized that dried Moringa leaves with high moisture content will have a high weight content. In this study, it was revealed that the room drying method had a significantly high weight content when compared to other drying methods, however, the moisture content was not found to be significantly different from other drying methods. The result showed that the moisture content in Moringa leaves after the drying process varied with the oven at 30°C containing the lowest water content of 22.22% and sun drying containing high moisture of 23.82%. This might be attributed to fact that the drying process was not evenly distributed due to the uneven drying temperatures and air circulation, which led to the differences in moisture contents of

Moringa leaves after drying. Aznury *et al.* [1] found opposite results where drying Moringa leaves in the oven at 60°C got the lowest moisture content and, in the oven, at 40°C found the highest moisture content. In this study, the weight differences were found significantly different with Moringa leaves dried in the oven at 30°C obtaining the highest weight and the oven at 60°C obtaining the lowest weight.

Effect of different drying methods on Proximate composition of *Moringa* leaves

The four drying methods had a significant difference on the content of moisture, fat, and ash (Table 4.1) in Moringa leaves. The sun drying method accounted for the lowest moisture content 5.876% and the oven drying method at 60°C had the highest fat content 8.10%. The oven drying method at 30°C accounted for the highest ash content at 12.17%. In contrast, the oven drying method at 60°C accounted for the highest moisture content of 6.696%, while no significant difference was observed on the protein content by different drying methods (Table 1).

Based on the results of the chemical composition of Moringa leaves dried by different drying methods obtained and tabulated in Table 1, the moisture percentage difference among the drying methods is highly significant, with the moisture content from the sun-dried Moringa powder being the lowest compared to other drying techniques. These results revealed that the sun-dried powder weight is lighter, if used as raw material in food processing, it will be needed in large quantities per mixture of the dough [9]. The moisture content of the four dehydrated Moringa leaf samples ranged from 5.88% to 6.70%, which closely aligns with findings by Afolabi *et al.* [23], who reported an average moisture content of 7.33%. Furthermore, Peñalver *et al.* [21] reported that the established mean contents of water are between 5 and 10%. However, the results contradict the findings of Satwase *et al.* [8], and Dwei and Fahilatunnur [24], who found that shadow drying of Moringa leaves had the highest moisture content of 6.2% and 6.77%, respectively compared with sun drying and oven drying at 60°C.

The protein content of the different dried Moringa was found insignificant in all drying methods, this implies that protein remained stable despite the different drying conditions. However, the highest content was found from Moringa leaves dried in the oven at 30°C at 27.57%. These results agree with those reported by Dewi and Fadhilatunnur [24] and Sani [25], who found that the protein content of dried Moringa leaves was 24.2% and 22.90%, respectively. Moreover, Afolabi *et al.* [23] reported that the normal protein values are between 19.15% and 28.8%, this proves that Moringa leaves dried in the oven at 30°C in this study have the potential to supply enough protein for human consumption.



Concerning the fat content in the Moringa leaves, the content ranged from 5.95% to 8.10%, with the samples dried in the oven at 30°C containing the highest fat content while those dried in the oven at 60°C had the lowest fat content. A report by Mbah *et al.* [2] found that the Moringa leaves dried in the oven had the lowest fat of 2.11%. In general, vegetables have a low-fat content, so from various reports the fat content in Moringa is found to be very low (between 5% - 6%), which can vary between plants of the same family or species, due to external conditions or internal conditions which influence the development of physiological processes in the leaves such as drying conditions [2, 9].

Ash content was found statistically superior in the leaves dried in the oven at 30°C (12.17%) and lowest at sun dried samples (9.47%). This makes the oven drying method at 30°C exceptionally good sources of minerals, which are important for the maintenance of normal health. These findings are consistent with the study of Dewi and Fadhilatunnur [24], where it was found that moringa leaves dried in the oven at 60°C (7.83%) had less ash content when compared to lower temperatures. The ash content obtained in this study indicated that Moringa leaves are a good source of inorganic minerals.

Effect of drying methods on the macro-nutrient elements of Moringa leaves

A comparative analysis in Figure 4 shows a significant variation between the contents in macronutrients ($p \leq 0.05$), except for Sodium (Na) which was found to be insignificant among drying methods. The analysis indicated that Moringa contains a wide spectrum of useful macro-elemental nutrients. Calcium content in the leaves was found statistically ($P \leq 0.05$) superior in an amount from the oven at 30°C. On the other hand, Magnesium was found to be statistically superior ($p \leq 0.05$) in the samples dried in the room (0.67%), while Potassium was found to be statistically superior ($p \leq 0.05$) in sun drying method (1.47%) and oven 30°C (1.43 %), and Phosphorous (P) was found to be statistically superior in the samples dried in the oven at 30°C (0.32%).



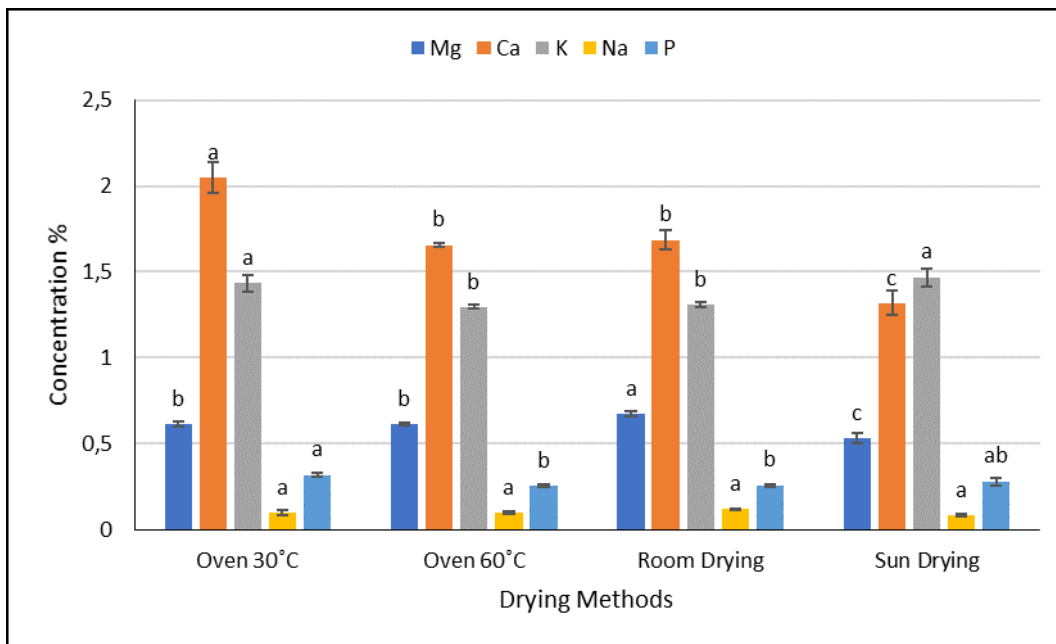


Figure 4: Macronutrient element concentrations (%) in Moringa leaves as influenced by drying methods

Different letters on columns indicate significantly different ($p \leq 0.05$)
Mn = Manganese, Zn = Zinc, Cu = Copper, and Fe = Iron

Effect of drying methods on the micro-nutrient elements of Moringa leaves

The analysis of micronutrient composition in Moringa leaves showed remarkable concentrations of micro-nutrient elements (Figure 5). The results showed high concentrations of Manganese at 35.3mg in samples dried in the oven at 30°C to be statistically superior ($p \leq 0.05$). The analysis also showed a significant variation between the contents of zinc which was found to be statistically superior ($p \leq 0.05$) in the samples dried in the sun at 16.04mg, on the other hand, Iron was found to be statistically superior ($p \leq 0.05$) in the samples dried in the oven at 30°C (94.5mg).

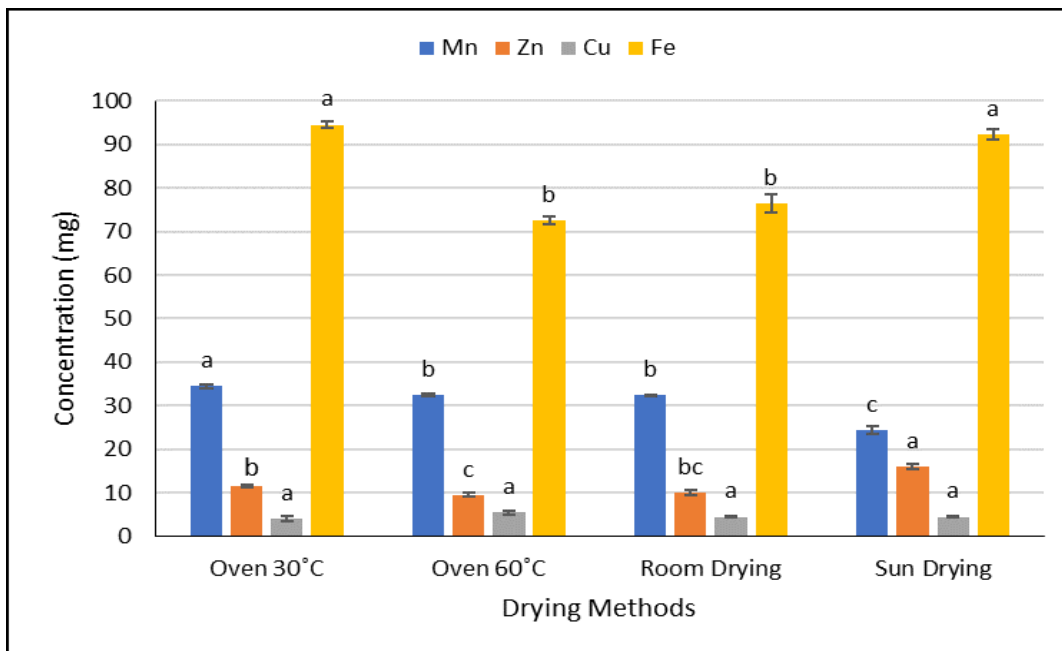


Figure 5: Micronutrient element Concentrations (mg) in Moringa leaves as influenced by drying methods

Different letters on columns indicate significantly different ($p \leq 0.05$)

Mn = Manganese, Zn = Zinc, Cu = Copper, and Fe = Iron

Figures 4 and 5 show the effect of drying methods on the Macro and Micro-nutrient minerals content of Moringa leaves. The mineral content of Moringa powder dried in the room and oven at 30°C shows the most stable number compared to the sun oven at 60°C methods. This might have been attributed to the high temperatures prevailing 60°C and direct heat from the sun which made minerals become destructed. A study by Babiker *et al.* [26] reported that sun drying and oven drying decreases the mineral content of magnesium (Mg), zinc (Zn), manganese (Mn), and iron (Fe) in edible botanicals because they are destructed by high temperatures. This agrees with the results obtained in this study. The content of minerals such as Zinc (Zn), and Iron (Fe) reduced significantly at oven 60°C, while Manganese (Mn) reduced significantly in the sun drying method.

Magnesium (Mg) which is one of the six essential macro-minerals in the body was greatly detected at 0.674% from the room drying method and least at 0.532% from the sun drying method in this study. These results are compatible with Afolabi *et al.* [23], who reported that mineral elements decrease when dried under heat. Magnesium in room-dried treatment was found to be statistically superior ($p \leq 0.05$) to all other drying methods. These results agree with the study of Weyh *et al.* [27], which found that magnesium content was higher in shade drying and lower in the direct sun drying method. Calcium (Ca) was detected greatly in the samples dried in the oven at 30°C (2.05%), which was the most abundant ($p \leq 0.05$) in preserving

calcium in the Moringa leaves. However, Weyh *et al.* [27] found opposite results where calcium content was higher in the direct sun drying method and lower in shade drying. This suggests that drying Moringa leaves at 30°C in the oven could efficiently meet human needs for calcium.

The highest concentration of 0.32% of phosphorus(P) was detected in Moringa dried in the oven at 30°C. This shows clearly that Moringa would provide the recommended daily intake of the nutrient per day; however, other sources of the nutrient must be consumed alongside it. Moringa leaves dried in the sun retained a significant amount of potassium (1.47%), outperforming other drying methods. This amount is sufficient to contribute to the recommended daily intake of potassium for humans.

Iron (Fe) was highly detected at 94.5mg/kg from the leaves dried in the oven at 30°C in this study. The study of Wehy *et al.* [27] revealed that iron was highly detected in shade drying methods when compared to other high-temperature drying methods. Reports showed that Moringa leaves have lower iron contents when exposed to higher temperatures, indicating that iron is a heat-sensitive element [27]. Hence, in this study, it was detected lower from the oven 60°C drying method. The dietary iron intake is linked to energy intake [28, 29].

The study found that Moringa leaves dried in the sun retained more zinc (16.04 mg) compared to other drying methods, making sun drying a superior method for preserving zinc content. These results are consistent with Mbah *et al.* [2] and Yahaswini [12], whose studies revealed that the sun drying method was found to be more effective in preserving Zinc content in Moringa than other methods. The findings show that Moringa dried in the sun has the potential to meet the recommended level of zinc intake. Because it has a significant amount of zinc, it may therefore help counteract fatigue, cancer and other health issues linked to zinc deficiencies [5].

CONCLUSION AND RECOMMENDATIONS FOR DEVELOPMENT

The results indicated the presence of a wide array of nutritionally important and health-promoting micro and macronutrients in the leaves of Moringa which varied when exposed to different drying methods. It showed each drying method contained significant amounts of protein, fat, carbohydrate, crude fibre and ash. In addition, it contains several minerals including calcium, sodium, potassium, phosphorus, iron, magnesium and zinc in significant amounts per drying method. The oven drying method at 30°C showed a highly significant amount of nutrients that are superior and abundant to other drying methods for most nutrients, followed by shade drying. The method has been shown to assist in the concentration of nutrients and facilitate



conservation and consumption, as such, it can be used to preserve nutrients and Moringa leaves when food is scarce.

It is recommended that Moringa leaves be dried in the oven at 30°C for maximum preservation of nutrients due to good and safe moisture content achieved after drying, which is fit for long-term preservation and highest cumulative nutrient retention. Additionally, it is suggested that Moringa should be consumed in powder form as it is easily stored and protected from moisture retention in storage.

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Conflict of interest

The authors affirm they have no financial, personal, or professional relationship that could have influenced the research, its results, or its interpretation.



Table1: The proximate composition of dried Moringa leaves subjected to different drying methods

Treatments	Parameters (%)			
	Protein	Ash	Moisture	Fat
Sun drying	27.17 ^a ± 0.35	9.47 ^b ± 0.47	5.876 ^c ± 0.11	8.666 ^{a±} 0.41
Room drying	27.23 ^a ± 0.23	10.30 ^b ± 0.03	6.186 ^b ± 0.06	7.318 ^b ± 0.24
Oven drying (30°C)	27.57 ^a ± 0.40	12.17 ^a ± 0.39	6.028 ^{ab} ± 0.11	5.950 ^c ± 0.18
Oven drying (60°C)	27.37 ^a ± 0.68	10.01 ^b ± 0.29	6.696 ^a ± 0.05	8.098 ^a ± 0.02
<i>p value</i>	0.934	<.001	<.001	<.001
CV%	3.9	7.2	3.2	7.5

Means in the same row in each classification bearing different letters differ significantly ($p \leq 0.05$)

REFERENCES

1. **Aznury M, Zikri A, Rachmadona N and MF Saputra** Analysing Effect of Temperature on Drying Moringa (*Moringa oleifera*) Leaves Using Photovoltaic Tray Dryer. *Journal of Hunan University Natural Sciences*, 2021; **48**.
2. **Mbah BO, Eme PE and AE Paul** Effect of drying techniques on the proximate and other nutrient composition of *Moringa oleifera* leaves from two areas in Eastern Nigeria. *Pakistan Journal of Nutrition*, 2012; **11**: 1044.
3. **Govender L, Pillay K, Siwela M, Modi A and T Mabhaudhi** Food and nutrition insecurity in selected rural communities of KwaZulu-Natal, South Africa - Linking human nutrition and agriculture. *International Journal of Environmental Research and Public Health*, 2017; **14**: 17.
4. **Chakona G and CM Shackleton** Household food insecurity along an agro-ecological gradient influences children's nutritional status in South Africa. *Frontiers in nutrition*, 2018; **4**: 72.
5. **Moyo B, Masika PJ, Hugo A and V Muchenje** Nutritional characterization of Moringa (*Moringa oleifera* Lam.) leaves. *African Journal of Biotechnology*, 2011; **10**: 12925-12933.
6. **Hasizah A, Djalal M, Mochtar AA and S Salengke** Fluidized bed drying characteristics of moringa leaves and the effects of drying on macronutrients. *Food Science and Technology*, 2022; **42**.
7. **Babu AK, Kumaresanb G, Raja VA and R Velrajb** Review of leaf drying: Mechanism and influencing parameters, drying methods, nutrient preservation, and mathematical models. *Renewable and Sustainable Energy Reviews*, 2018; **90**: 536-556.
8. **Satwase AN, Pandhre GR, Sirsat PG and YR Wade** Studies on Drying Characteristics and Nutritional Composition of Drumstick Leaves by Using Sun, Shadow, Cabinet and Oven Drying Methods, 2013; **2**: 2-4, 2: 584.
9. **Olabode ZAINAB, Akanbi CT, Olunlade B and AA Adeola** Effects of drying temperature on the nutrients of Moringa (*Moringa oleifera*) leaves and sensory attributes of dried leaves infusion. *Direct Research Journal of Agriculture and Food Science*, 2015; **3**: 177-122.



10. **Calín-Sánchez Á, Lipan L, Cano-Lamadrid M, Kharaghani A, Masztalerz K, Carbonell-Barrachina ÁA and A Figiel** Comparison of traditional and novel drying techniques and their effect on the quality of fruits, vegetables, and aromatic herbs. *Foods*, 2020; **9**: 1261.
11. **Alakali JS, Kucha CT and IA Rabi** Effect of drying temperature on the nutritional quality of *Moringa oleifera* leaves. *African Journal of Food Science*, 2015; **9**: 395-399.
12. **Yashaswini JP, Venkatachalapathy N, Sharma K, Jaganmohan R and A Pare** Effect of microwave vacuum drying on the nutritional composition of moringa (*Moringa oleifera*) leaves. *International Journal of Chemical Studies*, 2021; **9**: 2790-2795.
13. **Thamkaew G, Sjöholm I and FG Galindo** A review of drying methods for improving the quality of dried herbs. *Critical Reviews in Food Science and Nutrition*, 2021; **61**: 1763-1786.
14. **Manson AD and VG Roberts** Analytical methods used by the soil fertility and analytical services section. *Republic of South Africa, Pietermaritzburg* 2000.
15. **Manson AD and VG Roberts** Analytical Methods Used by the Soil Fertility and Analytical Services Section. KZN Agri-Report No. N/A/2001/04. KwaZulu-Natal Department of Agriculture and Environmental Affairs, Pietermaritzburg, South Africa, 2000.
16. **Jones DB** Factors for converting percentage of Nitrogen to percentages of Protein. *Journal of Nutrition*, 1931; **4**: 311-314.
17. **AOAC**. Association of Official Agricultural Chemists. Association of Official Analytical Chemistry, Official Methods of Analysis, 16th ed., Washington DC, USA, 2000.
18. **Stegmans M, Iliens S and H Hoebregs** Enzymatic, spectrophotometric determination of glucose, fructose, sucrose, and inulin/oligofructose in foods. *Journal of AOAC International*, 2004; **87**: 1200-1207.
19. **Silva PAD, Souza G, DE C, Paim APS and AF Lavorante** Spectrophotometric determination of reducing sugar in wines employing in-line dialysis and a multi-commuted flow analysis approach. *Journal of the Chilean Chemical Society*, 2018; **63**: 3994-4000.



20. **Ellison SL, Barwick VJ and TJD Farrant** Practical statistics for the analytical scientist: a bench guide. Royal Society of Chemistry, 2009.
21. **Peñalver R, Martínez-Zamora L, Lorenzo JM, Ros G and G Nieto** Nutritional and antioxidant properties of *Moringa oleifera* leaves in functional foods. *Foods*, 2022; **11**: 1107.
22. **Mansour SY, El-Moity A, Seham F, El-Shourbagy GA and HA Siliha** Effect of Drying Methods on Chemical Composition of Moringa Leaves Powder. *Zagazig Journal of Agricultural Research*, 2016; **43**: 2099-2114.
23. **Afolabi IS, Akpokene ON, Fashola DV and TC Famakin** Comparative evaluation of the nutritional benefits of some underutilized plant leaves. *Journal of Natural Product and Plant Resources*, 2012; **2**: 261-266.
24. **Dewi RTK and H Fadhilatunnur** Evaluation of Antibacterial Activity, Nutrients, and Total Bacterial Count of Moringa Leaf Powder with Various Drying Methods. *Carpathian Journal of Food Science and Technology*, 2020. **12**.
25. **Sani Yabo Z** Effects of drying methods on nutrient contents of *Moringa oleifera* (Lam.) leaves. 2015. <http://hdl.handle.net/123456789/735> Accessed August 2024.
26. **Babiker EE, Juhaimi FA, Ghafoor K and KA Abdoun** Effect of drying methods on the nutritional quality of young shoots and leaves of two Moringa species as non-conventional fodders. *Agroforestry Systems*, 2018; **92**: 717-729.
27. **Weyh C, Krüger K, Peeling P and L Castell** The role of minerals in the optimal functioning of the immune system. *Nutrients*, 2022; **14**: 64.
28. **Emenike AF and BI Eunice** Comparative analysis of the nutritional composition of three different drying methods of *Moringa oleifera* leaves. *International Journal of Applied Agricultural Research*, 2011; **6**: 131-138.
29. **Olayemi FF, Awagu FE and IE Bamishaiye** Comparative Analysis of the Nutritional Composition of Three Different Drying Methods of Moringa Leaves. *International Journal of Applied Agricultural Research*, 2011; **6**: 131-138.

