THE INTERNATIONAL JOURNAL OF SCIENCE & TECHNOLEDGE

Proximate Composition and Antioxidant Potential of *Moringa oleifera* Leaves as Influenced by Different Methods of Preservation

Oshinie Sandunika Dalugoda
Graduate Student, Department of Microbiology, University of Kelaniya, Sri Lanka
Dr. Ranjani Amarakoon
Senior Lecturer, Department of Microbiology University of Kelaniya, Sri Lanka

Abstract:
Moringa oleifera leaves are recognized as nutritionally and medicinally important for life. Maintaining the freshness of leaves is a challenge due to their very low shelf life. The aim of this study is to examine the effect of the nutritional quality of Moringa oleifera leaves by cost-effective preservation methods.
Samples of raw, sundried, oven-dried, and brine-preserved Moringa oleifera leaves were investigated for % proximate compositions based on AOAC methods. The antioxidant potential was analyzed via DPPH assay.
The moisture content was significantly ($p<0.05$) reduced from 40.37±0.08% (fresh) to 27.48±0.20% for Moringa oleifera in brine. Ash content was significantly ($p<0.05$) reduced from 9.12±0.03% (fresh) to 8.63±0.15% (sun-dried), 8.17±0.08% (oven dried), 7.60±0.08% (in brine). Crude protein content of Moringa oleifera in brine (in bottles) significantly ($p<0.05$) increased to 26.53±0.06% from 26.50±0.05% (fresh), 24.17±0.13% (sundried), 23.34±0.24% (oven dried). Crude fat content was significantly ($p<0.05$) reduced from 6.33±0.10% (fresh) to 5.26±0.09% (sun-dried), 4.30±0.15% (oven dried), 3.55 ±0.12% (in brine). Crude fiber content was significantly ($p<0.05$) reduced from 9.63±0.09% (fresh) to 8.47±0.08% (sun-dried), 8.17±0.03% (oven dried), 6.83±0.14% (in brine). Total carbohydrate content was significantly ($p<0.05$) increased from 8.20±0.29% (fresh) to 45.90±0.32% (sun-dried), 52.60±0.36% (oven dried), 26.01±0.17% (in brine).
The highest antioxidant potential was recorded in Moringa oleifera leaves in brine. (IC50 value is 54.6).
Therefore, Moringa oleifera leaves in brine are a product that enhances the quality of nutrients while increasing its shelf life. Sun-dried and oven-dried Moringa oleifera leaf powder is also a cost-effective way of preservation.

Keywords: *Moringa oleifera leaves, preservation in brine, proximate composition analysis, antioxidant potential*

1. Introduction

Moringa oleifera is a deciduous tree that is indigenous to North India, Pakistan, and Nepal (Martín Ortega & Segura Campos, 2018). It is spaciously grown in tropical and sub-tropical areas. In Sri Lanka, it can be especially seen in dry zones because it is highly resistant to droughts. There are 13 species of *Moringa,* and they vary from herbaceous plants to giant trees. In *Moringa oleifera* fresh leaves, flowers, fruits, and young pods are edible, and they are very delicious diets (I.F, Offor, et al., 2014a). The leaves of the tree are light green in color, compound, tripinnate, and 30-60 cm long. The terminal leaflets are obovate and are larger than the lateral leaflets. Lateral leaflets are elliptic in shape (Otu et al., 2020).

Moringa oleifera shows an optimum growth rate at a temperature around 25℃ 30℃and a net rainfall of 250 mm – 3000 mm. It needs sandy or loamy soil with a slightly acidic to a slightly basic pH for its healthy growth (Price, 2002).

Moringa oleifera is known as 'Drumstick tree' or 'Horseradish tree.' It is also known as 'miracle tree' or 'tree of life' due to its amazing importance for human begins and animals. *Moringa oleifera* leaves have a great pharmacological activity, including analgesic, anti-inflammatory, antiasthmatic, antiulcer, antispasmodic, antihyperglycemia, antioxidant, anticancer, and larvicidal activities (Singh & Prasad, 2013). *Moringa oleifera* leaves can be used as a chemotherapeutic agent against several cancers, such as lung cancers, colon cancers, pancreas cancers, etc. Leaves have also been used in Ayurveda medicine to treat malaria, fever, arthritis, high blood pressure, diabetes, headache, and HIV/AIDS (Martín Ortega & Segura Campos, 2018). *Moringa oleifera* leaves are capable of enhancing the immune reactions in the human body because they can significantly increase the white blood cells and minor changes in red blood cells and hemoglobin levels (Abd El-Gawad et al., 2020).

Moringa oleifera leaves contain a large number of bioactive compounds such as polyphenols, phenolic acids, vitamins, carotenoids, flavonoids, glucosinolates, alkaloids, tannins, oxalates, saponins, phytates and antioxidants (Martín Ortega & Segura Campos, 2018). The leaves of *Moringa oleifera* have an immense effect on people who are suffering from nutrient deficiency, and they can be used as a calcium and protein supplement for them (William et al., 2014). *Moringa oleifera* leaves are also an important asset for vegetarians because since they are unable to get proteins from meat, these

leaves can be used instead of meat. *Moringa oleifera* leaves contain many active metabolites with a significant biological effect. Some of them are myricetin, quercetin, kaempferol, rutin, caffeic acid, and ellagic acid (Tacer-Caba, 2019).

Moringa oleifera leaves contain precursors for hormones such as stigmasterol and sistosterol, which stimulate estrogen production and then influence the mammary gland ducts to produce milk (Martín Ortega & Segura Campos, 2018). Therefore, these leaves can be used to stimulate the lactation of feeding mothers. *Moringa oleifera* leaves also assist in maintaining bone health, the health of the nervous system, weight in the correct BMI range, etc. (DAAM, 2020). *Moringa oleifera* leaves are used to prevent atherosclerosis, alleviate oxidative DNA damage, and provide cardiac protection (Saini et al., 2015).

Moringa oleifera leaves have extraordinary qualities such as seven times more vitamin C than oranges, ten times more vitamin than carrots, seventeen times more calcium than milk, nine times more protein than yogurt, fifteen times more potassium than bananas, twenty-five times more iron than spinach (Lakshmipriya Gopalakrishnan et al., 2016). Traditional people use *Moringa oleifera* leaves while cooking high-heat foods such as prawns and crabs to reduce the heat contained in those foods.

Moringa oleifera leaves have excellent antibacterial and fungicidal activities. Today many resistant bacterial strains have evolved against antibiotics. However, the extracts of *Moringa oleifera* leaves can be used to fight against resistant bacterial strains and parasitic worms due to their low toxicity and low cost. Therefore, they can be used as alternatives or adjuvants for antibiotics. Methanolic and ethyl acetate extracts of *Moringa oleifera* leaves express great fungicidal activity. It can degrade the chitin in the cell walls of fungi. Since *Moringa oleifera* leaves have remarkable fungicidal activity, it is used to cure skin diseases, including skin lesions (DAAM, 2020). *Moringa oleifera* leaves can be used as a cosmetic agent to get glowing hair and skin.

Moringa oleifera leaves also can be used for consumption as other leafy vegetables such as Spinach, *Centella aisatica*, etc. In these decades, people have been highly interested in using *Moringa oleifera* leaves as a soup for breakfast, and it is a famous diet as a salad in some countries. Since *Moringa oleifera* leaves have the ability to reduce the oxidation process, it is used to enhance the shelf life of meat (Olusanya et al., 2020).

Today many experiments have been undertaken using *Moringa oleifera* leaves. As a result, scientists have been able to produce various products such as *Moringa* powder, *Moringa* tablets, *Moringa* capsules, *Moringa* face wash, *Moringa* soap, *Moringa* tea, and *Moringa* beverages (Gunalan, 2019).

Though many studies have been carried out in other countries, such as China and Indonesia, related to the preservation of *Moringa oleifera* leaves, there is a lack of studies on the preservation of *Moringa oleifera* leaves by using different methods in Sri Lanka. Therefore, the major objective of this study is to increase the shelf life of *Moringa oleifera* leaves by maintaining their nutritional quality.

2. Methodology

2.1. Collection of Samples

Fresh *Moringa oleifera* leaves were plucked from a *Moringa oleifera* tree growing at Kalapaluwawa, Rajagiriya (I.F, Offor, et al., 2014b).

2.2. Preparation of Samples

2.2.1. Drying of Fresh *Moringa Oleifera* Leaves

Fresh *Moringa oleifera* leaves (200g) were weighed using an electrical balance. Then *Moringa oleifera* leaves were dried under sunlight for 24 hours and in the oven (Philip Harris, UK) (50°C) for 2 hours. After that, dried leaves were grounded into a fine powder.

2.2.2. Packaging and Storage

Dried *Moringa oleifera* leaf powder was immediately packed into air-tight bottles, which were sterilized by using alcohol (70%). Bottles were stored at room temperature (28°C ± 2°C).

2.2.3. Canning of *Moringa Oleifera* Leaves in Brine

Moringa oleifera leaves were briefly immersed in boiling water (100° C) for 20 seconds, followed by an ice bath to rapidly cool the*m off*. Then blanched *Moringa oleifera* leaves were packaged in acidified brine solution at pH 3.8. Bottles were then exhausted, sealed, and pasteurized at 100°C for 30 minutes.

2.3. Analysis of Proximate Composition of Raw, Sun-dried, Oven-dried, and Moringa Oleifera Leaves in Brine

2.3.1. Determination of Moisture Content

Moisture content was determined using AOAC, 2012, with slight modifications. Sample (2g) was weighed into previously dried and weighed Petri dishes. It was then dried in the oven (Philip Harris, UK) at 105 ±1°C for 4 hours. Petri dishes were cooled and weighed until a constant weight was obtained.

2.3.2. Determination of Total Ash Content

Total ash content was determined using AOAC, 2012, with slight modifications. Sample (2 g) was measured to a pre-weighted dry crucible. The sample was then incinerated in the muffle furnace (Wise Therm, South Korea) at 550°C for 6 hours. Crucibles were cooled and weighed until a constant weight was obtained.

2.4. Determination of Crude Protein Content by Kjeldahl Method

In the digestion process, the protein content was determined using the micro-Kjeldahl method (AOAC, 2012) with slight modifications. Sample (2 g) was weighed and placed on cleaned digestion tubes. Then catalyst [3.5 g K_2SO_4 + 0.4 g $CuSO_4$. 5 H_2O (Sigma Aldrich)] and conc. H_2SO_4 (95-98%, 5.00 mL) were added. Digestion was carried out in the digester for 60 minutes at 410°C. Tube rack was then taken out of the block digester, placed carefully on a rack holder, and allowed to cool for 1 hour. Slowly, while stirring, distilled water (20 mL) was added to tubes.

In the distillation process, H_3BO_3 solution (20 mL) and a few drops of the indicator were added to an Erlenmeyer flask. Flask was placed under the tip of the condenser. A clean empty tube was placed in the distillation unit, and water (20 mL) and NaOH (20 mL) were added. The distillation process was then carried out.

In titration process, the solution in the Erlenmeyer flask was titrated with H_2SO_4 to the end point of the indicator. The crude protein content of the sample was calculated by multiplying the obtained Nitrogen content from the conversion factor of 6.25.

2.4.1. Determination of Crude Fat Content

Fat content was determined using the method of AOAC, 2012, with some modifications. Finely chopped sample (2 g) and anhydrous sodium sulphate (4.00g) were placed in an extraction thimble, and the mouth of the thimble was plugged with a piece of cotton wool. The extraction thimble with the sample was then placed in the Soxhlet apparatus. Petroleum ether (200.00 mL) and pumic chips were added into the previously cleaned and weighed round bottom flask. Flask was connected to the soxhlet extractor, and the condenser was fitted. It was refluxed for 5 hours. Once the refluxing was over, the solvent was distilled off, and the flask and the contents were placed in an oven at 105°C for two hours. Then the flask and the contents were allowed to cool in the oven for 30 minutes and were reweighed as before.

2.4.2. Determination of Crude Fiber Content

Crude fiber content was determined based on the method described by AOAC (2012) with slight modifications. 2g of defatted samples were transferred into a 400.0 mL beaker. Then H_2SO_4 (Sigma Aldrich) (5%, 50 mL) was added to the beaker, and the volume was made to 200 mL mark with distilled water. The content was brought to the boiling point and kept boiling exactly for 30 minutes while stirring with a glass rod during the boiling period. The volume was kept constant by adding hot water time-to-time. It was filtered through a 15.00 cm #4 Whatman filter paper on a Buchner funnel attached to the filter pump. The residue was then transferred to the funnel with a jet of hot water and washed with hot water until the filtrate was free from acid. This was checked by using a litmus paper. The residue was then scraped off from the filter paper with a spatula and placed in the same beaker, and the remaining last traces were with a jet of hot water.

NaOH (5%, 50 mL) was added, and the volume was made up to the mark by adding distilled water (200 mL). It was then brought to the boiling point and was kept boiling for 30 min. It was filtered immediately through the same piece of filter paper, and the residue was transferred to the filter by means of a jet of hot water. The residue was then washed with hot water and with HCl (Sigma Aldrich) (1%) and again with hot water until it was free from acid. Finally, it was washed twice with small amounts of alcohol (95%) and diethyl ether (Sigma Aldrich), and the residue was transferred into a porcelain dish. The remaining liquid was evaporated in an oven (Philip Harris, UK) at 100° C until the residue came to a constant weight. It was then allowed to cool and weighed. Then it was kept in a muffle furnace (Wise Therm, South Korea) at 500° C. It was allowed to cool, and the final weight was taken.

2.4.3. Determination of Total Carbohydrate Content

The total carbohydrate content of raw, sun-dried, oven-dried, and *Moringa oleifera* leaves in brine was calculated from the following equation. Total carbohydrate content = 100 - (moisture content% + ash content% + crude fat content% + crude fiber content % + crude protein content).

2.4.4. Determination of Antioxidant Potential

The antioxidant potential was determined by using 2, 2-diphenyl-1-picrylhydrazyl (DPPH) free radical scavenging activity measurement. Methanol was used as the solvent for Moringa oleifera leaf samples to carry out the DPPH assay. The antioxidant activity of the methanol extract of Moringa oleifera leaf samples was determined using a 96 well microtiter plate according to the method described by Mechmeche et al. (2019) with slight modifications.

2.4.5. Determination of Chemical Quality (pH)

The chemical quality was determined by measuring the pH according to the method described by (Menaka et al., 2011) with slight modifications.

2.5. Statistical Analysis

Minitab 16 statistical package was used for statistical analysis. One-way ANOVA technique and Tukey's multiple comparison tests were used to determine the significant differences in mean values of fermented *Moringa oleifera* leaf powder by *Lactobacillus plantarum*. ($p<0.05$ was considered significant)

3. Results and Discussion

3.1. Determination of Moisture Content

According to Turkey's comparison in ANOVA, there is a significant ($p<0.05$) reduction of moisture content in sun-dried ($7.57^{C}\pm0.03\%$) and oven-dried ($3.49^{D}\pm0.08\%$) *Moringa oleifera* leaf powder. This means there is an effect of drying on the moisture content of *Moringa oleifera* leaf powder. The moisture content of *Moringa oleifera* leaves in brine ($27.48^{B}\pm0.20\%$) has been significantly increased when compared with sundried ($7.57^{C}\pm0.03$) and oven dried ($3.49^{D}\pm0.08\%$) *Moringa oleifera* leaf powder. The percentage moisture content of raw ($40.37\pm0.08\%$) *Moringa oleifera* leaf powder shows a higher percentage. Hence, it confirms the fact that *Moringa oleifera* leaves are rich in moisture. It makes the conditions favorable for spoilage by microorganisms such as bacteria, thus reducing the shelf life of the product. Therefore, preservation is important to increase the shelf life by reducing the moisture content in *Moringa oleifera* leaves.

3.2. Determination of Ash Content

Moringa oleifera leaves are rich in minerals (L Gopalakrishnan et al., 2016). Minerals are essential for muscle contraction, regular heart rhythm, nerve impulse conduction, oxygen transport, etc. (Williams, 2005). According to Turkey's comparison in ANOVA, there is a significant ($p<0.05$) reduction of the ash content in *Moringa oleifera* leaves in brine ($7.60^{D}\pm0.17\%$). This may be probably due to the leaching of soluble minerals into processing water during the preservation period (Scheuer et al., 2021). Ash content in sun-dried ($8.63^{B}\pm0.15\%$) and oven-dried ($8.17^{C}\pm0.08\%$) *Moringa oleifera* leaf powder has been gradually reduced when compared with raw ($9.12^{A}\pm0.03\%$) *Moringa oleifera* leaf powder. This means there is an effect of drying in the ash content of *Moringa oleifera* leaf powder.

3.3. Determination of Crude Protein Content

According to Turkey's comparison in ANOVA, there is a significant ($p<0.05$) reduction of the crude protein content in sun-dried ($24.17^{B}\pm0.13\%$) and oven-dried ($23.34^{C}\pm0.24\%$) *Moringa oleifera* leaf powder. There is no significant ($p<0.05$) difference in the crude protein contents in raw ($26.50^{A}\pm0.05\%$), and *Moringa oleifera* leaves in brine ($26.53^{A}\pm0.06\%$). This means there is an effect of drying in the crude protein content of *Moringa oleifera* leaf powder.

3.4. Determination of Crude Fat Content

According to Turkey's comparison in ANOVA, there is a significant ($p<0.05$) reduction of the crude fat content in *Moringa oleifera* leaves in brine ($3.55^{D}\pm0.12\%$). Crude fat contents in sun-dried ($5.26^{B}\pm0.09\%$) and oven-dried ($4.30^{C}\pm0.15\%$) *Moringa oleifera* leaf powder also have been significantly ($p<0.05$) reduced when compared with raw ($6.33^{A}\pm0.10\%$) *Moringa oleifera* leaf powder. This means there is an effect of drying in the crude fat content of *Moringa oleifera* leaf powder. *Moringa oleifera* leaves contain a very low level of crude fat (Moyo et al., 2011). Therefore, it reduces the incidence of coronary heart disease (Plotnikoff & Higginbotham, 2007).

3.5. Determination of Crude Fiber Content

According to Turkey's comparison in ANOVA, there is a significant reduction of the crude fiber content in *Moringa oleifera* leaves in brine ($6.83^{D}\pm0.14\%$). This may be due to the softening of fibrous tissue during preservation. Sometimes, this also may be due to the bio-conversion of dietary fiber and lignocelluloses into protein (Scheuer et al., 2021). Crude fiber contents in sun-dried ($8.47\pm0.08\%$) and oven-dried ($8.17\pm0.03\%$) *Moringa oleifera* leaf powder also have been significantly ($p<0.05$) reduced when compared with raw (9.63 ± 0.09) *Moringa oleifera* leaf powder. This means there is an effect of drying in the crude fiber content of *Moringa oleifera* leaf powder.

In general crude fiber in plant-based foods is an essential component that increases the digestibility upon consuming foods rich in fiber. This study shows a greater fiber content, and it could serve as a good dietary fiber source providing more health benefits.

3.6. Determination of Total Carbohydrate Content

According to Turkey's comparison in ANOVA, there is a significant ($p<0.05$) increment of the total carbohydrate content in sun-dried ($45.90^{B}\pm0.32\%$) and oven-dried ($52.60^{A}\pm0.36\%$) *Moringa oleifera* leaf powder when compared with raw ($8.20^{D}\pm0.29\%$) *Moringa oleifera* leaf powder. This means there is an effect of drying on the total carbohydrate content of *Moringa oleifera* leaf powder. The total carbohydrate content in *Moringa oleifera* leaves in brine ($26.01^{C}\pm0.17\%$) also has been significantly ($p<0.05$) increased when compared with raw ($8.20^{D}\pm0.29\%$) *Moringa oleifera* leaf powder.

3.7. Determination of Antioxidant Potential

Antioxidants can be defined as reductants, and the inactivation of oxidizing agents by reductants can be explained as a type of redox reaction. *Moringa oleifera* leaves contain considerably higher amounts of phenols, flavonoids, and para-anthocyanin making it a good source for obtained antioxidant activity (Iqbal & Bhanger, 2006).

According to the results lowest IC 50 (the concentration of antioxidant required to give 50% inhibition of the probe in the antioxidant assay. Hence, the lower the IC50 value, the higher the antioxidant activity of a given food source) value was obtained (54.6) for *Moringa oleifera* leaves in brine indicating the highest antioxidant potential. IC50 values of sun-dried (136.5) and oven-dried (137.4) *Moringa oleifera* leaf powder have been increased when compared with raw *Moringa oleifera* leaf powder (135.6).

3.8. Analysis of Chemical Quality (pH)

According to the statistical analysis, there is a significant ($p<0.05$) reduction of pH in *Moringa oleifera* leaves in brine (3.8±0.06) when compared with raw (6.20±0.02), sun-dried (6.20±0.04) and oven-dried (6.30±0.05) *Moringa oleifera* leaf powder.

4. Conclusion

Proximate composition analysis of raw, sun-dried, oven-dried, and *Moringa oleifera* leaves in brine, moisture content, 40.37±0.08% (raw), 7.57±0.03% (sun-dried), 3.49±0.08% (oven-dried), 27.48±0.20% (in brine), ash content, 9.12±0.03% (raw), 8.63±0.15% (sun-dried), 8.17±0.08% (oven-dried), 7.60±0.08% (in brine), crude protein content, 26.50±0.05% (raw), 24.17±0.13% (sun-dried), 23.34±0.24% (oven-dried), 26.53±0.06% (in brine), crude fat content, 6.33±0.10% (raw), 5.26±0.09% (sun-dried), 4.30±0.15% (oven-dried), 3.55±0.12% (in brine), crude fiber content 9.63±0.09% (raw), 8.47±0.08% (sun-dried), 8.17±0.03% (oven-dried), 6.83±0.14% (in brine), total carbohydrate content 8.20±0.29% (raw), 45.90±0.32% (sun-dried), 52.60±0.36% (oven-dried), 26.01±0.17% (in brine) were recorded respectively.

IC50 values of raw, sun-dried, oven-dried, and *Moringa oleifera* leaves in brine were 135.6, 136.1, 136.5, and 54.6, indicating the highest antioxidant potential in *Moringa oleifera* leaves in brine.

The protein content of *Moringa oleifera* leaves enhances when preserved in brine from 26.50±0.05% (raw) to 26.53±0.06% (in brine) and increases its shelf life. Sun-dried and oven-dried *Moringa oleifera* leaf powder is also a cost-effective way of preservation and can be used as a direct food source.

5. References

i. Abd El-Gawad, E. A., El Asely, A. M., Soror, E. I., Abbass, A. A., & Austin, B. (2020). Effect of dietary Moringa oleifera leaf on the immune response and control of Aeromonas hydrophila infection in Nile tilapia (Oreochromis niloticus) fry. Aquaculture International, 28(1), 389–402. https://doi.org/10.1007/s10499-019-00469-0

ii. DAAM, E. (2020). Introduction to Moringa: a miracle plant.

iii. Gopalakrishnan, L, Doriya, K., & Kumar, D. S. (2016). Moringa oleifera: A review on nutritive importance and its medicinal application. Food Science and Human Wellness, 5(2), 49–56 | 10.1016/j.fshw.2016.04.001. Food Science and Human Wellness, 5(2), 49–56. https://sci-hub.se/https://www.sciencedirect.com/science/article/pii/S2213453016300362

iv. Gopalakrishnan, Lakshmipriya, Doriya, K., & Kumar, D. S. (2016). Moringa oleifera: A review on nutritive importance and its medicinal application. Food Science and Human Wellness, 5(2), 49–56. https://doi.org/10.1016/j.fshw.2016.04.001

v. Gunalan, S. (2019). Moringa for nutritional security (Moringa oleifera Lam.) Moringa Oleifera View project. www.botanyjournals.com

vi. I.F, Offor, R.C., E., & C.N, N. (2014a). Proximate Nutritional Analysis and Heavy Metal Composition of Dried Moringa Oleifera Leaves from Oshiri Onicha L.G.A, Ebonyi State, Nigeria. IOSR Journal of Environmental Science, Toxicology and Food Technology, 8(1), 57–62. https://doi.org/10.9790/2402-08115762

vii. I.F, Offor, R.C., E., & C.N, N. (2014b). Proximate Nutritional Analysis and Heavy Metal Composition of Dried Moringa Oleifera Leaves from Oshiri Onicha L.G.A, Ebonyi State, Nigeria. IOSR Journal of Environmental Science, Toxicology and Food Technology, 8(1), 57–62. https://doi.org/10.9790/2402-08115762

viii. Iqbal, S., & Bhanger, M. I. (2006). Effect of season and production location on antioxidant activity of Moringa oleifera leaves grown in Pakistan. Journal of Food Composition and Analysis, 19(6–7), 544–551. https://doi.org/10.1016/j.jfca.2005.05.001

ix. Martín Ortega, A. M., & Segura Campos, M. R. (2018). Medicinal Plants and Their Bioactive Metabolites in Cancer Prevention and Treatment. In Bioactive Compounds: Health Benefits and Potential Applications (pp. 85–109). Elsevier. https://doi.org/10.1016/B978-0-12-814774-0.00005-0

x. Mechmeche, M., Ksontini, H., Hamdi, M., & Kachouri, F. (2019). Production of bioactive peptides from tomato seed isolate by Lactobacillus plantarum fermentation and enhancement of antioxidant activity. Taylor & Francis. https://doi.org/10.1007/s10989-017-9655-8

xi. Menaka, T., Nagaraja, G., Yogesh, D., Kumar, U. S., & Prakash, L. (2011). Physicochemical Properties of flour and isolated starch from Jackfruit seeds (Artocarpus Heterophyllus lam). Undefined.

xii. Moyo, B., Masika, P. J., Hugo, A., & Muchenje, V. (2011). Nutritional characterization of Moringa (Moringa oleifera Lam.) leaves. African Journal of Biotechnology, 10(60), 12925–12933.

https://doi.org/10.5897/AJB10.1599

xiii. Olusanya, R. N., Kolanisi, U., van Onselen, A., Ngobese, N. Z., & Siwela, M. (2020). Nutritional composition and consumer acceptability of Moringa oleifera leaf powder (MOLP)-supplemented mahewu. South African Journal of Botany, 129, 175–180. https://doi.org/10.1016/j.sajb.2019.04.022

xiv. Otu, P. N. Y., Osae, R., Abdullateef, M. T., Cunshan, Z., Xiaojie, Y., & Azumah, B. K. (2020). Characterization of Moringa oleifera leaf polysaccharides extracted by coupling ionic liquid separation system with ultrasound irradiation. Journal of Food Process Engineering, 43(7), e13417. https://doi.org/10.1111/jfpe.13417

xv. Plotnikoff, R. C., & Higginbotham, N. (2007). Predicting low-fat diet intentions and behaviors for the prevention of coronary heart disease: An application of protection motivation theory among an Australian population. Http://Dx.Doi.Org/10.1080/08870449508401959, 10(5), 397–408. https://doi.org/10.1080/08870449508401959

xvi. Price, M. L. (2002). THE MORINGA TREE - CHE Network / the-moringa-tree-che-network.pdf/PDF4PRO. https://pdf4pro.com/view/the-moringa-tree-che-network-4c8b20.html

xvii. Saini, T., Kumar, S., & Narasimhan, B. (2015). Central Nervous System Activities of Indole Derivatives: An Overview. Central Nervous System Agents in Medicinal Chemistry, 16(1), 19–28. https://doi.org/10.2174/1871524915666150608103224

xviii. Scheuer, C., Boot, E., Carse, N., Clardy, A., Gallagher, J., Heck, S., Marron, S., Martinez-Alvarez, L., Masarykova, D., Mcmillan, P., Murphy, F., Steel, E., Ekdom, H. Van, & Vecchione, H. (2021). Disentangling inclusion in physical education lessons: Developing a resource toolkit for teachers. Physical Education and Sport for Children and Youth with Special Needs Researches – Best Practices – Situation, 343–354. https://doi.org/10.2/JQUERY.MIN.JS

xix. Singh, Y., & Prasad, K. (2013). Moringaid Tree Moringa Oleifera Leaf as Functional Food Powder: Characterization and Uses. International Journal of Agriculture and Food Science Technology, 4(4), 317–324. http://www.ripublication.com/ijafst.htm

xx. Tacer-Caba, Z. (2019). Different sources of glucosinolates and their derivatives. In Glucosinolates: Properties, Recovery, and Applications (pp. 143–180). Elsevier. https://doi.org/10.1016/B978-0-12-816493-8.00005-6

xxi. William, J. A., Iddrisu, L. N., Damian, T.-D., Kwame, O.-B., & Kwami, B. K. (2014). Nutrient composition of Moringa oleifera leaves from two agro-ecological zones in Ghana. African Journal of Plant Science, 8(1), 65–71. https://doi.org/10.5897/ajps2012.0727

xxii. Williams, M. H. (2005). Dietary Supplements and Sports Performance: Minerals. Journal of the International Society of Sports Nutrition©. A National Library of Congress Indexed Journal. ISSN, 2(1), 43–49. https://doi.org/10.1186/1550-2783-2-1-43

Appendix

Treatment	Nutrient Content (%)					
	Moisture *	Ash *	Crude Protein *	Crude Fat *	Crude Fiber *	Total Carbohydrate *
Raw	$40.37^{A}\pm0.08$	$9.12^{A}\pm0.03$	$26.50^{A}\pm0.05$	$6.33^{A}\pm0.10$	$9.63^{A}\pm0.09$	$8.20^{D}\pm0.29$
Sun-dried	$7.57^{C}\pm0.03$	$8.63^{B}\pm0.15$	$24.17^{B}\pm0.13$	$5.26^{B}\pm0.09$	$8.47^{B}\pm0.08$	$45.90^{B}\pm0.32$
Oven-dried	$3.49^{D}\pm0.08$	$8.17^{C}\pm0.08$	$23.34^{C}\pm0.24$	$4.30^{C}\pm0.15$	$8.17^{C}\pm0.03$	$52.60^{A}\pm0.36$
Brine	$27.48^{B}\pm0.20$	$7.60^{D}\pm0.17$	$26.53^{A}\pm0.06$	$3.55^{D}\pm0.12$	$6.83^{D}\pm0.14$	$26.01^{C}\pm0.17$

Table 1: Nutrient Content of Raw, Sun-dried, Oven-dried, and Moringa Oleifera Leaves in Brine
**The Values Are Mean ±Standard Deviation of the Replicates. The Values with Common Superscript Letters in Each Column Are Not Significantly Different (P<0.05)*

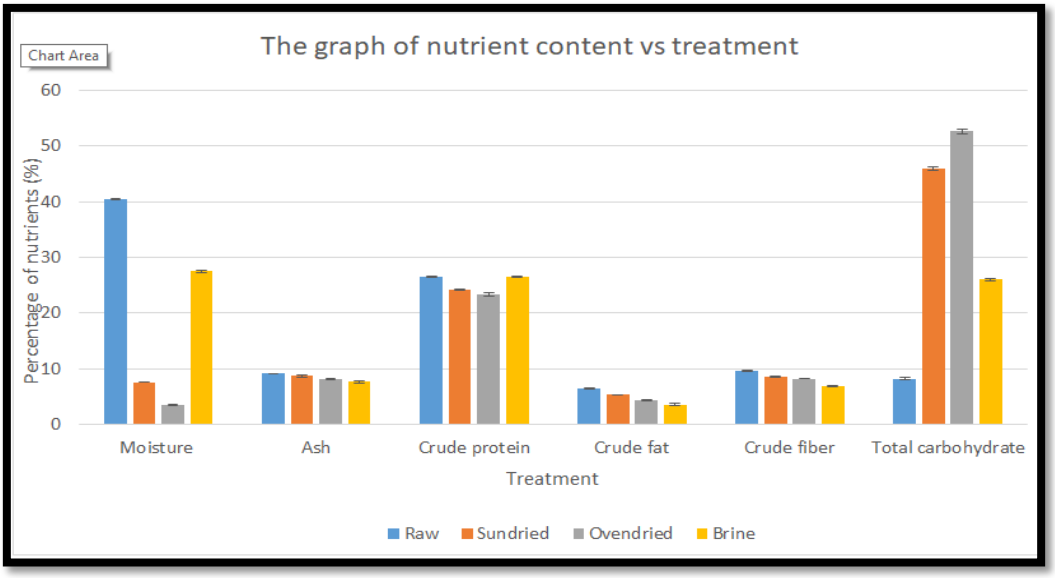

Figure 1: Bar Chart Representing the Nutrient Content of Raw, Sun-dried, Oven-dried, and Moringa Oleifera Leaves in Brine

Sample Concentration	Raw	Sun-dried	Oven-dried	Brine
1500 *	68.2	65.8	63.7	57.3
250 *	57.4	55.1	54.2	40.4
125 *	44.4	41.3	39.4	33.8
62.5 *	33.6	33.2	29.1	22.7
125 *	32.9	30.7	28.4	13.5

Table 2: Representing % Inhibition of Raw, Sun-dried, Oven-dried, and Moringa Oleifera Leaves in Brine

*The values are mean ±standard deviation of the replicates. The values with common superscript letters in each column are not significantly different ($p<0.05$).

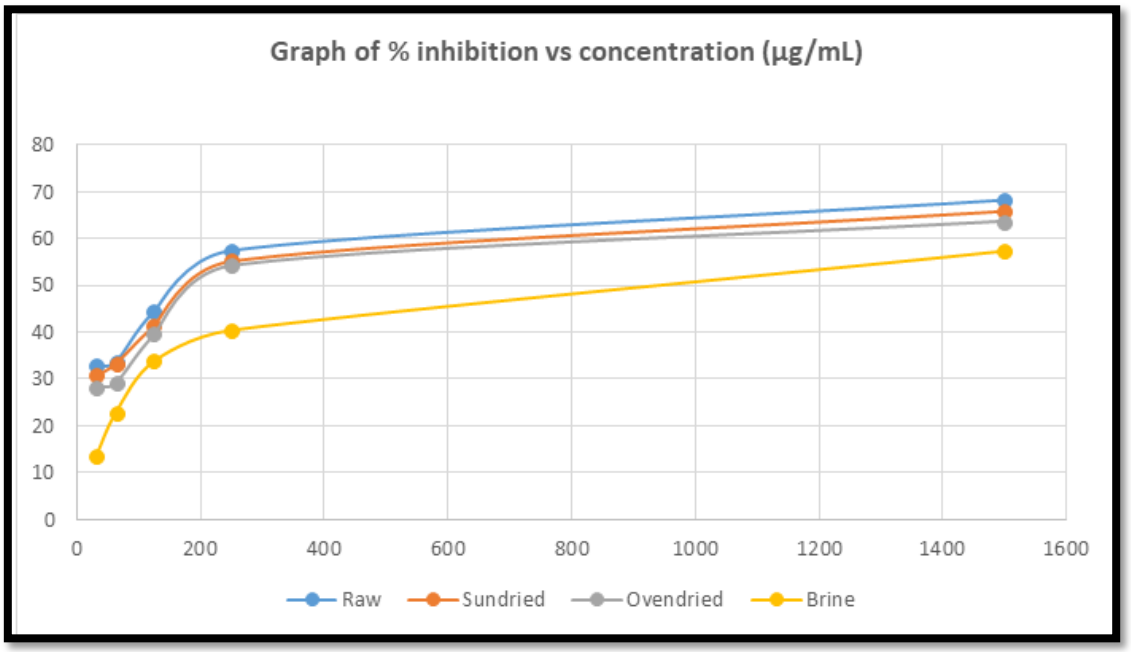

Figure 2: Variation of Antioxidant Potential in Raw, Sun-dried, Oven-dried, and Moringa Oleifera Leaves in Brine

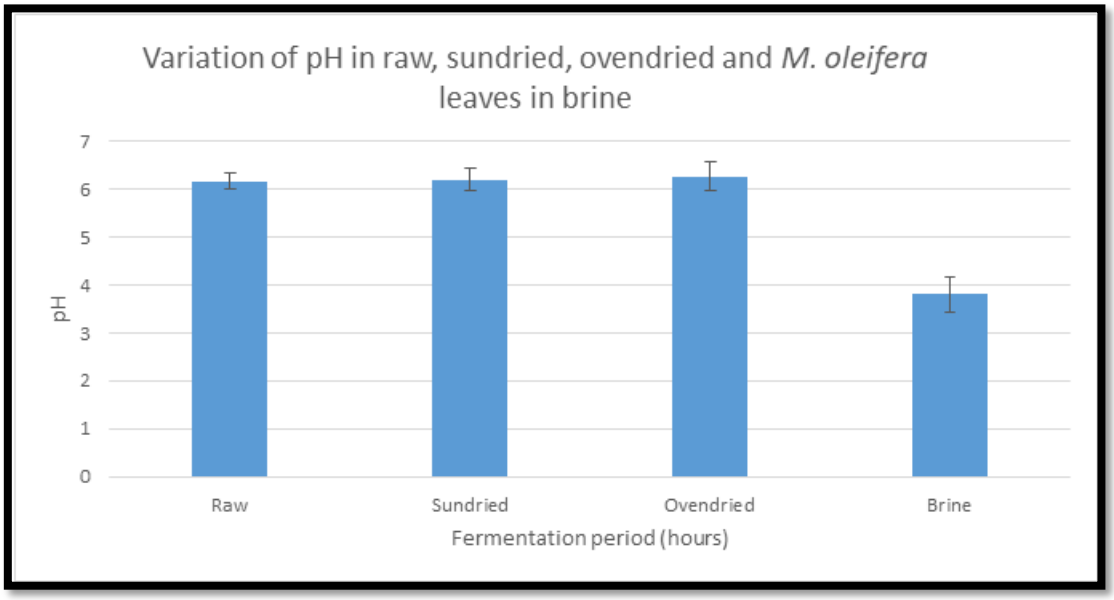

Figure 3: Variation of pH in Raw, Sun-dried, Oven-dried, and Moringa Oleifera Leaves in Brine. Bars Represent the Mean Standard Deviation