



## **Evaluation of the Nutritionally Valuable Mineral Composition of *Moringa oleifera* Leaf**

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### **Authors' contributions**

*This work was carried out in collaboration among all authors. Author GSD designed the study, performed the statistical analysis, wrote the protocol and wrote the first draft of the manuscript. Authors GD and ESC managed the analyses of the study. Author ESC managed the literature searches. All authors read and approved the final manuscript.*

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### **ABSTRACT**

*Moringa* plant parts are edible and considered as a highly nutritive vegetable globally. In this study, the essential nutrient elements, solid organic matter content (SOM) and phenolic compound of *Moringa oleifera* leaf extract obtained from two different zones of Plateau State, Nigeria was determined using standard laboratory procedures. The results obtained revealed that samples (A and B) of leaves of *Moringa oleifera* contained various quantities of valuable nutritive mineral elements such as chloride (14.49 mg per g and 13.44 mg per g), sodium (13.07 mg per g and 11.85 mg per g), Sulphate (13.07 mg per g and 11.85 mg per g), potassium (2.57 mg per g and 2.28 mg per g), calcium (2.57 mg per g and 2.28 mg per g), magnesium (5.59 mg per g and 5.67 mg per g), respectively while others such as ammonium, phosphate and iron had varying concentrations of valuable nutritional elements. There is no significant difference in the mineral contents of both samples. It also has high percentages of SOM of 81 and 82% in samples A and B as well as phenolics contents of 701.90 µg per g and 641.34 µg per g, respectively. These minerals are vital in the development and maintenance of the human health because the human body needs both macro and micro elements for its metabolism and proper development. Therefore, the

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*Moringa oleifera* plant could be an important source of essential elements of the human diet and could resolve some health-related issues due to high content of phenolics which contained antioxidant, anti-bacterial as well as anti-fungal properties.

**Keywords:** *Moringa*; leaves; evaluation; microelements; phenolics.

## 1. INTRODUCTION

Plants have been an important source of food and medicine for thousands of years and the demand for natural plants and its products as food supplement is on the increase in recent times, largely due to population explosion and increased failure of chemotherapy as a result of emergence of drug resistant species [1]. [2] stated that from time immemorial man depends on a vast variety of Plants for food as they played major role in maintenance of human health and getting rid of diseases such as cancer, cardiovascular diseases, age related muscular degeneration as well as malnutrition. [3] submitted that vegetables constitute major components of the human dietary requirements as it contains water soluble vitamins in the form of vitamins A, B, C and D, soluble fats and also a great variety of phytochemical constituents which have been claimed to have antioxidant, antibacterial, antifungal, antiviral and anti-carcinogenic properties. [4] submitted that mineral elements in human diet are required for the correct composition of body fluids, such as blood, and for the proper formation of tissues, bone, teeth, muscles and nerves. Such mineral elements also promote healthy nerve function as well as regulation of muscle tone, and supporting a healthy cardiovascular system. Just like vitamins, mineral elements also function as coenzymes that allow the body to perform its normal biochemical functions.

To this end, a variety of plant species ranging from green vegetables, medicinal plants, some fruits and leaves have been evaluated as viable ingredients for food and other uses by man and as special additives in animal feeds [5]. Furthermore, those alternative leafy vegetables have since been identified as an ally in the fight against deficiencies of macro- and micronutrients in humans [6,7].

Oduro et al. [8] stated that The World Health Organization (WHO) estimates that up to 80% of people still rely primarily on traditional remedies such as herbs for their medicines, and that the medicinal value of these plants is due to the presence of a variety of

phytochemicals and their elemental composition.

Amabye [9] noted that an appropriate amount and ratios of essential minerals are very important component of the dietary requirement of an organism and are necessary for healthy living. Therefore, the Food and Agricultural Organization [10] noted that research interest has focus on the utilization of plant whose various parts can be used for various purposes by man. One of such plants is *Moringa oleifera* belonging to the *Moringaceae* family and is a fast-growing plant that can survive harsh climatic conditions such as drought and is most widely cultivated in tropical and subtropical countries, such as India, Mexico, Malaysia, Indonesia, central and South America, Mexico, Hawaii, throughout Asia and Southeast Asia as well as a number of African countries including Nigeria. Consequently, [11] posited that *Moringa oleifera* plant has high biomass production of up to 2-4 ton/year/acre and could grow to an average height of up to 10M, additionally, oil is extracted from the seeds, which has proved to be effective in water purification [12,13].

In many countries of the world, every part of *Moringa* plant such as the leaves, fruits, flowers, and immature pods are edible and are considered as a highly nutritive vegetable [14,15,16]. In many developed countries, due to the rich mineral contents of *Moringa oleifera*, it is used as food supplement for the treatment of malnourished people especially nursing mothers and infants as well as an alternative to imported food supplements [2]. The Food and Nutrition Board, Institute of Medicine [17] reported the presence of polyphenols and antioxidants in the leaves of *Moringa oleifera* and that some Phytochemicals such as vanillin, omega fatty acids and carotenoids, ascorbates, tocopherols, beta-sitosterol, moringine, kaempferol and quercetin have been recovered from the flowers, roots, fruits and seeds of the plant. This investigation is therefore aimed at determining the nutritionally viable mineral content of *Moringa* leaves grown in northern and central region of Plateau state.

## 2. METHODOLOGY

### 2.1 Collection and Processing of *Moringa oleifera* Leaves

The *Moringa oleifera* leaves were collected at Damjing- Jibam (0488356N, 1065713E) of Chip District of Panksin LGA, (Central zone) and Batin area (0488385N, 1065745E) in Tabgwam-Heipang District of Barkin Ladi LGA (Northern zone) all of Plateau State (There are differences in environmental conditions such as temperature, soil texture and rain fall pattern between the two regions). Fresh leaf samples were collected from one-year old plant in the month of January, 2020 and placed in black labelled polythene bag and authenticated at the Botanical section of the Plateau State Polytechnic Barkin Ladi. Leaf samples were air-dried in the dark at room temperature for 2 weeks to allow for evaporation of moisture. After obtaining a constant weight for three days, the dried leaves were ground into fine powder using a dry mill grinder (Kenwood Ltd., UK) and passed through a sieve (24 mesh) and packed into sealed plastic bottles until required.

### 2.2 Laboratory Analyses of the Powdered Sample of *Moringa oleifera* Leaf

Powdered samples were analysed for elemental content, phenolic content, percentage water and solid organic matter. Extraction for phenolic content analysis was in 80% alcohol using procedures described by [18].

### 2.3 Water Extraction

To a 50 ml falcon tube, 5 grams of powdered leaf was extracted with 40 ml ultrapure water at 80°C for 30 minutes in a water bath shaker (Shaking Bath 5B-16, Techne Ltd., UK). After cooling, the pH and electrical conductivity were determined using SevenEasy and FiveGo (Mettler Toledo, Leicester, UK) pH and conductivity meters and the extract centrifuged at 5,000 rpm for 30 minutes. Following this, the samples were filtered using a 0.45 µm nylon membrane under vacuum. The filtrate was stored at 4°C until analysis within two weeks.

### 2.4 Determination of Solid Organic Matter Content (SOM)

Porcelain crucibles were half-filled with the powder, weighed again and placed in an incubator at 105°C (Fisher Scientific, UK) for 24

hours after which the crucibles were weighed again and placed in the muffle furnace (Sanyo Ltd., UK) at 550°C for 1 hour. Following this, the crucibles were weighed again and the organic matter and percentage water calculated as the loss on ignition.

### 2.5 Determination of Phenolic Compound Concentrations

The concentration of water extractable phenolics from the powdered sample was determined using the Folin-Ciocalteu colorimetric method described by [19,20,21,18] with some modifications. Briefly, 1 ml of the filtered extract was pipetted into a 1.5 ml self-locked Eppendorf tube (Fisher Scientific Ltd., Loughborough, UK), then oxidized with 50 µl Folin-Ciocalteu reagent (Sigma Aldrich Ltd., UK). The reaction was neutralized with 0.15 ml saturated sodium carbonate (Sigma Aldrich Ltd, UK) (200 g/l). A standard curve was prepared by adding 0-10 mg L<sup>-1</sup> phenol standard solutions, all preparations mixed and allowed to react for 1 hour 15 minutes at room temperature. Following incubation, for each standard and sample, 300 µl was pipetted into wells of clear flat 96-well microplate (Fisher Scientific, UK). The absorbance at 750 nm of the resulting blue colour was measured with a Spectra Max M2e spectrophotometer (Molecular devices Ltd, Wokingham, UK) and the phenolic concentration of the samples quantified against the standard curve.

### 2.6 Determination of Essential Nutrient Elements

The determination of element was carried out according to procedure described by [18,22,23]. Briefly, 5 ml of previously extracted water from *Moringa* leaf powder was pipetted into two separate 10 ml tubes labelled accordingly, and a set of 5 ml each of multi elements standard (Sigma Ltd, UK) prepared in a 10 ml tubes. These were then transferred into the Metrohm 850 Ion Chromatography equipment (Thermo Scientific Ltd., UK) and allowed to run for analysis. At the end of the analysis detectable values of elements present in the *Moringa* leaf samples were formed as chromatographic peaks which were further analyzed on Microsoft excel spread sheet as values of mineral elements detected in each sample.

### 2.7 Statistical Considerations

Data were analysed by one-way ANOVA to test for the effect of one factor, the value or level of

each element present in samples. SPSS v22 (IBM Corporation, New York, USA) was used for all analyses. A p value of <0.05 was used to denote significance for the ANOVA analysis.

### 3. RESULTS AND DISCUSSION

Assessment of the mineral element status of *Moringa* leaf obtained from the two zones on the Plateau showed that *moringa* plants grown in the two different regions has high content of phenolic compounds which are the main secondary metabolites in plants and a high percentage of solid biomass as well as rich in some essential

nutrients elements. There is no significant difference in all measured parameters ( $p > 0.05$ ) as observed in Figs. 1-3.

#### 3.1 Discussion

Analysis of the mineral composition in the present study revealed that *Moringa* leaves could be an interesting source of some essential nutrients such as chloride, sulfate, sodium, potassium, calcium, Iron, copper and magnesium as demonstrated in Fig. 1. Results obtained revealed varying concentrations of these vital nutrient elements in the two leaves of *Moringa*

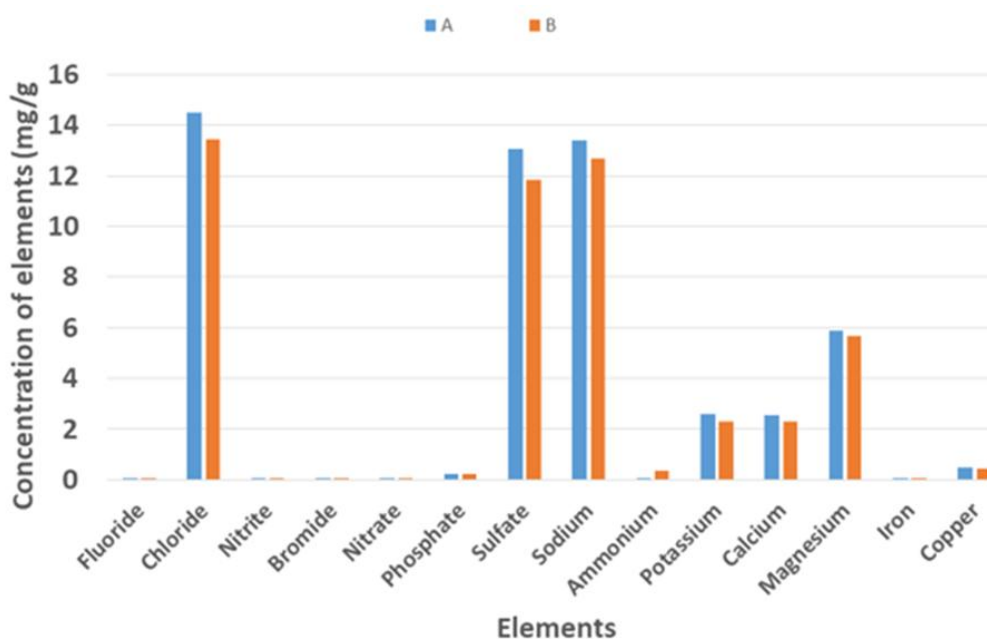


Fig. 1. Bar chart showing mineral elements in *Moringa oleifera* leaf

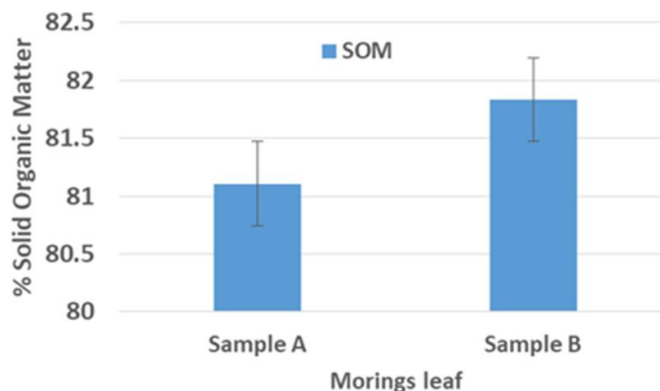
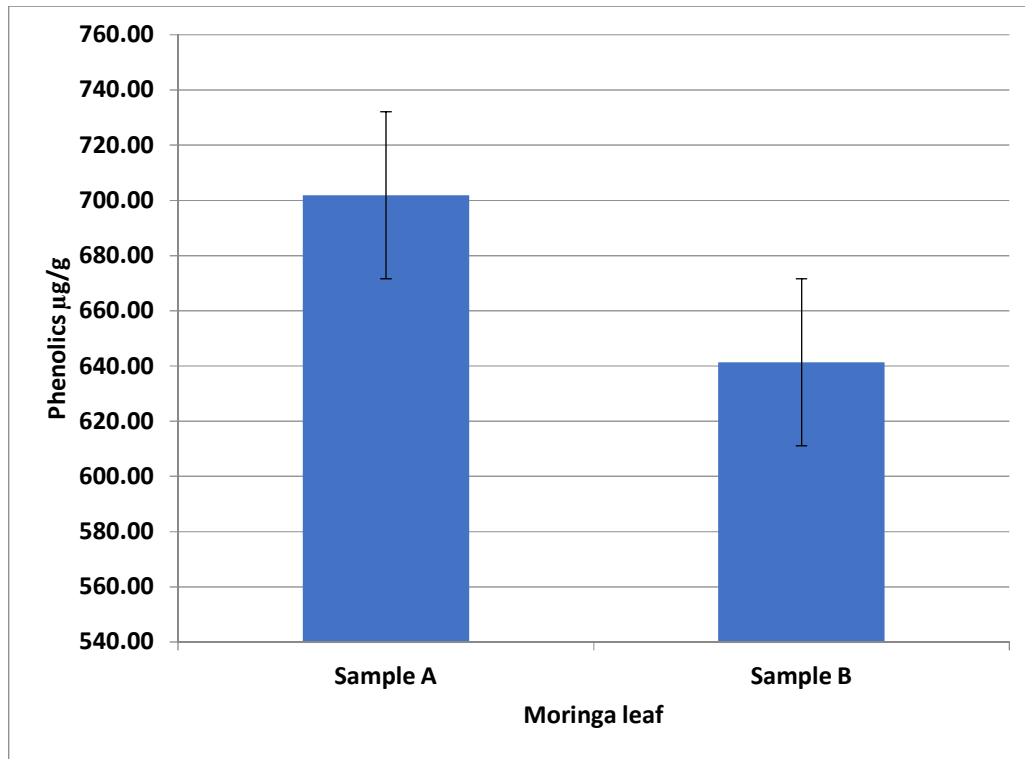


Fig. 2. Bar charts with standard error bars showing solid organic matter in the leaf of *Moringa oleifera*



**Fig. 3. Bar charts indicating phenolic concentration in *Moringa oleifera* leaf**

analyzed, as the leaves contained Chloride concentration of 14.49 mg per g in sample A and 13.44 mg per g in sample B. Sodium concentration of 13.07 mg per g and 11.85 mg per g were obtained for samples A and B respectively (Fig. 1). Analysis also revealed sulfate concentration of 13.07 mg per g and 11.85 mg per g for samples A and B respectively. Sodium content was 13.38 mg per g and 12.69 mg per g in both samples, the values of potassium and calcium were 2.57 mg per g, 2.28 mg per g and 2.53 mg per g and 2.31 mg per g in samples A and B respectively, while Magnesium content was 5.59 mg per g and 5.67 mg per g in samples A and B. Other nutrients elements such as iron, ammonium phosphate had varying concentrations of valuable nutritional elements as seen in Fig. 1. The differences in these elements between the two *moringa* leaves samples obtained from the two regions were not statically significant ( $p>0.05$ ).

These minerals are vital in the development and maintenance of the human health because the human body needs both macro and micro elements for its metabolism and proper development. For instance, chloride is an essential electrolyte in body cells, it is

responsible for maintaining acid base balance and equally maintain fluid movements across cells, it is also important in the production of hydrochloric acid an important digestive fluid found in the stomach lining [24]. Calcium is the major constituent of bone and teeth and the body needs it for the regulation of nerve and normal muscular function. Calcium is also required for expecting and lactating mothers and children in high amount for bones and teeth development. The value obtained from this result is lower than the daily recommended level of 800 mg/day for children as revealed by [2]. Sodium is an essential dietary requirement in human life and also plays key importance especially in maintaining blood pressure. Both sodium and potassium are principal cations in extracellular fluids, they play vital role in the regulation of plasma volume and acid base balance in the body. Magnesium is very important in calcium metabolism in bones and also involved in prevention of cardiovascular diseases, it also helps in regulating blood pressure and release of insulin. The recommended daily allowance for magnesium in adult is 350 mg/100 g similarly, that of iron in adult and children is 10 mg and 15 mg per day [14,25]. Copper is required in the body for enzymes production and biological

transfer of electron it is vital in the formation of red blood cells, maintain healthy bones, nerves, and immune function, sufficient copper is needed daily diet to help prevent cardiovascular disease, while Iron is essential for the formation of hemoglobin and so its deficit could result in anaemia [26].

Therefore, the leaf mineral concentration might make the plant an important source of essential elements for the human body. The chemical composition values also confirmed that *M. oleifera* leaves are an excellent food source, justifying its direct use in human nutrition or for the development of balanced diets for animal nutrition.

Similar observation was made by [27] as [25] revealed that *Moringa oleifera* leaves are nutritionally adequate and constitute a promising source of dietary minerals. [28] reported high nutrients content as well as elements found in different samples of *Moringa oleifera* from The Philippines while [29] carried out the proximate and elemental analysis of *Moringa oleifera* and other leafy vegetables grown in Minna, Nigeria and reported varying amount of both macro and micro elements.

The results obtained also shows that the two leaf samples of *Moringa* contained 81% and 82% of solid organic matter as seen in Fig. 2. There was however no significant difference in the phenolic contents in the two leaf samples examined ( $p>0.05$ ). The nutritional value of herbs depends on the chemical composition in dry mass, especially on concentrations of mineral components and other compounds such as proteins, vitamins and crude fiber [30].

The results of present study revealed that *Moringa oleifera* leaf contains an appreciable amount of Phenolic compound as sample A and B had 701.90  $\mu\text{g}$  per g and 641.34  $\mu\text{g}$  per g respectively with no significant difference between the two plants from the different regions ( $p>0.05$ ) (Fig. 3). Indicating that differences in soil texture and other environmental conditions might not have any negative impact on the growth and development of the plant. Phenolic compounds have anti-oxidant activity and are secondary metabolites which have anti-bacteria and antifungal properties and found in abundant in plants hence play vital role in protection against diseases.

Lately, phenolic compounds have received significant interest based on active reports of

their role in holding back a variety of human illnesses. Several studies have reported the advantages of consuming herbs rich in phenolic which includes anti-aging, antioxidant and ant-proliferation agents [31]. Therefore, the high percentage of phenolics obtained from the two samples could be of medicinal interest.

#### 4. CONCLUSION

There are no significant differences in the nutritionally valuable mineral contents, solid organic matter as well as the phenolic contents in the two leaves of *Moringa oleifera* grown in the two different regions of Plateau State of Nigeria the environmental differences in the two regions notwithstanding.

Consequently, the leaf of *Moringa oleifera* plant contains some nutritionally valuable mineral which could improve the dietary requirements in most developing Countries. It could also contribute significantly to the nutrient requirement of livestock species and could also serve as ingredients in the formulation of Infants formula, food supplements and food formulation. It could also curtail malnutrition and improve healthy living among poor people living in those areas due to the high phenolic contents in the plant.

#### DISCLAIMER

The products used for this research are commonly and predominantly use products in our area of research and country. There is absolutely no conflict of interest between the authors and producers of the products because we do not intend to use these products as an avenue for any litigation but for the advancement of knowledge. Also, the research was not funded by the producing company rather it was funded by personal efforts of the authors.

#### COMPETING INTERESTS

Authors have declared that no competing interests exist.

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