

## Trace Elements and Proximate Analysis of *Boswellia dalzielii* Stem Bark

Yakubu S.; Vandi S.; and Rejoice A. J.

Department of Science Laboratory Technology, Federal Polytechnic, Mubi, Adamawa State, Nigeria.

Corresponding author: [thlizayaks70@gmail.com](mailto:thlizayaks70@gmail.com)

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### Abstract

*Boswellia dalzielii* (*B. dalzielii*) Hutch is a tree plant of the Burseraceae family found in Savannah woodlands. The decoction of stem bark has been reported to be useful in treating gastrointestinal diseases, rheumatism, septic sores, and sexual ailments. Additionally, it has demonstrated antifungal, antibacterial, and anti-inflammatory properties. The research was undertaken to evaluate the trace element contents and nutritional contents of the stem bark of *B. dalzielii* using standard methods of the Association of Official Analytical Chemists (AOAC). The elemental analysis showed the presence of: Zn ( $5.82 \pm 0.021$  mg/kg), Cu ( $4.22 \pm 0.017$  mg/kg), Mn ( $31.24 \pm 0.114$  mg/kg), and Fe ( $9.12 \pm 0.318$  mg/kg), Se ( $3.13 \pm 0.223$  g/kg) Cr ( $0.0026 \pm 0.211$  mg/kg), Co ( $0.00$  mg/kg), Mo ( $0.0016 \pm 0.001$  mg/kg), Cd ( $0.0037 \pm 0.117$  mg/kg), Ni ( $0.0016 \pm 0.324$  mg/kg), and I ( $4.15 \pm 0.214$  mg/kg). While the proximate analysis revealed the presence of the following: ash content ( $5.97 \pm 0.315\%$ ), moisture ( $6.22 \pm 0.115\%$ ), protein ( $18.52 \pm 0.018\%$ ), fiber ( $16.2 \pm 0.215\%$ ), crude fat ( $6.02 \pm 0.002\%$ ), and carbohydrate ( $31.73 \pm 0.224\%$ ). Trace elements have well-characterized physiological functions within the body. They regulate biological processes, thereby stabilizing the structures of cells when they are supplied at the normal level, but their deficiency leads to different kinds of diseases. The study suggests that the trace elements present in the bark sample of *B. dalzielii* may be of value and may have prognostic significance in the early diagnosis and therapy evaluation of some diseases, especially various types of cancer, as well as in anti-diabetic agents. The results of the proximate analysis depict the potentiality of the plant as a good source of nutraceuticals.

**Keywords:** *B. dalzielii*, Nutraceutical, Proximate Analysis, Stem Bark, Trace Elements.

### Introduction

The use of plants as remedies for different types of ailments among different communities has been around as long as human history. Although it's a global trend, Africa in particular, blessed with biodiversity, has retained this old tradition of preparing extracts from plants, known as concoction, decoction, or infusion, as a reliable way of curbing different ailments, which have been shown to be effective and safer over time, thereby meeting their health needs cheaply (Yakubu et al., 2023). There has been a strong recommendation from WHO endorsing the effectiveness and benefits of plant-based medicines as alternative medicines, especially in continents like Africa.

Several scientific research have shown plants to possess secondary metabolites which exhibit antibacterial, antifungal, antiseptic and antibiotic properties making them a good ingredient for drug development (Ben-Yehoshua et al., 2011).

*Dazielii* has been commonly used as a repellent that drives away flies and mosquitoes from rooms by simply burning the stem bark. Decoction prepared from the stem bark is used for rheumatism, septic sores, sexual illnesses, and gastrointestinal disorders. (Baha'uddeen et al., 2017). It has also demonstrated potency in folk medicine as anti-arthritis, anti-diarrhoea, anti-bacterial, anti-hepatitis, anti-inflammatory, and anti-HIV/AIDS. It has also been used in the treatment of dental-related ailments and has shown effectiveness in the treatment of swellings, bronchitis, coughs, gastric disorders, asthmatic attacks, pulmonary diseases, and skin ailments. (Osuntokun et al., 2017) In the same vein, the aqueous stem bark extract of *B. dalzielii* revealed the presence of tannins, glycosides, flavonoids, alkaloids, anthracene, saponin, and saponin glycosides. (Wessling-Resnick, M., 2015)

*Boswellia dalzielii* Hutch is a tree plant of the Burseraceae family found in savannah forests. It is commonly found in North-Western Nigeria. Common names for the plant include Frankincense tree, in Hausa is referred to as "arrarabi", "Kaushi" in Kanuri, "debro" in Babur/Bura, and "mofu" in Marghi. The plant is also called "piangwogu" in Ghana and Upper Volta; "etan" in Ethiopia, "libanos" in Greek, and "luban" in Arabic. (Umar et al., 2018)

## Statement of Research Problem

Aside from conventional drugs, traditional medicine is gaining popularity as its application increases across the globe, especially in Africa. There are reports of effective management of ailments that have defied conventional medication using traditional methods through the application of herbs. Although the use of preparations from plants has been effective, the knowledge of the plant's chemical constituents, dosage, and side effects has not been known by traditional medicine practitioners. This constitutes a huge setback that could lead to numerous unwanted results, like outbreaks or even death. There is an immediate need to bridge the gap by providing scientific approaches such as determination of elemental concentrations, proximate analysis, toxicity evaluation, etc.

## Aim and Objectives

The aim of this research is to determine the elemental concentration and proximate analysis of the stem bark of *B. dalzielii*.

The specific objectives are to:

- Determine the elemental concentration in the stem bark using Atomic Absorption Spectroscopy (AAS).
- Carry out proximate analysis of the stem bark of the plant using Standard Methods of the Association of Official Analytical Chemists (AOAC) .

### **The Significance of the Study**

It provides information and a guide for the traditional medicinal practitioners who utilize the plant for the treatment of diseases but are deficient in knowledge of the concentration implications.

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### **Material and methods**

#### **Materials**

Materials used include the following: beaker (1000 mL, 500 mL, and 250 mL), funnel, glass rod, spatula, mortar, pestle, filter paper, conical flask (500 mL), dropping pipette, water bath, weighing balance, methanol, distilled water,  $\text{HNO}_3/\text{H}_2\text{O}_2$ , Whatman filter paper, volumetric flask, muffle furnace, porcelain crucible, and AAS.

#### **Sample Preparation**

The plant stem bark was allowed to air-dry at room temperature before being ground into a fine powder with a mortar and pestle. The mixture was then sieved through a mesh sieve and stored for analysis.

#### **Determination of Elemental composition**

The conventional procedure was followed with minor modifications to determine the trace elements. About 2 g of the plant sample was heated in a porcelain crucible at 550 °C in a muffle furnace after the powdered samples had been sieved through a 2 mm rubber sieve. The resulting ash was then heated slowly on a hot plate until brown odors dissipated after dissolving it in 5 mL of  $\text{HNO}_3/\text{H}_2\text{O}_2$  (1:1). About 5 mL of deionized water was added to the residual material in the crucible, and the mixture was heated until a colorless solution was achieved. Each crucible's residual material was mixed with 5 mL of deionized water and boiled until a colorless solution was achieved. The mineral solution was transferred into a 100-ml volumetric flask by passing it through a Whatman filter paper, and the volume was raised to the mark with deionized water. The atomic absorption spectrophotometer (AAS)

was utilized to analyze the elements in this solution. The concentration of each element was determined using the dry matter percentage.

### Determination of Proximate Analysis

In determining the proximate parameters, standard methods of the Association of Official Analytical Chemists (AOAC, 1990) were adopted. Moisture content was determined by drying samples in an oven at 110 °C until a constant weight was attained. The determination of proteins in terms of nitrogen was done by the micro Kjeldahl method (Hussain et al., 2010). The nitrogen value was converted to protein by multiplying by a factor of 6.25. Crude fats were determined by the Soxhlet apparatus using n-hexane as a solvent. The ash values were obtained by heating samples at 550 °C in a muffle furnace for 3 hours. The carbohydrate content was determined by subtracting the total protein, fiber, moisture, fat, and ash content from the total dry matter. The crude fiber was also determined by the method described. The energy value estimation was done by summing the multiplied values for protein, fat, and carbohydrate by their respective factors. Hussain et al. (2010).

## Results and Discussion

### Results

**Table i:** Quantitative Chemical Analysis of Minerals present in *B. dalzielii* stem bark methanol extract

| Sample              | Zn             | Cu             | Mn              | Fe             | Se             | Cr               | Mo               | Co | Cd               | Ni               | I              |
|---------------------|----------------|----------------|-----------------|----------------|----------------|------------------|------------------|----|------------------|------------------|----------------|
| <i>B. dalzielii</i> | 5.82±<br>0.021 | 4.22±<br>0.017 | 31.24±<br>0.114 | 9.12±<br>0.318 | 3.13±<br>0.223 | 0.0026±<br>0.211 | 0.0016±<br>0.001 | ND | 0.0037±<br>0.117 | 0.0016±<br>0.324 | 4.15±<br>0.214 |

Values expressed as Mean ± SD

**Table ii:** Percentage proximate Composition of *B. dalzielii* stem bark

| S/NO. | Parameters        | Composition |
|-------|-------------------|-------------|
| 1     | Moisture (%)      | 6.22±0.115  |
| 2     | Ash (%)           | 6.00±0.315  |
| 3     | Crude protein (%) | 16.00±0.018 |
| 4     | Crude fiber (%)   | 18.51±0.215 |
| 5     | Crude fat (%)     | 32.00±0.002 |
| 6     | Carbohydrate (%)  | 6.62±0.224  |

Values expressed as Mean ± SD

### Discussion

In human systems, trace elements play a variety of significant roles. Some of these roles are necessary for enzyme processes, in which they draw substrate molecules and help them convert to particular end products. Additionally, some of them participate in redox processes, which are crucial for producing and using metabolic energy, by giving or receiving electrons. A portion of them play structural roles and are in charge of maintaining

the stability of significant biological molecules. Moreover, several trace elements play crucial roles in biological processes. For instance, iron (Fe) has the ability to bind, transport, and release oxygen inside the body (Alain, 2006). In actuality, even though trace elements are necessary for biological processes, high concentrations of these elements can be harmful to the body's health and cause a number of deadly illnesses.

#### Zinc (Zn) Concentration

The concentration of zinc (Zn) in the stem bark of *B. dalzielii* is  $3.14 \pm 0.223$ , significantly higher than *Swertia macrosperma* leave and stem ( $0.44 \pm 0.017$  and  $0.45 \pm 0.047$ ) (Qurbonova Salima, 2023). It is also above WHO/FAO acceptable limits. Zn is a necessary trace element that is present in almost 300 distinct enzymes, an important trace metal that acts as a cofactor for several enzymes involved in metabolism and cell development (Falah & Saja, 2017). Zinc plays a role in the metabolism of proteins, carbohydrates, lipids, and energy as an element in several enzymes. Zinc is a necessary element in many metabolic pathways and is necessary for the proper operation of many bodily systems (Plum & Haas, 2010). It is especially important for maintaining healthy skin and is necessary for a strong immune system and infection resistance. Zinc is essential for growth and cell division, as well as insulin activity. It plays significant roles in the metabolism of the ovaries' and testes', with proven activity in protein and DNA synthesis and liver function (Hussain et al., 2011). Exposure to high levels of zinc for several months may cause anemia, damage the pancreas, and decrease levels of high-density lipoprotein (HDL) cholesterol. (ATSDR, (2005)

#### Iron (Fe) Concentration

The content of iron (Fe) in the stem bark of *B. dalzielii* is  $9.112 \pm 0.318$  mg/kg, significantly lower than *Swertia macrosperma* leave and stem ( $16.34 \pm 0.250$  mg/kg and  $11.70 \pm 0.895$  mg/kg) (Hussain et al., 2011). The concentration of Fe in the stem of *B. dalzielii* is above WHO/FAO acceptable limits. Hemoglobin has been shown to contain a higher percentage of Fe in the human body. It is an erythrocyte protein that transports oxygen from the lungs to the tissues and also accounts for the red color of blood. The chain of activity involving the transport of oxygen to the muscles is basically a function of myoglobin, which has Fe as its essential component. Other functions of Fe include growth, development, the synthesis of connective tissues, and certain hormones. It also contributes to normal cellular functioning. (Hussain et al., 2011)

#### Selenium (Se) Concentration

The results of this current work have revealed the concentration of Se in the stem bark of *B. dalzielii* to be  $2.14 \pm 0.223$  mg/kg. The result is higher than the report of Ismail (Jasha & Petevino, 2016). Showing the concentration of Se to be  $0.098 \pm 0.008$  mg/kg in tea leaves. Se is an important trace element that contributes significantly to human health. It is usually present in selenoproteins as selenocysteine. It is also found in glutathione peroxidases and thioredoxin reductase, which are antioxidants enzymes (Jasha & Petevino, 2016)

### Copper (Cu) Concentration

The concentration of Cu in the stem bark of *B. dalzielii* as presented in Table 1 is  $4.24 \pm 0.017$  mg/kg. The results of *Swertia macrosperma* leaf and stem were  $0.71 \pm 0.241$  mg/kg and  $0.77 \pm 0.229$  mg/kg, which is lower in concentration than *B. dalzielii*. While the results of tea leaf ( $13.9 \pm 0.90$  mg/kg) are significantly higher compared to the stem bark of *B. dalzielii*. (Jasha & Peteveno, 2016)

Cu is a necessary component of many enzymes, including lactase, tyrosinase, ascorbic acid oxidase, catalase, peroxidase, cytochrome oxidase, and monoamine oxidase (SOD). Furthermore, copper is a component of many different enzymes and is therefore involved in a wide range of metabolic processes. For instance, the SOD's Cu content aids in the process of converting superoxide into oxygen and hydrogen peroxide. Cu is a vital micronutrient required by the neurological and hematopoietic systems. It is essential for the development of myelin sheaths in the neurological system, the growth and creation of bone, the incorporation of iron into hemoglobin, the absorption of iron from the gastrointestinal tract, and the transfer of iron from tissues to plasma (Jasha & Peteveno, 2016).

### Manganese (Mn) Concentration

The content of Mn determined in the stem bark of *B. dalzielii* is  $31.33 \pm 0.114$  mg/kg. It is the highest compared to all other elements determined in the plant. It is higher than the content of Mn determined in the leaf and root of *Swertia macrosperma* ( $5.25 \pm 0.076$  and  $4.31 \pm 0.016$  mg/kg) and also higher than *Potentilla volgens* leaf and root ( $4.32 \pm 0.009$  and  $2.12 \pm 0.0016$ ), and is above the acceptable limit prescribed by WHO/FAO (Ismail, 2019). This could lead to infertility, nervous system challenges, etc. (ASDR, 2012)

Manganese is one of the essential elements required by the body in a tiny amount. The average human body contains about 12 mg of Mn. A higher percentage is found in the skeletal system; a lesser amount is found in some body tissues like the central nervous system, brain, liver, and kidneys. Formation of connective tissues, bones, clotting of blood, and sex hormones. Similarly, Mn helps with sugar regulation in the body, making significant contributions to calcium absorption, carbohydrate metabolism, and fat metabolism. Mn is also necessary for normal brain and nerve function. In addition, Mn is a key component of enzyme systems, including oxygen-handling enzymes. It is a component of the antioxidant SOD, which helps fight free radicals.

### Cobalt (Co) Concentration

Cobalt is a key constituent of vitamin B<sub>12</sub> and is essential for hemoglobin synthesis. It also plays a significant part in the synthesis of neurotransmitters and amino acids. Co ions can enter the human body through a number of routes, including the food chain, the respiratory system, the skin, and biomaterials. It is usually transported via protein and blood to tissues and cells of the body. Nutritional deficiency is uncommon, but in recent times, metal emissions from implants like prosthetic hips have caused cobalt toxicity, which has resulted

in neurological symptoms like hand tremor, incoordination, vertigo, depression, altered vision, and hearing loss. Similarly, hypothyroidism symptoms, heart symptoms (cardiomyopathy and arrhythmias), and polycythemia are other signs of cobalt toxicity (Qais et al., 2013).

#### Chromium (Cr) Concentration

The content of Cr in the stem bark of *B. dalzielii* is  $0.0026 \pm 0.211$  mg/kg. The content is lower compared to tea leaves ( $0.45 \pm 0.100$ ), *Swertia macrosperma* leaf and root ( $2.03 \pm 0.36$  and  $1.26 \pm 0.0016$ ), and *Valeriana jatamansi* leaf and root ( $3.07 \pm 0.403$  and  $0.91 \pm 0.0059$ ) (David et al., 2018). The amount of Cr in biological materials has been well investigated. Research has revealed that chromium leads to notable elevations in enzyme activity and plays a crucial role in the metabolism of carbohydrates, fatty acid and cholesterol synthesis from acetate in the liver, and enhanced glucose metabolism by means of insulin activation. Moreover, it has been discovered that chromium increases the sensitivity of bodily tissues to insulin. It is an essential cofactor for insulin's function.

#### Molybdenum (Mo) Concentration

The content of Mo in the stem bark of *B. dalzielii* is ( $0.0016 \pm 0.001$ ) lower than the contents in the following plants: *Swertia macrosperma* leaf ( $0.0722 \pm 0.003$ ), *Potentilla volgens* leaf and root ( $4.32 \pm 0.009$ ), and *Valeriana jatamansi* ( $0.161 \pm 0.005$ ). David et al. (2018). Molybdenum (Mo), an important micronutrient, is required as a catalytically active metal. Sulfite oxidase, xanthine oxidoreductase, aldehyde oxidase, and mitochondrial amidoxime reductase are the four enzymes in humans that are dependent on Mo. To gain biological activity and fulfill its function in enzymes, Mo has to be complexed by a pterin compound, thus forming the molybdenum cofactor. David et al. (2018).

#### Nickel (Ni) Concentration

The content of Ni is  $0.016 \pm 0.324$  mg/kg, as presented in Table 1. The concentration is lower than in tea leaf ( $3.40 \pm 0.30$  mg/kg) (Burjonrappa & Miller, 2012). The body's highest quantity of nickel is found in nucleic acids, especially RNA, and it is believed that nickel may play some role in the structure or function of proteins. Nickel is viewed to function as a cofactor in the activation of several enzymes involved in the use or breakdown of glucose. Ni may contribute to the synthesis of prolactin, which in turn affects the production of human breast milk (Burjonrappa & Miller, 2012).

#### Iodine (I) Concentration

Iodine is an essential trace element that is needed at every stage of life, with the most crucial periods being during pregnancy and the early years of childhood. The thyroid hormones thyroxine (T<sub>4</sub> tetraiodothyronine) and triiodothyronine (T<sub>3</sub> triiodothyronine) have iodine as a necessary component. Iodine deficiency is not common; however, it is seen in people with goiter as a result of thyroid malfunctioning. Symptoms of iodine deficiency

may include extreme fatigue, slowing of both physical and mental processes, weight gain, facial puffiness, constipation, and lethargy. Babies born to iodine-deficient mothers may be lethargic and difficult to feed (Sydor & Zamble, 2013).

### Proximate Analysis

The results of the proximate analysis of the methanol extract of the stem bark of *B. dalzielii* are presented in Table 2. The results showed the moisture content to be 6.20%, ash (6.00%), crude fiber (16.00%), crude protein (19.00%), fats (6.62%) carbohydrates (32.0%).

### Moisture content

The moisture content is lower than the reports earlier presented for some legumes: *Myrtigyna inermis* leaf extracts (4.8%), and *Tetracarpidium conophorum* (43.3%) (Sydor and Zamble, 2013). The leaves of *Chenopodium. ambrosioides* showed moisture content to be (89.40%), *Ocimum graissimum* (80.80%), *Venormia amgygaldalina* (79.20%), *Morinder lucida* (70.20%), *Porquetina nigrescens* (70.01%), *Mangefera indica* (60.40%), *Bombax buonopozense* roots (53%), and *Zinger of finale* roots (15.02%). Further reports showed *Carlpologia intea* roots and *Microdenus perberula* have 8.9% and 8.75, respectively, which are slightly higher values than *B. dalzielii*. However, the proximate analysis of the *Aspillia kotschya* plant showed a moisture content of 5.7%, which is lower than that of *B. dalzielii*. The plant's moderate moisture content allows for the action of water-soluble enzymes and coenzymes that are essential for its metabolic processes. Therefore, the conducive environment needed by organs for effective functioning is dependent on the moisture content of the plant. (Sydor and Zamble 2013)

### Ash content

From table 2, the ash content of the sample is 6.00%. Comparing the sample's ash content to the leaves of *C. ambrosoides*, *V. amygdalina*, *O. gratissimum*, *M. lucida*, *P. nigrascens*, *M. indica*, and *M. inermis*, which were 17%, 17.2%, 14.30%, 12.25%, 12.20%, 12.04%, and 9%, respectively, it is significantly lower (Romani, 2013). The ash contains the inorganic constituents of the plant sample, usually obtained after all the organic composition of the plant has been burned. There is a huge correlation between the ash and the mineral composition of plants. The value obtained for the plant under consideration therefore depicts fewer elements in the plant.

### Crude fiber content

The percentage of crude fiber in the stem bark of *B. dalzielii* was 16.00%. The value is higher than *Aspillia Kotschyi* (9.06%). Similarly, proximate analysis of *M. lucida* leaf, bark, and stem showed moisture contents of 8.75%, 10.56%, and 10.12%, respectively, which were lower than *Myrtagina inermis* (30%). It is largely higher compared to *B. dalzielii* stem bark. Dietary fibers have numerous biological functions, which include the treatment of gastrointestinal disorders, high blood pressure, high cholesterol, high blood sugar, colon cancer, and waste

elimination. The results of this investigation indicate that *B. dalzielii* stem bark may help in the treatment of some illnesses, as previously reported (Romani, 2013).

### Crude protein content

The percentage crude protein as presented in Table 1 was 18.51%, which is significantly higher than that of *M. lucida* leaf, bark, and stem (Seyi et al., 2022). Further proximate analysis of the following species: *V. amygdalina* (18.22%), *C. ambrosioides* (11.30%), *P. nigrescens* (10.20%), *M. lucida* (10.20%), *O. gratissimum* (10.05%), *M. indica* (9.05%), the roots of *L. cuponiodes* (17.55%), *Carpolobia lutea* (15.25%), *Ocoba spinose* roots (17.05%), and *Microdesmis puberula* (16.85%) were all lower than that of *B. dalzielii* stem bark, while *M. inermis* showed a higher percentage. Protein is essential for many bodily processes, including growth, fluid balance, hormone and enzyme production, and the maintenance of a robust immune system. (Adam et al., 2017)

### Carbohydrate content

The carbohydrate content (32.2%) is higher than that of *M. inermis*, milk apples, white apples, and water apples to be 8.65%, 12.68%, and 8.49%, respectively. In comparison to *V. amygdalina*, *M. lucida*, *O. gratissimum*, *C. ambrosioides*, *M. indica*, and *P. nigrescens*, which had carbohydrate contents of 54.00%, 51.66%, 50.6%, 43.76%, 40.23%, and 36.03%, respectively, the stem bark of *B. dalzielii* has a slightly lower carbohydrate content. Further reports revealed a higher content of carbohydrate in the roots of *L. cuponiodes* (45.70%), *Carpolobia lutea* (52.10%), *Microdesmis puberula* (58.85%), and *Ocoba spinose* (51.25%) (Adam et al., 2017). Consequently, the carbohydrate contents place *B. dalzielii* stem bark among plants that are considered good sources of carbohydrate. Carbohydrates play several roles in living organisms, including providing energy. Byproducts of carbohydrates are involved in the immune system, the development of disease, blood clotting, and reproduction.

### Fats content

The percentage fat content is 6.62 percent. Which is lower compared to the *Ocimum gratissimum* plant, which had a crude fat percentage of  $43.51 \pm 0.32$  (Jasha & Petevino, 2016). Similarly, the parentage crude fat observed in *M. lucida* leaf, bark, and stem were 16.19%, 14.45%, and 12.01%, respectively, which were also higher than *B. dalzielii*. Further research carried out showed crude fat for *Aspillia kotschy* to be 0.83%, *cleome* and *laptadenia* leaves 3.00% and 2.83% were relatively lower than *B. dalzielii*. The crude fat percentage (6.62%) observed in this investigation suggests that *B. dalzielii* may not be a very good source of nutritional fat. The consumption of dietary fat and oil provides energy for the body's daily metabolism. (Adam et al., 2017; Keta et al., 2018).

## Conclusion

The essential elements (Zn, Cu, Mn, Fe, Cr, Co, Mo, Ni and I), which were found to be present in the stem bark of *B. dalzielii*, play a significant role as cofactors for certain enzymes that aid metabolism and are involved in the synthesis of some hormones and connecting tissues.

The results have shown higher concentrations above the WHO/FAO standards for zinc (Zn), iron (Fe), and manganese (Mn). Although they are harmless, at higher concentrations they could pose health risks such as zinc intoxication, hemochromatosis, impairment in fertility, kidney stones, etc. This underscores the need to monitor the concentration levels in the extracts administered to patients undergoing traditional medication. Similarly, the results of the proximate analysis depict the potentiality of the plant as a good source of nutraceuticals, especially carbohydrate and protein.

## Recommendations

- Further research can be carried out to isolate bioactive components of the plant and characterize their structures using NMR
- The toxicity assay may be carried out on the extracts to determine the safety level of these medicinal plants for human consumption.
- More so, a comparative analysis should be carried out to compare the potency of the leaves, stems, and roots.
- Drug design and development could be done on the plant considering the wide application of the plant in traditional medicine across different communities.

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