



# Plant Archives

Journal homepage: <http://www.plantarchives.org>  
doi link : <https://doi.org/10.51470/PLANTARCHIVES.2021.v21.S1.213>

## ELEMENTAL COMPOSITION AND PROXIMATE ANALYSIS OF FIVE COMMONLY USED AFRICAN MEDICINAL PLANTS

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### ABSTRACT

The global acceptance of the therapeutic relevance of plants as cure for several diseases is due to the presence of myriad of bioactive phytoconstituents. The five selected plants used in this study include: *Telfairia occidentalis*, *Ocimum gratissimum*, *Vernonia amygdalina*, *Hibiscus sabdariffa* and *Moringa oleifera* traditionally serve as sources of food and nutraceuticals in Nigeria. Therefore, this study was designed to estimate proximate and elemental contents of selected parts of five commonly used African plants collected from African Centre for Herbal Research Institute (ACHRI) farm in University of Ilorin, Ilorin, Nigeria. This was carried out using standard procedures of analysis (proximate analysis) as well as Spectrophotometry and Atomic Absorption Spectrophotometry (elemental analysis). The proximate analysis of the plants revealed that leaves of *Ocimum gratissimum* had the highest (12.65%) moisture content while Calyces of *Hibiscus sabdariffa* had the lowest (9.57%) moisture. The fat content for seeds of *Moringa oleifera* was highest (21.00%) with leaves of *Vernonia amygdalina* having the lowest fat (13.4%). Also, leaves of *Ocimum gratissimum* had the highest contents of Ash and Crude Protein (28.00% and 0.23% respectively), while the lowest concentrations for Ash and Crude Protein were recorded for leaves of *Telfairia occidentalis* (14.00% and 0.11% respectively). Meanwhile, leaves of *Telfairia occidentalis* had the highest crude fibre composition (64.33 %) and the lowest crude fibre was found in seeds of *Moringa oleifera* (17.18 %). All the plants showed various concentrations (in mg/g) for Na, K, Ca, Cu, Fe, Zn, Cr and Ni. Although Pb was absent in three of the five plants, Cd and Cr were present in trace amount. The presence of appreciable quantities of important nutrients in the plants, beneficial in healthcare, supports their popular medicinal use in the management of diseases. Therefore, the plants can be potential sources of nutrients with potential application in foods and nutraceuticals.

**Keywords :** *Telfairia occidentalis*, *Moringa oleifera*, *Vernonia amygdalina*, *Ocimum gratissimum*, *Hibiscus sabdariffa* and proximate analysis

### Introduction

Nature has endowed humanity with a wide variety of plants for exploration as food and medicine. The activity of these plants when consumed as food or taken as drug is dependent on the chemical composition of their component parts (Ekhaise *et al.*, 2010). *Telfairia occidentalis* (family: *Cucurbitaceae*) is popularly known as Fluted pumpkins, Oyster nut, Oil nut, 'Ugwu' (Igbo-Nigeria), 'Ewekoro' (Yoruba-Nigeria) and 'Ikong' (Efik/Ibibio-Nigeria) (Gbile, 1984). *Telfairia occidentalis* is widely cultivated for its palatable and nutritious leaves. The antioxidant property of *T. occidentalis* with high contents of polyphenols especially flavonoids has been reported (Obboh *et al.*, 2010). Various parts of the plant including the leaf and seed have been reported to possess antidiabetic activity (Aderibigbe *et al.*, 1999; Eseyin *et al.*, 2010).

*Ocimum gratissimum* (family: *Lamiaceae*), though indigenous to India, is grown widely in West Africa including Nigeria. It is specifically grown in most compounds in Africa and sold in market places. It has been of great use in different communities for traditional medicinal purposes. It is commonly called Sweet basil or Tea bush. Locally, it is called 'Efinrin' by the Yorubas (Nigeria), 'Nchuanwu' by the Igbos (Nigeria) and 'Ufuo-yibo' in Urhobo (Nigeria) (Elujoba, 2000). It is used to treat different diseases of upper respiratory tract, diarrhoea, headache, skin disease, pneumonia, fever and conjunctivitis (Correa, 1932). Recent studies on *Ocimum gratissimum* suggested that it is infact a useful medication for people living with Human Immune Deficiency Virus (HIV), and Acquired Immune Deficiency Syndrome, AIDS (Elujoba, 2000).

*Vernonia amygdalina* (family: *Asteraceae*), has about 200 species (Audu *et al.*, 2012).

The plant is a shrub of 2 to 5 m with petiolate leaf of about 6 mm diameter and elliptic shape. It is commonly called Bitter leaf (due to its bitterness to the tongue) and locally known in Nigerian languages as *Etidot* (Efik), *Uzi* (Ebir), *Onugbu* (Igbo) and *Chusar duki* (Hausa). Elsewhere in Africa, it is called *Muop* or *Ndole* (Cameroon), *Tuntwano* (Tanzania) and *Mululuza* (Uganda) (Mbang *et al.*, 2008). The leaves are green with a characteristic odour and bitter taste (Audu *et al.*, 2012). *Vernonia amygdalina* leaf is either consumed after extraction as tonic for the treatment of various illness or used as vegetable for cooking African soups (Imaga and Bamigbetan, 2013). The bitter taste is suspected to result from the presence of alkaloids, saponins, tannins and glycoside (Ologunde *et al.*, 1992). The presence of these phytochemicals and its antioxidant activity may be related to its actions against many ailments (Obob and Enobhayisobo, 2009). The leaf extract of *Vernonia amygdalina* is used in medicine as an antimalarial, antimicrobial, laxative, antihelminthic, antithrombotic and antidiabetic agent (Audu *et al.*, 2012). *Vernonia* leaves is also effective in the treatment of parasitic infections (Kigigha and Onyema, 2015). According to Audu *et al.* (2012), the leaves are used traditionally as vegetable to stimulate the digestive system, and to reduce fever.

Roselle, *Hibiscus sabdariffa* (family: *Malvaceae*) is unique and cultivated in many tropical regions for its leaves, seeds, stem and calyces. There are more than 300 tropical and sub-tropical species of *Hibiscus* (Anderson, 2006). *Hibiscus sabdariffa*, which is of African origin, was planted in Sudan about 6000 years ago (McClintock and Tahir, 2004). Roselle takes about six months to mature. The leaves of Roselle plants are divided into three to five lobes and they are arranged on the stem alternately. Each calyx lobe of the Roselle flower has a prominent central rib and two marginal ribs. Flowers are white to pale yellow in colour, with fleshy and soft calyces. The colour of the petals may vary from white to pink, red, orange, purple or yellow (Wilson, 1993). The plant is consumed as hot and cold drinks by a lot of individuals in Nigeria and beyond. The calyces after drying are used to make tea, syrup, jams and jellies which are consumed as beverages (Eslaminejad and Zakaria, 2011). The young leaves and calyces of *Hibiscus sabdariffa* are taken as cooked vegetable or cut and made into vegetable sauce (Amusa, 2004). Ethnobotanical information on *Hibiscus sabdariffa* revealed diuretic, diaphoretic, uricosuric, antibacterial, antifungal agent, mild laxative, sedative, antihypertensive, antitussive, gastrointestinal disorder treatment, hypercholesterolemia treatment, kidney stone treatment, liver damage treatment, agent for decreasing the viscosity of the blood, and agent for treating the after effects of drunkenness (Alarcon-Aguilar *et al.*, 2007). Extracts of *Hibiscus sabdariffa* are used medicinally to treat allergies, toothaches, infections and a host of other diseases. For instance, the juice from Roselle leaves has been used to treat conjunctivitis (McClintock and Tahir, 2004). Similarly, leaves of *Hibiscus sabdariffa* are used as an antiscorbutic for the treatment of scurvy, to relieve fevers, as emollient, diuretic, sedative and can also be applied as a poultice to treat sores and ulcers (Duke, 2009).

*Moringa oleifera* (commonly known as 'Drumstick tree' or 'Horseradish tree'), is the most widely cultivated species of the *Moringaceae* family. *Moringa oleifera* is effective in the management of malnutrition (Gopalakrishnan *et al.*, 2016). It is rich in vitamins due to the significantly

high levels of essential phytochemicals present in its leaves and seeds. Vitamins like beta-carotene of vitamin A, vitamin B such as folic acid, pyridoxine and nicotinic acid, vitamin C, D and E also present in *M. oleifera* (Mbikay, 2012). In fact, moringa is said to provide seven times more vitamin C than oranges, ten times more vitamin A than carrots, seventeen times more calcium than milk, fifteen times more potassium than bananas and twenty five times more iron than spinach (Rockwood *et al.*, 2013). The leaves of *M. oleifera* are rich in minerals like calcium, potassium, zinc, magnesium, iron and copper (Kasolo *et al.*, 2010). The plant contains phytochemicals such as tannins, sterols, terpenoids, flavonoids, saponins, anthraquinones, alkaloids and reducing sugar as well as anti-cancerous agents like glucosinolates, isothiocyanates, glycoside compounds and glycerol-1-9-octadecanoate (Berkovich *et al.*, 2013). *Moringa oleifera* is often said to be relevant in the cure of more than 300 diseases. The presence of potent phytochemicals makes it a good medicinal agent capable of curing more than 300 diseases (Gopalakrishnan *et al.*, 2016). Based on their descriptions and different nutritional and medicinal uses, this research aimed to identify, by means of quantification, the different proportions of compounds and elements present in these plants which can influence and enhance their safety, efficacy of usage, applications and storage.

## Materials and Methods

### Reagents/Chemicals

All reagents used were of analytical grade and are products of British Drug House (BDH) England, E. Merck, Darmstadt, Germany and Aldrich Chemical Company.

### Plant Collection and Extract Preparation

Various plant parts used for this study were freshly collected for the five selected plants from the University of Ilorin African Centre for Herbal Research Ilorin (ACHRI) farm site. They were air-dried at room temperature and pulverized using an electric blender and stored in air tight containers for subsequent use. Exactly 200g of powdered plant parts were macerated in 2L of distilled water for 24 hours with intermittent shaking using orbital shaker. The mixtures were then filtered using Whatman No 1 paper and then lyophilized to give the crude aqueous extracts used for analyses.

### Proximate analyses

This refers to the determination of the major constituents of the medicinal plants' extracts used to assess if a sample is within its normal compositional parameters or has been adulterated. This method partitioned nutrients in the extracts into 5 components: ash, crude protein, fat, and moisture. Exactly 10g of the powdered samples were each exhaustively processed for various parameters as described by AOAC (1990). The methods described by AOAC (2010) were used for the determination of crude fibre, fat, protein, carbohydrate, ash and moisture contents of the plant parts.

### Determination of Moisture content

Moisture is determined by the loss in weight that occurs when the extract is dried to a constant weight in an oven. About 2g of the extract was weighed into a silica dish previously dried and weighed. The sample was then dried in an oven at 65 °C for 36 hours, cooled in a desiccator and

weighed. The drying and weighing continued until a constant weight was achieved.

$$\% \text{ Moisture} = \frac{(\text{Weight of extract + dish before drying}) - (\text{Weight of extract + dish after drying}) \times 100}{\text{Weight of extract taken}}$$

Since the water content of feed varied widely, ingredients and feed are usually compared for their nutrient content on moisture free or dry matter (DM) basis.

$$\% \text{ DM} = 100 - \% \text{ Moisture}$$

#### Determination of Fat content

The ether extracts of the five plants were analysed using the Soxhlet apparatus. About 150 mL of an anhydrous diethyl ether (petroleum ether) of boiling point of 50 °C was placed in the flask. Exactly 5g of the extract was weighed into a thimble plugged with cotton wool and placed into the extractor; the ether in the flask was then heated. As the ether vapour reached the condenser through the side arm of the extractor, it condensed to liquid form and dropped back into the sample in the thimble. The ether soluble substances were dissolved and carried into solution through the siphon tube back into the flask. The extraction continued for at least 4 hours. The thimble was removed and most of the solvent was distilled from the flask into the extractor. The flask was then disconnected and placed in an oven at 65 °C for 4 hours, cooled in a desiccator and weighed.

$$\% \text{ Ether extract} = \frac{(\text{Weight of flask + extract}) - (\text{tare weight of flask}) \times 100}{\text{Weight of extract}}$$

#### Determination of Ash Content

Exactly 5 g of extract accurately weighed in a crucible which has been ignited and tarred. The crucible was placed in a drying oven at 100 °C for 24 hours. The crucible was transferred to a cool muffle furnace and the temperature was increased step wise to 550°C. The temperature was maintained for 8 hours or until a white ash was obtained. If white ash was not obtained after 8 hours, the ash was moistened with distilled water, slowly dried on a hot plate and re-ash at 550 °C to constant weight. The crucible was removed and placed in a desiccator and weighed soon after cooling.

The percentage ash content (wet weight basis) was calculated as follows:

$$\% \text{ ASH (wet)} = \frac{(\text{weight of crucible and ash} - \text{weight of crucible})}{(\text{weight of crucible and extract} - \text{weight of crucible})} \times 100$$

The ash content on dry basis (when moisture content is known) was calculated as follows:

$$\% \text{ ASH (dry)} = \frac{\% \text{ ash (wet)}}{(100 - \% \text{ moisture})} \times 100$$

#### Determination of Crude Fibre

The organic residue left after sequential extraction of feed with ether can be used to determine the crude fibre, however if a fresh sample was used, the fat in it could be extracted by adding petroleum ether, stirred and allowed to settle and decanted. This was done three times. The fat-free material was then transferred into a flask/beaker and 200mL of pre-heated 1.25% H<sub>2</sub>SO<sub>4</sub> was added and the solution was gently boiled for about 30minutes, maintaining constant volume of acid by the addition of hot water. The Buchner flask funnel fitted with Whatman filter was pre-heated by

pouring hot water into the funnel. The boiled acid sample mixture was then filtered hot through the funnel under sufficient suction. The residue was then washed several times with boiling water (until the residue was neutral to litmus paper) and transferred back into the beaker. Then 200 mL of pre-heated 1.25% NaOH was added and boiled for another 30 minutes. Filtered under suction and washed thoroughly with hot water and twice with ethanol. The residue was dried at 65 °C for about 24 hours and weighed. The residue was transferred into a crucible and placed in muffle furnace (400 to 600°C) and ashed for 4 hours, then cooled in desiccators and weighed.

$$\% \text{ Crude fibre} = \frac{(\text{Dry weight of residue before ashing} - \text{weight of residue after ashing}) \times 100}{\text{weight of extract}}$$

#### Determination of Crude Protein

Crude protein is determined by measuring the nitrogen content of the feed and multiplying it by a factor of 6.25. This factor is used because most protein contains 16% nitrogen. Crude protein is determined by Kjeldahl method. The method involves: Digestion, Distillation and Titration.

**Digestion:** About 2g of the extract was weighed into Kjeldahl flask and 25mL of concentrated sulphuric acid, 0.5g of copper sulphate, 5g of sodium sulphate and a speck of selenium tablet were added. Heat in a fume cupboard was applied slowly at first to prevent undue frothing, digestion continued for 45 minutes until the digester became clear pale green. It was left until completely cooled and 100mL of distilled water was rapidly added. The digestion flask was rinsed 2 to 3 times and the rinsing was added to the bulk.

**Distillation:** Distillation apparatus was used for distillation. The distillation apparatus was steamed up and about 10 mL of the digest was added into the apparatus via a funnel and allowed to boil. 10 mL of sodium hydroxide was added from the measuring cylinder so that ammonia was not lost. It was distilled into 50 mL of 2% boric acid containing screened methyl red indicator.

**Titration:** The alkaline ammonium borate formed was titrated directly with 0.1N HCl. The titre value which was the volume of acid used was recorded. The volume of acid used was fitted into the formula which became:

$$\% \text{ N} = \frac{14 \times \text{VA} \times 0.1 \times \text{w} \times 100}{1000 \times 100}$$

Where, VA = volume of acid used, w= weight of sample and %crude protein = %N x 6.25

#### Elemental analyses

Using the procedures described by (Oshodi, 1992), evaluation of micro-mineral (Ca, Cu, Pb, Fe, Zn, Cd, Cr, Ni,) and macro-mineral (Na and K) contents were done using Atomic Absorption Spectrophotometry and Flame Emission Photometry respectively.

#### Estimation of Alkali Metals (Na and K) by Flame Photometry

Sodium and potassium contents of the extracts were estimated using 410 Flame Photometer (Sherwood Scientific, Cambridge UK). Standard solutions of sodium chloride were prepared to set the peak readings for the concentrated solution. The aqueous diluted versions of the extracts were analysed via the sodium optical filter and the sodium



emission intensity were recorded. The sodium filter was replaced with the potassium filter for the potassium analysis of the extracts and the readings were recorded.

### Estimation of Other Metals by Atomic Absorption Spectrophotometer

Other elemental contents (calcium, copper, lead, iron, zinc, cadmium, chromium and nickel) of the extracts were analysed by the 211 ACCUSYS Atomic Absorption Spectrophotometer (Buck Scientific, Connecticut USA).

### Statistical Analysis

All statistical analyses of data were carried out using the IBM Statistical Package for Social Sciences (SPSS version 20). The results were expressed as mean  $\pm$  SEM of three replicates. Statistical significance was determined by analysis of variance (ANOVA). Significant differences between groups were determined in ANOVA using Duncan.

## Results and Discussion

### Results

The % moisture content ranged between 9.57 and 12.64% for the five plant extracts where *Ocimum*

*gratissimum* exhibited the highest moisture content. The % fat content ranged between 13.40 and 21.00% and *Moringa oleifera* had the highest fat content. The % ash content ranged between 14.00 and 28.00% with *Ocimum gratissimum* exhibiting the highest ash content. The % crude protein content ranged between 0.11 and 0.22% with *Ocimum gratissimum* having the highest value. Similarly, % crude fibre was between 17.18 and 64.33 % with leaves of *T. occidentalis* having the highest crude fibre (64.33 %) while the seeds of *M. oleifera* had the lowest crude fibre composition (17.18 %)(Table 1).

The elemental analyses showed that calcium and potassium are the most abundant mineral contents; and ranged between 7.30 $\pm$ 0.12 and 12.50 $\pm$ 0.17 mg/g; 14.0 $\pm$ 0.10 and 36.0 $\pm$ 0.31 mg/g respectively. While the other elemental contents were in trace quantities: sodium (0.02 $\pm$ 0.00 to 2.60 $\pm$ 0.05 mg/g), copper (3.00 $\pm$ 0.10 to 4.10 $\pm$ 0.14 mg/g), lead (0.01 $\pm$ 0.0 mg/g), iron (0.15 $\pm$ 0.01 to 0.60 $\pm$ 0.02 mg/g), zinc (0.23 $\pm$ 0.01 to 0.79 $\pm$ 0.04 mg/g), cadmium (0.0001 $\pm$ 0.0 to 0.004 $\pm$ 0.0 mg/g), chromium (0.002 $\pm$ 0.0 to 0.006 $\pm$ 0.0 mg/g) and nickel (0.001 $\pm$ 0.00 to 0.710 $\pm$ 0.02 mg/g) (Table 2).

**Table 1:** Proximate composition of various parts of five common African medicinal plants

| Sample                        | Moisture         | Fat              | Ash (%)          | Crude Protein   | Crude Fibre      |
|-------------------------------|------------------|------------------|------------------|-----------------|------------------|
| <i>Telfairia occidentalis</i> | 11.33 $\pm$ 0.26 | 15.40 $\pm$ 0.21 | 14.00 $\pm$ 0.21 | 0.11 $\pm$ 0.01 | 64.33 $\pm$ 1.12 |
| <i>Moringa oleifera</i>       | 9.71 $\pm$ 0.11  | 21.00 $\pm$ 0.23 | 20.00 $\pm$ 0.30 | 0.11 $\pm$ 0.01 | 17.18 $\pm$ 0.17 |
| <i>Ocimum gratissimum</i>     | 12.65 $\pm$ 0.20 | 15.40 $\pm$ 0.18 | 28.00 $\pm$ 0.32 | 0.23 $\pm$ 0.02 | 43.51 $\pm$ 0.32 |
| <i>Vernonia amygdalina</i>    | 10.37 $\pm$ 0.20 | 13.40 $\pm$ 0.12 | 24.00 $\pm$ 0.20 | 0.11 $\pm$ 0.01 | 32.93 $\pm$ 0.21 |
| <i>Hibiscus sabdariffa</i>    | 9.57 $\pm$ 0.14  | 16.60 $\pm$ 0.10 | 16.00 $\pm$ 0.16 | 0.21 $\pm$ 0.02 | 26.83 $\pm$ 0.12 |

Values are expressed as mean  $\pm$  SEM of three replicates

**Table 2:** Elemental constituents of various parts of five common African medicinal plants

| Sample                        | Calcium          | Copper          | Lead           | Iron            | Zinc            | Cadmium          | Chromium        | Nickel           | Sodium          | Potassium       |
|-------------------------------|------------------|-----------------|----------------|-----------------|-----------------|------------------|-----------------|------------------|-----------------|-----------------|
|                               | (mg/g)           |                 |                |                 |                 |                  |                 |                  |                 |                 |
| <i>Telfairia occidentalis</i> | 7.30 $\pm$ 0.12  | 3.90 $\pm$ 0.12 | ND*            | 0.60 $\pm$ 0.02 | 0.79 $\pm$ 0.04 | 0.0001 $\pm$ 0.0 | 0.004 $\pm$ 0.0 | 0.500 $\pm$ 0.01 | 0.02 $\pm$ 0.00 | 18.0 $\pm$ 0.21 |
| <i>Moringa oleifera</i>       | 12.50 $\pm$ 0.17 | 3.00 $\pm$ 0.10 | ND*            | 0.15 $\pm$ 0.01 | 0.23 $\pm$ 0.01 | 0.0001 $\pm$ 0.0 | 0.003 $\pm$ 0.0 | 0.001 $\pm$ 0.00 | 2.60 $\pm$ 0.05 | 15.0 $\pm$ 0.20 |
| <i>Ocimum gratissimum</i>     | 10.50 $\pm$ 0.11 | 4.00 $\pm$ 0.12 | ND*            | 0.42 $\pm$ 0.02 | 0.38 $\pm$ 0.01 | 0.004 $\pm$ 0.0  | 0.002 $\pm$ 0.0 | 0.360 $\pm$ 0.01 | 2.40 $\pm$ 0.03 | 36.0 $\pm$ 0.31 |
| <i>Vernonia amygdalina</i>    | 8.60 $\pm$ 0.08  | 4.00 $\pm$ 0.15 | 0.01 $\pm$ 0.0 | 0.46 $\pm$ 0.02 | 0.28 $\pm$ 0.02 | 0.003 $\pm$ 0.0  | 0.002 $\pm$ 0.0 | 0.710 $\pm$ 0.02 | 2.00 $\pm$ 0.03 | 21.0 $\pm$ 0.18 |
| <i>Hibiscus sabdariffa</i>    | 7.60 $\pm$ 0.10  | 4.10 $\pm$ 0.14 | 0.01 $\pm$ 0.0 | 0.31 $\pm$ 0.02 | 0.39 $\pm$ 0.02 | 0.004 $\pm$ 0.0  | 0.006 $\pm$ 0.0 | 0.110 $\pm$ 0.01 | 2.40 $\pm$ 0.04 | 14.0 $\pm$ 0.10 |

Values are expressed as mean  $\pm$  SEM of three replicates; ND\* = Not detected

### Discussion

Proximate and elemental analyses of medicinal plants are ways of profiling them so as to determine the class of chemicals and elements in them which are all associated with their use and authenticity. The nutritional and medicinal activities of plants are a function of these elements and compounds. The goal is to improve their nutritional and medicinal benefits, enhance safety when consumed and provide evidence-based insight as to how the plants should be collected, processed, handled and stored. These constituents vary with the environmental and climatic conditions present in the areas where the plants dwell (Marshall, 1988). Evaluation of the proximate composition of edible plant parts is to establish their nutritional significance since the use of plants and their products is dependent on the

kind and amount of constituents present in them (Almeida *et al.*, 2011).

Moisture content depends on the environmental conditions such as humidity, temperature, harvest time, and climate as well as storage conditions. The moisture contents of plants vary depending on the kind of plant and the plant part in consideration (James *et al.*, 2010). A maximum of 11.33% as obtained in this analysis agrees with results of a similar proximate analysis done by (Asaolu *et al.*, 2012) on various Nigerian leafy vegetables inclusive of three of the five plants assessed in this study. Low moisture content (below 15%) reduces the chance of microbial growth and contamination in these plants upon storage (Adegbe *et al.*, 2016), a desirable stability attribute in herbal products. Similarly, moisture content of food can also enhance the

digestion of digestible fibre in it since this will increase the surface area of food thus allowing for increased enzyme activity.

A fat content of 21% in *Moringa oleifera*, as obtained in this study, is higher than that of all the vegetables considered in the work of (Asaolu et al., 2012) with their fat content ranging between 5.02 and 15.55%. This is in contrary to a fat content of 32.50% obtained from the seeds of *Moringa oleifera* as reported by (Adegbe et al., 2016). It can therefore be inferred that the seed of *Moringa oleifera* is a good source of nutritional fat relative to other plants.

Ash content measures the quantity of minerals (inorganic components) present in plant parts. While some of these minerals may improve nutritional benefits, some of them can inhibit the growth of microorganisms or impact on the physical stability of the plant product (Julian, 2016). Ash is also indicative of high digestibility of the plant (Ibrahim et al., 2010). The very high ash content of 28% obtained for *Ocimum gratissimum* conflicts with the results of similar proximate analysis conducted on the dried plants by (Asaolu et al., 2012). The ash content being significantly higher can be attributed to the soil and environmental conditions of the area of collection of this plant, or possible contamination of the dried plant.

Protein is vital for various body functions such as body development, maintenance of fluid balance, formation of hormones, enzymes and sustaining strong immune function (Mau et al., 1999; Emebu and Anyika, 2011). The levels of protein in these plants were relatively low. However, this low quantity can be relevant as a supplement for the protein energy requirement of the body and in the maintenance of protein-related body functions. The low protein content in these plants may suggest their importance in enzyme formation, instead of being a storage pool for protein energy requirement by the system.

Dietary fibers play numerous biologically roles indigestive disorders, elimination of wastes, cholesterol-lowering, lowering of risk of coronary heart disease, hypertension, constipation, diabetes, colon and breast cancer (Hussain et al., 2009). High fibre content in leaves of *Telfairia occidentalis* may suggest that the leaf may aid in the management of many disorders.

Mineral elements are physiologically important in specific quantities for proper functioning, growth and development of the system (Igwenyi et al., 2014). Mineral element content in plants is dependent on the characteristics of soils (Kruczek, 2005). Mineral elements in plants are responsible for their activities against different diseases because of the correlation between mineral content in the human body with some disease conditions. Similarly, all metalloenzymes (e. g. antioxidant enzymes) require minerals for their activity (Abdulkadir et al., 2011). Calcium plays an important part in the formation of bone, human blood and extra cellular fluid it is necessary for the normal functioning of cardiac muscles, blood coagulation and milk clotting, regulation of cell permeability, nerve-impulse transmission and in the mechanism of the neuromuscular system (Houston and Harper, 2008; Sakina, 2013). Potassium and sodium are intracellular cations that control the electric potential of the body's nerve pressure (Adeyeye and Aye, 2005). Sodium functions to regulate the amount of water retained in the body at any given time, and its passage to and from the cells which

is relevant in various functions of the body. Inadequate  $\text{Na}^+$  and  $\text{K}^+$  which are mostly required in living cells, may lead to inadequate electrolyte balance in blood and poor enzymatic activity (Alli, 2009).

The plants contain an obvious abundance of macronutrients such as calcium, sodium and potassium, as well as biologically relevant quantities of micronutrients. Presence of these physiologically relevant nutrients in all the plants suggests that the plants could be used as nutritionally valuable and healthy ingredients to improve health. Hence, they are therefore recommended for inclusion in diets for nutritional supplementation.

## Conclusion

Proximate and elemental analyses play an important role in understanding the nutritional and medicinal compositions and applications of different plant parts as well as factors that influence their stability and genuity. This analysis revealed that the five plants in consideration: *Telfairia occidentalis*, *Moringaoleifera*, *Vernonia amygdalina*, *Ocimum gratissimum* and *Hibiscus sabdariffa* have low moisture content, low levels of protein, high ash and fat contents, high levels of macronutrients and low levels of trace metals. These plants are therefore edible, nutritionally beneficial and may serve to correct various health anomalies.

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