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Nutritional properties of *Nauclea latifolia* root and leaves

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Abstract

Nauclea latifolia is a medicinal plant that is valuable and native to Africa and Asia. It has served as herbal medicine for treating different ailments and diseases. The importance of herbal plants is not just for their medicinal effects but also their nutritional value. This study determined the proximate, vitamin, and mineral compositions of *N. latifolia* root and leaves using atomic absorption spectroscopy (AAS). The result revealed that *N. latifolia* root has moisture (5.436%), ash (7.377%), crude fat (5.012%), crude fibre (4.769%), crude protein (6.30%), carbohydrate (71.106%), while the leaf contains moisture (4.127%), ash (5.998 %), crude fat (3.998 %), crude fibre (6.713 %), crude protein (11.90 %), and carbohydrates (67.264%). On the other, vitamins A, C, D and E were 28.65 mg/L, 188.165 mg/100g of extract, 42 mg/L, and 23.86 mg/L, respectively, in the root and 15.197 mg/L, 783.20 mg/100 g, 45.60 mg/L, and 14.095 mg/L, respectively in the leaves. The root and leaf mineral content ranges from 0.351 to 8.278 ppm and 0.135 to 7.988 ppm, respectively. *N. latifolia* root and leaves have an appreciable content of vitamins A, C, D, and E. They contain reasonable amounts of minerals like phosphorus, calcium, zinc, ıron, magnesium, sodium and potassium. They could be a good source of carbohydrates, protein, and fibre for the development of the body. Their low ash and moisture contents make their storage easy. Therefore, *N. latifolia* root and leaves will make a good nutrient source for the ever-growing human population

Keywords: *Nauclea latifolia*; Proximate analysis; Vitamin composition; Mineral content; Atomic absorption spectroscopy (AAS)

1. Introduction

The importance of herbal plants is not just for their medicinal purposes but also for consuming their nutrients.[1] Herbal plants constitute an essential part of the human diet in Africa and the world. They provide adequate nutrients, which are essential in reducing the risk of diseases and maintaining good health. They are also rich sources of oil, carbohydrates and proteins depending on the plant consumed.[2,3] Nutrients, commonly regarded as nourishment, provide natural resources for cell growth, proliferation, and energy for powering cellular metabolism.[3]

Nutritional analysis originated in 1861, and since then, it has been continuously developed, modified and improved. Nowadays, almost all food products must have standardized nutritional labels.[4] The nutritional labels state information about the food product's calorific value, total and saturated fat, cholesterol, dietary fibre, sugars, proteins, vitamins, and minerals.[5] It is also crucial for the standardized nutritional labels to present content information on the following six

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constituents: protein, fat, fibre, moisture, ash and carbohydrates, where the constituents generally are known as "proximates", and the process of determining their contents is known as proximate analysis.[4] The proximate analysis of plant materials is significant as it shows the respective percentages of a plant's protein, fat, carbohydrate, fibre, ash, moisture, and dry matter content. Hence, their food value is identified and confirmed.[6] These proximate components are of interest to the food and nutraceutical industries for product development, quality control (QC) or other regulatory purposes.[7]

Nauclea latifolia is a medicinal plant that is native to Africa and Asia. It is mainly found in the tropical rainforest zone and the savanna woodlands in west and central Africa.[8–10] All the plant parts contain nutrients and are helpful, especially in treating diseases known to man.[6] To contribute to the existing knowledge of the nutritional potentials of the plant, we explored the difference in quantities of the nutrients in the root and leaf of *N. Latifolia* obtained from the southeastern part of Nigeria.

2. Material and methods

Laboratory equipment used includes a milling machine (Local miller), analytical weighing balance (OHAUS Model 2610), laboratory oven (Surgienfield Instrument, England), laboratory water bath, atomic absorption spectrophotometer (Varian AA240), UV spectrophotometer, Soxhlet apparatus (SoxtecTM 2050 automated analyzer), muffle furnace, and other apparatuses. All chemicals used were of analytical grade.

2.1. Plant Collection, Identification and Preparation

The root and leaves of *N. latifolia* were collected in mid-July at Nsukka town of Enugu State, South East, Nigeria and authenticated by a plant taxonomist, Mr Felix Nwafor, Department of Pharmacognosy and Environmental Medicine, Faculty of Pharmaceutical Sciences, University of Nigeria, Nsukka, Nigeria. The leaves and roots were washed with water and air-dried at room temperature to a constant weight. The samples were then pulverized to a uniform size using the local milling machine and passed through a 1 mm sieve. The powdered plant materials were stored in newly bought and thoroughly washed airtight plastic containers to prevent contamination and kept on a cool, dry shelf at room temperature before use for analysis.

2.2. Proximate Analysis

2.2.1. Determination of moisture content

The moisture content of the samples was determined according to the AOAC method.[11] Two Petri dishes were washed and dried in the oven for a few minutes and labelled for the two samples (root and leaves of *N. latifolia*). 2 g of each sample were weighed into their respective Petri dishes. The weight of the petri dish and sample was noted before drying each sample in the oven at 100 ^{0}C. Every 30 minutes, the weight of the petri dish and sample was noted until a constant weight was obtained. The percentage of moisture content was calculated using the following equation

$$\% \text{ moisture content } = \frac{W_1 - W_2}{W_3} \text{x } 100 \qquad \text{……..Equation 1}$$

Where

W_1 = weight of Petri dish and sample before drying
W_2 = weight of Petri dish and sample after drying
W_3 = weight of the sample

2.2.2. Determination of ash content

The ash content of the samples was determined according to the AOAC method.[11] Two empty platinum crucibles were washed and dried in an oven for a few minutes. The crucibles were labelled and weighed. About 2 g of each sample was weighed into its platinum crucible and placed in a muffle furnace at 500 ^{o}C for 3 hours. After incinerating, the sample's platinum crucibles were cooled in a desiccator and weighed. The percentage of ash content was calculated as follows:

$$\% \text{ ash content } = \frac{W_3 - W_1}{W_2} \text{x } 100 \qquad \text{……Equation 2}$$

Where

W_1 = weight of the empty platinum crucible
W_2 = weight of the sample
W_3 = weight of platinum crucible and ash after incinerating

2.2.3. Determination of crude fat

The crude fat content of the samples was determined using the AOAC method. [11] 250 mL boiling flasks were washed and dried in an oven at 100 °C for about 30 minutes. The flasks were transferred into a desiccator and allowed to cool. 2 g of each sample were accurately weighed out and transferred into their respective labelled thimbles. The cooled boiling flasks were also weighed and correspondingly labelled. The boiling flasks were each filled with 300 mL of petroleum ether with a boiling point of 40-60 °C and put on the heating mantle. The extraction thimbles were plugged lightly with cotton wool, and the soxhlet apparatus was assembled and refluxed for about 6 hours. The thimbles were removed carefully, and the petroleum ether was collected in the vacuum condenser and drained into a container for re-use. When the flasks were almost free of petroleum ether, they were removed and dried in the oven at 110 °C for 1 hour, then transferred into a desiccator, allowed to cool, and then weighed. The percentage yield of the crude fat content was calculated as follows:

$$\% \text{ Crude fat } = \frac{\text{weight of fat}}{\text{weight of sample}} \text{ x } 100 \text{.....Equation 3}$$

2.2.4. Determination of crude fibre

The crude fibre content of the samples was determined according to the AOAC method. [11] 2 g of samples were weighed into conical flasks containing 200 mL of 1.25 g of sulphuric acid (H_2SO_4) solution per 100 mL separately. The mixture was boiled under reflux for 30 minutes. The solution obtained was filtered through a sieve cloth on a fluted funnel. The residue was washed with boiling water until the washings were no longer acidic. The residue was then transferred to a beaker with 200 mL of a solution containing 1.25 g of carbonate-free sodium hydroxide (NaOH) per 100 mL of distilled water, boiled for 30 minutes, and filtered. The residue was washed with boiling water until the washings were no longer alkaline. The final residue was sieved through a thin but closed pad of washed and ignited asbestos into a gooch crucible and then weighed. It was dried in an oven for 30 minutes at 100 °C. The dried residue was incinerated, allowed to cool and weighed.

Calculation:

$$\% \text{ Crude fibre } = \frac{\text{weight of fibre}}{\text{weight of sample}} \text{x } 100 \text{.....Equation 4}$$

2.2.5. Determination of crude proteins

Crude protein was determined using the Kjeldahl method, which involved three steps. [5] 1 g of each sample was weighed into a 300 mL Kjeldahl flask. 1 g of the Kjeldahl catalyst mixture (copper (II) sulphate and potassium sulphate) and 20 mL of sulphuric acid were added to the sample flask. The flasks were closed with a stopper and shaken. The mixture was heated cautiously in a digestion rack under fire, occasionally swirling until a clear solution was seen. The clear solution was then allowed to stand for 30 minutes to cool. After cooling, it was made up to about 100 mL with distilled water to avoid caking. 5 mL of the solution was transferred to the Kjeldahl distillation apparatus. A 250 mL receiver beaker containing 10 mL of 10% boric acid and indicator mixture (containing five drops of bromocresol blue and one drop of methylene blue) was placed under the condenser of the distillation apparatus so that the tap was about 20 cm inside the beaker. 5 mL of 40% NaOH solution was added to the digested sample solution in the apparatus, and distillation commenced immediately until 50 drops got into the receiver beaker. The content of the receiver beaker was titrated using 0.01 N hydrochloric acid until the pink colour was observed. The titre value reading was taken, and the determination of protein present in the samples was calculated as follows:

$$\% \text{ Nitrogen} = \text{Titre value x } 0.01 \text{ x } 14 \text{ x } 4 \quad \text{.....Equation 5}$$

$$\% \text{ Protein} = \% \text{ Nitrogen x } 6.25 \quad \text{.....Equation 6}$$

2.2.6. Determination of carbohydrates

The carbohydrate content of the samples was determined by a different method[12], which involved adding the percentages of crude protein, crude fibre, moisture content, ash content, and crude fat and subtracting the total from 100%, as shown below,

% Carbohydrate = 100 – (% moisture + % ash + % fibre + % fat + % protein)…… Equation 7

2.3. Determination of Vitamins

2.3.1. Determination of vitamin A

Vitamin A was determined using Kirk and Sawyer's calorimetric method.[13] About 1 g of each sample and standard vitamin A was mixed with 30 mL of absolute ethanol in separate beakers, and 3 mL of 50% potassium hydroxide (KOH) solution was added to each mixture and boiled gently for 30 minutes under reflux. The mixture was filtered and washed with distilled water. From the residue obtained, vitamin A was extracted with 50 mL of diethyl ether thrice. The extract was evaporated to dryness at a low temperature and then dissolved in 10 mL of isopropyl alcohol. 1 mL of the prepared standard vitamin A solution and the dissolved extracts were transferred to separate cuvettes; the respective absorbance was read in a spectrophotometer meter at 325 nm with isopropyl alcohol as reagent blank at zero.

Calculation:

$$\text{The conc. of Vit. A} = \frac{\text{Absorbance of sample}}{\text{Absorbance of standard}} \text{x Concentration of standard Vit. A} \quad \text{……Equation 8}$$

2.3.2. Determination of vitamin E

Vitamin E was determined using the Futter – Mayer Colometric method with the Association of Vitamin Chemists.[13] A 1 g of each sample was mixed with 10 mL of ethanoic sulphuric acid and boiled gently under reflux for 30 minutes. It was transferred to a separating funnel and treated with 30 mL diethyl ether three times, recovering the ether layer each time; the ether extract was transferred to a desiccator and dried for 30 minutes later, evaporated to dryness at room temperature. The dried extracts were dissolved in 10 mL of absolute ethanol. 1 mL of each dissolved extract and an equal volume of standard vitamin E were transferred to separate tubes. 5 mL of absolute ethanol and 1 mL of concentrated nitric acid solution were added, the mixtures were allowed to stand for 5 minutes, and the respective absorbance was measured in a spectrophotometer at 410 nm.

Calculation**:**

$$\text{Conc. of Vitamin E} = \frac{\text{Absorbance of sample}}{\text{Absorbance of standard}} \text{x Concentration of standard Vit. E} \quad \text{Equation 9}$$

2.3.3. Determination of vitamin C

Vitamin C content was determined by the titrimetric method reported by Kirk and Sawyer.[13] About 2 g of each powdered sample was weighed and homogenized in 6% EDTA solution. The homogenates were filtered, and the filtrates were used for the analysis. 20 mL of 30% potassium iodide (KI) solution was added to each filtrate, and each mixture was titrated against 0.1 M copper(II) sulphate ($CuSO_4$) solution. A black colouration marked the endpoint. KI solution as reagent blank was also titrated, and the readings were taken.

Vitamin C content was calculated based on the relationship below 1 mL of 0.1 M $CuSO_4$ = 0.88 mg vitamin C. The concentration of ascorbic acid in the samples was calculated and expressed as mg/100 g of the sample

$$\text{Vitamin C mg/100g} = \frac{100 \text{ x } 0.88 \text{ x (titre} - \text{blank)}}{\text{weight of sample}} \quad \text{……..Equation 10}$$

2.3.4. Determination of vitamin D

The experiment was carried out in the dark to avoid photolysis of vitamin D once the spectrum was complete. 5 g of the sample was homogenized and saponified with 2.5 mL of alcoholic KOH in a water bath at 60 ^{o}C for 30 minutes. The saponified extract was transferred to a separating funnel containing 15 mL of petroleum ether and mixed well. The lower aqueous layer was collected and transferred to another separating funnel, while the upper petroleum ether layer was collected into a beaker. The extraction was repeated until the aqueous layer became colourless. A small amount of anhydrous sodium hydroxide was added to the petroleum ether extract to remove excess moisture. The final volume of the petroleum ether extract was noted. The absorbance of the yellow-coloured petroleum ether extract was read in a spectrophotometer at 450 nm using petroleum ether as blank.

Calculation:

$$\text{Amount of vitamin D} = \frac{\text{Absorbance 450 x volume of the sample x 100 x 4}}{\text{weight of sample}} \text{..... Equation 11}$$

2.4. Analysis of Minerals

2 g of the powdered samples of *N. latifolia* root and leaves were weighed and transferred into two separate beakers. Aqua regia was prepared by adding concentrated nitric acid (HNO_3), H_2SO_4 and perchloric acid. Each sample was digested with 20 mL of aqua regia and stirred. The sample mixtures were heated for 20 minutes. After heating, 30 mL of distilled water was added to each sample and filtered. The filtrates were used for the analysis using atomic absorption spectroscopy. The standard mineral solutions of ıron (Fe), magnesium (Mg), sodium (Na), zinc (Zn), calcium (Ca), potassium (K), and phosphorous (P) in the optimum concentration range were prepared. These reference solutions were prepared by diluting the single stock element solutions (1000 ppm) with 200 mL of 2 N HNO_3.

Minerals analysis was done according to the American Public Health Association (APHA) method[14] using a Varian AA 240 atomic absorption spectrophotometer with an air/acetylene flame and respective hollow-cathode lamps composed of the elements for absorbance measurements. Each metal has its characteristic absorption wavelength. The wavelengths used for the elements were as follows: 213.9 nm (zinc), 422.7 nm (calcium), 589 nm (sodium), 248.3 nm (iron), 285.2 nm (magnesium), 766.5 nm (potassium), and 420 nm (phosphorus). Calibration and measurement of absorbance of each element against a blank at its unique wavelength were prepared. After the preparation of calibration curves for each component, the absorbance of each element in each filtrate was read at its wavelength from the spectrophotometer and its concentration in the *N. latifolia* root and leaf samples was extrapolated from the standard curve.

3. Results

Table 1 Proximate composition of *N. latifolia* root and leaves

Proximates	Root (%)	Leaves (%)
Moisture content	5.436 ± 2.32	4.127 ± 1.33
Ash content	7.377 ± 0.98	5.998 ± 1.58
Crude fat content	5.012 ± 1.82	3.998 ± 1.42
Crude fibre content	4.769 ± 3.56	6.713 ± 3.88
Crude protein content	6.30 ± 0.15	11.90 ± 1.66
Carbohydrate content	71.106 ± 10.98	67.264 ± 8.99

Table 2 Vitamin composition of *N. latifolia* root and leaves

Vitamins	Root (mg/100g)	Leaves (mg/100g)
A	28.647 ± 1.15	15.197 ± 0.96
C	188.165 ± 1.08	783.20 ± 1.56
D	42 ± 0.98	45.60 ± 1.00
E	23.857 ± 1.03	14.095 ± 0.66

Table 3 Mineral composition of *N. latifolia* root and leaves

Minerals	Root (ppm)	Leaves (ppm)
Iron (Fe)	0.452	0.135
Magnesium (Mg)	4.909	5.139
Sodium (Na)	0.351	0.193
Zinc (Zn)	0.378	0.322
Calcium (Ca)	6.784	7.289
Potassium (K)	5.378	6.289
Phosphorous (P)	8.278	7.988

4. Discussion

4.1. Proximate composition of N. latifolia root and leaves

From the results in Table 1, the leaves *N. latifolia* had a lower moisture content (4.127%) than the root (5.436%). High moisture content shows that the plant can be a good water source for the body cells[15]. However, regarding natural product stability, high moisture content promotes microbial contamination and chemical degradation as it provides a medium for many reactions to occur[16]. Therefore, a low moisture content of samples allows for a longer shelf life.[17] Nevertheless, the moisture content of the leaves and root of *N. latifolia* obtained in this study was low compared with 11.29% and 12.48% previously reported for *N. latifolia* leaves and root, respectively, 68.93% for the leaves obtained in another study[6], and within BP specified limits of ≤ 6%.

The amount of ash content obtained in the root and leaves of *N. latifolia* was 7.377 and 5.998%, respectively, as shown in (Table 1). Ash content is generally recognized as a measure of quality for assessing the functional properties of foods.[16] Measuring ash content is essential because mineral matter may be the cause of the pharmacological effect of the plant.[15] Low ash content reveals low inorganic content/adulterants[17]; high ash content in plants suggests high mineral content and improved nutritional quality. However, this might not always be the case; it could be the reverse if the plant contains toxic metals that contribute to the percentage of ash content.[12]

Table 1 shows that crude fat content was 3.998 and 5.012% for *N. latifolia* leaves and roots, respectively. Generally, leafy vegetables are known for their low lipid content.[6] Low-fat content in plants reveals that the plant is not an oil species.[17] Leafy vegetables are poor sources of lipids; therefore, the increase in the consumption of vegetables would naturally lower fat intake.[15] The acceptable macronutrient ranges (its percentage of energy) for fat is 20 – 35%.[19] The fat content of the root was low compared to the 32.04% reported elsewhere for *N. latifolia* root.[1]

The crude fibre of *N. latifolia* root and leaves was found to be 4.769 and 6.713%, respectively, as shown in Table 1. The fibre content is higher in the leaves and lower in the root. The high fibre content of plants causes drawbacks in human nutrition as they cause intestinal irritation and are low in nutrient availability as humans cannot digest them easily.[6] Recent studies have found an association between high-fibre diets and a lower incidence of cardiovascular diseases risk of coronary disease, hypertension, diabetes and large bowel cancers.[19,20] Hence, plant fibre is an integral part of a diet. The moderate amount of fibre found in *N. latifolia* leaves has shown that it is suitable to be added to a diet to keep the body safe from these diseases.

The roots' and leaves' protein content was 6.30 and 11.90%, respectively. The protein content of the leaves was higher than the 8.65% reported by Jide and Adenike[17] but close to the value (12.51%) reported by Eze and Obinwa[6] for *N. latifolia* leaves. The acceptable macronutrient range (per cent of energy) for protein is 5 – 3%[18]; the protein content of *N. latifolia* root and leaves obtained in this study was within limits. This shows that the leaves of *N. latifolia* have a good protein content value, proving its use as a rich source of protein supplement for animals fed with the plant leaves practised in many parts of Africa.[6]

The carbohydrate content found in *N. latifolia* root and leaves, as shown in Table 1, was 71.106 and 67.264%, respectively. The acceptable macronutrient range (per cent of energy) for carbohydrates is 45 – 65 %[18]; the carbohydrate content of the samples was a little above the normal limits. Carbohydrates are essential nutrients required

for a balanced diet. An adequate quantity is required for optimum function of the brain, heart, nervous and immune systems[12] as they supply energy to the brain cells, muscles and blood.[16] Since *N. latifolia* root (71.106%) and leaves (67.264%) have high carbohydrate content, their consumption could provide the body with the fuel and energy required for daily activities. The estimated carbohydrate content for the root (71.106%) and leaves (67.264%) of *N. Latifolia* was higher compared to 62.90 and 55.80% for the same plant reported by Jide and Adenike.[17]

4.2. Vitamin composition of *N. latifolia* root and leaves

Humans cannot synthesize most vitamins, with few exceptions. Therefore, we need to obtain them from food and supplements.[5] Vitamin A, also called retinol, belongs to the fat-soluble vitamin class. It plays a vital role in eye adjustment to light changes, bone growth, tooth development, reproduction, cell division, gene expression, and immune system regulation.[21] The recommended dietary allowance (RDA) for vitamin A is 600 - 900 µg/day for adults, while its tolerable upper intake level (TUL) is 3,000 µg.[22] Vitamin A in the root (28.65 mg/L) and leaves (15.20 mg/L) of *N. latifolia* is present in moderate amounts but significantly greater than the recommended dietary allowance, so it can satisfy the RDA if taken in a reasonable quantity.

Vitamin C was found to have a concentration of 188.17 mg/100 g and 783.20 mg/100 g in *N. latifolia* root and leaves, respectively, as shown in Table 2. *N. latifolia* leaves have a higher content of vitamin C than root. Vitamin C (ascorbic acid), a water-soluble vitamin, is essential for iron absorption and collagen synthesis. It also helps heal wounds and bone formation while improving overall immune function.[23] The recommended dietary allowance (RDA) for Vitamin C is 45 – 90 mg/day.[18] The vitamin C content in both *N. latifolia* root and leaves is very high compared to the standard RDA. However, it can be supplemented in the diet in small amounts.

From the results in Table 2, the Vitamin D content in the roots and leaves of *N. latifolia* was found to be 42 and 45 mg/L, respectively. Vitamin D benefits the body by playing a role in immunity, controlling cell growth and may protect against osteoporosis, cancer, and other diseases. Children especially need adequate vitamin D to develop strong bones and healthy teeth.[24] The adequate intake (AI) for vitamin D is set at 5 – 20 µg/day, while its tolerable upper intake level (UL) is 50 µg for people nine years of age and older.[18] The *N. latifolia* roots and leaves having a content of 42 and 45 mg/L, respectively, show that vitamin D is significantly higher than the AI standard but below the UL standard. The plant could be a good source of dietary vitamin D to overcome the nutritional deficiency of vitamin D if supplemented in the diet.

Vitamin E, also known as tocopherol, benefits the body by acting as an antioxidant and helps protect vitamins A and C, red blood cells, and essential fatty acids from destruction. It might help prevent heart disease and cancer.[24] The vitamin E content in the root (23.86 mg/L) and leaves (14.10 mg/L), as shown in Table 3, is high when compared to the recommended dietary allowance (RDA) of Vitamin E, which is 11 – 15 mg/day.[18] Conversely, vitamin E's tolerable upper intake level (UL) ranges from 200 – 300 mg for children and 600 – 1000 mg for adults.[22] Consuming vitamin E above the RDA does not result in any added benefits nor pose a risk for toxicity, especially from food.

Vitamins A, C, D, and E are well-known antioxidants, and many studies show a link between regularly eating an antioxidant-rich diet and a lower risk of heart disease, cancer, Alzheimer's disease, and several other diseases.[21,22]

4.3. Mineral composition of N. latifolia root and leaves

Minerals are inorganic substances present in all body tissues and fluids. Their presence is required to maintain specific physical and chemical processes essential to life.[12]

Iron is essential for haemoglobin formation. Iron deficiency anaemia is characterized by insufficient oxygen-carrying capacity, a common nutritional problem affecting many people worldwide.[17]. Iron's recommended dietary allowance (RDA) is 8 – 18 mg/day.[18] The amount of iron found in *N. latifolia* root and leaves was 0.453 and 0.135 mg/L, below the standard RDA. Its presence in the plant indicates that it could be a good source of dietary iron to overcome the nutritional deficiency of iron if supplemented in a sufficient quantity.

Magnesium is an essential mineral, and its many functions include helping with muscle and nerve function, regulating blood pressure, and supporting the immune system. Getting enough of this mineral can also help prevent or treat chronic diseases, including Alzheimer's disease, type 2 diabetes, cardiovascular disease, and migraine.[24] The magnesium content of the root and leaves of *N. latifolia* was 4.909 and 5.139 mg/L, respectively. The values obtained were low to meet the recommended daily allowance (RDA) of 80 – 400 mg/day.[2]

Zinc helps form many enzymes, which function in energy metabolism and wound healing. It also helps in DNA synthesis, storage, release, and function of insulin and the development of sexual organs and bones.[2,17] Zn's standard

recommended dietary allowance (RDA) is 12 – 35 mg/day for adults and 3 – 5 mg/day for children.[19] The zinc content of the root and leaves of *N. Latifolia* obtained in this study was significantly low compared to the standard RDA but can satisfy the dietary allowance if taken sufficiently.

Calcium is found in the skeletons and helps form and maintain bone, blood clotting and muscle contraction.[16] The standard adequate ıntake of calcium is 0.21 – 1.2 g/day[18]; calcium content present in both the root (6.784 mg/L) and leaves (7.289 mg/L) of *N. latifolia* was lower than the adequate intake.

Sodium and potassium are involved in body water and acid-base balance and are the major extracellular and intracellular minerals. They are also involved in the transport of some non-electrolytes in the body.[17] Na's standard adequate ıntake is 1.5 g/day, while K's standard adequate ıntake is 3 – 4.7 g/day.[18] The Na and K content of *N. latifolia* root and leaves, as shown in Table 3, were significantly lower than the standard requirement. Still, its presence in the plant signifies that *N. latifolia* can be a source of sodium and potassium if taken adequately.

The high potassium content compared to sodium led to a low Na/K ratio, which is favourable from a nutritional point of view, as diets with a low Na/K ratio are associated with a lower incidence of hypertension and arteriosclerosis.[16] This may explain the rationale behind the use of the plant as herbs in managing hypertension, as reported by Odey *et al*.[25]

Phosphorus was found to be the most abundant mineral element present in the plant. Phosphorus is essential in bone and teeth formation.[17] The concentration of phosphorus in the root (8.278 ppm) and leaves (7.988 ppm) of *N. latifolia* can contribute to human nutrition for phosphorus intake if taken in adequate amounts since the RDA of phosphorus is 700 mg[19], which is significantly higher than the content determined in the samples

5. Conclusion

This study revealed that *Nauclea latifolia* root and leaves examined have an appreciable vitamin A, C, D, and E content. The plant has low ash content, contains a good amount of minerals, including phosphorus, calcium, zinc, iron, magnesium, sodium and potassium, and could be a good source of carbohydrates, protein and fibre for the development of the body. The results of this research work have shown the nutritional potential of *N. latifolia*. Thus, *N. latifolia* root and leaves could be of nutritional benefit and can be exploited in nutraceuticals.

Compliance with ethical standards

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Disclosure of conflict of interest

The authors confirm that there are no known conflicts of interest.

References

[1] Egbung GE, Atangwho IJ, Iwara IA, et al. Chemical composition of root and stem bark extracts of Nauclea latifolia. Sch Res Libr. 2013;5(3):193-196.

[2] Achikanu CE, Ude CM, Ugwuokolie OC. Determination of the vitamin and mineral composition of common leafy vegetables in southeastern Nigeria. Int J Curr Microbiol Appl Sci ·. 2013;2(11):347-353.

[3] Chen Y, Michalak M, Agellon LB. Importance of Nutrients and Nutrient Metabolism on Human Health. YALE J Biol Med. 2018;91:95-103.

[4] BÜCHI Labortechnik. Guidebook to Proximate Analysis. News & Analysis on Food & Beverage Development. Published 2020. Accessed March 12, 2022. https://www.foodnavigator.com

[5] Nielsen S. Food Analysis.; 4th edition; Springer New York Dordrecht Heidelberg London, 2010. doi:10.1007/978-1-4419-1478-1

[6] Eze OS, Obinwa E. Phytochemical and Nutrient Evaluation of the Leaves and Fruits of *Nauclea latifolia* (Uvuru-ilu) Commun Appl Sci. 2014;2(1):8-24. http://infinitypress.info/index.php/cas/article/view/368

[7] Thangaraj P. Proximate Composition Analysis. In: Thangaraj P, ed. Pharmacological Assays of Plant-Based Natural Products. Vol 71. Springer International Publishing; 2016:21-31. doi:10.1007/978-3-319-26811-8

[8] Iheagwam FN, Israel EN, Kayode KO, Decampos OC, Ogunlana OO, Chinedu SN. *Nauclea latifolia* Sm . Leaf Extracts Extenuates Free Radicals, Inflammation, and Diabetes-Linked Enzymes. Hindawi Oxidative Med Cell Longev. 2020;2020:1-13. doi: 10.1155/2020/5612486

[9] Olusola SE. The phytochemical screening and antibacterial potential of African peach *Nauclea latifolia* leave extracts against some clinical isolates of pathogenic bacteria from Clarias gariepinus. COAST J Fac Sci. 2020;1(2):164-171.

[10] Ottah C., Etuk E., Bello S., Bilbis L, Ndodo N., Otta V. Antıoxıdant capacıty and dna damage protectıve actıvıty of the root extract of Nauclea latıfolıa. World J Pharm Res. 2018;7(9):22-32. doi:10.20959/wjpr20189-11838

[11] AOAC. Methods of Analysis: 18th Ed. Washington, DC: Association of Official Analytical Chemists, 2005.

[12] Aletan UI, Kwazo HA. Analysis of the Proximate Composition, Anti-Nutrients and Mineral Content of Maerua Crassifolia Leaves. Niger J Basic Appl Sci. 2019;27(1):89-96.

[13] Kirk RS, Sawyer R. Pearson's Composition and Analysis of Foods (9th ed.). London: Addison-Wesley Longman, Inc. Chapter 2 & 14, 1991.

[14] American Public Health Association. Cold–Vapour Atomic Absorption Spectrometric Method: Standard Methods for the Examination of Water and Wastewater. 20th Edition, Inc. Washington DC USA. 1995.

[15] Achi NK, Onyeabo C, Ekeleme-egedigwe CA, Onyeanula JC. Phytochemical, Proximate Analysis, Vitamin and Mineral Composition of Aqueous Extract of Ficus capensis leaves in South Eastern Nigeria. J Appl Pharm Sci. 2017;7(03):117-122. doi:10.7324/JAPS.2017.70319

[16] Ooi D, Iqbal S, Ismail M. Proximate Composition, Nutritional Attributes and Mineral Composition of Peperomia pellucida L. (Ketumpangan Air) Grown in Malaysia. Molecules. 2012;17:11139-11145. doi:10.3390/molecules170911139

[17] Jide FF, Adenike AO. Comparative Nutritional Compositions of the Leaves , Bark and Root of Nauclea latifolia. J Med Biol Sci Res. 2016;2(7):127-130.

[18] Institute of Medicine. Dietary Reference Intakes for Energy, Carbohydrates, Fiber, Fat, Fatty Acids, Cholesterol, Protein, and Amino Acids (Macronutrients). The National Academic Press; 2005. doi:10.17226/10490

[19] Adebayo EA, Oloke JK, Aina DA, Bora TC, Adegoke E. Antıoxıdant and nutrıtıonal ımportance of some pleurotus specıes. J Microbiol Biotechnol Food Sci. 2014;3(4):289-294.

[20] Gbadamosi I, Kalejaye AO. Comparison of the antioxidant activity, phytochemical and nutritional contents of two antihypertensive ethnomedicinal plants. Ife J Sci. 2017;19(1):147-158. doi: 10.4314/ijs.v19i1.15

[21] Ravisankar P, Reddy AA, Nagalakshmi B, Sai O, Kumar BV, Anvith PS. The Comprehensive Review on Fat Soluble Vitamins. IOSR J Pharm. 2015;5(11):12-28.

[22] Clifford J, Kozil A. Fat-Soluble Vitamins : A, D, E, and K.; Colorado: Colorado State University; 2021. pp: 1- 5, 9.315

[23] Alma L. Fat-Soluble vs Water-Soluble Vitamins. Very well health. 2021. Accessed March 8 2022. https://www.verywellhealth.com/fat-vs-water-soluble-998218?print.

[24] Akram M, Munir N, Daniyal M. Vitamins and Minerals : Types, Sources and Their Functions, (Egbuna C, Dable-Tupas G, eds.). Springer Nature; 2020. doi:10.1007/978-3-030-42319-3

[25] Odey MO, Johnson JT, Iwara IA, et al. Effect of antihypertensive treatment with root and stem bark extracts of *Nauclea latifolia* on serum lipid profile. G. J. P&A Sc and Tech. 2012; 2(4): 78-84.