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Proximate, phytochemical and micronutrient compositions of *Dialium guineense* and *Napoleona imperialis* plant parts

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Abstract

The aim of this study was to assess the proximate, phytochemicals and micronutrient analysis of *Dialium guineense* and *Napoleona imperialis* plant parts. The proximate, phytochemicals and micronutrient analysis of *Dialium guineense* and *Napoleona imperialis* plant parts were analyzed using standard methods. The qualitative and quantitative findings showed the presence of rich bioactive compounds such as alkaloid (0.11-0.98%), saponin (0.21-0.99%), tannin (0.10-0.99)%, flavonoid (0.11-0.88)%, glycoside (0.001-0.089)%, quinone (0.003-0.89)%, steroid (0.10-0.89) % and reducing sugar (0.0005-0.99)%. The proximate analysis revealed that the dominant components were ash *D. guineense* (73.6-90%) and *N. imperialis* (94.7-95.45%), moisture - *D. guineense* (5.8-20%) and *N. imperialis* (7.6-25%), while carbohydrate, protein, fibre and fat contents were relatively low. The vitamin content of the different parts of *D. guineense* and *N. imperialis* showed that a total of 6 vitamins were present. Vitamin C showed the highest concentration between 0.57 and 0.98 mg/ml, while vitamin D between 0.02 and 0.06 mg/ml showed the lowest concentration. Among the analyzed minerals, magnesium content was the highest (0.12-0.87) mg/100 g followed by calcium (0.054-0.56) mg/100 g and zinc (0.04-0.09) mg/100 g; however, the other elements were found at very low amounts. The plant samples were shown to possess significant amount of nutrients and phytochemicals, suggesting its beneficial effect in enhancing metabolic processes via enzyme activation hence its ethno-medicinal potential.

Keywords: Proximate; Phytochemicals; Micronutrient; Plant parts; Vitamins

1. Introduction

Velvet tamarind also known as black velvet is a common name for *Dialium guineense*, a genus of a legume belonging to the family of Fabaceae and sub-family of Caesalpinioideae. The pulp of the fruit is edible and sweet, with fairly low levels of ascorbic acid and tannin. It is a fairly good source of protein and minerals [1]. Velvet tamarind (*Dialium guineense*) can be found in West African countries such as Ghana where it is known as Yoyi, Sierra Leone, Senegal, and Nigeria where it is known as Awin in Yoruba, Icheku in Igbo and Tsamiyar kurm in Hausa [2]. The fruits are widely sold in local markets and are consumed fresh by people of all ages as a snack. Some elderly people consume non-alcoholic drink made from the fruit. *Dialium guineense* pulp flour is found to have desirable physicochemical and sensory properties which may predispose it as a useful raw material for food industries, especially for the production of highly-sought-after candy [3]. The flowers and leaves are eaten as vegetables and the gum obtained from the seed is added to many kinds of food in Japan to improve their viscosity [4]. The bark is used as chewing stick (indigenous tooth brush) among Nigerian populace [2]. Different parts of the tree have been used in folkloric medicine for treatment of different diseases: the bark in cancer, headache, and pains. Ovuakporie-Uvo *et al.*, [5] reported the usefulness of the bark for oral hygiene and stomach ache among the Esan tribe of Edo state; the leaves are used as a remedy in fever, prenatal pains and edema;

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the fruits in diarrhoea, bronchitis, severe cough, wound, stomach ache, malaria [2]. The fruits of the plant are chewed among some women in south-east Nigeria to improve lactation and check genital infection, vitamin C, presence of antioxidants [2, 6]. Previous studies have shown that the plant contains saponins which are presumed to add to the cleaning effect of teeth and at the same time prevent carries and plaque [7].

Napoleona imperialis belongs to the family of Lecythidaceae that grows in all regions of Nigeria and other parts of West Africa [8]. *Napoleona imperialis P. Beauv* is the most widespread Napoleona in Nigeria. This small evergreen tropical West African plant is commonly known as Ntum in Ikwuano of Ibo language, Ukpakonrisa in Edo, Obu-anagbo and Otukuche in Igala, Nkpodu, all in Nigeria. It can also be found in places such as Benin Republic, Gabon, Democratic Republic of Congo, Southward of Angola as well as Nigeria [9].

Some species of *Napoleona* such as, *N. imperialis P. Beauv., N. vogelli Hook* and *N. gossweileri Baker F*. are economically important [9]. Though *Napoleona imperialis* is one of the lesser-known plants, its economic importance has partially been reported by Nwaehujor et al. [8]. These include the use of the leaves for medicinal purposes and the twigs as traditional chew sticks. It has been reported that, different parts of the plant are used for different purposes in different regions; mulching and fodder (leaves and twigs); and firewood, chewing sticks and ethnomedicine (stem and root). The sweet pulp around the seeds is eaten especially by children. The juice from the fruits and pods are consumed by many while the seeds are discarded [10]. The seeds have very low human food preference or any industrial use as of now and could therefore form an alternative feed ingredient for livestock production [11, 12]. The phytochemicals readily found in *N. imperialis* include; glycosides, tannins, proteins, and saponins. The roots of *N. imperialis* have been reported to contain important phytochemicals such as alkaloids, flavonoids, tannins, steroids, glycoside, saponins, carbohydrate, resin and proteins, and possess anti-oxidant and free-radical scavenging properties [13]. They are significant as medicinal plants and sources of food but no detailed comparative work on these species has been done to date. Several reports have shown that *N. imperialis* has anti-bacterial, wound healing, anti-hypertensive, anti-implantation, and abortifacient properties. The leaves show the presence of cyanide, glycosides, tannins, proteins, and saponins. Though, *N. imperialis* is one of the lesser-known plants, its economic importance has partially been reported [8, 14, 15]. A proper understanding of their proximate mineral and nutrient compositions will lower the over dependence of many communities and industries on few arable crops for vegetables and herbal drugs. In addition, knowledge of their composition would enable one to know the better type of vegetables to eat or feed to animals at any given time. Hence, this study was carried out to establish the presence of proximate, phytochemical and micronutrients of *D. guineense* and *N. imperialis*.

2. Material and methods

2.1. Collection and processing of plant materials

The different parts of *D. guineense and N. imperialis* were harvested from Nkanu community in Enugu State. The two plants were identified by a taxonomist Mr Alfred Ozioko of the International Centre for Ethnomedicine and Drug Development Nsukka, Enugu State. The different parts (fruit pulp, leaves, stem barks and roots) of *D. guineense and N.imperialis* were washed with distilled water thrice to remove impurities while the fruits were carefully de-capped and seeds removed. The plant materials were air-dried in a well-ventilated room for four weeks, until they became friable. The fruit pulp, leaves, roots and stem bark were pulverized individually using mortar and pestle and were transferred into a pre-cleaned air tight container until further use.

2.2. Proximate Analysis

The proximate analysis of the plant samples was determined using standard analytical methods [16].

2.2.1. Total ash content

This was done by the furnace incineration gravimetric methods. 5.0 g of each sample was measured into a pre- weighed porcelain crucible. The samples were burnt to ashes in a muffle furnace at 550^{o}C until they became completed ashed, they were cooled in desiccator and weighed. The percentage ash content was calculated as thus:

$$Ash\ (\%) = \frac{W_2 - W_3}{W_2 - W_1} * 100$$

Where,
W_{1_2}= weight of empty crucible;

W_2= Weight of crucible + sample before ashing;
W_3= Weight of crucible + sample after ashing.

2.2.2. Moisture content

Porcelain/silica crucible was washed thoroughly and dried in the oven. 5.0 g of each sample was weighed into a pre-weighed, pre-dried and cooled crucible, and then placed in the oven to dry at 150°C for 2 hr until a constant weight was obtained. The crucible and were allowed to cool in a desiccator before weighing. The percentage moisture content was calculated using the equation below:

$$Moisture\ (\%) = \frac{W_2 - W_3}{W_2 - W_1} * 100$$

Where,
W_1 = weight of empty crucible;
W_2= weight of empty crucible + sample before drying;
W_3 = weight of crucible + sample after drying.

2.2.3. Crude fibre

5 g of each of the sample was boiled in 150 ml of 1.25% of H_2SO_4 solution for 30 minutes under reflux. The boiled sample was washed in several portions of hot water using a two- fold cloth to trap the particles. It was returned to the flash and boiled again in 150 ml of 1.25% Na0H for another 30 minutes under same condition. After washing in several portion of hot water the sample was allowed to drain, dried before and transferred to a pre-weighed crucible where it was dried in the oven at 105ºC. It was then placed in a muffle furnace where it was burnt. The percentage crude fibre content was calculated as follows:

$$Crude\ fibre\ (\%) = \frac{W_2 - W_3}{W_2 - W_1} * 100$$

Where,
W_1= Weight of sample;
W_2 = Weight of crucible + sample after washing, boiling and drying;
W_3= weight of crucible + sample ash.

2.2.4. Crude fat

This was determined by solvent extraction gravimetric method. 5 g of each of the sample was wrapped in a Whatman filter paper and put in a thimble. The thimble placed in a Soxhlet reflux flask and mounted unto a weighed extraction flask containing 200 ml of petroleum ether. The upper of the reflux flask was connected to a water condenser. The solvent (petroleum ether) was heated, vaporized and condensed into the reflux flask. This process was repeated for 4 hr before the defatted sample was removed, the solvent recovered and the oil extract was left in the flask. The flask (containing) the oil extract was dried in the oven at 60ºC for 30 minutes to remove any residual solvent. It was cooled in a desiccator and weighed. The percentage weight of fat extract was determined as:

$$Fat\ (\%) = \frac{W_2 - W_3}{W_2 - W_1} * 100$$

Where
W_1=weight of empty extraction flask;
W_2= weight of flask + sample before defatting;
W_3= weight of flask + fat extract.

2.2.5. Carbohydrates

One gram each of the sample was dissolved with 100 ml of distilled. After the filtration process, 10 ml of the filtrate was transferred to a separate test tube labeled as test tube A. From test tube A; 5 ml was taken from it, with addition of another 5 ml of distilled water and transferred into a separate test tube labeled as test tube B. It was done repeatedly to test tube C. 2 ml of biuret reagent was added to each of the test tubes. The solution was allowed to stand for 5 min. The absorbance was read on the spectrophotometer at 630 nm.

Preparation of stock/ standard solution

0.5 g of glucose was dissolved in 100 ml of distilled water. After filtration process, 10 ml of the filtrate was transferred into a separate test tube labelled as test tube A. from test tube A, 5 ml was taken from it with addition of 5 ml of distilled water it was transferred into a separate test tube labelled as test tube B. it was done repeatedly to test tube C, D and E respectively. 2 ml of biuret reagent was added to each of the test tubes. The solution was allowed to stand for 5 min. Before it was taken to spectrophotometer in order to take the absorbance at 630 nm.
The graph of the absorbance was plotted against the concentration.
The molar absorptivity of the known sample was used to trace the carbohydrate content of the sample.

2.2.6. Protein content

Finely ground 0.5 g sample was weighed into a Kjeldahl digestion flask and anhydrous $NaSO_4$ and 1 g of $CuSO_4$ added. 20 mL of conc. H_2SO_4 was also added and the mixture allowed digesting by heating under a fume cupboard until a clear solution was obtained. The digest was carefully transferred into a distillation flask and 100 mL of distilled water, 60 mL of 40% NaOH and piece of zinc added to digest in the distillation. The mixture was then distilled into a 250 mL conical flask containing 4% boric acid, 100 mL distilled water and 3 drops of screen methyl indicator. A total of 250 mL distillate was collected and titrated against 0.1 M HCl. The experiment was done in triplicate to reduce experimental error and the values generated were used to calculate the percentage of crude protein in the sample. The nitrogen content and hence the protein content was calculated using the formula below.

1ml of NH_2SO_4 = 14 mg

$$\text{Protein (\%) } N_2 \text{ (\%)} \times 6.25$$

$$N_2(\%) = \frac{100 * N14Vt * T.B}{W * 1000 * VA}$$

Where
W= Weight of sample of sample (0.5g);
N= Normality of titrant (0.02N H2S04);
Vt= total digest volume (100ml);
T= sample titre value;
B= blank titre value.

2.3. Qualitative Phytochemical Ananlysis

The qualitative phytochemical analysis of the plant samples was determined as described previously [17].

2.4. Quantitative Phytochemical Analysis

2.4.1. Determination of Alkaloid content

Applying alkaline precipitation gravimetric method, 5.0 g of the sample was weighed out into a conical flask; 200 ml of 10% acetic acid in ethanol was measured out and added into the conical flask containing the sample. The mixture was allowed to stand at room temperature for 4 hours before it was filtered through a filter paper. The filtrate was then reduced to a quarter of its original volume by evaporation over a steam bath. The alkaloid in the extract was precipitated by drop wise addition of concentrated NH_4OH until full turbidity was obtained. The precipitate was washed with 1% NH_4OH solution, dried in the oven at 100°C for an hour; it was cooled in a desiccator and reweighed. By difference, the weight of alkaloid was determined and expressed as a percentage of the sample analyzed [18].

2.4.2. Determination of Flavonoid

Using ethyl acetate precipitation method, 20 g of the sample was weighed out and hydrolyzed by boiling in 100 mL of 2M hydrochloric acid solution for about 35 min. The hydrolysate was filtered to recover the filtrate which was treated with ethylacetate. The precipitated flavonoid was recovered by filtration using weighed filter paper (W_1). After drying in the oven at 100ºC for 30 min, it was cooled in a desiccator and reweighed (W_2). The values gotten were used to calculate the percentage of flavonoid in the sample [18].

2.4.3. Determination of tannin content

5 g of the finely ground sample was weighed and transferred into 250 mL conical flask and 50 mL of distilled water added and shook vigorously for an hour. The resulting solution was filtered into a volumetric flask and 5 mL of the filtrate pipetted out into a test tube. 0.1g of tannic acid was dissolved in 100 mL of water to form tannic acid solution. 5 mL of the tannic acid solution was pipetted out into another 50 ml volumetric flask. A blank sample was also prepared using 5 ml of distilled water. The three samples were incubated for 1.5 hours at 20 – 300C and the sample was then filled with distilled water up to mark of 50 mL of the volumetric flask. The absorbance of the three samples was measured at 760 nm using spectronic 21D. The values generated were used to calculate the tannin content [18].

2.4.4. Determination of saponin

Using double solvent extraction method, 20 g of the finely ground sample was weighed out into a conical flask. 100 mL of 20% aqueous ethanol was added into the sample, it was heated over a water bath for 4hrs with continuous stirring at about 55 °C. The mixture was filtered and the residue re- extracted with another 100 mL of 20% ethanol. The combined extract was reduced to about 40 mL over a water bath at 90ºC, and the concentrate transferred into 250 mL separating funnel and 40 mL of pet-ether was added and shook vigorously. Separation was by partition during which the ether layer was discarded and the aqueous layer reserved. Saponin was extracted with 60 mL of normal butanol. The combined extract was washed with 5% aqueous NaCl solution, and evaporated to dryness in a pre-weighed beaker (W_1) and was dried at 60ºC in the oven and reweighed (W_2). The saponin content was determined by difference and calculated as a percentage of the original sample [18].

2.4.5. Determination of Phenol content of the sample

Using the spectrophotometric method described previously, 5 g of the finely ground sample was weighed out into a conical flask, and 50 mL of petroleum ether measured out and added into the same conical flask, and left to stand for 3 hr. The mixture was filtered to obtain the residue. 50 mL of diethyl ether was added into the residue, the mixture was covered and heated in a water bath for 15 minutes. 5 mL of the extract was pipetted into a 50 mL flask, followed by 10 mL distilled water and 2 mL ammonium hydroxide solution. The mixtures were made up to mark and left to react for 30 min for colour development. This was measured at 505 nm; the values generated were used to calculate the phenol content [18].

2.4.6. Determination of Hydrogen Cyanide

20 g of each of the sample was weighed into different conical flasks containing 200 mL of distilled water and allowed to stand for 2 hr. The cyanide was distilled into a 20 mL of 10% NaOH solution by the aid of a condenser, 25 mL of the distillate was pipetted out, 25 mL of distilled water and 25 ml of NH_3 solution were added into the distillate. It was titrated against 0.1M $AgNO_3$ and a persistent yellow colour observed. The titer value gotten was used to calculate the HCN content [18].

2.5. Vitamins Determination

The vitamins were determined by the dry ash extraction method using atomic absorption spectrometry (AAS) [16].

2.5.1. Wet digestion of sample

1 g of each of the dried sample was weighed out into a digestion flask and 20 ml of the acid mixture of (650 ml conc. HNO_3, 80 ml perchoricacid, and 20 ml concentrated H_2SO_4) was added. The mixture was heated until a clear digest was obtained. The digest was diluted with distilled water to the 25 ml mark, appropriate dilutions were then made for each element.

2.6. Mineral content determination

Determination of iron, zinc, calcium, chromium, manganese, magnesium by atomic absorption spectrometry (ASS) principle [18]. In this technique the atom of an element was vaporized and atomized in the flame. The atoms then absorbed the light at a characteristic wavelength. The source of the light is a hollow cathode lamp, which is made up of the same element, to be determined. The lamp produces radiation of an appropriate wavelength, which while passing through the flame is absorbed by a photo- detector read out system. The amount of energy absorbed is proportional to the concentration of the element in the sample.

3. Results

3.1. Proximate analysis

The proximate analysis as shown in Figure 1 revealed that *N. imperialis* dried root part contains the highest percentage of ash (95.45%) while *N*. *imperialis* dried stem bark part has the lowest percentage ash content (73.68%). For the moisture content, the highest percentage (25%) was observed in *N. imperialis* dried stem bark part, and the lowest percentage was observed In *D. guineense* dried leaf part (5.8%). Highest percentage of carbohydrate was found in *D. guineense* dried root part (1.08%) and lowest in *N. imperialis* dried leaf part (0.016%). For protein content, highest percentage was observed in *N. imperialis* dried stem part (1.00%) and lowest in *D. guineense* dried leaf part (0.09%). Highest percentage of crude fibre content was found in *D. guineense* dried root part (0.9%) and lowest in *D. guineense* dried pulp part (0.11%). The fat content was highest in *N. imperialis* dried leaf part (0.77%) and lowest in *D. guineense* dried pulp part (0.23%).

3.2. Qualitative phytochemical of the dried plant parts *D. guineense* and *N. imperialis*

Table 1 indicates the preliminary phytochemical results of the dried plant parts of D. guineense and N. imperialis. We observed the presence of alkaloid, saponin, flavonoid, tannin, phenol and steroid in all the dried plant part at various degrees, while quinone was present in all the dried plant part except D. guineense dried leaf part. Glycoside and reducingsugar were present in D. guineense dried root, pulp, stem bark parts and absent in the rest.

3.3. Quantitative phytochemical

Quantitative phytochemical analysis as shown in Figure 2 revealed that the presence of alkaloid with the highest percentage in both *D. guineense* dried root part (0.89 mg/g) and *N. imperialis* dried stem bark part (0.89 mg/g), while lowest percentage in both *N. imperialis* dried leaf part and *N. imperialis* dried root part (0.11 mg/g). Saponin had the highest percentage in *D. guineense* dried pulp part (0.99 mg/g) and lowest in *D. guineense* and *N. imperialis* dried leaf parts respectively (0.21 mg/g). For glycoside, the highest percentage occurred in *D. guineense* dried pulp part (0.885 mg/g) and lowest in *D. guineense* dried leaf part and *N. imperialis* dried stem bark part respectively (0.001 mg/g). Flavonoid had the highest percentage in *D. guineense* dried leaf part (0.88%) and the lowest percentage in *N. imperialis* leaf part (0.11 mg/g). The percentage of quinone was highest in *D. guineense* dried pulp part (0.89 mg/g) and lowest in *D. guineense* dried leaf part (0.003 mg/g). For tannin, the percentage was highest in *D. guineense* dried pulp part (0.10 mg/g) and lowest in *D. guineense* dried leaf part (0.99 mg/g). Steroid had the highest percentage inboth *D. guineense* dried pulp and leaf parts and lowest percentage in *D. guineense* dried root part (0.10 mg/g). Finally, reducing sugar had the highest percentage in *D. guineense* dried pulp part (0.87 mg/g) and lowest percentage in *N. imperialis* stem bark part (0.0005 mg/g).

3.4. Vitamin's composition of the different dried parts of *D. guineense* and *N. imperialis*

Vitamins analysis as shown in Figure 3 revealed vitamin D to have the highest percentage (0.06%) in *D. guineense* dried leaf part followed by *N. imperialis* dried stem bark part (0.05%) and lowest percentage (0.018%) in *D. guineense* dried root part. Vitamin A had the highest percentage (0.94%) in *N. imperialis* dried root part, followed by *D. guineense* leaf dried part (0.09%) and lowest percentage (0.23%) in *D. guineense* dried stem bark part. Vitamin B6 had the highest percentage content (0.89%) in *N. imperialis* dried leaf part, followed by *N. imperialis* dried root part (0.54%) and lowest percentage content (0.23%) in *D. guineense* dried leaf part but absent in *D. guineense* dried root part. For Vitamin B12, the highest percentage was found in *N. imperialis* dried leaf part (0.66%), followed by *N. imperialis* dried stem bark part (0.65%) and (0.12%) in *D. guineense* dried root part.Vitamin C had the highest percentage in *D. guineense* dried root part (0.98%), followed by *N. imperialis* dried stem bark part (0.93%) and *N. imperialis* dried leaf part (0.57%). Vitamin E was highest in *D. guineense* dried leaf part (0.77%), followed by *N. imperialis* in both dried stem bark (0.67%) and root part (0.67%) and lowest in *D. guineense* dried root part (0.34%).

3.5. Mineral composition of the different dried parts of *D. guineense* and *N. imperialis*

Figure 4 revealed the different percentages of the minerals present in the dried plant samples. Iron (Fe) composition was seen to be highest in *D. guineense* dried root part (0.52 mg/g) and lowest composition in *D. guineense* dried stem bark part (0.025 mg/g). Zinc (Zn) was highest in D*. guineense* dried root part (0.09 mg/g) and lowest in *D. guineense* dried pulp part (0.04 mg/g). Calcium (Ca) had the highest composition in *N. imprialis* dried root part (0.56 mg/g) and lowest composition was observed in *D. guineense* stem bark part (0.015 mg/g). Chromium (Cr) had the highest composition in *D. guineense* dried pulp part (0.08 mg/g) and lowest composition in *D. guineense* dried stem bark part (0.00004 mg/g). Potassium (K) was highest in *N. imprialis* dried leaf part (0.98 mg/g) and lowest in *D. guineense* stem

bark part (0.45 mg/g) but was absent in *D. guineense* and *N. imprialis* dried root parts. *D. guineense* dried pulp part had the highest composition (0.0007 mg/g) of manganese (Mn), while *N. imprialis* dried leaf part had the lowest composition (0.0001 mg/g), but was absent in *D. guineense* and *N. imprialis* dried root parts. Magnsium (Mg) was absent in *D. guineense* and *N. imprialis* dried root parts, *N. imprialis* dried stem bark part (0.89 mg/g) had the highest composition while *D. guineense* dried pulp part had the lowest composition (0.12 mg/g). Phosphorus (P) had the highest composition in *D. guineense* dried pulp part (0.67 mg/g) and the lowest composition in *D. guineense* dried stem bark part (0.34 mg/g). Sodium (Na) had the highest composition in *D. guineense* dried leaf part (0.56 mg/g) and lowest composition in *N. imprialis* dried stem bark part (0.34 mg/g).

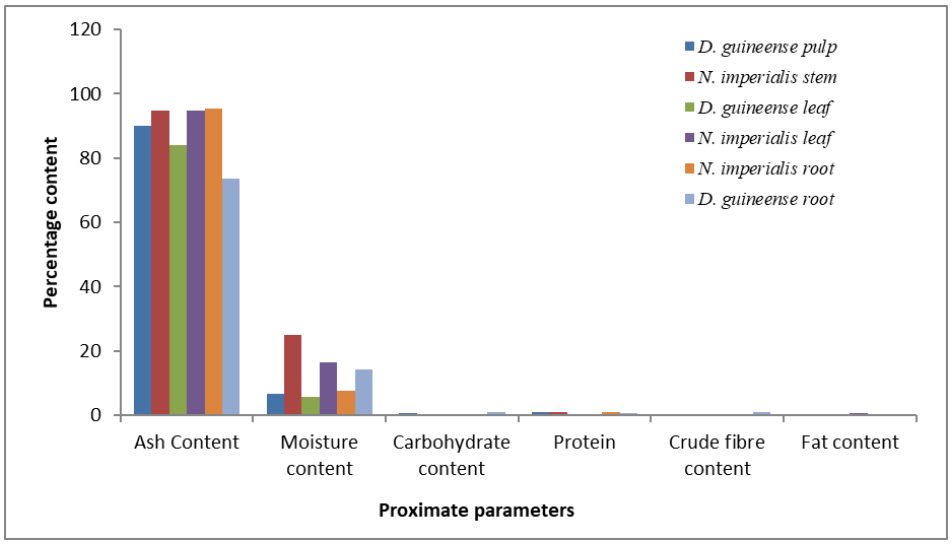


Figure 1 Proximate analysis of the different dried parts of *D. guineense* and *N. imperialis*

Table 1 Qualitative phytochemical analysis of the different dried parts of *D. guineense* and *N. imperialis*

Plant Sample	Alkaloid	Saponin	Glycoside	Flavonoid	Tanin	Phenol	Steriod	Reducing Sugar	Quinone
D. guineense Root	+ +	+ +	+	+	+ + +	+	+ + +	+	+ +
D. guineense Leaf	+	+ +	Nil	+ + +	+ + +	+	++ +	Nil	Nil
D. guineense Pulp	+ + +	+ + +	+ + +	+ + +	+ + +	++ +	+ + +	+	+ + +
N. imperialis Stem	+ + +	+ + +	Nil	+ +	+ +	+ +	+ +	Nil	+ +
N. imperialis Leaf	+	+	Nil	+	+ + +	+	+ +	Nil	+
D. guineense Stem	+ ++	+ + +	+	+	+ + +	+	+	+	+
N. imperialis Root	+	+ +	Nil	+	+ + +	+	+	Nil	+

+ Indicates Low + + Indicates Moderate + + + Indicates High

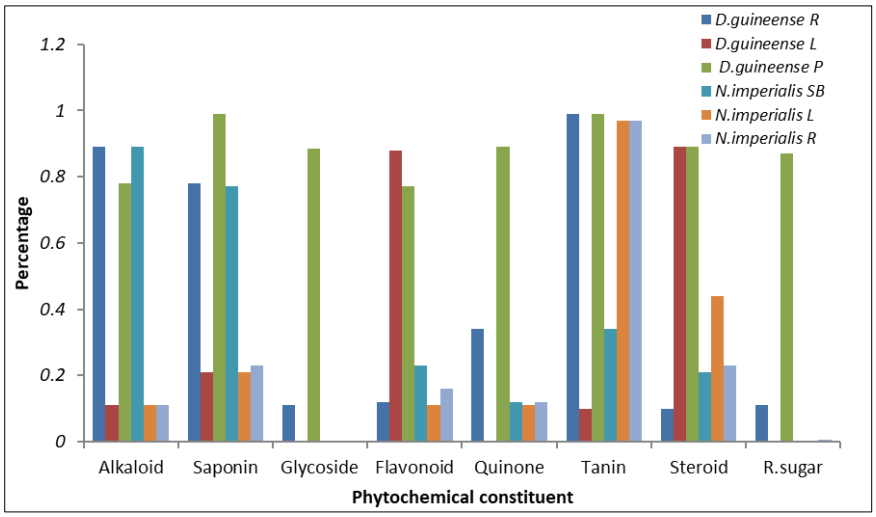
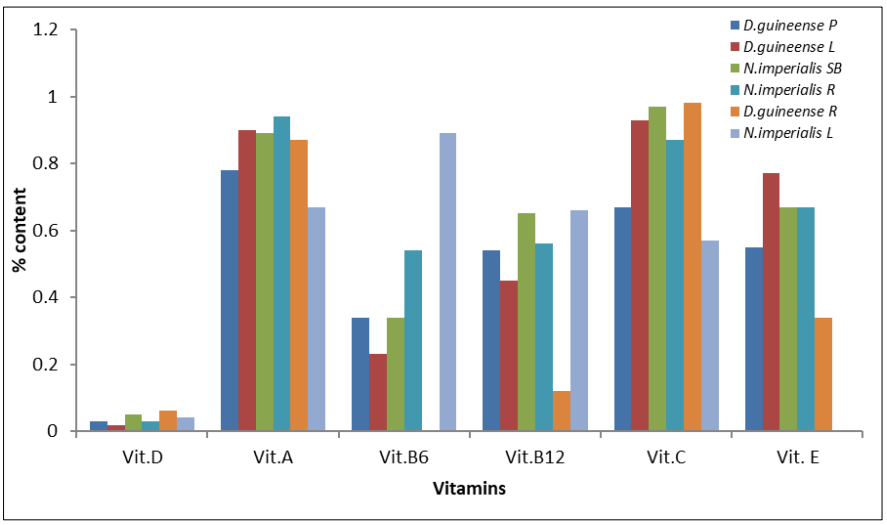
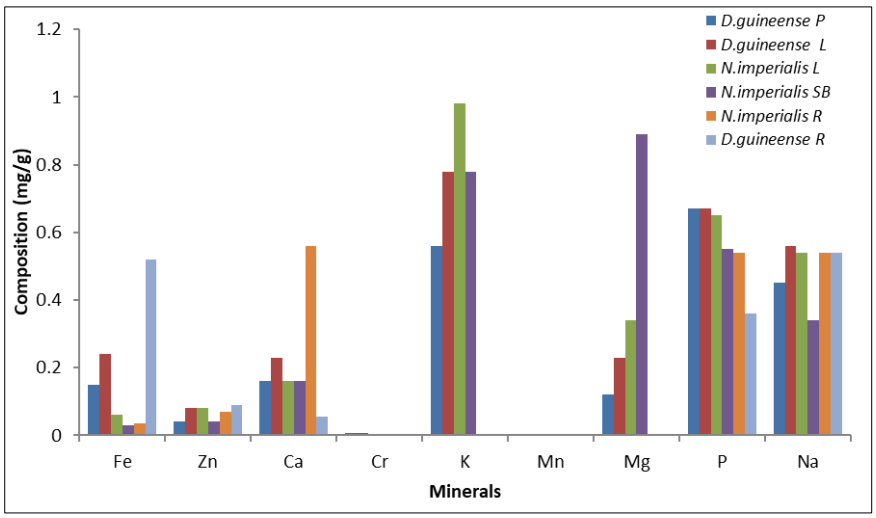


Figure 2 Quantitative phytochemical analysis of the different dried parts of *D. guineense* and *N. imperialis*



P-pulp, L-leaf, SB-stem bark and R-root

Figure 3 Vitamin composition of the different dried parts of *D. guineense* and *N. imperialis*



P-pulp, L-leaf, SB-stem bark and R-root

Figure 4 Mineral composition of the different dried parts of *D. guineense* and *N. imperialis*

4. Discussion

The results from Fig 1 revealed that the dominant components of the proximate analysis were ash *D. guineense* (73.6-90%) and that of *N*. *imperialis* (94.7-95.45%) and moisture *D. guineense* (5.8-20%) and that of *N. imperialis* (7.6-25%), while carbohydrate, protein, fibre and fat contents were relatively lower. Literature searches have revealed that ash content levels is an indication of the level of the inorganic matter present. They are also expected to facilitate the metabolic processes, growth and development while moisture contents display more information about the storage/shelf life and the viability of microorganism growth. Carbohydrates can regulate nerve tissue. Proteins, on the other hand, can serve as enzymatic catalyst, growth control and cell differentiation.

The result shows that the moisture content of the different parts *D. guineense* ranges from 5.8-20% while that of *N. napoleona* ranges from 7.6-25%. This was moderately high when compared to the moisture content of legumes, which ranges between 7.0 and 11.0% [19]. The high moisture content of this sample implies that storage for a longer period will lead to spoilage, since higher moisture content could lead to food spoilage through increased microbial action [20]. The result also indicates that the protein content of the different parts of *D. guineense* ranges from 0.09-0.9%, while that of *N. imperialis* ranges from 0.13-1.00%. This is extremely lower than in such protein rich food as beans, cowpea, pigeon peas, melon and pumpkin all ranging between 23.1 – 33.0 % [21]**.** It can be deduced from the study that the low level of protein in this wild fruit could be due to high level of moisture content [22].

The carbohydrate content of different parts of *D. guineense* ranging from 0.45-1.08% was recorded, while that of *N. imperialis* ranges from 0.02-0.2% and that is extremely low compared with the acceptable values for legumes 20 – 60% of dry weight [21]. The low carbohydrate value of the sample could be due to high levels of moisture [22].

The proximate composition gives crude fat of the different parts of *D. guineense* ranging from 0.23-0.67%, while that of *N. imperialis* ranges from 0.24-0.27%. This is extremely lower than values reported for soya beans, cashew nut and *beniseed* which are 23.5%, 36.7% and 42.3% respectively [23]. It can therefore be said that the level of fat in this wild fruit is good as it is within the accepted range described by Committee on Food Protection, National Academy of Sciences, Washington D. C. [24].

The crude fibre of the different parts of *D. guineense* recorded a value range from 0.11-0.90% and that of *N*. *imperialis* ranging from 0.12-0.45% which is moderately lower than the value reported for African *elemi* pulp with 1.39% respectively [25]. Vanhauwaert et al. [26] reported that diet low in fibre was undesirable.

The ash content of the different parts of *D. guineense* were determined ranging from 73.6-90% and that of *N*. *imperialis* ranging from 94.7-95.45% which is extremely higher than the reported values of 3.7% and 4.2% for sesame and canarium album respectively [27]. The result implied that *D. guineense* and *N*. *imperialis* are good sources of minerals.

The qualitative phytochemical analysis of the different plant parts of *D. guineense* and *N*. *imperialis* from Table 1 revealed the presence of alkaloid, saponins, tannins, phenol, flavonoids and steroids. This is in agreement with the findings of Enweani et al. [28]. Glycoside was present in the root, stem bark and heavily present in the pulp of *D. guineense* while it was absent in *D. guineense* leaf *as well as* different parts of *N*. *imperialis*. This is contrary to the findings of Okerulu et al. [29]. On the other hand, reducing sugar was also present in all the different parts of *D. guineense* and absent in all the different parts of *N*. *imperialis.* The quantitative phytochemical analysis of the different plant parts of *D. guineense* and *N*. *imperialis* indicates that alkaloids, saponins, tannins, phenol, flavonoids and steroids were found in all the different parts of *D. guineense* and *N*. *imperialis* at various degrees. The alkaloid content recorded for the *D. guineense and N. imperialis plant parts range from 0.11-0.98%*, this is similar to the value of 0.850% reported for African *elemi* pulp [25], but above the permissible limit of 20 mg/100g, equivalent to 0.04% [30, 31].

Alkaloids are the most efficient therapeutically significant plant substances. Pure, isolated and synthetic derivatives are used as basic medicinal agent because of their analgesic, antiplasmodium and bacterial properties. Caution should be taken in the consumption of plant materials with very high concentration of alkaloid because they could inhibit certain mammalian enzymes activities such as those of cyclic adenosine monophosphate (AMP) [32]. European Food Safety Authority (EFSA) [33] stated that since cooking only lowers alkaloid content of foods by 40 – 50%, highly sensitive individuals should avoid this category of food entirely. Thus, as high as 0.8% alkaloid content of *D. guineense and N. imperialis* fruit implies that it is toxic and should be boiled or cooked to reduce the percentage alkaloid.

The quantitative phytochemical result indicates saponin content of the different parts of *D. guineense and N. imperialis to range from 0.21-0.99%. This is in line with the findings of* Igidi and Edene, [27] when compared to the value of 0.75% reported for the fruit of *Napoleona vogelii* and 0.68% reported for the *N. imperialis* seed [34]. A high saponin diet can

inhibit dental and platelet aggregation in treatment of hypercalciuria in human (excessive urinary calcium excretion, an antidote against acute lead poisoning) [35]. Saponin also decreases blood lipids, lower cancer risks and blood glucose response as well as possess antioxidant activity. Toxicology studies of saponin using relevant experimental models have established that even at an upper concentration of 3.5%, saponin was safe and failed to cause systemic side effect [27].

The tannins content of the different parts of *D. guineense* showed a value that range from 0.10 to 0.99%, while that of *N*. *imperialis* range from 0.34 to 0.97%. The presence of tannins implied that the leaf has astringent properties, quickens the healing of wound and inflamed mucous membrane [36], anti-microbial properties and protecting the kidney from inflammation [37]. This supports its folkoric uses. The high tannin content in the sample also implies severe nutritional challenge to animals or humans due to its affinity for certain digestive enzymes.

The phytochemical result also showed that the flavonoid content of different parts of *D. guineense* ranges from 0.12 to 0.88%, and *N*. *imperialis* range from 0.11 to 0.23%. This value is moderately lower when compared to the value of 1.0% reported for African *elemi* pulp [27]. However, George et al [38] reported that high amounts of flavonoid help protect blood vessels from rupture or leakage, enhance the power of vitamin C; protect cells from oxygen damage and prevent excessive inflammation.

High amounts of flavonoid do not appear to cause unwanted side effects. The level of flavonoid found in the different parts of *D. guineense* and *N*. *imperialis* show that they are essential for human consumption [27]. It inferred that the plant has biological functions such as protection against allergies, inflammation free radical, palate aggregation, microbes, ulcer and strong anticancer activities [36].

For the vitamin content, a total of 6 vitamins were present. Vitamin C showed the highest concentration between 0.57 and 0.98 mg/ml, while vitamin D between 0.02 and 0.06 mg/ml showed the lowest concentration. The result revealed that the different parts of *D*. *guineense* and *N*. *imperialis* contained 0.23-0.94 mg/ml of vitamin A, which apart from helping in growth, also promote resistance to disease, delays aging, and preside over the health of the eyes, nails and hairs [37]. The samples contained the B complex vitamin B6 which range from 0.23 to 0.89 mg/ml, and B12 between 0.12 and 0.66 mg/ml which was required for normal growth, functioning of the heart and nervous system, eyes, formation of co-enzyme for cellular respiration [39]. The sample contains vitamin C (0.57-0.98 mg/ml). The extracts of leaves and seed coat have been reported to be very rich in vitamin C [40], which helps in the health of lungs and bronchia, teeth and gums, bones and joints and purifies the blood. It prevents the free radical damage that triggers the inflammatory cascade and associated with reduced severity of inflammatory conditions such as asthma, osteoarthritis and rheumatoid arthritis [41]. Therefore, it could be used in the herbal medicine for the treatment of common cold and prostate cancer [40]. Presence of antioxidant and vitamin C makes it an ideal food additive to boost the body's immunity level [2]. It also contains vitamin E (0.34-0.77mg/ml) which is a good antioxidant, necessary for the formation of red blood cells and the structure, recovery and maintenance of muscle and other tissues [42].

From table 3 above, among the analyzed minerals, magnesium content was the highest, at about (0.12-0.87) mg/100g, followed by calcium (0.054-0.56) mg/100 g and zinc (0.04-0.09) mg/100 g; however, the other elements were found at very low amounts. All the analyzed minerals were present in all parts of the plants except potassium, manganese and magnesium which were absent in the plant roots. Potassium, phosphorus, sodium and magnesium contents were higher than the rest, ranging from 0.02-0.98, 0.34-0.89, 0.34-0.56 and 0.02-0.89 mg/g respectively, however, the other elements were found at very low amounts. The presence of magnesium in the sample provides its usefulness for the reactions involved in converting vitamin D to its active form and therefore, leading to the formation of adenosine triphosphate (ATP), as constituent to release parathyroid hormone and to relax the muscles [43]. Another important element found in the different parts of the plants, calcium, is known to help ease insomnia, regulate the passage of nutrients through cell walls and stimulate muscle [44]. The considerable concentration of zinc gives significant value to *D*. *guineense* and *N*. *imperialis*, because this element could be required by the body to maintain the proper functioning of the smell sense, to keep the immune system healthy, to build proteins, to trigger enzymes and also to create DNA. The obtained results were very close to those found by ElMostafa et al [45]. Iron is an essential trace element for haemoglobin formation, normal functioning of the central nervous system and oxidation of carbohydrates, protein and fats [46]. The iron content of *D. guineense and N. imperialis* range from 0.25 to 0.89 mg/g which is similar to the values reported for some cultivated vegetables such as lettuce (0.7 mg/100 g) and cabbage (0.3 mg/100 g). This shows that different parts of *D. guineense* and *N*. *imperialis* could be a potential source of iron supplement for human and livestock and also help in boosting of the blood level in anemic conditions [47].

5. Conclusion

The plant samples were shown to possess significant amount of nutrients and phytochemicals such as saponins, tannins, flavonoids, alkaloids, glycosides, etc. These findings are interesting essentially at the present time where the problems of emerging and re-emerging resistant strains of microorganism are becoming the order of the day and will lower the over dependence of many communities and industries on few arable crops for vegetables and herbal drugs.

Remarkably, *D. guineense* and *N*. *imperialis* plants are readily available in Nigeria and at lower cost. Owing to this fact, there ought to be a monitory strategy for the consumption of the fruits as many women and others do consume this fruit to an endless point. Further researches could be done to investigate the toxicity effect of the fruit of *D*. *guineense* and *N*. *imperialis*.

Compliance with ethical standards

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Disclosure of conflict of interest

No conflict of interest.

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