Comparative Evaluation of Nutritional and Phytochemical Profiling of Seeds and Leaves of Dennettia tripetala for Pharmacological Applications

Julius Gbenga Omosebi[1], Mercy Kikelomo Omosebi[2], Hawawu Alake Olorunoje[3]

[1]Department of Applied Chemistry, The Federal Polytechnic, Ado-Ekiti, Nigeria

[2] The National Association of Science and Technology Students (NASTES), Nigeria

[3] Department of Science Laboratory Technology, The Federal Polytechnic, Ado-Ekiti, Nigeria

*Corresponding Author E-mail: omosebi_jg@fedpolyado.edu.ng

ABSTRACT

Medicinal herbs and plant foods have been recognized for a long time as a major source of nutrients and bioactive constituents that fight against diseases and promote good health. There is need to explore the nutritional potential and nutraceutical value of plants, hence, this study assesses and compare the nutritional and phytochemical profiles of pepper fruit (Dennettia tripetala) seeds and leaves using standard analytical procedures. The results of the proximate analysis show that the leaves contain moisture 11.13%, ash 5.17%, fat 7.65%, crude fiber 9.18%, protein 15.21% and carbohydrate 51.66% while the seeds show moisture 10.77%, ash 4.84%, fat 4.52%, crude fiber 8.31%, protein 12.85% and carbohydrate 58.71%. Mineral analysis show that the seeds contain potassium (362.40 ppm), Ca (116.65 ppm), sodium (102.55 ppm), magnesium (28.29 ppm), zinc (1.25 ppm), iron (0.55 ppm) and copper (0.51 ppm) while the leaves have potassium (415.60 ppm), Ca (190.65 ppm), sodium (81.65 ppm), magnesium (33.53 ppm), zinc (1.78 ppm), iron (0.88 ppm) and copper (0.33 ppm). The result of phytochemical screening shows that the seeds and leaves contain alkaloids, tannins, flavonoids, terpenoids and cardiac glycosides. However, saponin, steroids and anthraquinones were present in the seeds but absent in the leaves while reducing sugar is present only in the leaves. In addition, phlobotannins are absent in both the seeds and leaves. The findings revealed that both the seeds and leaves of contains vital sources of phytochemicals and nutrients. The seeds show a distinct bioactive constituent which mark it

therapeutic uses while the leaves show a more equip nutraceutical properties contributing to its nutritional uses. Based on the plants ethnomedicinal uses, this work supports and provide information on the use of *Dennettia tripetala* parts such as the leaves and seeds in nutritional, pharmacological and health applications.

Keywords: Medicinal herbs; Dennettia tripetala; bioactive components; qualitative phytochemicals; proximate analysis; mineral composition.

Introduction

Plant foods and medicinal herbs have long been recognized as important sources of nutrients and bioactive compounds that promote health and prevent disease, particularly in developing countries where traditional medicine remains an integral component of primary healthcare [1, 2].

Plants contain essential minerals required for a balanced diet, as well as a wide range of primary and secondary metabolites that influence human health and nutrition [3, 4]. They provide important macronutrients, micronutrients, and bioactive compounds that contribute to health maintenance and disease prevention [5, 6]. In addition, plants are rich sources of essential fatty acids, vitamins, flavonoids, phenolic compounds, proteins, and carbohydrates, all of which contribute to their nutritional and therapeutic value. The prevention and management of chronic diseases such as cancer, diabetes, inflammatory and cardiovascular diseases have been linked to these bioactive constituents [7, 8]. Therefore, the interest in studying plant species as functional foods and sources of bioactive compounds for the improvement of human health and nutrition is increasing.

G. Baker, a native spice plant from West Africa, commonly known as pepper fruit, is primarily distributed in Nigeria. It is widely valued by local communities for its unique pungent flavour and medicinal properties and is called Ata Igbere by the Yoruba ethnic group in southwestern Nigeria [9]. According to ethnobotanical surveys, its fruits, seeds, bark, leaves and roots can be used to treat a variety of condition such as microbial infections, hyperglycemia, toothache, nausea, fever,

cough and inflammation [9 – 12]. The leaves of this plant are added to herbal preparations for their medicinal properties, while its seeds are widely consumed for their unique flavour and are often dried and stored to extend its shelf life [13]. Plant has been reported to be nutritionally important with significant levels of proteins, dietary fibre, carbohydrates, lipids and mineral contents [14]. Its edible parts contain antioxidant vitamins such as A, C and E [9, 15, 16, 17]. Bioactive constituents such as alkaloids, saponins, tannins, flavonoids, terpenoids, steroids, phenolic compounds and cardiac glycosides have been identified as active phytochemicals. These components are associated with several pharmacological activities like antimicrobial, antidiabetic, antioxidant, antihypertensive, anti-inflammatory and analgesic effect [9, 10, 12, 15, 17].

Academic circles have produced sufficient research on the fruits and seeds of this species, but research related to its leaves remains very limited. Reports show that the chemical composition of the leaves is comparable to that of the other parts of the species and the leaves have prominent antioxidant and antimicrobial activities [18]. It can be deduced that the leaves may represent an underappreciated source of pharmacologically and nutritionally important compounds.

According to literature on *D. tripetala,* studies deal with specific plant parts, especially the fruits and seeds due to their economic significance and general consumption, while little or no attention is given to compare the seeds and leaves. Moreso, there is inadequate information on the bioactive compounds and nutrient distribution between these plant organs which are ethnomedicinally important. Accumulation of nutrients and secondary metabolites are likely to differ since different plants tissues perform unique physiological processes. This may have a certain influence on their nutraceutical potentials. Therefore, comparative evaluation of the leaves and seeds is significant in getting to know the plant part with the most important potential for specific food, phytopharmaceutical and nutraceutical applications. This kind of information will promote sustainable use of the plant resource and may encourage the use of the leaves which are underutilized despite their reported medicinal value.

The novelty of this study is the adoption of a unified analytical framework to simultaneously assess the nutritional composition and phytochemical characteristics of the seeds and leaves of . This method can clarify the abundance and distribution patterns of the components found in this species, and the data generated from this work can provide support for screening the optimal applicable plant part of this species for use in the nutritional, pharmaceutical and industrial sectors. Therefore, this study aimed to comparatively evaluate the nutritional composition and phytochemical profiles of the seeds and leaves of in order to support their potential applications in food science, pharmacology, and herbal medicine.

Materials and method

Sample collection and preparation

Sample collection and preparation

Dennettia tripetala leaves and fruits (Figure 1) were collected from farmland in Ondo town, Ondo state, Nigeria.

Figure 1: Image of Dennettia tripetala (A) plant showing the leaves, and (B) seeds

Permission was obtained from the farm owner prior to the sample collection. The collection and use of the plant material were conducted in accordance with local regulations and institutional guidelines. The plant material was taxonomically identified and authenticated by Mr. Komolafe O.D. (Organic and Natural Product Chemist) of the Federal Polytechnic, Ado-Ekiti. Voucher specimens were prepared and deposited in the Department of Agricultural Technology, School of Agriculture and Agricultural Technology, The Federal Polytechnic, Ado-Ekiti, for future reference. The seeds were manually separated from the fruits. The leaves and seeds were washed thoroughly with clean water, sun-dried, and subsequently air-dried at room temperature until a

constant weight was obtained. The dried samples were separately milled into fine powder using an electric blender and stored in airtight containers until required for analysis. For all analyses, sufficient quantities of the powdered samples were prepared. 100 g each of dried leaf and seed powders were obtained and used for the various nutritional, mineral, and phytochemical analyses (Figure 2).

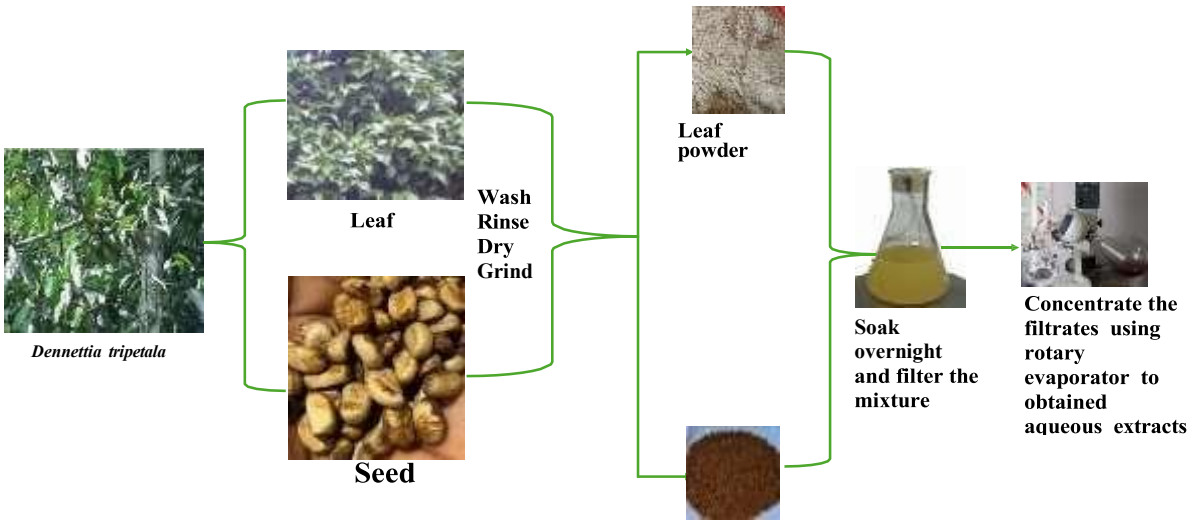

Figure 2: Flow chart for the preparation of the samples for proximate, mineral and phytochemical analysis

Determination of proximate composition

The proximate parameters such as ash, moisture, fibre, fat and protein of the sample were evaluated following the procedure as described by AOAC [19]. Carbohydrate was calculated by difference. All determinations were carried out in triplicate, and results were expressed as mean values.

Determination of Moisture Content: 2 g of each powdered sample was weighed into a previously dried and weighed moisture dish (W1). The dish containing the sample was weighed (W2) and dried in a thermostatically controlled oven at 105 °C for 3 h. The dish was cooled in a desiccator and reweighed (W3). Drying, cooling, and weighing were repeated until a constant weight was obtained. Moisture content was calculated as:

$$\% \text{ Moisture} = \frac{W2 - W3}{W2 - W1} \times 100 \quad (1)$$

w_1 = weight of empty dish

w_2 = weight of empty dish + sample

w_3 = weight of empty dish + sample after drying

Determination of Ash content: A silica dish was heated to 350 °C in a muffle furnace for approximately fifteen minutes. After being taken out and allowed to cool for approximately an hour in a desiccator, the crucible was weighed (W_1). 2 g of each powdered sample was weighed into a pre-weighed silica crucible (W_2). After the crucible was put into the muffle furnace, the temperature gradually rose from 200 to 450 ºC. After being taken out of the furnace and placed in a desiccator, the crucible was left to cool. Both the content and the crucible were reweighed (W_3) (20). The ash content was calculated as:

$$\% \text{ Ash} = \frac{W_3 - W_1}{W_2 - W_1} \times 100 \quad (2)$$

w_1 = weight of empty crucible

w_2 = weight of empty crucible + sample

w_3 = weight of empty crucible + sample after ashing

Determination of Protein content: Kjeldahl flasks were filled with 1 g each of the powdered sample. As a standard blank, tyrosine was weighed into a different Kjeldahl flask. As a catalyst, a mixture of potassium and copper sulfate (10:150) was added to the samples. K_2SO_4 and $CuSO_4 5H_2O$. Little anti bumping granules was added to the solutions to prevent bombing of the flask by the acid. The samples were digested by adding 10 ml of concentrated H_2SO_4 acid. Until the samples were clear, the digestion flasks were kept in the digester at 400 ºC for a while.

In order to capture the ammonia vapor from the digest, 15 ml of boric acid (H_3BO_3) were put in a 200 ml conical flask, which was used as the receiving flask. Two drops of a mixed indicator (methylene + methyl red) were added to the boric acid, and 10 ml of digested sample were combined with 10 ml of distillation water in a digestion flask. The conical flask and the Kjeldahl flask were then placed in the nitrogen/protein determinator, and the Kjeldahl flask was filled with

NaOH until the color changed. The sample was then steamed and distilled into the conical flask. The distillate was titrated with 0.05M HCl. The nitrogen content was calculated as follows:

$$\% \text{ Nitrogen} = \frac{(V2-V1)\times C \times 0.0140 \times V}{W \times Vo} \times 100 \quad (3)$$

V1 – blank volume
V2 – sample volume
C - molarity of acid
V - digested solution volume (ml)
W - sample weight
Vo- Volume of distillate (ml)

Crude protein = % Nitrogen × Conversion factor (6.25) (4)

Determination of Crude fiber: 2 g of the dried sample was digested with 200 mL of 1.25% sulfuric acid solution under reflux for 30 min. The mixture was filtered and washed thoroughly with distilled water. The residue was then digested with 200 mL of 1.25% sodium hydroxide solution under reflux for 30 min, filtered, and washed repeatedly with distilled water until neutral. The resulting residue was transferred into a pre-weighed crucible (W1), dried in an oven at 105 °C to constant weight and weighed (W2). The crucible was subsequently ashed in a muffle furnace at 500 °C for 30 min, cooled in a desiccator, and reweighed (W3). The crude fiber content was calculated as:

$$\% \text{ Crude fiber} = \frac{W2 - W3}{W2 - W1} \times 100 \quad (5)$$

w1 = weight of empty crucible

w2 = weight of empty crucible + sample after drying

w3 = weight of empty crucible + sample after ashing

Determination of Crude fat: 2 g of the sample was weighed and wrapped in a weighed filter paper. Round bottom flask was filled up to 2/3 of the mark with n-hexane. The Soxhlet extractor was fixed up with a reflux condenser. Heated with heating mantle with temperature of 40-60 ^{0}C for 6 hours and removed. The residue was transferred inside the oven and oven dried for 1 hour. It was transferred inside a desiccator and allowed to cool. The residue was weighed and calculation for fat content is as follows:

$$\% \text{ Crude fat} = \frac{\text{Weight } of\ the\ residue}{Weight\ of\ the\ sample} \times 100 \quad (6)$$

Determination of Carbohydrate content: It was calculated as:

$$\% carbohydrate = 100 - (\% moisture + \% protein + \% fat + \% fiber + \% ash) \quad (7)$$

Minerals analysis

5 g each of the samples were weighed in a separate crucible and heated to 550 ºC for six hours in a muffle furnace until it had totally turned to ash. The ashing temperature of 550 °C was selected in accordance with standard procedures for plant mineral analysis to ensure complete oxidation of organic matter while minimizing volatilization losses of major mineral elements. The ash was dissolved in 15ml of aqua regia (a mixture of nitric acid and hydrochloric acids in ratio 1:3) in a 100 ml conical flask and allow to stand for 30 minutes. The solutions were later heated vigorously for 30 minutes, cooled, filtered and made up to 50ml with distilled water in a volumetric flask, poured into sample bottles and labeled. Atomic absorption spectrophotometers (AAS) (Buck Scientific AAS Model 211 VGP) and Jenway Digital Flame Photometers (PFP7 Model) were used to measure the mineral concentrations of the digested sample. All experimental analyses were conducted in triplicate and the mean value taken.

Determination of phytochemicals

A conical flask was filled with 100 ml of distilled water, 10 g of each powder, and cotton wool plugs. The samples were shaken periodically while being let to stand at room temperature for the whole night. Whatman No. 1 filter paper was used to filter each sample, and a Rotary Evaporator (Model: RE2000B) was used to concentrate the filtrates **(Figure 2).** Figure 3 shows the flow chart for the preparation of the extracts.

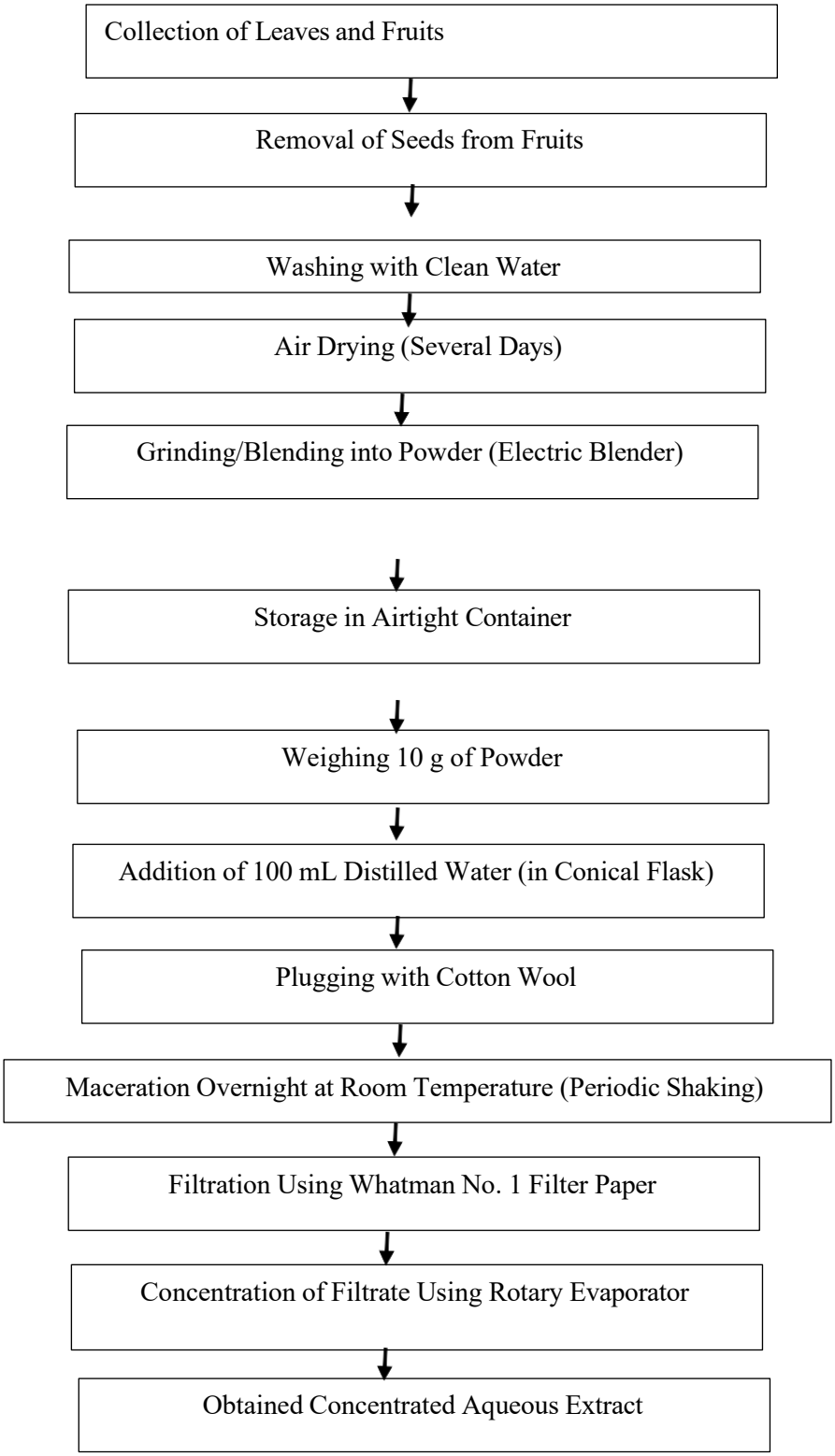

Figure 3: Flow chart for the preparation of the extracts

Phytochemical screening of the extracts was estimated with the procedure adopted by Olorunoje *et al.,* [21] with a slight modification. Three independent samples of each extract (leaves and seeds) were tested under identical conditions.

Test for Alkaloids: 3 drops of Wagner's reagent were added to a portion of the extract. The appearance of a reddish-brown precipitate indicated alkaloids presence.

Test for Saponin: 2 mL of the extract were mixed with 6 mL of distilled water in a test tube and shaken vigorously. The display of a stable, tenacious froth shows saponins presence.

Tannin: 10% alcoholic $FeCl_3$ solution were treated with 2 mL of extract. The development of a greenish or blue coloration was indicative of tannins.

Phlobatannin: The existence of phlobatannins was demonstrated by the red precipitate that formed when 5 ml of extract were heated with 5 ml of 1% hydrochloric acid.

Anthraquinone: 5 ml of benzene were used to dissolve 1 milliliter of extract, which was then filtered. The filtrate was mixed with 5 ml of a 10% ammonium solution. The presence of free hydroxyl anthraquinone is indicated by the presence of pink or red color in the ammonia lower phase.

Flavonoid: To 1ml of the filtrate, few drops of 20% NaOH solution were added. The suspension was observed for yellow colouration that turns colorless when excess diluted HCl was added indicated flavonoids presence.

Steroid: Acetic acid (2 ml) was added to 0.5 ml of extract after which 2ml of concentrated H_2SO_4 was added. The change in colour from violet to blue colour shows that steroids is present.

Cardiac Glycosides: 0.5 g of extract was dissolved in 2 ml of glacial acetic acid and 1 ml of ferric chloride was added. Formation of reddish brown colouration at the interface was taken as evidence for the presence of cardenolides.

Terpenoid: After mixing about 4 ml of extract with 2 ml of chloroform, 3 ml of concentrated H_2SO_4 was carefully added to the mixture to create a thin layer. Terpenoids are indicated by a reddish-brown hue near the contact.

Reducing Sugar: 5 drops of Fehling's solution and 1 ml of water were added to 0.5 ml of extract. The mixture was boiled for five minutes and observed for brick red precipitate indicating the reducing sugar presence.

Results and Discussion

The result of proximate analysis (Table 1) indicates significant differences in the macronutrient composition between the seeds and leaves of . As seen in Figure 4, the leaves have larger percentages of protein (15.21%), ash (5.17%), fat (7.65%), and crude fiber (9.18%) than the seeds (protein: 12.85%; ash: 4.84%; fat: 4.52%; crude fiber: 8.31%). On the other hand, compared to the leaves (51.66%), the seeds have a substantially larger carbohydrate content (58.71%). This pattern is consistent with the widespread knowledge that seeds are frequently used as reproductive structures that are high in stored carbohydrates and energy-dense [22, 23]. The moisture content of both seeds and leaves was low at 10.77% and 11.13%, respectively. These values are indicative of storage stability similar to

what has been reported in some tropical medicinal plants such as *Aframomum melegueta* (10.30%), *Monodora myristica* (12.6%), *Piper guineense* (10.9%), *Syzygium aromaticum* (8.61%), and *Xylopia aethiopica* (9.54%), which similarly exhibited relatively low moisture contents that favor prolonged storage [12, 24].

Table 1: Result of proximate analysis of the seeds and leaves of

Sample	Moisture (%)	Ash (%)	Fat (%)	Crude Fibre (%)	Protein (%)	Carbohydrate (%)
Seed	10.77 ± 0.12	4.84 ± 0.05	4.52 ± 0.07	8.31 ± 0.08	12.85 ± 0.09	58.71 ± 0.15
Leaf	11.13 ± 0.10	5.17 ± 0.06	7.65 ± 0.08	9.18 ± 0.07	15.21 ± 0.10	51.66 ± 0.12

Values are means of three replicates

D. tripetala leaves recorded a higher protein value of 15.21% compared to 12.85% in seeds. The leaves contain dietary proteins required for cellular processes including tissue repair and growth. However, higher protein values have been observed in some green vegetables and spices in Nigeria [25; 26]. A higher crude protein content of 17.55% has been reported for the leaves of *Piper guineense*, however, lower protein contents of 11.70% and 8.73% have been reported for the leaves of *Manihot esculenta* and *Piper nigrum*, respectively [25, 26], indicating that the protein content of *D. tripetala* leaves compares favorably with many tropical medicinal plants. Protein content is also related to antioxidant activity in medicinal plants according to previous literature [27].

The significant fat content of the leaves (7.65%) may add to their energy content and provide vital fatty acids [12]. Table 1 and Figure 5 show that the crude fiber content of the seeds (8.31%) and leaves (9.18%) suggests their potential contribution to digestive system. Dietary fiber has been associated with improved bowel function, glycemic control, and prevention of colorectal illnesses [28, 29]. The proven nutritional value of agricultural products high in fiber further supports the functional dietary potential of plant materials [21, 30].

Given their biological significance in plant multiplication and the early growth of seedlings, the

seeds' high carbohydrate content suggests that they are a significant source of energy [12, 31]. The ash concentration, which indicates the total mineral content, is higher in leaves (5.17%) than in seeds (4.84%), suggesting a richer mineral profile in the foliage [12]. Mineral-rich plant components are often prioritized in the development of nutraceuticals due to their micronutrient density [12]. This result is in line with more thorough phytochemical screening studies that show the range of minerals and secondary metabolites present in portions of medicinal plants [27].

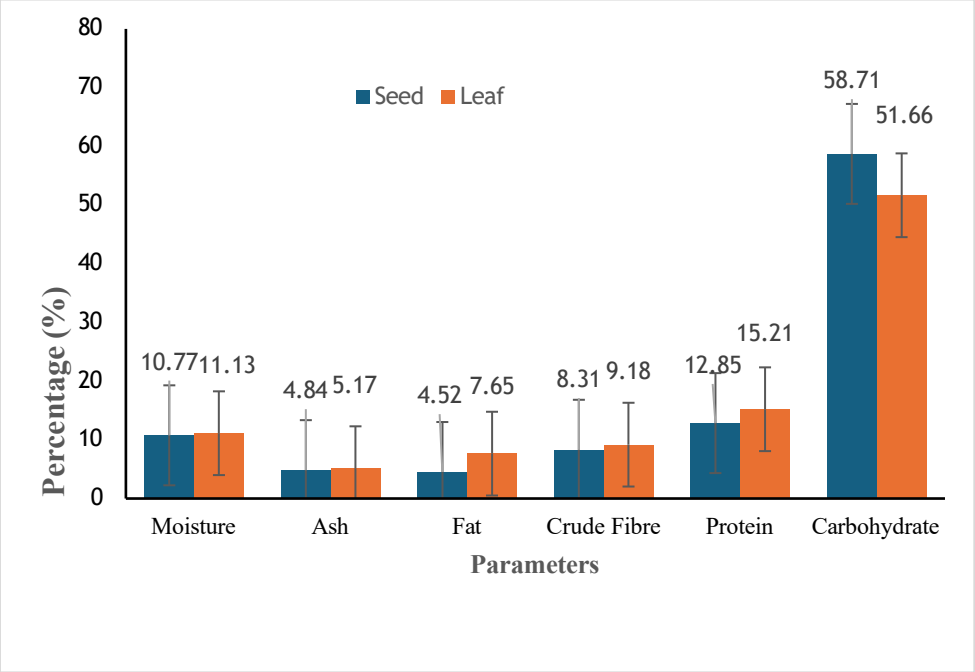

Figure 4: Result of proximate analysis of the seeds and leaves of

Table 2 show the elemental composition of *D. tripetala* seeds and leaves. Such elemental profile is required to know the quality and potential health benefits of plant-based foods [32, 33].

Table 2: Result of mineral composition of the seeds and leaves of

Sample	Na (ppm)	Ca (ppm)	K (ppm)	Mg (ppm)	Fe (ppm)	Cu (ppm)	Zn (ppm)
Leaf	81.65 ± 1.25	190.65 ± 2.10	415.60 ± 3.00	33.53 ± 0.80	0.88 ± 0.02	0.33 ± 0.01	1.78 ± 0.05
Seed	102.55 ± 1.50	116.65 ± 1.80	362.40 ± 2.50	28.29 ± 0.70	0.55 ± 0.01	0.51 ± 0.02	1.25 ± 0.04

Values are means of three replicates

When compared to the seeds, the leaves have significantly higher concentrations of calcium (Ca), potassium (K), and magnesium (Mg). In particular, seeds have 116.65 ppm Ca, 362.40 ppm K, and 28.29 ppm Mg, while leaves have 190.65 ppm Ca, 415.60 ppm K, and 33.53 ppm Mg (Figure 5). Since calcium is essential for bone health and other metabolic processes, the increased calcium concentration in leaves is especially significant [34, 35]. Numerous underused leafy greens are acknowledged as essential providers of mineral nutrients that treat dietary inadequacies, particularly in areas with limited access to a variety of food sources [36]. High potassium is beneficial in maintaining electrolyte balance and blood pressure homeostasis [12], as seen in Table 2, the potassium levels in leaves is 415.60 ppm and seeds is 362.40 ppm. Phytochemical and antioxidant studies of medicinal plants also show the synergistic effect of bioactive compounds and trace minerals in therapeutic efficacy [27].

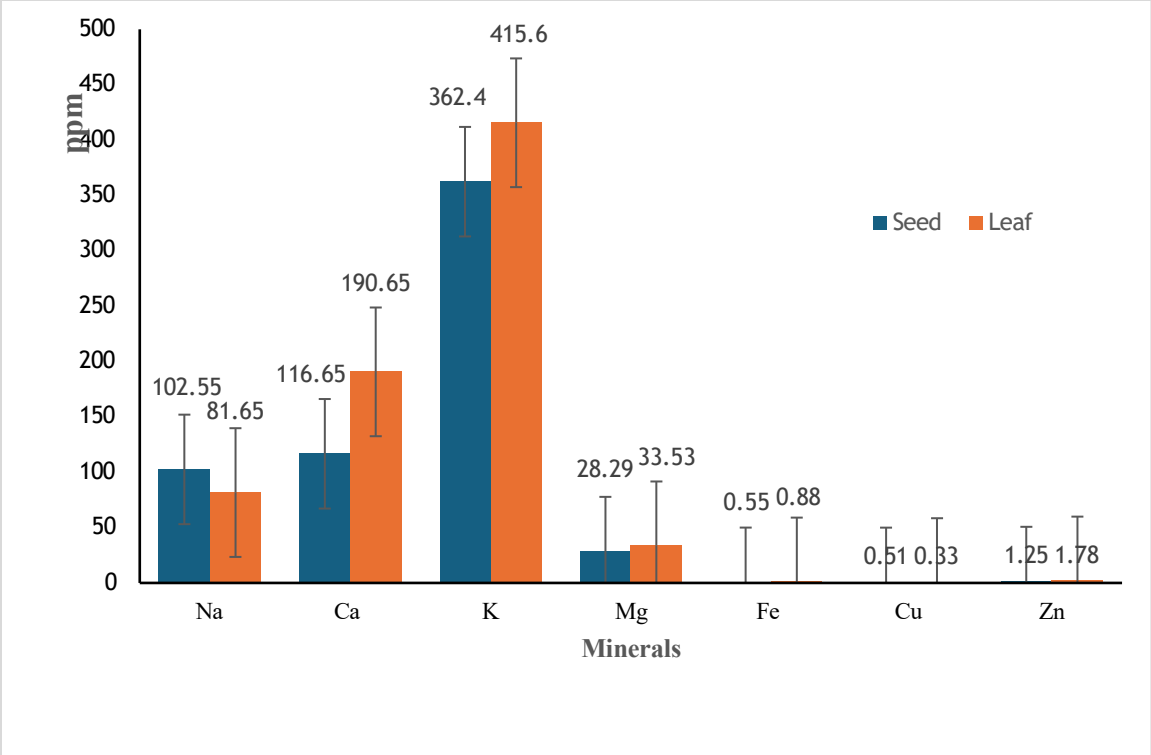

Figure 5: Result of the mineral analysis of seeds and leaves

Moreso, the concentration of sodium (Na) and copper (Cu), are higher in the seeds (102.55 ppm and 0.51 ppm) than in the leaves (81.65 ppm and 0.33 ppm) respectively. However, zinc (Zn), are

iron (Fe), are slightly higher in leaves than the seed (Table 2). Iron, zinc and copper are important trace minerals that enhance immunological function, enzyme activity and oxygen transport apart from their nutritional value [33]. Olorunoje *et al.,* [30] stated that plant materials rich in minerals may be investigated strategically for the development of functional foods and nutraceuticals applications. Therefore, is a potential source of micronutrients due to the appreciable minerals present. Calcium, potassium, magnesium, iron, zinc, and copper are present, which suggests that they could be used in phytopharmaceutical preparations, mineral fortification formulations, and dietary supplements to address micronutrient shortages and improve general metabolic health.

The bioactive components present in *D. tripetala* seeds and leaves is shown in Table 3. Alkaloids, tannins, cardiac glycosides, flavonoids, and terpenoids are present in both seeds and leaves (Table 3). However, reducing sugars and steroids are only found in the leaves, whilst saponins and anthraquinones are only found in the seeds. Interestingly, neither the seeds nor the leaves contain phlobotannins.

Table 3: Result of phytochemical screening of the seeds and leaves of

Parameters	**Seed**	**Leaf**
Alkaloid	Present	Present
Saponins	Present	Absent
Tannins	Present	Present
Phlobotannins	Absent	Absent
Anthraquinones	Present	Absent
Cardiac glycosides	Present	Present
Flavonoids	Present	Present

Terpenoids	Present	Present
Reducing sugar	Absent	Present
Steroid	Present	Absent

The shared presence of flavonoids, terpenoids and alkaloids in both leaves and seeds points to their potential broad pharmacological activities, including anti-inflammatory, antimicrobial and antioxidant properties [11, 37, 38]. For instance, flavonoids are widely known for their potent antioxidant capacity, which help fight oxidative stress linked to a number of chronic illnesses [10, 39]. Flavonoid-rich extracts frequently correspond with substantial free radical inhibition capacity, according to recent antioxidant screening of medicinal plants [27]. Additionally, terpenoids have a variety of biological functions, such as anti-malarial and anti-cancer properties [40]. *D. tripetala* seeds contains saponins which is absent in the leaves. In addition to their well-known detergent-like properties, saponins have been associated with immune-modulating and cholesterol-lowering actions [41, 42].

Also, anthraquinone is only present in the seeds. Anthraquinones are well known for their laxative and antibacterial qualities [43]. On the other hand, distinct metabolic pathways and their applications are suggested by the discovery of steroids and reducing sugars in the leaves. Steroids have been reported to have anti-inflammatory or hormonal effects [44]. The disparity in the phytochemicals and nutritional values in the various plant parts observed in this study suggest that *D. tripetala* seeds can serve as a source of therapeutic agent and as ingredients in functional foods while the leaves can be use as nutraceutical supplements and phytomedicines.

Conclusion

This study showed that plant organs have unique nutrient and bioactive profile, indicating the potential value of its seeds and leaves. Higher protein and some mineral elements such as K, Ca, Mg, Fe in the leaves indicates its dietary nutrient intake potential. Whereas, carbohydrate content

is higher in the seeds with the presence of various bioactive constituents. The phytochemicals and nutrients in these plant organs may be useful in food, nutraceutical and phytopharmaceutical applications. Therefore, strategic utilization of plant parts for specific health intervention should be examined. Further investigation on quantifying and characterizing the bioactive compounds for specific therapeutic applications are required.

ORCID

- Julius Gbenga Omosebi : 0000-0001-7961-8513
- Mercy Kikelomo Omosebi : 0009-0008-1749-8171
- Hawawu Alake Olorunoje: 0009-0006-9499-2785

Figures Originality

The figures used in the manuscript are original and not reproduced from any published articles.

List of Abbreviations

- **AOAC** – Association of Official Analytical Chemists
- **AAS** – Atomic Absorption Spectrophotometer
- **ppm** – parts per million
- **W1, W2, W3** – Weight measurements at different stages
- **°C (oC)** – Degrees Celsius

Authors' contributions

J.G.: Conceptualization, Methodology, Software, Validation, Formal Analysis, Investigation, Data Curation, Writing – Original Draft Preparation, Writing – Review & Editing, Visualization, Project Administration, Supervision. **M.K, H.A:** Investigation, Resources, Data Curation, Writing – Review & Editing, Visualization, Supervision.
All authors have read and agreed to the published version of the manuscript.

Availability of data and materials

The data supporting the findings of this study are included in the manuscript.

Ethics Committee Approval and Consent to Participate Not applicable

This study did not involve human participants or animal subjects. Plant material was collected with the permission of the farm owner, in accordance with local regulations and institutional guidelines.

AI Disclosure

Bohrium AI-based tool was used solely for language editing and formatting. No AI tool was used to generate or paraphrase the scientific content of the manuscript. The authors take full responsibility for the accuracy, originality, and integrity of the work.

Consent for publication

Not applicable

Conflicts of Interest

The authors declared no conflicts interests regarding this manuscript.

Funding

No external funding was received for this research.

Acknowledgement

The authors are grateful to the research facilities provided by Applied Chemistry Department, The Federal Polytechnic Ado-Ekiti.

References

1. Riaz M, Khalid R, Afzal M, Anjum F, Fatima H, Zia S, Rasool G, Egbuna C, Mtewa AG, Uche C.Z., Aslam MA. (2023). Phytobioactive compounds as therapeutic agents for human diseases: A review. *Food Sci Nutr*. Apr 17;11(6):2500-2529. doi: 10.1002/fsn3.3308.
2. Kussmann M, Abe Cunha DH, Berciano S. (2023). Bioactive compounds for human and planetary health. *Front Nutr*. Jul 17;10:1193848. doi: 10.3389/fnut.2023.1193848.
3. Gürbüz, N., Uluişik, S., Frary, A., & Doğanlar, S. (2018). Health benefits and bioactive compounds of eggplant. *Food Chemistry*, 268, 602–610. https://doi.org/10.1016/j.foodchem.2018.06.093
4. Samtiya M, Aluko RE, Dhewa T, Moreno-Rojas JM. (2021). Potential Health Benefits of Plant Food-Derived Bioactive Components: An Overview. *Foods*. Apr 12;10(4):839. doi: 10.3390/foods10040839.
5. Liu, R. H. (2013). Health-promoting components of fruits and vegetables in the diet. *Advances in Nutrition*, 4(3), 384S–392S. https://doi.org/10.3945/an.112.003517
6. Tufail, T., Fatima, S., Bader Ul Ain, H., Ikram, A., Noreen, S., Rebezov, M., Al-Farga, A., Saleh, R., & Shariati, M. A. (2025). Role of phytonutrients in the prevention and treatment of chronic diseases: A concrete review. *ACS Omega*, 10(13), 12724–12755. https://doi.org/10.1021/acsomega.4c02927
7. Rolnik, A., & Olas, B. (2020). Vegetables from the Cucurbitaceae family and their products: Positive effect on human health. *Nutrition*, 78, 110788. https://doi.org/10.1016/j.nut.2020.110788
8. Borecka, M., & Karaś, M. (2025). A Comprehensive Review of the Nutritional and Health-Promoting Properties of Edible Parts of Selected *Cucurbitaceae* Plants. *Foods*, *14*(7), 1200. https://doi.org/10.3390/foods14071200.
9. Iseghohi, S. O. (2015). A review of the uses and medicinal properties of (Pepperfruit). *Medicines*, 3(4), 104–111. https://doi.org/10.3390/medsci3040104
10. Omage S.O., Orhue N.E.J., Omage K. (2018). Evaluation of the phytochemical content, in vitro antioxidant capacity, biochemical and histological effects of fruits in healthy rats. *Food Sci Nutr.,* Nov 19;7(1):65-75. doi: 10.1002/fsn3.792.
11. Muhammed, D., Adebiyi, Y. H., Odey, B. O., Alawode, R. A., Lawal, A., Okunlola, B. M., Ibrahim, J., & Berinyuy, E. B. (2021). (Pepper Fruit), a review of its ethno-medicinal use, phyto-constituents, and biological properties. *GSC Advanced Research and Reviews*, 6(3), 035–043. https://doi.org/10.30574/gscarr.2021.6.3.0024
12. Evuen U.F., and Kpomah E.D. (2023). Phytochemical and Nutritional Constituents of Leaf

Extracts of Two Edible Medicinal Plants in Nigeria: A Comparative Appraisal. *Journal of Complementary and Alternative Medical Research*, 23(1), 9-21. DOI: 10.9734/JOCAMR/2023/v23i1468.

13. Daniyan, M. O., Adeyipo, T. F., Oyemitan, I. A., Okwuese, P. B., Ekundina, V. O., & Akanmu, M. A. (2021). In vivo and in silico studies of essential oil reveal the potential harmful effects of habitual consumption of the plant seed. *Toxicology Reports*, 8, 1488–1497. https://doi.org/10.1016/j.toxrep.2021.07.019.
14. Jegede, O. O., Akintomide, A. A., Onibi, G. E., Azeez, F. T., & Osowe, C. O. (2025). Proximate composition and phytochemical properties of pepper fruit (*Dennettia tripetala*). *Sustainability in Food and Agriculture*, 6(2), 83–86. https://doi.org/10.26480/sfna.02.2025.83.86
15. Okwu, D. E., & Morah, F. N. I. (2004). Mineral and nutritive value of fruits. *Fruits*, 59(6), 437–442. DOI: 10.1051/fruits:2005006.
16. Okwu, D.E. (2005). Phytochemicals, Vitamins and Mineral Content of Two Nigerian Medicinal Plants. *International Journal of Molecular Medicine and Advance Sciences*, 1, 375-381. https://doi.org/10.36478/ijmmas.2005.375.381.
17. **Muhammed, D., Adebiyi, Y. H., Odey, B. O., Alawode, R. A., Lawal, A., Okunlola, B. M., Ibrahim, J., & Berinyuy, E. B. (2021).** *Dennettia tripetala* (Pepper Fruit), a review of its ethno-medicinal use, phyto-constituents, and biological properties. *GSC Advanced Research and Reviews*, 6(3), 035–043. https://doi.org/10.30574/gscarr.2021.6.3.0024
18. Egharevba, H. O., & Idah, E. A. (2015). Major compounds from the essential oil of the fruit and comparative phytochemical studies of the fruits and leaves of Baker f. found in North Central Nigeria. *International Journal of Pharmacognosy and Phytochemical Research*, 7(6), 1262–1266.
19. AOAC. (1992). *Official methods of analysis* (15th ed.). Association of Official Analytical Chemists. Washington, DC, USA.
20. Sola, A. O., Temitayo, O. O., Olufunke, A., and Shittu, F. (2019). Chemical composition, nutritional values and antibacterial activities of watermelon seed (Citrullus lanatus). *International Journal of Biochemistry Research & Review*, 27(1), 1-9. https://doi.org/10.9734/IJBCRR/2019/v27i130113.
21. Olorunoje H.A., Omosebi J.G., and Abdulrahman N.A. (2025). Comparative Evaluation of Phytochemicals in Potato Peels: Implications for Waste Utilization and Alternative Medicine. *Advanced Journal of Chemistry, Section B, Natural Products and Medical Chemistry*, 7(4), 326-337. https://doi.org/10.48309/AJCB.2025.522466.1331.

22. Oyetayo, F. L., & Ogundare, O. L. (2018). Chemical composition of the pepper fruit () seed flour. *The FASEB Journal*, 32(S1), 536.13. https://doi.org/10.1096/fasebj.2018.32.1_supplement.536.13
23. Van den Oever, S. P., Maruta, C. K., Schreiner, M., & Mayer, H. K. (2024). "Exotic" seeds from Southern Africa as potential Novel Foods? – Chemical composition of manketti nuts (*Schinziophyton rautanenii*) and ushivi beans (*Guibourtia coleosperma*). *Food Research International*, 184, 114200. https://doi.org/10.1016/j.foodres.2024.114200.
24. Okorafor, L. M., Eneji, I. S., & Sha'Ato, R. (2019). Proximate and Elemental Analysis of Local Spices Used in Nigeria. *Chemical Science International Journal*, 1–9. https://doi.org/10.9734/csji/2019/v28i230135.
25. Fowomola M.A., Girigisu S., & Yusuf K.S. (2023). Nutritional and anti-nutritional properties of sweet cassava (*Manihot esculenta*) and black pepper (*Piper nigrum*) leaves. *World Journal of Advanced Research and Reviews*, 20(1), 1148–1155. https://doi.org/10.30574/wjarr.2023.20.1.2107.
26. Uzoekwe, N. M., & Ezenwajiugo, C. E. (2023). Phytochemicals, Elemental and Proximate analyses of *Piper Guineense* Leaves. *Journal of Applied Sciences and Environmental Management,* 27(4), 657–663. https://doi.org/10.4314/jasem.v27i4.3.
27. Afuwape, O. M., Omosebi, J. G., & Ayodele, O. M. (2025). Phytochemical analysis and antioxidant screening of selected medicinal plants for secondary metabolites. *Advanced Journal of Chemistry, Section B: Natural Products and Medical Chemistry*, 7(4), 272–285. https://doi.org/10.48309/ajcb.2025.517442.1322
28. Agbo, E., Anosike, E., & Baiyeri, K. (2021). Effects of fruit ripening stages on nutritional composition of pepper fruit (*Dennettia tripetala*). *In Nigerian Journal of Horticultural Science,* 25 (3), 48-56.
29. Lageiro, M., Fernandes, J., Marques, A. C., Simões, M., & Coelho, A. R. F. (2025). Nutritional Characterization of Fruits from Three African Plant Species: Dialium guineense Willd, *Parkia biglobosa Jacq.* and *Andansonia digitata L. Plants*, 14(15), 2344. https://doi.org/10.3390/plants14152344.
30. Olorunoje, H. A., Omosebi, J. G., Nwovu, O., & Afuwape, O. M. (2026). Evaluation of pineapple (*Ananas comosus*) crown for nutritional and medicinal applications. *International Journal of Advanced Biological and Biomedical Research*, 14(2), 146–159. https://doi.org/10.48309/ijabbr.2026.2064415.1624
31. Adebiyi, Y. H., Dauda, M., Babatunde, R. O., Odey, B. O., Aderemi, O., Suleiman, O. I., & Enenche, T. (2020). Effects of diet supplemented with on growth performance of albino rats.

Advanced Research in Life Sciences, 4(1), 16-21. https://doi.org/10.2478/arls-2020-0013.

32. Hayatuddeen, A., Chiroma, T. M., Umar, B. N., & Bashir, M. (2019). Comparative Analysis of Phytochemicals Screening, Proximate and Elemental Analysis of *Anacardium occidentale* L. Nuts and *Carica papaya* Seeds. *Journal of Applied Life Sciences International*, 1–5. https://doi.org/10.9734/jalsi/2019/v21i430111.
33. Liu, X., Mu, X., Peng, L., Liu, J., Lu, Q., Yang, Y., Guo, T., Tang, H., & Xie, H. (2023). Multi-element fingerprinting approach for geographical authentication of *Amomum tsaoko* seed. *Industrial Crops and Products*, 195, 116345. https://doi.org/10.1016/j.indcrop.2023.116345
34. Okunlola, G. O., Olatunji, O. A., Olowolaju, E. D., Refai, A. B., Makanjuola, A. O., & Adeosun, I. E. (2023). Assessment of Nutritional Value of Selected Underutilized Green Leafy Vegetables in Southwestern Nigeria. *Journal of Applied Sciences and Environmental Management*, 27(10), 2265–2273. https://doi.org/10.4314/jasem.v27i10.18.
35. Alum, E. U., Oyika, M. T., & Ugwu, O. P. C. (2023). Comparative analysis of mineral constituents of ethanol leaf and seed extracts of Datura stramonium. *IDOSR Journal of Applied Sciences*, 143–151. https://doi.org/10.59298/idosr/2023/12.1.7906.
36. Shembe, P. S., Ngobese, N. Z., Siwela, M., & Kolanisi, U. (2023). The potential repositioning of South African underutilised plants for food and nutrition security: A scoping review. *Heliyon*, 9(6), e17232. https://doi.org/10.1016/j.heliyon.2023.e17232.
37. Mordi, J. C., Ichipi-Ifukor, P. C., Kweki, G. R., Ichipi-Ifukor, R. N., Oyem, J. C., & Dennis-Eboh, U. (2021). Preliminary toxicology profile of (Pepper Fruit) methanolic leaves extract. *Clinical Phytoscience*, 7(1), Article 62. https://doi.org/10.1186/s40816-021-00298-w
38. Enema O.J., Umoh U.F., & Johnny, I.I. (2024). GC-MS Analysis, Quantitative Phytochemical Profile and In vitro Antioxidant Studies of the Stem Bark of . *European Journal of Medicinal Plants*, 35(4), 30–41. https://doi.org/10.9734/ejmp/2024/v35i41196.
39. Ugheighele, S. E., Imafidon, K. E., Choudhary, M. I., Shakil, A., & Okoro, E. E. (2022). Isolation of quercetin and avicularin from Baker f. seeds, and evaluation of the oxidative stress management capacity and cytotoxic activities of its acetone extract and fractions. *Chemistry Africa*, 5(5), 1275–1285. https://doi.org/10.1007/s42250-022-00413-5
40. Owoeye, T. F., Akinlabu, K. D., & Ajani, O. O. (2023). Proximate composition, phytochemical screening and mineral content studies of leaves extract of *Adenanthera pavonina*. Arab *Journal of Basic and Applied Sciences*, 30(1), 317–328. https://doi.org/10.1080/25765299.2023.2215437.
41. Osemwenkhae, O.P., & Orumwensodia, K.O. (2022). In vitro antioxidant effect and phytochemical composition of aqueous extract of seed. *Nigerian Journal of Life Sciences*,

5(1), 215–222. https://doi.org/10.52417/njls.v5i1.225.

42. Alaebo, P. O., Achi, N. K., Ezurike, P. U., Cemaluk, A., Egbuonu, C., Nwuke, C. P., Chukwuka, E. W., Onochie, A. U., & Abuchi, F. J. (2025). Phytochemical composition, antibacterial activity, proximate and mineral analysis of methanol extract from combined seeds and peels of *Picralima nitida*. *Universal Journal of Pharmaceutical Research*, 10(1), 39–44. https://doi.org/10.22270/ujpr.v10i1.1268
43. Orji E.E., Oyewole T.A., & Ishaku E. (2025). HPLC Analysis and Nutritional Comparison of Three Indigenous Plants (*Parquetina nigrescens, Vernonia amygdalina, and Piper guineense*) for Enhanced Dietary Decision in Ekiti State Nigeria. *International Journal of Science and Technology Research Archive*, 8(1), 110–117. https://doi.org/10.53771/ijstra.2025.8.1.0030.
44. Salawu, A. R., Onyegbula, A. F., Lawal, I. O., Akande, S. A., & Oladipo, A. K. (2018). Comparative study of the Nutritional, Phytochemical and Mineral Compositions of the nuts of Tropical Almond (*Terminalia catappa*) and Sweet Almond (*Prunus amygdalus*). *Ruhuna Journal of Science*, *9*(1), 70. https://doi.org/10.4038/rjs.v9i1.37.