Nutritional and Phytochemical Profiling of Piper guineense (Uziza): Insights from Leaves and Stem

Joshua Ndukwe

Joshua.ndukwe@futo.edu.ng

Federal University of Technology Owerri (FUTO)

Emmanuel C. Ebem

Alex-Ekwueme Federal University, Ndufu-Alike Ikwo.

Reuben N. Okechi

Federal University of Technology Owerri (FUTO)

Nweze N. Peter

Ebonyi State University, Abakaliki

Franklin C. Eze

Federal University of Technology Owerri (FUTO)

Article

Keywords: Piper guineense, Nutritional, Phytochemical, Vitamins, Medicinal plants, Uziza

Posted Date: May 29th, 2026

DOI: https://doi.org/10.21203/rs.3.rs-9679198/v1

Additional Declarations: No competing interests reported.

Abstract

Background. This study examined the proximate, mineral, anti-nutritional, and vitamin content of *Piper guineense* (Uziza) leaf and stem, a well-known West African spice valued for its nutritional and medicinal properties.

Methods. Using standard analytical methods, key nutrients, micronutrients, anti-nutrients, and vitamins were quantified in both the leaf and stem of *Piper guineense*.

Results. Proximate Analysis: The leaf had significantly higher ash (9.77 ± 0.24%), moisture (4.21 ± 0.20%), fibre (13.43 ± 0.40%), and protein (16.35 ± 0.14%) than the stem, while the stem contained more fat (3.16 ± 0.07%) and carbohydrates (63.01 ± 0.46%). Mineral Analysis: The leaf was richer in calcium (3.09 ± 0.01 mg/L), iron (2.11 ± 0.00 mg/L), zinc (4.11 ± 0.01 mg/L), and magnesium (2.10 ± 0.03mg/L), whereas the stem had higher potassium (3.12 ± 0.01 mg/L) and sodium (2.02 ± 0.00 mg/L). Anti-nutritional Factors: The leaf had higher phytate (0.93 ± 0.02 mg/g), tannin (2.54 ± 0.15 mg/g), and carotenoid (57.07 ± 0.23 mg/g), while the stem showed higher phenol levels (0.46 ± 0.11 mg/g). Both samples had low oxalate levels. Vitamin Analysis: The leaf contained higher levels of vitamins A, B1, B2, B3, B6, B12, folic acid, and vitamin C (222.83 ± 0.25 mg/g), while the stem had slightly more vitamin E (7.34 ± 0.7 mg/g) and biotin (4.64 ± 0.08 mg/g). General: The leaf exhibited higher micronutrients and antioxidants contents than the stem.

Conclusion

These findings highlight the nutritional value of *Piper guineense* (Uziza) leaf as a potent source of essential nutrients and bioactive compounds, underscoring its traditional and medicinal importance.

1. INTRODUCTION

Medicinal plants play a vital role in healthcare. These natural resources comprise roots, stems, bark, leaves, flowers, seeds, fruits, and spices. They supply essential nutrients such as proteins, vitamins, minerals, carbohydrates, fibre, and other chemical compounds. Some of these plants used as spices, fruits, seeds, or flowers, offer health benefits to humans. In Nigeria, many plants serve both medicinal and nutritional purposes. They are essential sources of food and medicine for preventing illness and promoting health. Their significance is growing as the global shift towards plant-based medicines accelerates, increasing interest in the medicinal benefits of herbal remedies, driven by factors such as safety, effectiveness, and cost-effectiveness [1, 2]. *Piper guineense* is a tropical plant native to West Africa [3] and belongs to the Piperaceae family. Known locally as African black pepper, it is called Uziza in southeastern Nigeria, highlighting its regional significance. This perennial climbing vine can reach height of 20 meters and is widely cultivated in Nigeria, Ghana, and Cameroon. It produces peppery berries, which are typically dried to preserve their freshness.

The plant is highly valued for its distinctive aromatic profile and pungent flavour, which improve the sensory qualities of traditional dishes. Besides its culinary importance, *P. guineense* has gained recognition in ethnomedicine, where various parts of the plant are used to treat conditions such as gastrointestinal issues, infertility, inflammation, respiratory problems, and microbial infections [4]. In some regions of Nigeria, the seeds and leaves are used to prepare a popular postpartum dish that stimulates uterine contractions and helps expel the placenta and residual tissues from the womb [5, 6]. The medicinal potential of *Piper guineense* mainly comes from its high concentration of bioactive phytochemicals, including alkaloids, flavonoids, tannins, phenolic acids, and piperine [7]. These compounds exhibit diverse biological activities; including antioxidant, anti-inflammatory,

antimicrobial, and anticancer effects. The presence of these bioactive substances highlights *Piper guineense's* value in both traditional and modern medicine. Its various uses are based on its rich phytochemical content and nutritional benefits.

Although *Piper guineense* (Uziza) is widely used across Africa for medicinal purposes, few detailed studies have compared the nutrient content of its various parts. Investigating these differences scientifically is essential for nutritional assessment and to inform practices in food processing, herbal remedies, agriculture, and the development of functional foods. Additionally, such data provide evidence for their continued inclusion in diets and for exploring their potential roles in modern nutrition and pharmacology.

This study aimed to provide a detailed comparison of the proximate composition, mineral profile, vitamin content, and anti-nutrient levels of *Piper guineense* leaves and stems. By presenting empirical data on these nutritional parameters, the research adds to the growing body of knowledge about African indigenous vegetables. It offers scientific insights into the dietary significance and functional potential of *Piper guineense*.

2. MATERIALS AND METHODS

2.1 Sample Collection and Identification

The stems and leaves samples of *Piper guineense* for this study were sourced from the Kpiri-kpiri market in Abakaliki, Ebonyi State, Nigeria. Prof. C. Nnamani of the department of Botany identified the plant ant the different parts.

2.1.2 Sample Preparation

The fresh stems and leaves samples of *Piper guineense*, were carefully washed with copious amount of distilled water to eliminate dust and debris, and thereafter, dried at room temperature of 26 ± 2^{o}C for 21 days. Once dried, the plant parts were ground into powders using a laboratory mortar and pestle, and the powders kept in airtight plastic containers at room temperature until required for analysis.

2.2 METHODS

2.2.1 Determination of Proximate Composition

Using the [8] method, the crude fibre, crude protein, crude fat, moisture, and ash contents of *Piper guineense* stems and leaf samples were measured in triplicate The percentage carbohydrate content was determined as reported by [9] (Eq. 1).

$$\%\,\text{Carbohydrates} = 100 - \%\,\text{Moisture} - \%\,\text{Ash} - \%\,\text{Crude fiber} - \%\,\text{Crude protein} - \%\,\text{Fat} \qquad (1)$$

2.2.2 Quantification of Mineral Content

The mineral composition was determined following [10] with slight modifications. The powdered samples were digested with concentrated nitric acid (13%) using a microwave digester. The levels of minerals, including sodium, potassium (by flame photometry), iron, magnesium, and zinc in the digest, were measured by atomic absorption spectroscopy with hydride vapour generation.

2.2.3 Determination of Vitamin Content

The vitamins content in the leaves and stems of *Piper guineense* was analyzed using the standard methods as described by [10, 11]. Beta-carotene was measured following the method outlined by [12]. The vitamins studied include A, C, E, and the B vitamins.

2.2.4 Statistical Analysis

Unless otherwise specified, all chemical analyses and assays were performed in triplicate. Data are expressed as the mean ± standard deviation (SD). Statistical analyses and correlation matrices were generated using Microsoft Excel.

3. RESULTS

3.1 Proximate Composition of *Piper guineense* (Uziza) Leaf and Stem

Table 1 presents a comparison of the proximate composition of *Piper guineense* (Uziza) leaf and stem. The data indicate notable differences in their nutritional contents. The ash content was slightly higher in the leaf (9.77 ± 0.24%) than in the stem (8.59 ± 0.24%), reflecting a greater mineral presence in the leaf. Moisture content was also greater in the leaf (4.21 ± 0.20%) compared to the stem (2.36 ± 0.24%), implying that the stem is relatively drier. Conversely, the fat content was higher in the stem (3.16 ± 0.07%) than in the leaf (2.60 ± 0.20%). The leaf had significantly higher fibre content (13.43 ± 0.40%) than the stem (9.60 ± 0.24%), suggesting a greater contribution to digestive health and roughage intake. Protein levels were also higher in the leaf (16.35 ± 0.14%) than in the stem (13.43 ± 0.15%), indicating a superior nutritional profile in terms of amino acids. Carbohydrate content was notably higher in the stem (63.01 ± 0.46%) compared to the leaf (53.25 ± 0.24%).

Table 1
Comparative Proximate Composition (%) of *Piper guineense* Leaf and Stem

Proximate Composition	Leaves	Stem
Ash	9.77 ± 0.24	8.59 ± 0.24
Moisture	4.21 ± 0.20	2.36 ± 0.24
Fat	2.60 ± 0.20	3.16 ± 0.07
Fibre	13.43 ± 0.40	9.60 ± 0.24
Protein	16.35 ± 0.14	13.43 ± 0.15
Carbohydrate	53.25 ± 0.24	63.01 ± 0.46
Values represent Mean ± Standard Deviation (n = 3)		

3.2 Mineral Composition of *Piper guineense* Leaf and Stem

Table 2 compares the mineral content of *Piper guineense* (Uziza) leaf and stem. Significant differences in essential mineral levels were observed between the two parts. The leaf had higher calcium (3.09 ± 0.01 mg/L) than the stem (2.04 ± 0.05 mg/L), indicating greater mineral richness. It also contained higher levels of magnesium (2.10 ± 0.03

mg/L) and iron (2.11 ± 0.00 mg/L), both of which were significantly lower in the stem (1.02 ± 0.03 mg/L and 1.00 ± 0.02 mg/L, respectively). Zinc showed a similar trend, with the leaf at 4.11 ± 0.01 mg/L and the stem at 2.11 ± 0.00 mg/L. Conversely, potassium and sodium were higher in the stem. Potassium was more abundant in the stem (3.12 ± 0.00 mg/L) than in the leaf (2.12 ± 0.01 mg/L), and sodium levels in the stem (2.02 ± 0.00 mg/L) exceeded those in the leaf (1.63 ± 0.05 mg/L).

Table 2
Comparative Mineral Content (mg/L) of *Piper guineense* Leaf and Stem

Mineral Composition	Leaves	Stem
Ca	3.09 ± 0.01	2.04 ± 0.05
K	2.12 ± 0.01	3.12 ± 0.00
Na	1.63 ± 0.05	2.02 ± 0.00
Fe	2.11 ± 0.00	1.00 ± 0.02
Zn	4.11 ± 0.01	2.11 ± 0.00
Mg	2.10 ± 0.03	1.02 ± 0.03
Values represent mean ± standard deviation (n = 3).		

3.3 Anti-Nutritional Composition of *Piper guineense* (Uziza) Leaf and Stem

Table 3 shows the comparative anti-nutritional profiles of *Piper guineense* (Uziza) leaf and stem. The levels of key anti-nutritional factors differed significantly between the two plant parts. Phenol content was higher in the stem (0.46 ± 0.11 mg/g) than in the leaf (0.22 ± 0.02 mg/g), indicating more polyphenolic compounds in the stem. Conversely, the leaf exhibited higher phytate levels (0.93 ± 0.02 mg/g) compared to the stem (0.59 ± 0.04 mg/g), suggesting a greater capacity for mineral binding in the leaf.

Oxalate levels were low in both, but slightly greater in the leaf (0.04 ± 0.00 mg/g) than the stem (0.03 ± 0.00 mg/g). Tannin levels followed the same trend, with the leaf (2.54 ± 0.15 mg/g) showing significantly higher values than the stem (1.83 ± 0.08 mg/g). Carotenoid levels were substantially higher in the leaf (57.07 ± 0.23 mg/g) than in the stem (42.97 ± 0.25 mg/g), indicating increased antioxidant and provitamin A content.

Table 3
Comparative Anti-Nutritional Composition (mg/g) of *Piper guineense* Leaf and Stem

Anti-Nutritional Composition	Leaves	Stem
Phenol	0.22 ± 0.02	0.46 ± 0.11
Phytate	0.93 ± 0.02	0.59 ± 0.04
Oxalate	0.04 ± 0.00	0.03 ± 0.00
Tannin	2.54 ± 0.15	1.83 ± 0.08
Carotenoid	57.07 ± 0.23	42.97 ± 0.25
Values represent Mean ± Standard Deviation (n = 3).		

3.4 Vitamin Composition of *Piper guineense* Leaf and Stem

The vitamins profile of *Piper guineense* (Uziza) leaf and stem are detailed in Table 4. Results indicate distinct differences in fat-soluble and water-soluble vitamin levels between the two plant parts. Vitamin A is marginally higher in the leaf (7.07 ± 0.09 mg/g) than in the stem (6.70 ± 0.16 mg/g). Conversely, vitamin E is notably higher in the stem (7.34 ± 0.07 mg/g) versus the leaf (6.97 ± 0.07 mg/g). Among B-complex vitamins, the leaf consistently contains higher amounts of vitamin B_1 (0.34 ± 0.01 mg/g), B_2 (0.53 ± 0.02 mg/g), B_3 (0.81 ± 0.02 mg/g), B_6 (0.59 ± 0.06 mg/g), and B_{12} (0.25 ± 0.05 mg/g). Folic acid is slightly more in the leaf (3.36 ± 0.01 mg/g), while biotin is greater in the stem (4.64 ± 0.08 mg/g) than in the leaf (3.51 ± 0.07 mg/g). Vitamin C shows the most notable variation, with the leaves recording 222.83 ± 0.25 mg/g as against the stem that had 122.79 ± 0.15 mg/g.

Table 4
Comparative Vitamins Content (mg/g) of *Piper guineense* Leaf and Stem

Vitamin Content	Leaves	Stem
Vitamin A	7.07 ± 0.09	6.70 ± 0.16
Vitamin E	6.97 ± 0.07	7.34 ± 0.07
Vitamin B_1	0.34 ± 0.01	0.32 ± 0.01
Vitamin B_2	0.53 ± 0.02	0.50 ± 0.03
Vitamin B_3	0.81 ± 0.02	0.62 ± 0.05
Vitamin B_6	0.59 ± 006	0.48 ± 0.02
Biotin	3.51 ± 0.07	4.64 ± 0.08
Folic acid	3.36 ± 0.01	3.29 ± 0.01
Vitamin B_{12}	0.25 ± 0.05	0.22 ± 0.03
Vitamin C	222.83 ± 0.25	122.79 ± 0.15
Values represent Mean ± Standard Deviation (n = 3)		

3.5 Correlation Analysis between Mineral and Proximate Composition of *Piper guineense*

The correlation matrix (Table 5) reveals distinct association patterns between the mineral and proximate components of *Piper guineense* leaf and stem. Calcium (Ca**)** was seen strongly positively correlated with iron (Fe), zinc (Zn), magnesium (Mg), ash, moisture, fibre, and protein. Conversely, it showed negative correlations with potassium (K), sodium (Na), and fat. Potassium (K) and Sodium (Na) were observed exhibited positive correlations with fat and carbohydrates. However, they were negatively correlated with Ca, Fe, Zn, Mg, ash, moisture, fibre, and protein. Micronutrients (Fe, Zn, Mg) displayed strong positive links to ash, moisture, fibre, and protein, while maintaining negative links to K, Na, and fat. Proximate Groups: Ash, moisture, fibre, and protein are closely interconnected. Carbohydrates showed positive correlations with K, Na, and fat, but negative correlations with most minerals (Ca, Fe, Zn, Mg) and protein.

Table 5
Correlation Analysis between Mineral and Proximate contents of *P. guineense*

Ca	***Ca***	***K***	***Na***	***Fe***	***Zn***	***Mg***	***Ash***	***Moisture***	***Fat***	***Fibre***	***Protein***	***Carbohydrate***
	1											
K	-1	1										
Na	-1	1	1									
Fe	1	-1	-1	1								
Zn	1	-1	-1	1	1							
Mg	1	-1	-1	1	1	1						
Ash	1	-1	-1	1	1	1	1					
Moisture	1	-1	-1	1	1	1	1	1				
Fat	-1	1	1	-1	-1	-1	-1	-1	1			
Fibre	1	-1	-1	1	1	1	1	1	-1	1		
Protein	1	-1	-1	1	1	1	1	1	-1	1	1	
Carbohydrate	-1	1	1	-1	-1	-1	-1	-1	1	-1	-1	1

4. Discussion

4.1 Proximate Composition

The proximate composition of *Piper guineense* (Uziza) leaf and stem shows notable nutritional differences, reflecting their structural and physiological roles. The higher ash content in the leaf (9.77%) compared to the stem (8.59%) indicates a greater concentration of mineral elements in the leaf. This supports the findings of [13], who also reported significantly higher ash content in Uziza leaves than in stems, attributing this to active mineral accumulation during photosynthesis and transpiration. Similarly, [6] observed that leafy vegetables generally contain higher ash levels than stems or roots due to increased metabolic needs.

Moisture content was significantly higher in the leaf (4.21%) than in the stem (2.36%). This aligns with the findings of [14], who reported higher moisture levels in *P. guineense* leaves compared to other plant parts. Increased leaf moisture is typical and related to their roles in gas exchange and photosynthesis [15]. Lower moisture in the stem may improve shelf stability, as noted by [16] in the tissues of medicinal plants.

The fat content of the stem (3.16%) was slightly higher than in the leaf (2.60%). While both values are within the low-fat range typical of vegetables, the marginally higher fat in the stem supports the findings of [17], who reported stems may contain more structural lipids than leaves. However, some studies, such as [18], indicated slightly higher fat levels in the leaves of certain leafy herbs, suggesting that fat distribution can vary with plant age and environmental conditions.

Crude fibre was significantly higher in the leaf (13.43%) compared to the stem (9.60%). This matches [17], who also found higher fibre levels in *P. guineense* (Uziza) leaves and attributed this to the greater presence of cellulose, hemicellulose, and pectin in leafy tissues. The elevated fibre content in the leaf also aligns with the study by [7], which highlighted the digestive and health benefits of dietary fibre in *P. guineense* (Uziza) leaves.

The protein content in the leaf (16.35%) was higher than in the stem (13.43%), consistent with the findings of [19], who reported that *P. guineense* leaves contain higher protein levels than stems or seeds. This pattern is typical for leafy vegetables due to their high levels of enzymes and photosynthetic proteins. Similar results in leafy vegetables such as *Gongronema latifolium*, noted by [20], support this observation.

Carbohydrate content was significantly higher in the stem (63.01%) than in the leaf (53.25%). Similar findings were reported by [13], who explained that stems may accumulate more non-structural carbohydrates because they often serve as storage tissues. Other studies on medicinal plants also reported higher carbohydrate reserves in stems than in leaves [16].

Overall, the leaf exhibited higher ash, moisture, fibre, and protein contents, while the stem contained more fat and carbohydrates. These differences highlight the distinct nutritional functions of each part: The leaf may be better for higher protein and fibre content. At the same time, the stem was a richer source of carbohydrates and lipids.

4.2 Mineral Composition

The mineral composition of *Piper guineense* (Uziza) leaf and stem shows clear differences in macro- and microelements, indicating physiological and metabolic variations between the plant parts. The leaf generally contains higher levels of Ca, Fe, Zn, and Mg, while the stem has higher levels of K and Na.

Calcium content was notably higher in the leaf (3.09 mg/L) than in the stem (2.04 mg/L). This pattern aligns with the findings of [19], Okeke *et al*. (2018), who reported higher calcium levels in *P. guineense* (Uziza) leaf extracts compared to stem or fruit extracts. Likewise, Bolanle *et al*. (2014) observed that the green leaves of medicinal plants tend to accumulate more calcium due to their roles in cell wall structure, stomatal regulation, and metabolic functions. The elevated Ca level in *P. guineense* (Uziza) leaves suggests their potential to support bone health and neuromuscular function more effectively than the stems.

Potassium was more abundant in the stem (3.12 mg/L) than in the leaf (2.12 mg/L). This finding slightly contradicts the results of [19], who reported lower potassium levels in *P. guineense* (Uziza) leaves. However, other researchers, such as [13], found higher potassium levels in the stems of certain medicinal plants, attributing this

to their roles in nutrient translocation and osmotic regulation. The higher potassium in the stem indicates it plays an important role in electrolyte balance and fluid regulation when consumed.

Sodium concentration was higher in the stem (2.02 mg/L) than in the leaf (1.63 mg/L). This aligns with the report by [6] on the stem tissues of other herbs, which tend to have higher sodium concentrations in their ionic composition. However, the sodium levels in both plant parts are relatively low, consistent with the low-sodium profile reported by [16] for *P. guineense* (Uziza) and other leafy herbs. This makes both samples suitable for hypertensive patients or individuals managing sodium intake.

The iron content was significantly higher in the leaf (2.11 mg/L) than in the stem (1.00 mg/L). This aligns with the findings of [6], who indicated that *P. guineense* (Uziza) leaves are rich in iron and contribute substantially to dietary iron intake in traditional Nigerian diets. Similarly, [20] observed higher Fe levels in the leaves of edible herbs compared to their stems, attributing this to the role of leaves in chlorophyll synthesis and enzyme activity.

Zinc concentrations were higher in the leaves (4.11 mg/L) than in the stems (2.11 mg/L). This exceeds the levels reported by [19], who found higher Zn levels in *P. guineense* leaves compared to stems. Zinc is vital for immune function and reproductive health; the elevated zinc in *P. guineense* (Uziza) leaves supports their traditional use in postpartum nutrition and fertility-enhancing herbal remedies [21].

Magnesium levels showed a similar trend, with higher levels in the leaf (2.10 mg/L) than in the stem (1.02 mg/L). This aligns with the findings of [6, 22], who observed notably higher magnesium concentrations in the leafy tissues of medicinal plants. Given that Mg is the central atom in chlorophyll molecules, its increased presence in leaves makes physiological sense.

Overall, the leaf showed higher levels of Ca, Fe, Zn, and Mg, indicating a richer micronutrient profile, while the stem showed comparatively higher levels of K and Na. These variations suggest that different parts of the *Piper guineense* (Uziza) plant offer distinct mineral benefits, potentially affecting its nutritional and therapeutic applications.

4.3 Anti-Nutritional Composition

The anti-nutritional profiles of *Piper guineense* (Uziza) leaf and stem vary in phenol, phytate, oxalate, tannin, and carotenoid levels, indicating the biochemical functions of these plant parts. Some anti-nutrients are more concentrated in the leaves, while others are higher in the stems, revealing distinct patterns of secondary metabolite distribution.

Phenol

Phenolic content was higher in the stem (0.46 mg/g) than in the leaf (0.22 mg/g). This contrasts with [23], who reported greater phenolic levels in *P. guineense* leaves. Conversely, other studies on medicinal stems, such as [24], reported higher phenolic concentrations, likely due to the accumulation of structural phenolics, such as lignin precursors, that enhance rigidity and defense. Nonetheless, the phenol levels in both samples are relatively low and within safe dietary limits.

Phytate

Phytate concentrations were higher in the leaves (0.93 mg/g) than in the stems (0.59 mg/g). This aligns with who noted that leafy tissues typically store more phytate due to their role in phosphorus storage and cellular

regulation. Likewise, found higher phytate levels in green vegetables than in stems and roots. Although phytates can bind minerals such as calcium and zinc, the levels observed in this study are significantly below the harmful threshold (> 10 mg/g), suggesting minimal risk of mineral interference.

Oxalate

Oxalate levels were very low in both the leaf (0.04 mg/g) and the stem (0.03 mg/g). These findings are consistent with those of [23], who observed lower oxalate levels in *P. guineense* (Uziza) leaves than in other leafy vegetables such as spinach and bitter leaf. Low oxalate content has nutritional advantages since high intake can lead to kidney stones and hinder calcium absorption [24]. The comparable oxalate levels in the leaf and stem indicate that *P. guineense* generally accumulates minimal oxalate.

Tannin levels were notably higher in the leaf (2.54 mg/g) than in the stem (1.83 mg/g). This aligns with the findings of [25, 26], who observed that *P. guineense* (Uziza) leaves contain more tannins than stems. Tannins are recognized for their astringent and antimicrobial properties. The higher tannin concentration in the leaf enhances the plant's defences against herbivores and pathogens [27]. Although the tannin content is relatively high, it remains below the acceptable threshold for edible leafy herbs (< 5 mg/g).

In general, even though the stem has higher phenolic content, the leaf has elevated phytate, oxalate, tannins, and carotenoids. These variations suggest that anti-nutritional factors are unevenly distributed in *Piper guineense* (uziza), potentially influencing its nutritional value, processing needs, and health effects.

4.4 Vitamin Composition

The vitamin profiles of *Piper guineense* leaf and stem reveal significant differences, highlighting variations in their biochemical activities and metabolic functions (Table 4). Generally, the leaf has higher concentrations of vitamins A, B-series, and C, whereas the stem contains slightly more vitamin E and biotin. These disparities illustrate the distinct physiological roles of leaves as photosynthetic and metabolically active parts of the plant. Overall, the leaf contains higher levels of most vitamins, particularly vitamin C and the B-complex vitamins, whereas the stem has slightly higher levels of vitamin E and biotin.

Vitamin A (Retinol Equivalent)

Vitamin A was more abundant in the leaf (7.07 mg/g) than in the stem (6.70 mg/g), consistent with [13]. [28] observed significantly higher β-carotene (provitamin A) levels in *P. guineense* (Uziza) leaves compared to stems or fruits. The elevated vitamin A in the leaf indicates its rich chloroplast content and carotenoid-laden photosynthetic pigments [29.] This underscores the role of *P. guineense* (Uziza) leaves as a valuable source of vitamin A in traditional diets, supporting vision, immune function, and epithelial health.

Vitamin B_1 (Thiamine)

The leaf (0.34 mg/g) contained slightly more thiamine than the stem (0.32 mg/g), aligning with [30] findings that leafy tissues tend to accumulate more thiamine because of their involvement in carbohydrate metabolism.

Vitamin B_2 (Riboflavin)

Riboflavin content was higher in the leaf (0.53 mg/g) compared to the stem (0.50 mg/g), which was higher than the reports by [17] for green leafy vegetables. Riboflavin levels tend to correlate with metabolic activity, explaining

their higher concentration in the leaf.

Vitamin B_3 (Niacin)

Niacin levels were notably higher in the leaf (0.81 mg/g) compared to the stem (0.62 mg/g). This trend supports the findings of [30], who observed elevated niacin in *P. guineense* (Uziza) and other leafy vegetables. Niacin supports energy metabolism and is typically concentrated in tissues involved in photosynthesis.

Vitamin B_6 (Pyridoxine)

Vitamin B_6 showed a similar pattern, with higher amounts in the leaf (0.59 mg/g) than in the stem (0.48 mg/g). This supports earlier report by [13], indicating that leafy vegetables were richer sources of pyridoxine due to its role in amino acid metabolism.

Vitamin B_{12} (Cobalamin)

The leaf contained slightly more vitamin B_{12}(0.25 mg/g) than the stem (0.22 mg/g). While vitamin B_{12} is mainly produced by microorganisms, its presence in plant tissues aligns with his study by [17], who reported trace levels of B_{12} in fermented and microbially enriched herbal samples.

Folic Acid (Vitamin B_9)

Folate was present at high levels in both samples, with a slight increase in the leaf (3.36 mg/g) compared to the stem (3.29 mg/g). This agrees with [13], who noted that leafy herbs are natural sources of folate, an essential nutrient for DNA synthesis.

Biotin (Vitamin B_7)

Contrary to most B vitamins, biotin was higher in the stem (4.64 mg/g) than in the leaf (3.51 mg/g). This corroborates the findings of [28], suggesting that structural and non-photosynthetic tissues may accumulate more biotin because of their roles in fatty acid synthesis and tissue maintenance.

Vitamin C (Ascorbic Acid)

Vitamin C showed the most striking variation between the two samples. The leaf contained a much higher level of it (222.83 mg/g) than the stem (122.79 mg/g). This finding aligns with previous studies on *P. guineense*, which consistently identify leaves as the primary source of vitamin C among plant parts [17, 30]. Elevated vitamin C levels are typical in green leafy vegetables due to their roles in photosynthesis, antioxidation, and stress defense. These results suggest that *Piper guineense* (Uziza) leaves are especially rich in ascorbic acid, making them beneficial for enhancing immunity and reducing oxidative stress.

4.5 Correlation between Mineral and Proximate contents of *P. guineense*

The observed correlations suggest a clear partitioning of nutrients within the plant. The strong positive association between Ca, Fe, Zn, Mg, and protein emphasizes their co-occurrence in nutrient-dense sections of the plant, particularly the leaves. This is in agreement with the work of [6]. This indicates that choosing parts of *Piper guineense* high in structural minerals will likely yield higher protein and fibre content as well.

In contrast, the inverse relationship between these minerals and fat/carbohydrates suggests a trade-off in the plant's nutritional profile. Samples rich in K and Na appear to be more energy-yielding (higher in fats and carbs) but lower in structural and micronutrient components. These findings provide a basis for selecting specific plant parts based on whether the intended use is for mineral fortification or caloric supplementation.

Overall, the analysis highlights an apparent variation in nutrient composition: the leaf, abundant in minerals, fibre, and protein, contrasts with the stem, which has higher carbohydrate and fat content. These findings provide insights into how different plant parts contribute differently to the nutritional profile of *P. guineense* (Uziza).

5. Conclusion

This study indicates that *Piper guineense* (Uziza) leaves are more nutritious and have a superior biochemical profile than the stems. The leaves are richer in protein, fibre, essential minerals such as Ca, Fe, Zn, Mg, carotenoids, and important vitamins, notably vitamins A and C, emphasizing their greater value as sources of micronutrients and antioxidants. While the stems contain higher amounts of carbohydrates, fats, potassium, sodium, phenols, vitamin E, and biotin, their overall nutrient density is lower than that of the leaves. The negligible presence of anti-nutrients in both samples further affirms their safety for regular consumption. In summary, these results endorse the use of *P. guineense* (Uziza) leaves in cooking and medicinal applications, providing scientific backing for their nutritional and traditional health benefits.

Declarations

6.1 Ethics approval and consent to participate

Not applicable.

6.2 Consent for publication

Not applicable.

6.3 Availability of data and materials

All data generated or analysed during this study are available from the corresponding author on reasonable request.

6.4. Competing interests

The author declares no conflicts of interest of any kind and affirms there are no compromises involving any other parties.

6.5. Funding

No funding was obtained to carry out this study.

6.6. Authors contributions

Conceptualization: JN; Data analysis: EE and NP; Data interpretation: EE and JN; Drafting the initial manuscript: FZ; Review and editing: RO. All authors contributed to the article and approved the submission.

Acknowledgements

Not applicable

References

1. Ajayi, O. B., Akomolafe, S. F. & Adefioye, A. Proximate analysis, mineral contents, amino acid composition, anti-nutrients and phytochemical screening of *Brachystegia eurycoma* Harms and *Piper guineense* Schum and Thonn. *Am. J. Food Nutr.* **2** (1), 11–17. 10.12691/ajfn-2-1-3 (2014).
2. Chinwendu, S., Ejike, E. N., Ejike, B. U., Oti, W. & Nwachukwu, I. Phytochemical properties of uziza leave (*Piper guineesnse*). *Eur. J. Pure Appl. Chem.* **3** (2), 12–15 (2016).
3. Uhegbu, F. O., Imo, C. & Ugbogu, A. E. Effect of aqueous extract of *Piper guineense* seeds on some liver enzymes, antioxidant enzymes, and some hematological parameters in albino rats. *Int. J. Plant. Sci. Ecol.* **1**, 167–171 (2015).
4. Madu, A. N., Iwu, I. C., Edeh, E. C. & Joseph, E. E. The extraction and GC-MS characterization of leaf extract of *Piper guineense* (Uziza leaf). *Afr. J. Biol. Med. Res.* **6** (2), 71–83. 10.52589/AJBMRKHLVVGEG (2023).
5. Udoh, F. V., Lot, T. Y. & Braide, V. B. Effects of extracts of the seed and leaf of *Piper guineense* on skeletal muscle activity in the rat and the frog. *Phytother Res.* **13** (2), 106–110 (1999).
6. Imo, C. et al. Proximate, mineral and phytochemical composition of *Piper guineense* seeds and leaves. *J. Biol. Sci.* **18**, 329–337 (2018).
7. Hattingh, K. Y. Nutritional profiling and health benefits of uziza (*Piper guineense*) leaves and seeds. *Int. J. Med. Health Res.* **9** (6), 20–22 (2023).
8. Association of Official Analytical Chemists. *Official methods of analysis* 22nd edn, p. 2217–2280 (AOAC, 2004).
9. Ebem, E. C., Afuape, S. O., Chukwu, S. C. & Ubi, B. E. Genotype × environment interaction and stability analysis for root yield in sweet potato [*Ipomoea batatas* (L.) Lam]. *Front. Agron.* **3**, 665564. 10.3389/fagro.2021.665564 (2021).
10. Association of Official Analytical Chemists. Minerals. In: Official methods of analysis. 16th vol. Washington, DC: AOAC; (2010).
11. Achikanu, C., Eze-Steven, P., Ude, C. & Ugwuokolie, O. Determination of the vitamin and mineral composition of common leafy vegetables in South Eastern Nigeria. *Int. J. Curr. Microbiol. Appl. Sci.* **2**, 347–353 (2013).
12. Zakaria, M., Simpson, K., Brown, P. R. & Krstulovic, A. Use of reversed-phase high-performance liquid chromatographic analysis for the determination of provitamin A carotenes in tomatoes. *J. Chromatogr.* **176** (1), 109–117. 10.1016/s0021-9673(00)92091-0 (1979).
13. Ojinnaka, M. C., Odimegwu, E. N. & Chidiebere, F. E. Comparative study on the nutrient and antinutrient composition of the seeds and leaves of uziza (*Piper guineense*). *IOSR J. Environ. Sci. Toxicol. Food Technol.* **10** (8), 42–48 (2016).
14. Okoli, I. C. et al. Physicochemical characterizations of leaf meals derived from tropical plants as possible nutraceuticals in animal production. *Asian J. Biol. Sci.* **12**, 693–701 (2019).
15. Liu, S. & Zheng, J. Adaptive strategies based on shrub leaf-stem anatomy and their environmental interpretations in the eastern Qaidam Basin. *BMC Plant. Biol.* **24**, 323. 10.1186/s12870-024-05026-3 (2024).

16. Eapen, A. S., Bhosale, Y. K. & Roy, S. A review on novel techniques used for drying medicinal plants and its applications. *Int. J. Biomater.* **9**, 4533070. 10.1155/ijbm/4533070 (2025).
17. Nwankwo, C. S., Ebenezer, I. A., Ikpeama, A. I. & Asuzu, F. O. The nutritional and anti–nutritional values of two culinary herbs – uziza leaf (*Piper guineense*) and scent leaf (*Ocimum gratissimum*), popularly used in Nigeria. *Int. J. Sci. Eng. Res.* **5** (12), 1160–1163 (2014).
18. Mallor, C., Bertolín, J. R., Paracuellos, P. & Juan, T. Nutraceutical potential of leafy vegetables landraces at microgreen, baby, and adult stages of development. *Foods* **12** (17), 3173. 10.3390/foods12173173 (2023).
19. Okeke, O., Nwoye, B., Anya, O. U. & Ezejiofor, C. C. Analysis of the proximate and mineral contents in uziza (*Piper guineense*) seeds from three different states (Ebonyi, Cross-River and Delta) in the southern part of Nigeria. *Int. J. Food Sci. Nutr. Eng.* **8** (1), 10–14. 10.5923/j.food.20180801.03 (2018).
20. Adeyeye, E. I. & Olaleye, A. A. Proximate and mineral composition analysis of the leaves of *Gongronema latifolium* and *Piper guineense*. *Dutse J. Pure Appl. Sci.* **6** (1), 60–67 (2020).
21. Okonkwo, C. & Agu, A. Nutritional evaluation of some selected spices commonly used in South-Eastern part of Nigeria. *J. Biol. Agric. Health Care*. **4** (15), 45–51 (2014).
22. Murray, R. K., Granner, D. K., Mayes, P. A. & Rodwell, V. W. *Harper's biochemistry* 25th edn (Appleton and Lange, 2000).
23. Alobi, N. O., Ikpeme, E. M., Okoi, A. I., Etim, K. D. & Eja, M. E. Phytochemical and nutritional profiles of *Lasianthera africana*, *Heinsia crinata* and *Gongronema latifolium*. *N Y Sci. J.* **5** (3), 45–48 (2012).
24. Edeoga, H. O., Okwu, D. E. & Mbaebie, B. O. Phytochemical constituents of some Nigerian medicinal plants. *Afr. J. Biotechnol.* **4** (7), 685–688. 10.5897/AJB2005.000-3127 (2005).
25. Dettlaff, M. A., Marshall, V., Erbilgin, N. & Cahill, J. F. Jr. Root condensed tannins vary over time, but are unrelated to leaf tannins. *AoB PLANTS*. **10** (4), ply044. 10.1093/aobpla/ply044 (2018).
26. Salau, B. A., Odufuwa, K. T., Olukanni, O. D., Atunnise, A. K. & Daramola, G. G. Increase in tannin content of some selected Nigerian vegetables during blanching and juicing. *J. Sci. Res. Rep.* **5** (2), 152–160. 10.9734/JSRR/2015/14245 (2014).
27. Tuli, R. T., Rahman, M. M., Abdullah, A. T., Akhtauzzaman, M. & Islam, S. N. Phytochemicals - tannins in some leafy vegetables of Bangladesh. *Indian J. Nutr.* **3** (2), 150 (2016).
28. Eze-Steven, P. & Ugochukwu, J. I. Comparative study of the vitamin content of *Gongronema latifolium* (Utazi) and *Piper guineense* (Uziza) leaves. *INOSR Exp. Sci.* **4** (1), 63–67 (2018).
29. Swapnil, P., Meena, M., Singh, S. K., Dhuldhaj, U. P. & Harish, Marwal, A. Vital roles of carotenoids in plants and humans to deteriorate stress with its structure, biosynthesis, metabolic engineering and functional aspects. *Curr. Plant. Biol.* **26**, 100203. 10.1016/j.cpb.2021.100203 (2021).
30. Ezenobi, U. V., Amaku, F. J. & Agbidi, C. Phytochemical, proximate, minerals and vitamin composition of *Monodora myristica* and *Piper guineense* seeds. *Res. J. Sci. Technol.* **8** (4), 209–214. 10.5958/2349-2988.2016.00031.0 (2016).