DOI: https://doi.org/10.4314/njbmb.v40i2.11 NJBMB (2025) 40(2) 214-219

Nigerian Journal of Biochemistry and Molecular Biology

The Official Publication of the Nigerian Society of Biochemistry & Molecular Biology (NSBMB). Journal homepage: https://www.nsbmb.org.ng/journals/

e-ISSN: 2659-0042

Research Article

Comparative Phytochemical Analysis of *Uvaria chamae* Leaves and Roots: Medicinal and Nutritional Implications

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OPEN ACCESS

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ARTICLE HISTORY
Received: 21/02/2025
Reviewed: 19/04/2026
Revised: 21/02/2025
Accepted: 19/04/2026
Published: 05/08/2026

CITATION
Ezeadichie S.O., Ikekpeazu J.E., Katchy A. U., Wariso M., Ugwu C.C., and Onwuka O.M. (2025). Quantitative-comparative phytochemical analysis of *Uvaria chamae* leaves and roots: medicinal and nutritional implications. *Nigerian Journal of Biochemistry and Molecular Biology*. 40(2), 214-219
https://doi.org/10.4314/njbmb.v40i2.11

ABSTRACT

Uvaria chamae (Annonaceae) is a medicinal plant widely utilized in African traditional medicine for its therapeutic and nutritional benefits. This study conducted a quantitative–comparative phytochemical analysis of the leaves and roots of *Uvaria chamae* to evaluate their bioactive composition and potential health implications. Validated classical gravimetric and titrimetric assays were employed, and results were expressed as mean ± SEM. Key phytochemicals identified included tannins, flavonoids, alkaloids, saponins, cardiac glycosides, oxalate, and phytate. The leaves contained significantly higher concentrations of tannins (2.70 ± 0.12%), flavonoids (8.30 ± 0.15%), alkaloids (4.40 ± 0.09%), and cardiac glycosides (9.00 ± 0.20%) compared with the roots (1.07 ± 0.08%, 3.90 ± 0.10%, 2.40 ± 0.06%, and 4.00 ± 0.18%, respectively) ($p < 0.05$–0.01). Although saponin and phytate levels showed no significant difference, the roots exhibited slightly higher phytate content (0.12 ± 0.02%) than the leaves (0.07 ± 0.01%). Both plant parts contained similar oxalate concentrations (0.054 ± 0.002%). These variations suggest differential metabolic roles between plant organs and indicate the potential therapeutic relevance of the leaves, which warrants further pharmacological and toxicological validation. The relatively low phytate and oxalate contents also imply favorable nutritional safety. Overall, this study highlights the phytochemical diversity of *Uvaria chamae*, emphasizing its promise as a source of bioactive compounds for herbal medicine and functional food development.

Keywords: *Uvaria chamae; Phytochemical analysis; Medicinal plants; Bioactive compounds; Nutritional applications.*

INTRODUCTION

Medicinal plants have played a fundamental role in traditional healthcare systems worldwide, providing natural remedies for various ailments (Ajuzie et al., 2022; Onwuka et al., 2022). *Uvaria chamae*, a member of the Annonaceae family, is widely recognized in traditional medicine for its therapeutic potential. Different parts of the plant, particularly the leaves and roots, are used in ethnomedicine for managing conditions such as fever, inflammation, and microbial infections. However, there is limited comparative scientific data on their phytochemical composition, which is essential for understanding their medicinal and nutritional relevance (Kumar et al., 2023; Patel et al., 2024).

Phytochemicals such as tannins, flavonoids, alkaloids, saponins, phytates, cardiac glycosides, and oxalates are bioactive compounds that contribute to the pharmacological properties of medicinal plants. These compounds exhibit diverse biological activities, including antioxidant, anti-inflammatory, antimicrobial, and cardioprotective effects (Nwosu et al., 2023; Jain et al., 2024; Zhang et al., 2024). While previous studies individual

components of *Uvaria chamae*, a systematic comparison of its leaves and roots is lacking, leading to a fragmented understanding of their relative medicinal and nutritional benefits (Sarkar et al., 2024).

This study aims to conduct a comparative phytochemical analysis of *Uvaria chamae* leaves and roots to determine variations in bioactive compound concentrations. By elucidating these differences, the study provides insights into the optimal use of the plant in herbal medicine and dietary applications. The findings will contribute to the growing body of knowledge on medicinal plants, guiding future pharmacological and nutraceutical applications of *Uvaria chamae*.

MATERIALS AND METHODS

Plant collection, identification and preparation

Fresh leaves and roots of *Uvaria chamae* were collected in April 2024 from a natural stand in Oba, Anambra State, Nigeria (6.048°N, 6.867°E). The plant was taxonomically identified and authenticated by P.O. Ugwuzor, Herbarium Curator, Department of Botany, Nnamdi Azikiwe University, Awka.

The plant materials were washed with distilled water, air-dried under shade at room temperature (25–28°C) for 14 days to prevent loss of heat-labile constituents, and pulverized into fine powder using an electric grinder (Philips HR 2102 model). The powdered samples were sieved (mesh size 0.5 mm), transferred into airtight amber bottles, labeled, and stored at 4°C until analysis.

Quantity analysis method and procedures

Flavonoid determination

Flavonoid content was determined using the method described by Ifemeje et al. (2014). Briefly, 10 g of the plant sample was extracted with 100 mL of 80% aqueous methanol at room temperature and allowed to stand for 5–10 minutes. The solution was then filtered through Whatman No. 42 filter paper (125 mm). The filtrate was transferred into a crucible, evaporated to dryness, and weighed to a constant weight. The percentage flavonoid content was calculated by the difference:

$$Flavonoid\ content\ (\%) = \frac{w_2 - w_1}{Weight\ of\ sample} \times 100$$

Where:

- W1 = weight of the empty crucible
- W2 = weight of the crucible with residue

Cardiac glycoside determination

The cardiac glycoside content was analyzed using the method described by Ifemeje et al. (2014). One gram of the plant sample was mixed with 5 mL of aqueous methanol and allowed to stand for 10 minutes. A 1 mL aliquot of the extract was transferred to a 100 mL beaker, followed by the addition of 1 mL of 2% dinitrosalicylic acid (DNS) solution and 1 mL of 5% aqueous NaOH. The mixture was boiled for 2 minutes in a water bath at 95–100°C until a brick-red precipitate was observed, indicating a positive result. The sample was filtered using pre-weighed Whatman No. 42 filter paper, dried at 50°C in an oven, and reweighed. The percentage of cardiac glycoside was calculated using the formula:

$$Cardiac\ glycoside\ (\%) = \frac{w_2 - w_1}{Weight\ of\ sample} \times 100$$

Alkaloid determination

The alkaloid content was determined following the method described by Obadoni and Ochuko (2001). Five grams of the plant sample was placed in a 250 mL beaker, and 200 mL of 10% acetic acid in ethanol was added. The mixture was covered and allowed to stand for 4 hours at room temperature (25°C). The solution was filtered, and the filtrate was concentrated in a water bath until it was reduced to one-quarter of the original volume. Concentrated ammonium hydroxide (NH_4OH) was added dropwise until precipitation was complete. The precipitate was collected using a pre-weighed filter paper, washed with dilute NH_4OH, dried, and reweighed. The percentage of alkaloid content was calculated as:

$$Akaloid\ \ (\%) = \frac{w_2 - w_1}{Weight\ of\ sample} \times 100$$

Phytate determination

Phytate content was determined using the method of Young and Greaves (1940), as modified by Lucas and Markakes (1975). Briefly, 0.2 g of the sample was soaked in 100 mL of 2% HCl for 3 hours. After filtration, 50 mL of the filtrate was mixed with 100 mL of distilled water, followed by the addition of 10 mL of 0.3% ammonium thiocyanate as an indicator. The solution was titrated with standard $FeCl_3$ solution (0.00195 g Fe/mL).

Saponin determination

The saponin content was determined using the method of Obadoni and Ochuko (2011). Five grams of the sample was placed in 20% acetic acid in ethanol and allowed to stand in a water bath at 50°C for 24 hours. The solution was then filtered and concentrated to one-quarter of the original volume. Concentrated NH_4OH was added dropwise until precipitation was complete. The precipitate was collected, dried, and weighed. The percentage of saponins was calculated using the formula:

$$Saponin\ (\%) = \frac{w_2 - w_1}{Weight\ of\ sample} \times 100$$

Tannin determination by titration

Tannin content was determined using the Folin-Denis titration method as described by Pearson (1974). Twenty grams of the crushed sample was extracted with 100 mL of petroleum ether for 24 hours. The sample was filtered,

allowed to stand for 15 minutes to evaporate the petroleum ether, and then re-extracted using 100 mL of 10% acetic acid in ethanol for 4 hours. The filtrate was collected, and 25 mL of NH_4OH was added to precipitate the tannins. The precipitate was heated to remove excess NH_4OH, and the final volume was measured. A 5 mL aliquot was taken, mixed with 20 mL of ethanol, and titrated with 0.1 M NaOH using phenolphthalein as an indicator. Tannin content was calculated as follows:

$$C_1V_1 = C_2V_2$$

Where:

- C_1 = concentration of tannic acid
- C_2 = concentration of NaOH
- V_1 = volume of tannic acid
- V_2 = volume of NaOH used

Oxalate determination by titration

Oxalate content was determined through digestion, oxalate precipitation, and permanganate titration, following the method described by Ifemeje *et al.* (2014).

Digestion

• Two grams of the sample was suspended in 190 mL of distilled water in a 250 mL volumetric flask.
• Ten milliliters of 6 M HCl was added, and the mixture was digested at 100°C for one hour.
• The solution was cooled and diluted to 250 mL with distilled water.

Oxalate

• A 125 mL portion of the filtrate was adjusted to pH 4.5 using NH_4OH.
• The solution was heated to 90°C, cooled, and filtered to remove iron precipitates.
• The filtrate was reheated to 90°C, and 10 mL of 5% $CaCl_2$ solution was added while stirring.
• The solution was cooled and allowed to stand overnight at 25°C.
• The precipitate was centrifuged at 2500 rpm for 5 minutes, then dissolved in 10 mL of 20% sulfuric acid.

Permanganate titration

• A 125 mL aliquot of the filtrate was heated to near boiling and titrated with 0.05 M $KMnO_4$ until a faint pink color persisted for 30 seconds.
• The oxalate content was calculated using the formula:
Oxalate content (%) = (T × Vme × DF) / (ME × MF) × 100
Where:
• T = titre value
• Vme = volume of mass equivalent (1 mL of 0.0519 M $KMnO_4$ = 0.00225 g oxalic acid)
• DF = dilution factor (Vt / A where Vt = 300 mL and A = 125 mL)
• ME = molar equivalent of $KMnO_4$ in oxalate
• MF = mass of sample used.

Although chromatographic and spectrophotometric methods (e.g., HPLC, GC-MS) provide greater sensitivity and compound resolution, the present study employed validated classical gravimetric and volumetric protocols (Obadoni and Ochuko, 2001; Ifemeje et al., 2014; Pearson, 1974) suitable for comparative phytochemical quantification. This approach ensured reproducibility and cost-effectiveness under local laboratory conditions.

Data analysis

Data were analyzed using descriptive statistics. The qualitative analysis describes the presence and relative concentration of various phytochemicals in different solvents, while the quantitative analysis provides specific measurements of phytochemical concentrations in the leaves and roots of *Uvaria chamae*. All quantitative determinations were carried out in triplicate, and data were expressed as mean ± SEM. Statistical comparisons between leaves and roots were analyzed using the student's t-test in SPSS version 25.0 (IBM Corp., USA). A p-value of <0.05 was considered statistically significant.

RESULTS

Results of quantitative analysis of phytochemicals

Data were analyzed using descriptive statistics. The qualitative analysis describes the presence and relative concentration of various phytochemicals in different solvents, while the quantitative analysis provides specific measurements of phytochemical concentrations in the leaves and roots of *Uvaria chamae*. All quantitative determinations were carried out in triplicate, and data were expressed as mean ± SEM. Statistical comparisons between leaves and roots were analyzed using the student's t-test in SPSS version 25.0 (IBM Corp., USA). A p-value of <0.05 was considered statistically significant.

Table 1. Quantitative Analysis of Selected Pytochemicals in *Uvaria chamae* Leaves and Roots

Phytochemicals	Leaves (%)	Roots (%)	Significance (*p*-value)
Tannins	2.70 ± 0.12	1.07±0.08	*p*< 0.05
Flavonoid	8.30 ± 0.15	3.90±0.10	*P*< 0.01
Alkaloids	4.40 ± 0.09	2.40±0.06	*P*< 0.05
Saponins	4.20 ± 0.10	3.60±0.08	ns
Phytate	0.07 ± 0.01	0.12±0.02	ns
Cardiac Glycosides	9.00 ± 0.20	4.00±0.18	*P* < 0.01
Oxalate	0.054 ± 0.002	0.54±0.002	ns

Values are expressed as mean ± SEM of triplicate determinations. Statistical comparison between leaves and roots was performed using Student's t-test ($p < 0.05$ considered significant.

DISCUSSION

The comparative phytochemical analysis of *Uvaria chamae* leaves and roots revealed marked variations in bioactive compound composition, consistent with patterns observed in other members of the Annonaceae family (Adepoju *et al.,* 2020; Eze *et al*., 2018). The leaves exhibited higher concentrations of flavonoids, alkaloids, tannins, cardiac glycosides, and saponins than the roots, whereas phytate and oxalate contents remained low in both plant parts. These findings suggest differential biosynthetic activity between aerial and underground tissues, which may influence their pharmacological potential.

The higher flavonoid content in the leaves (8.30%) compared to the roots (3.90%) aligns with reports on *Uvaria afzelii* and *Annona senegalensis*, where leaf extracts contained abundant polyphenols with antioxidant and anti-inflammatory potential (Olawale *et al*., 2022; Patel et al., 2022). Although flavonoids are known to modulate oxidative stress pathways, their biological activity in *U. chamae* should be confirmed through targeted antioxidant and enzyme inhibition assays.

Similarly, the elevated cardiac glycoside concentration in the leaves (9.00%) may indicate potential cardioprotective effects, as such compounds influence cardiac contractility and heart rhythm (Sinha et al., 2021; Patil *et al*., 2023). However, due to their narrow therapeutic window, quantitative pharmacological and toxicological validation remains essential before clinical extrapolation. The moderate alkaloid levels (4.40% in leaves vs. 2.40% in roots) may contribute to the traditional use of U. chamae for pain relief and antimicrobial purposes, but their exact mechanisms of action and safety profile must be further elucidated through bioassays and molecular studies (Goswami *et al.,* 2023).

Tannins and saponins were also present in appreciable quantities, suggesting possible roles in antimicrobial defense, immune modulation, and gastrointestinal protection (Adebayo *et al.,* 2023; Jain *et al*., 2022). These compounds, widely distributed in Annonaceae species, have been implicated in membrane stabilization and anti-inflammatory activity. Nevertheless, their physiological effects in *U. chamae* are yet to be experimentally verified.

Regarding nutritional implications, both oxalate (0.054%) and phytate (0.07–0.12%) levels were within the safe dietary range (<2%), suggesting minimal antinutritional risk (FAO/WHO, 2011). At these concentrations, oxalate is unlikely to interfere significantly with calcium metabolism or increase renal stone risk (Schwille *et al.,* 2023). Similarly, phytate content is low enough to avoid substantial mineral chelation while potentially offering antioxidant benefits (Siddiqui *et al.*, 2022). However, a complete nutritional assessment would require proximate composition and mineral bioavailability analyses to establish a balanced risk–benefit perspective.

The observed inter-part differences in phytochemical composition may result from differential secondary metabolite biosynthesis influenced by environmental conditions, physiological roles, and organ-specific gene expression. Such differences underscore the adaptive chemical diversity within *U. chamae* and other tropical medicinal plants. Comparative studies from Asian and South American Annonaceae species (e.g., *Annona muricata, Uvaria grandiflora*) have similarly reported higher polyphenol and glycoside levels in leaves compared to roots (Rodríguez *et al.,* 2021; Chen *et al*., 2020), reinforcing the trend observed in this study.

CONCLUSION

This study demonstrates clear quantitative differences in the phytochemical composition of *Uvaria chamae* leaves and roots, with the leaves exhibiting higher concentrations of flavonoids, cardiac glycosides, alkaloids, tannins, and saponins, while both plant parts contained low and nutritionally safe levels of phytate and oxalate. These findings provide a scientific basis for the traditional medicinal use of *U. chamae*, particularly its leaves, but should be regarded as preliminary observations. Given that classical gravimetric and volumetric techniques were employed, the present data primarily offer a broad comparative profile. Future studies incorporating advanced chromatographic and spectroscopic approaches (e.g., HPLC, GC–MS, LC–MS/MS) are recommended to achieve compound-level characterization, enhance analytical sensitivity, and validate compound identity and purity. Furthermore, bioactivity-guided assays, toxicological evaluations, and clinical validation are required to establish mechanistic and therapeutic relevance. Nutritional investigations should also assess mineral bioavailability, potential interactions between phytochemicals, and the overall dietary implications of *Uvaria chamae* consumption. Overall, the study contributes valuable preliminary insight into the phytochemical landscape of *Uvaria chamae*, supporting its ethnomedicinal relevance within the Annonaceae family and emphasizing the need for modern analytical and pharmacological follow-up to fully realize its potential in phytomedicine and nutritional science.

AUTHORS' CONTRIBUTIONS

Conceptualization, SOE. and JEI.; methodology, all author.; validation, SOE, JEI. and KA.; formal analysis, KA.; investigation, MW, CCU, OMO.; resources, all author.; data curation, SOE; writing—original draft preparation, SOE.; writing—review and editing, OMO.; supervision, JEI.; project administration, SOE.; funding

acquisition, none. All authors have read and agreed to the published version of the manuscript.

FUNDING STATEMENT

This research did not receive any specific grant from funding agencies.

CONFLICT OF INTEREST

There is no conflict of interest associated with the study and there is nothing to declare.

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