Future Natural Products
doi: 10.34172/fnp.200 2024;10(2):x-x https://fnp.skums.ac.ir

Original Article

Phytochemical Composition, Nutritional Value, and Antioxidant Properties of *Anthocleista djalonensis*

Joseph Raymond Enoghase[1*], **Silvanus Olu Innih**[1]

[1]Department of Anatomy, School of Basic Medical Sciences, University of Benin, Benin, Nigeria

*Corresponding Author: Joseph Raymond Enoghase, Email: joseph.enoghase@bmedsci.uniben.edu

Received: February 27, 2025
Revised: June 23, 2025
Accepted: July 09, 2025
ePublished: xx xx, 2025

Abstract

Background and aims: Traditional medicinal plants represent a vital source of bioactive compounds with therapeutic potential. *Anthocleista djalonensis*, a member of the Gentianaceae family, is extensively utilized in African traditional medicine for the treatment of diabetes, malaria, hypertension, and gastrointestinal disorders. This study aims to investigate the phytochemical composition, nutritional profile, and antioxidant properties of the stem bark of *Anthocleista djalonensis* in order to provide scientific validation for its traditional applications and to explore potential modern uses.

Methods: The stem bark of *Anthocleista djalonensis* was collected from Benin City, Nigeria, and authenticated for accuracy. Aqueous extraction of the plant material was conducted using a freeze-drying method to preserve the bioactive compounds. Phytochemical screening was performed to identify the presence of tannins, flavonoids, alkaloids, saponins, and phenolics. Proximate analysis was conducted to determine the moisture, protein, fat, fiber, ash, and carbohydrate content of the stem bark. The antioxidant activity was evaluated using the DPPH radical scavenging assay, with results compared to those of Vitamin C as a standard reference.

Results: The qualitative screening of *Anthocleista djalonensis* stem bark revealed the presence of key phytochemicals, including alkaloids, saponins, tannins, flavonoids, and phenols. Proximate analysis indicated the composition of the bark as follows: 6.2 ± 0.025% protein, 37 ± 1.6% fat, 0.11 ± 0.010% fiber, 9.3 ± 0.19% ash, 47 ± 1.8% carbohydrate, and 25 ± 0.91% moisture. Antioxidant activity, measured using the DPPH radical scavenging assay, demonstrated a significant dose-dependent free radical scavenging effect, yielding an IC_{50} of 36.25 ± 1.03 µg/mL. This was compared to ascorbic acid, which exhibited an IC_{50} of 21.87 ± 0.92 µg/mL, with a statistically significant difference noted ($p < 0.05$).

Conclusion: The findings from this study support the traditional medicinal use of *Anthocleista djalonensis* and underscore its potential for nutraceutical and pharmaceutical applications. The presence of various phytochemicals and notable antioxidant activity indicates that this plant may serve as a valuable source of bioactive compounds. Further research aimed at isolating and characterizing these bioactive constituents could pave the way for the development of novel therapeutic agents, enhancing our understanding of their mechanisms and potential health benefits.

Keywords: *Anthocleista djalonensis*, Phytochemicals, Nutraceuticals, Traditional medicine, Antioxidant activity

Cite this article as: Enoghase JR, Innih SO. Phytochemical composition, nutritional value, and antioxidant properties of *Anthocleista djalonensis*. Future Nat Prod. 2024;10(2):x–x. doi: 10.34172/fnp.200.

Introduction

Natural products are fundamental to drug discovery and public health initiatives due to their structural diversity and extensive range of bioactivities (1–5). Within this field, the genus *Anthocleista* (Gentianaceae)—which includes a small group of shrubs and trees found primarily in tropical Africa, Madagascar, and the Comoros—has attracted significant ethnopharmacological interest. Notably, *Anthocleista djalonensis* A. Chev. is commonly used in West Africa for treating various health conditions, such as metabolic, infectious, and inflammatory diseases, including diabetes, malaria, hypertension, and gastrointestinal disorders (6–9). Preliminary pharmacological studies have shown that extracts from different parts of *Anthocleista djalonensis* exhibit a range of beneficial activities, including hypoglycaemic, antiplasmodial, antimicrobial, antiproliferative, and fertility-enhancing effects (10–17).

Despite the promising findings regarding *Anthocleista djalonensis*, the current understanding of this species is still quite fragmented. Firstly, the reported phytochemical profiles of *Anthocleista djalonensis* vary significantly,

which can be attributed to differences in geographic origin, climatic conditions, and extraction methods used in various studies (18–20). Secondly, although compounds such as tannins, phenolics, saponins, and alkaloids have been identified, there is a lack of quantitative data that directly correlates these constituents with specific bioactivities, making it difficult to ascertain their contributions to the observed effects.

Additionally, there is limited knowledge regarding the nutritional composition of the stem bark, which is crucial for assessing its potential as a nutraceutical ingredient. Finally, the antioxidant capacity of *Anthocleista djalonensis* has not been systematically compared to established standards, such as ascorbic acid, which hampers the ability to evaluate its efficacy in this regard.

To address these existing gaps in knowledge, the present study aims to: (i) characterize the major phytochemical classes present in the stem bark of *Anthocleista djalonensis*; (ii) provide a thorough proximate analysis of its macronutrient and mineral content; and (iii) quantify its free radical-scavenging activity using the DPPH assay, comparing the results to those of vitamin C. By integrating chemical, nutritional, and functional endpoints, this research seeks to create a comprehensive dataset that will inform the rational development of *Anthocleista djalonensis*-based nutraceuticals. Additionally, this study will lay the groundwork for future mechanistic investigations into the bioactive properties of this species, ultimately contributing to a better understanding of its potential health benefits and applications in dietary supplements.

Materials and Methods

Plant Collection and Identification

The stem bark of *Anthocleista djalonensis* used in this research was sourced from a farm in Benin City, Nigeria. It was identified and authenticated by a plant taxonomist from the Department of Plant Biology and Biotechnology at the Faculty of Life Sciences, University of Benin. The specimen was assigned the herbarium number UBH-A594. Following authentication, the bark was air-dried at a controlled temperature of 28 ± 2 °C before being pulverized for further analysis.

Preparation of Plant Extract

One hundred grams of the bark powder from *Anthocleista djalonensis* was extracted in 1 liter of distilled water for 24 hours, with intermittent shaking at room temperature. After the extraction period, the mixture was filtered, and the resulting filtrate was freeze-dried using a lyophilizer (Christ Alpha 1-4 LDPlus) to obtain a dry aqueous extract. The extraction yield was determined to be 11.8 ± 0.4% (w/w). For subsequent assays, stock solutions were prepared at a concentration of 10 mg/mL in water.

Phytochemical Quantification and Assay Validation

Total phenolics, flavonoids, tannins, saponins, and alkaloids were quantified using spectrophotometric methods (Jenway 6150), following the protocols established by Singleton and Rossi (21), Harborne (22), Ilahy et al (23), Makkar et al (24), and Hagerman and Butler (25), respectively. Calibration curves, generated from eight different concentrations, demonstrated linearity with R^2 values of 0.998 for phenolics, 0.997 for flavonoids, 0.999 for tannins, 0.996 for saponins, and 0.995 for alkaloids. The limits of detection (LOD) ranged from 0.3 to 1.2 µg mL^{-1}, and the intra-assay relative standard deviations (RSDs) were less than 4%.

Nutritional Composition

The analysis of ash (26), moisture (27), crude fat (Soxhlet) (28), crude protein (micro Kjeldahl; N × 6.25) (29), and crude fiber was conducted following the methods outlined by AOAC (2019). Total carbohydrate content (%) was calculated by difference, a widely accepted method when direct enzymatic hydrolysis is impractical in complex plant matrices. This approach has demonstrated a strong correlation ($r > 0.95$) with chromatographic determinations.

Measurement of DPPH Scavenging Activity

The free radical scavenging activities of each plant extract were assessed using a stable DPPH standard method, as described in references (30, 31), with minor modifications. A 0.1 mM DPPH solution was mixed with the extract at concentrations ranging from 5 to 100 µg mL^{-1} and incubated for 30 minutes in the dark. The absorbance was measured at 518 nm, and the percentage of inhibition was plotted against the logarithm of concentration to determine the IC_{50} value.

Results

Phytochemical Screening, Nutritional Composition, and DPPH Radical Scavenging Activity of Anthocleista djalonensis

Table 1 demonstrates the presence and relative abundance of various phytochemicals in the stem bark of *Anthocleista djalonensis*. The analysis indicates that saponins, tannins, reducing sugars, and steroids are present in substantial quantities, as denoted by "++". This suggests a significant potential for these compounds to contribute to the plant's

Table 1. Phytochemicals present in *Anthocleista djalonensis* stem bark

Constituents tested for	Inference
Saponins	++
Flavonoids	+
Tannins	++
Reducing Sugar	++
Steroids	++
Inulins	+
Alkaloids	+
Phlobatannins	+

therapeutic properties. Additionally, flavonoids, inulins, alkaloids, and phlobatannins are also present, albeit in lower quantities (indicated by "+"), which indicates their existence but in lesser abundance compared to the aforementioned compounds.

Present [Mild +] Present [Abundant ++]

Further quantitative analysis identified tannins as the most concentrated constituent, followed by phenolics, saponins, flavonoids, and alkaloids. These findings underscore the potential pharmacological significance of the stem bark, particularly in antioxidant-related applications (Table 2).

The nutritional composition derived from proximate analysis revealed that the bark contains high levels of carbohydrates and fats, along with considerable moisture and protein content. The ash content indicates a reasonable presence of minerals, while the fiber content was found to be relatively low (Table 3).

DV = Daily Value.

Both *Anthocleista djalonensis* (represented in blue) and Vitamin C (represented in red) exhibited an increase in radical scavenging activity as the concentration increased. The results indicate the following:

- Vitamin C demonstrated a higher rate of inhibition compared to *Anthocleista djalonensis* across all tested concentrations. This finding establishes Vitamin C as a more potent antioxidant.
- The scavenging activity of *Anthocleista djalonensis* also increased significantly with concentration, suggesting that the stem bark possesses notable antioxidant properties.

While *Anthocleista djalonensis* shows promise as an antioxidant source, it is important to note that its antioxidant activity is less potent than that of Vitamin C (Figure 1).

Discussion

The phytochemical analysis of *Anthocleista djalonensis* stem bark (Table 1) reveals a diverse and rich profile of bioactive compounds, many of which possess well-documented pharmacological properties. Notably, saponins were identified in abundant quantities (++), consistent with their established roles in lowering cholesterol, modulating immune responses, and exhibiting antimicrobial and anti-inflammatory effects (32). This finding supports previous research conducted by Anyanwu et al (6) and positions *A. djalonensis* as a potential candidate for the management of cardiovascular and infectious diseases. Tannins, also present in high abundance, are recognized for their astringent, antioxidant, and antimicrobial properties, with applications in wound healing and gastrointestinal health. Even in moderate concentrations, these compounds contribute to the reduction of oxidative stress and the risk of chronic diseases (33, 34). Their prevalence in this species is consistent with reports from related species, such as *Anthocleista schweinfurthii*, suggesting a trend that may be characteristic of the genus. The presence of flavonoids, although moderate (+), indicates some antioxidant potential, which aligns with studies on *A. djalonensis* that demonstrate variable flavonoid content depending on extraction methods and environmental conditions (35-40).

The quantitative analysis of phytochemicals in *Anthocleista djalonensis* stem bark, as presented in Table 2, provides significant insights into the concentrations of various bioactive compounds. Alkaloids (7.29 ± 0.14 %) are present at relatively high and consistent levels, supporting their role in the plant's analgesic, anti-inflammatory, and antimicrobial properties (41). Given their potency and narrow therapeutic index, further studies are warranted to identify specific alkaloids and assess their safety profiles.

Tannins (7111 ± 351 mg/kg) and phenolics (1607 ± 37 mg/kg) are found in substantial quantities and are likely key contributors to the extract's antioxidant and antimicrobial activities (42–44). The synergy between these compounds, particularly among condensed and hydrolysable tannins, may enhance radical scavenging capabilities (45, 46). However, potential antagonistic interactions with alkaloids could influence the overall bioactivity in vivo.

Saponins (725 ± 8.5 mg/kg) and flavonoids (336 ± 20 mg/

Table 2. Phytochemicals parameters present in *Anthocleista djalonensis* stem bark

S/N	Parameters	Unit	Concentration
1	**Alkaloid**	**(%)**	7.294 ± 0.14%
2	**Tannins**	**mg/kg**	7111 ± 351 mg/kg
3	**Phenolics**	**mg/kg**	1607 ± 37 mg/kg
4	**Saponins**	**mg/kg**	725 ± 8.5 mg/kg
5	**Flavonoid**	**mg/kg**	336 ± 20 mg/kg

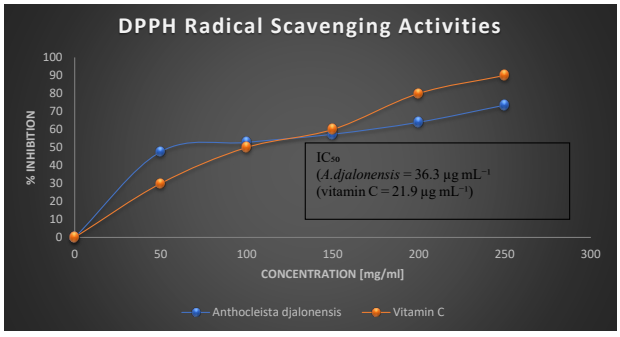

Figure 1. Graph illustrating the DPPH radical scavenging activity at various concentrations of Vitamin C and stem bark extracts from *Anthocleista djalonensis*

Table 3. Proximate analysis of *Anthocleista djalonensis* stem bark

Anthocleista djalonensis	Moisture (%DV)	Protein (%DV)	Fat (%DV)	Fibre (%DV)	Ash (%DV)	Carbohydrate (%DV)
	25 ± 0.91	6.2 ± 0.052	37 ± 1.6	0.11 ± 0.010	9.3 ± 0.19	47 ± 1.8

kg) are present in moderate amounts and may contribute to immune modulation, cholesterol reduction, and antioxidant effects (47). Although these levels are lower than those found in some medicinal plants, such as *Panax ginseng*, they nonetheless enhance the plant's therapeutic profile. In comparison, alkaloid levels in *A. djalonensis* are lower than those observed in *A. schweinfurthii* (6). However, the tannin and phenolic content is consistent with that of plants such as *Terminalia catappa*, *Cassia fistula*, and *Camellia sinensis*, which are recognized for their gastrointestinal and antioxidant benefits (24, 48, 49).

Table 3 presents the proximate composition of *Anthocleista djalonensis* stem bark, offering essential insights into its nutritional and chemical properties. The proximate analysis encompasses moisture, protein, fat, fiber, ash, and carbohydrate content, all of which are critical for understanding the overall dietary and potential health implications of *Anthocleista djalonensis*.

The moisture content of *Anthocleista djalonensis* stem bark **(25 ± 0.91%)** is relatively high compared to many other plant materials. Elevated moisture levels can influence shelf stability, the extraction of bioactive compounds, and the overall drying processes required for utilization in traditional medicine or as dietary supplements (50). This moisture content underscores the need for appropriate drying techniques if preservation or powdering for formulation in herbal medicines is intended.

The protein content of *Anthocleista djalonensis* (6.2 ± 0.052%) is moderate in comparison to many other plant materials. Protein is essential for plant structure and function, as well as for providing essential amino acids that may be beneficial in nutritional applications (50). Although *Anthocleista djalonensis* has a relatively low protein content, it is unlikely to be regarded as a primary protein source. Nevertheless, its inclusion in broader food systems may contribute to overall dietary protein intake.

The fat content in *Anthocleista djalonensis* stem bark (37 ± 1.6%) is notably high, which is atypical for many traditional medicinal plants. Elevated fat levels suggest that the plant may serve as a viable source of fatty acids, which are associated with various health benefits, including anti-inflammatory properties and support for cardiovascular health (51). However, this high fat content also necessitates careful consideration of lipid-based extraction methods if bioactive compounds are to be isolated for pharmacological studies.

The fiber content in *Anthocleista djalonensis* stem bark (0.11 ± 0.010%) is extremely low, which may limit its utility in promoting digestive health. Dietary fiber plays a crucial role in gut health by aiding digestion and preventing constipation (51). This low fiber level may influence recommendations for its use in food matrices, particularly in contexts where fiber content is typically desired for associated health benefits.

A lipid-rich matrix can enhance the oral bioavailability of lipophilic phytochemicals, such as sterols and triterpenoids (52). However, this high fat content also presents challenges regarding oxidative stability, requiring the incorporation of antioxidant co-formulants or encapsulation methods to prevent rancidity (53). Additionally, the low dietary fiber content limits the prebiotic benefits typically sought in functional foods (54). To address this, blending the bark powder with high-fiber carriers, such as oat bran, could help balance macronutrient profiles while preserving bioactive compounds (55). Furthermore, the elevated fat content may increase energy density, an important consideration for products aimed at weight management (56).

The ash content of *Anthocleista djalonensis* (9.3 ± 0.19%) provides an estimation of the mineral content within the plant material. An ash content of approximately 9.3% indicates that *Anthocleista djalonensis* contains a variety of minerals that are essential for various physiological functions when consumed (57). This level of mineral content can enhance the nutritional profile of traditional recipes or formulations that incorporate this species, potentially contributing to overall health and well-being.

The carbohydrate content of *Anthocleista djalonensis* (47 ± 1.8%) is significantly high, constituting the bulk of its composition. Carbohydrates serve as a primary energy source and are essential for maintaining energy levels in various biological processes (58). This high carbohydrate content suggests that the stem bark could be a valuable energy source in traditional diets or natural remedies.

The DPPH assay is a widely used method for evaluating the antioxidant capacity of various substances. It measures the ability of antioxidants to donate an electron or hydrogen atom to the DPPH radical, which leads to the neutralization of the radical and a subsequent reduction in its absorbance. A decrease in absorbance correlates with an increase in radical scavenging activity, indicating higher antioxidant potential (59).

Antioxidant Activity

As illustrated in Figure 1, Vitamin C—commonly used as a reference standard—exhibits strong DPPH radical scavenging activity that increases with concentration, eventually plateauing at higher doses, which indicates saturation. Similarly, the extract of *Anthocleista djalonensis* stem bark shows a concentration-dependent increase in scavenging activity. At lower concentrations (e.g., 5 mg/mL), its antioxidant activity is significantly lower than that of Vitamin C; however, as the concentration increases, the efficacy of the extract improves, approaching that of Vitamin C at higher levels. This trend suggests that the extract may contain multiple antioxidant constituents that could act synergistically to enhance its radical-scavenging capacity.

While Vitamin C consistently outperforms the extract at lower concentrations, the extract's performance at higher concentrations indicates promising antioxidant potential. These findings highlight the need for further investigation into optimizing extraction methods and formulation strategies to maximize the radical-scavenging properties

of *Anthocleista djalonensis* extract. Such enhancements could expand its applications in functional foods or dietary supplements aimed at combating oxidative stress and promoting health (55).

The demonstrated antioxidant activity of *Anthocleista djalonensis* highlights its potential for developing functional foods and nutraceuticals. Antioxidants are essential in mitigating oxidative stress-related diseases, providing protective effects against various conditions, including heart disease, cancer, and neurodegenerative disorders (60).

Given its traditional uses and substantiated antioxidant capacity, *Anthocleista djalonensis* presents a valuable opportunity for integration into contemporary medicinal practices. Its rich history in traditional medicine, combined with scientific evidence supporting its antioxidant properties, positions it well for inclusion in formulations designed to enhance overall health and combat oxidative stress.

Clinical and Nutraceutical Relevance

The bioactive profile of *Anthocleista djalonensis* bark reveals several promising clinical and nutraceutical opportunities. The abundance of tannins in the extract is noteworthy, as these compounds are recognized for their astringent and antimicrobial properties. Tannins can support wound healing when applied topically and may also be formulated into oral supplements aimed at addressing gastrointestinal conditions, potentially aiding in the management of issues such as diarrhea and inflammation.

Additionally, the presence of phenolic compounds in *Anthocleista djalonensis* is significant due to their established antioxidative mechanisms. These compounds are valuable in combating oxidative stress, which is associated with aging, cardiovascular disease, and metabolic syndrome.

The alkaloid content of *Anthocleista djalonensis* reflects both a high concentration and low variability, indicating consistent accumulation across samples and analytical replicability. This consistency reinforces the therapeutic relevance of alkaloid-rich fractions, many of which are recognized for their antimicrobial, anti-inflammatory, and neuropharmacological effects. However, due to the potent bioactivity and narrow therapeutic windows often associated with alkaloid compounds, it is crucial to further characterize specific alkaloid subtypes and conduct detailed toxicological profiling prior to clinical application.

These observations highlight the necessity of conducting in vivo studies to evaluate systemic bioavailability, pharmacodynamics, and safety under physiological conditions. Such studies are essential not only for validating the antioxidant and therapeutic claims derived from in vitro assays but also for clarifying potential synergistic or antagonistic interactions among the various constituent classes present in the extract.

Collectively, the phytochemical richness of *Anthocleista djalonensis* bark—marked by the presence of abundant tannins, phenolics, and alkaloids—alongside its confirmed free radical scavenging capacity, positions it as a strong candidate for nutraceutical or phytopharmaceutical development. These bioactive compounds not only contribute to the antioxidant properties of the bark but also suggest potential therapeutic applications in various health-related contexts. However, successful formulation of products derived from *Anthocleista djalonensis* will necessitate addressing certain challenges, particularly its high fat and low fiber content. These factors can impact product stability, efficacy, and consumer acceptability.

Conclusion

The study confirmed that *Anthocleista djalonensis* stem bark is rich in bioactive compounds, particularly tannins and phenolics, which contribute significantly to its therapeutic and nutritional potential. The plant's notable antioxidant properties not only support its traditional medicinal applications but also highlight its potential for development into nutraceuticals and functional foods. Additionally, the high carbohydrate and fat content further enhance its utility as a nutritional supplement, making it a versatile candidate for various health-related formulations. Given its broad range of bioactive compounds, *Anthocleista djalonensis* holds promise for both pharmaceutical and industrial applications. Future research should prioritize isolating specific compounds and understanding their mechanisms of action to elucidate how they contribute to the plant's health benefits.

Authors' Contribution

Conceptualization: Joseph Raymond Enoghase, Silvanus Olu Innih.
Data curation: Joseph Raymond Enoghase, Silvanus Olu Innih.
Formal analysis: Joseph Raymond Enoghase, Silvanus Olu Innih.
Investigation: Joseph Raymond Enoghase.
Methodology: Joseph Raymond Enoghase.
Project administration: Joseph Raymond Enoghase.
Resources: Joseph Raymond Enoghase, Silvanus Olu Innih.
Software: Joseph Raymond Enoghase, Silvanus Olu Innih.
Supervision: Joseph Raymond Enoghase.
Validation: Joseph Raymond Enoghase, Silvanus Olu Innih.
Visualization: Joseph Raymond Enoghase.
Writing–original draft: Joseph Raymond Enoghase, Silvanus Olu Innih.
Writing–review & editing: Joseph Raymond Enoghase, Silvanus Olu Innih.

Competing Interests

The authors declare that there are no known conflicts of interest or personal relationships that could have influenced the work reported in this paper.

Declaration of Data Availability

The data supporting the findings of this study can be obtained from the corresponding author upon reasonable request. Interested parties can contact the corresponding author directly via their email address for further information.

Ethical Approval

The research adhered to the guidelines set forth by the research ethics committee for animal handling and treatment at the University of Benin's College of Medical Sciences. Ethical approval

for the study was granted, with the assigned approval number CMS/REC/2023/340.

Funding
Nil.

References

1. Aware CB, Patil DN, Suryawanshi SS, Mali PR, Rane MR, Gurav RG, et al. Natural bioactive products as promising therapeutics: a review of natural product-based drug development. S Afr J Bot. 2022;151:512-28. doi: 10.1016/j.sajb.2022.05.028.
2. Hu Q, Jiang L, Yan Q, Zeng J, Ma X, Zhao Y. A natural products solution to diabetic nephropathy therapy. Pharmacol Ther. 2023;241:108314. doi: 10.1016/j.pharmthera.2022.108314.
3. Lin LT, Hsu WC, Lin CC. Antiviral natural products and herbal medicines. J Tradit Complement Med. 2014;4(1):24-35. doi: 10.4103/2225-4110.124335.
4. Singla RK, De R, Efferth T, Mezzetti B, Sahab Uddin M, Sanusi, et al. The International Natural Product Sciences Taskforce (INPST) and the power of Twitter networking exemplified through #INPST hashtag analysis. Phytomedicine. 2023;108:154520. doi: 10.1016/j.phymed.2022.154520.
5. Singla RK, Joon S, Sinha B, Kamal MA, Simal-Gandara J, Xiao J, et al. Current trends in natural products for the treatment and management of dementia: computational to clinical studies. Neurosci Biobehav Rev. 2023;147:105106. doi: 10.1016/j.neubiorev.2023.105106.
6. Anyanwu GO, Nisar-ur-Rehman, Onyeneke CE, Rauf K. Medicinal plants of the genus *Anthocleista*--a review of their ethnobotany, phytochemistry and pharmacology. J Ethnopharmacol. 2015;175:648-67. doi: 10.1016/j.jep.2015.09.032.
7. Togola A, Diallo D, Dembélé S, Barsett H, Paulsen BS. Ethnopharmacological survey of different uses of seven medicinal plants from Mali, (West Africa) in the regions Doila, Kolokani and Siby. J Ethnobiol Ethnomed. 2005;1:7. doi: 10.1186/1746-4269-1-7.
8. Awah FM, Tufon E, Uzoegwu PN. Free radical scavenging activity and phenolic contents of *Anthocleista djalonensis* (Loganiaceae) leaf extract. Int J Biol Chem Sci. 2010;4(6):2314-23. doi: 10.4314/ijbcs.v4i6.64933.
9. Okoli AS, Iroegbu CU. Evaluation of extracts of *Anthocleista djalonensis*, *Nauclea latifolia* and *Uvaria afzalii* for activity against bacterial isolates from cases of non-gonococcal urethritis. J Ethnopharmacol. 2004;92(1):135-44. doi: 10.1016/j.jep.2003.12.015.
10. Kroa E, Doh SK, Soko YN, Yohou KS, Koulaï OJ, Gbogbo M, et al. Effect of the aqueous extract of *Anthocleista djalonensis* A. Chev (Gentianaceae) stem bark on the glycaemia of rabbits. Int J Biol Chem Sci. 2016;10(2):552-8. doi: 10.4314/ijbcs.v10i2.9.
11. Bla BK, Dagnogo O, Kipré RG, Ballé OG, Trébissou JD, Djaman JA. Antiplasmodial activity of *Anthocleista djalonensis* leaves extracts against clinical isolates of *Plasmodium falciparum* and multidrug resistant K1 strains. World J Adv Res Rev. 2020;8(3):130-8.
12. Akinyemi AI, Ogundare AO. Antibacterial properties of the leaf extracts of *Anthocleista djalonensis* A. Chev on some pathogenic organisms. Eur J Med Plants. 2014;4(1):75-85.
13. Ojiakor EN, Okoye IE. Phytochemical studies and antimicrobial activity of *Anthocleista djalonensis* (Okpokolo leaf). J Chem Pharm Res. 2015;7(5):70-2.
14. Okoro IS, Umoh SD, Anyam JV, Msugh-Ter Manyi M, Adegbe C. In-vitro antimicrobial properties and phytochemical constituents of *Anthocleista djalonensis* leaf extracts. J Drug Des Med Chem. 2017;3(5):71-6. doi: 10.11648/j.jddmc.20170305.12.
15. Okeke UB, Igbinaduwa PO, Ozolua RI. Effects of *Anthocleista djalonensis* (Chev.) methanol root bark extract on some fertility parameters in male rats. Niger J Pharm Sci. 2019;15(2):187-92. doi: 10.4314/njpr.v15i2.6.
16. Akpan EJ, Okokon JE, Etuk IC. Antiplasmodial and antipyretic studies on root extracts of *Anthocleista djalonensis* against *Plasmodium berghei*. Asian Pac J Trop Dis. 2012;2(1):36-42. doi: 10.1016/s2222-1808(12)60009-7.
17. Samuel TA, James AB, Adebesin O, Okafor I, Iwalokun BA. Phytochemical investigation and anti-proliferative effects of *Rauvolfia vomitoria*, *Calliandra portoriscensis* and *Anthocleista djalonensis* on human breast cancer (MCF-7) cell line. Afr J Biomed Res. 2021;24(3):403-11.
18. Al-Hmadi H, El Mokni R, Joshi RK, Ashour ML, Hammami S. The impact of geographical location on the chemical compositions of *Pimpinella lutea* Desf. growing in Tunisia. Appl Sci. 2021;11(16):7739. doi: 10.3390/app11167739.
19. Khattak KF, Rahman TR. Effect of geographical distributions on the nutrient composition, phytochemical profile and antioxidant activity of *Morus nigra*. Pak J Pharm Sci. 2015;28(5):1671-8.
20. Liu Y, Chen P, Zhou M, Wang T, Fang S, Shang X, et al. Geographic variation in the chemical composition and antioxidant properties of phenolic compounds from *Cyclocarya paliurus* (Batal) Iljinskaja leaves. Molecules. 2018;23(10):2440. doi: 10.3390/molecules23102440.
21. Singleton VL, Rossi JA. Colorimetry of total phenolics with phosphomolybdic-phosphotungstic acid reagents. Am J Enol Vitic. 1965;16(3):144-58. doi: 10.5344/ajev.1965.16.3.144.
22. Harborne AJ. Phytochemical Methods: A Guide to Modern Techniques of Plant Analysis. London: Springer Science & Business Media; 1998.
23. Ilahy R, Hdider C, Lenucci MS, Tlili I, Dalessandro G. Phytochemical composition and antioxidant activity of high-lycopene tomato (*Solanum lycopersicum* L.) cultivars grown in Southern Italy. Sci Hortic. 2011;127(3):255-61. doi: 10.1016/j.scienta.2010.10.001.
24. Makkar HP, Francis G, Becker K. Bioactivity of phytochemicals in some lesser-known plants and their effects and potential applications in livestock and aquaculture production systems. Animal. 2007;1(9):1371-91. doi: 10.1017/s1751731107000298.
25. Hagerman AE, Butler LG. Protein precipitation method for the quantitative determination of tannins. J Agric Food Chem. 1978;26(4):809-12. doi: 10.1021/jf60218a027.
26. Ismail BP. Ash content determination. In: Ismail BP, Nielsen SS, eds. Nielsen's Food Analysis Laboratory Manual. Cham: Springer International Publishing; 2024. p. 129-31. doi: 10.1007/978-3-031-44970-3_14.
27. Nielsen SS. Determination of moisture content. In: Nielsen SS, ed. Food Analysis Laboratory Manual. Boston, MA: Springer; 2010. p. 17-27. doi: 10.1007/978-1-4419-1463-7_3.
28. Wilson BR, Pearson AM, Shorland FB. Effect of total lipids and phospholipids on warmed-over flavor in red and white muscle from several species as measured by thiobarbituric acid analysis. J Agric Food Chem. 1976;24(1):7-11. doi: 10.1021/jf60203a040.
29. 29.Salo-Väänänen PP, Koivistoinen PE. Determination of protein in foods: comparison of net protein and crude protein (N × 6.25) values. Food Chem. 1996;57(1):27-31. doi: 10.1016/0308-8146(96)00157-4.
30. Siripongvutikorn S, Pumethakul K, Yupanqui CT, Seechamnanturakit V, Detarun P, Utaipan T, et al. Antioxidant and nitric oxide inhibitory activity of the six most popular instant Thai curries. Foods. 2024;13(2):178. doi: 10.3390/foods13020178.
31. Musa KH, Abdullah A, Al-Haiqi A. Determination of DPPH free radical scavenging activity: application of artificial neural

networks. Food Chem. 2016;194:705-11. doi: 10.1016/j.foodchem.2015.08.038.
32. Sharma P, Tyagi A, Bhansali P, Pareek S, Singh V, Ilyas A, et al. Saponins: extraction, bio-medicinal properties and way forward to anti-viral representatives. Food Chem Toxicol. 2021;150:112075. doi: 10.1016/j.fct.2021.112075.
33. Sharifi-Rad M, Anil Kumar NV, Zucca P, Varoni EM, Dini L, Panzarini E, et al. Lifestyle, oxidative stress, and antioxidants: back and forth in the pathophysiology of chronic diseases. Front Physiol. 2020;11:694. doi: 10.3389/fphys.2020.00694.
34. Khodaie L, Sharma A, Shah PJ, Surana V. The relationship between the cold and dry nature of herbs and their tannin content: bridging traditional knowledge and modern-day science. J Res Pharm. 2023;27(6):2487-96.
35. Cole TJ, Short KL, Hooper SB. The science of steroids. Semin Fetal Neonatal Med. 2019;24(3):170-5. doi: 10.1016/j.siny.2019.05.005.
36. Tawfick MM, Xie H, Zhao C, Shao P, Farag MA. Inulin fructans in diet: role in gut homeostasis, immunity, health outcomes and potential therapeutics. Int J Biol Macromol. 2022;208:948-61. doi: 10.1016/j.ijbiomac.2022.03.218.
37. Guarino MP, Altomare A, Emerenziani S, Di Rosa C, Ribolsi M, Balestrieri P, et al. Mechanisms of action of prebiotics and their effects on gastro-intestinal disorders in adults. Nutrients. 2020;12(4):1037. doi: 10.3390/nu12041037.
38. Ketnawa S, Hamanaka D, Wongpoomchai R, Ogawa Y, Setha S. Low intensity of high-pressure processing increases extractable recovery of polyphenols and antioxidant activities of non-astringent persimmon fruit. LWT. 2021;151:112162. doi: 10.1016/j.lwt.2021.112162.
39. Popoola O. Phytochemical status of different solvent extracts of *Anthocleista djalonensis* A. Chev leaves. Int Ann Sci. 2020;8(1):62-9. doi: 10.21467/ias.8.1.62-69.
40. Tsopjio FN, Tchamango SR, Momeni J, Monde G, Tsopmejio JP, Ngassoum MB, et al. Removal of chlorophyll and tannins from *Anthocleista schweinfurthii* Gilg leaves by electrocoagulation using iron electrodes: optimization using response surface methodology. J Chem Technol Biotechnol. 2020;95(7):2001-8. doi: 10.1002/jctb.6388.
41. Fabricant DS, Farnsworth NR. The value of plants used in traditional medicine for drug discovery. Environ Health Perspect. 2001;109(Suppl 1):69-75. doi: 10.1289/ehp.01109s169.
42. Sharma RK, Micali M, Pellerito A, Santangelo A, Natalello S, Tulumello R, et al. Studies on the determination of antioxidant activity and phenolic content of plant products in India (2000-2017). J AOAC Int. 2019;102(5):1407-13. doi: 10.5740/jaoacint.19-0136.
43. Tarasiuk A, Mosińska P, Fichna J. Triphala: current applications and new perspectives on the treatment of functional gastrointestinal disorders. Chin Med. 2018;13:39. doi: 10.1186/s13020-018-0197-6.
44. Huang D, Ou B, Prior RL. The chemistry behind antioxidant capacity assays. J Agric Food Chem. 2005;53(6):1841-56. doi: 10.1021/jf030723c.
45. Quideau S, Deffieux D, Douat-Casassus C, Pouységu L. Plant polyphenols: chemical properties, biological activities, and synthesis. Angew Chem Int Ed Engl. 2011;50(3):586-621. doi: 10.1002/anie.201000044.
46. Saini N, Anmol A, Kumar S, Wani AW, Bakshi M, Dhiman Z. Exploring phenolic compounds as natural stress alleviators in plants- a comprehensive review. Physiol Mol Plant Pathol. 2024;133:102383. doi: 10.1016/j.pmpp.2024.102383.
47. Vinson JA, Hao Y, Su X, Zubik L. Phenol antioxidant quantity and quality in foods: vegetables. J Agric Food Chem. 1998;46(9):3630-4. doi: 10.1021/jf980295o.
48. Lacramioara O, Rosu CM. Total polyphenols, flavonoids contents and antioxidant activity of *Rosa* sp. genotipes from different altitude of Romanian regions. J Exp Mol Biol. 2021;22(1):15-26. doi: 10.47743/jemb-2021-56.
49. Vishnoi H, Bodla RB, Kant R. Green tea (*Camellia sinensis*) and its antioxidant property: a review. Int J Pharm Sci Res. 2018;9(5):1723-36. doi: 10.13040/ijpsr.0975-8232.9(5).1723-36.
50. Yang WZ, Hu Y, Wu WY, Ye M, Guo DA. Saponins in the genus *Panax* L. (Araliaceae): a systematic review of their chemical diversity. Phytochemistry. 2014;106:7-24. doi: 10.1016/j.phytochem.2014.07.012.
51. Food and Agriculture Organization (FAO). Dietary Protein Quality Evaluation in Human Nutrition: Report of an FAO Expert Consultation. FAO; 2011. p. 1-66.
52. Mouhid L, Corzo-Martínez M, Torres C, Vázquez L, Reglero G, Fornari T, et al. Improving in vivo efficacy of bioactive molecules: an overview of potentially antitumor phytochemicals and currently available lipid-based delivery systems. J Oncol. 2017;2017:7351976. doi: 10.1155/2017/7351976.
53. Musakhanian J, Rodier JD, Dave M. Oxidative stability in lipid formulations: a review of the mechanisms, drivers, and inhibitors of oxidation. AAPS PharmSciTech. 2022;23(5):151. doi: 10.1208/s12249-022-02282-0.
54. Brownawell AM, Caers W, Gibson GR, Kendall CW, Lewis KD, Ringel Y, et al. Prebiotics and the health benefits of fiber: current regulatory status, future research, and goals. J Nutr. 2012;142(5):962-74. doi: 10.3945/jn.112.158147.
55. Timm M, Offringa LC, Van Klinken BJ, Slavin J. Beyond insoluble dietary fiber: bioactive compounds in plant foods. Nutrients. 2023;15(19):4138. doi: 10.3390/nu15194138.
56. Drewnowski A, Darmon N. The economics of obesity: dietary energy density and energy cost. Am J Clin Nutr. 2005;82(1 Suppl):265S-73S. doi: 10.1093/ajcn/82.1.265S.
57. Lawrence GD. Dietary fats and health: dietary recommendations in the context of scientific evidence. Adv Nutr. 2013;4(3):294-302. doi: 10.3945/an.113.003657.
58. 58.Slavin J. Fiber and prebiotics: mechanisms and health benefits. Nutrients. 2013;5(4):1417-35. doi: 10.3390/nu5041417.
59. Oluwayomi PO, Janet AM, Oduola LI. Proximate, mineral, and vitamin composition of *Anthocleista djalonensis* A. Chev. Future Nat Prod. 2020;5(2):21-32.
60. Blois MS. Antioxidant determinations by the use of a stable free radical. Nature. 1958;181(4617):1199-200. doi: 10.1038/1811199a0.