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(RESEARCH ARTICLE)

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Evaluation of the phytochemical, nutritional, elemental composition and antioxidant profile of the ethanolic extract of *Alternanthera paronychioides* (Smooth Joy Weed)

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Abstract

This study evaluated the phytochemical, nutritional, elemental composition and the antioxidant capacity of the ethanolic extract of *Alternanthera paronychioides (EEAP)*. Phytochemical screening of EEAP identified the presence of tannins, saponins, glycosides, phenols, terpenoids, and saponin glycosides. The nutritional analysis indicated the presence of significant macronutrients, including crude protein, crude fat, crude fiber, and ash content. Additionally, the plant contained notable elements of about seventy-two such as Iron(5.046±3.418mg/L), Zinc (Zn) (0.165±0.130mg/L), Antimony (Sb) (0.0196±0.005mg/L), Tin (Sn) (0.038 ± 0.029mg/L), Chromium (Cr) (0.041 ± 0.000mg/L), and Manganese (Mn) (0.195 ± 0.055mg/L) among others. GC-MS analysis further confirmed the presence of about thirty-four bioactive compounds such as linoleic acid, methyl stearate, phytol and several others. The total flavonoids and phenolic content of the extract were quantified as 0.983 ± 0.002g/ml and 1.869 ± 0.011 mg GAE/ml respectively indicating a high concentration of bioactive compounds. DDPH scavenging antioxidant assay shows that EEAP demonstrated potent inhibitory activity with an IC_{50} value of 0.185± 0.005µM. In traditional medicine, *Alternanthera paronychioides* is used for treating conditions such as hyperuricemia, gout, rheumatic arthritis, nephritis, cystitis, uremia, diabetes, and systemic neuralgia. These findings support its potential therapeutic effects and highlight its nutritional and antioxidant properties, making it a promising candidate for future health applications.

Keywords: *Alternanthera Paronychioides*; Ethanolic Extract; Antioxidant Capacity; Phytochemical Screening; Nutritional Composition; Bioactive Components

1. Introduction

Alternanthera paronychioides, commonly known as "Joyweed," is a plant species belonging to the Amaranthaceae family. It is native to tropical and subtropical regions and is recognized for its medicinal properties. Joyweed has been traditionally used in various folk medicines for the treatment of different ailments, ranging from digestive disorders to skin conditions. However, despite its traditional use and anecdotal evidence of its therapeutic potential, comprehensive scientific studies on its phytochemical composition, nutritional profile, mineral content, antioxidant capacity, and bioactive components are limited.

Phytochemicals are bioactive compounds naturally occurring in plants. They are classified into various groups, including phenolic compounds, flavonoids, alkaloids, terpenoids, and others. These compounds are synthesized by plants as secondary metabolites and play a crucial role in their defense mechanisms against biotic and abiotic stressors. Additionally, phytochemicals contribute to the colour, flavour, and aroma of plants and possess diverse biological

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activities, such as antioxidant, antimicrobial, anti-inflammatory, and anticancer properties [1]. Comprehensive phytochemical analysis is essential to identify and quantify these bioactive compounds, providing insights into the plant's medicinal properties and potential applications in healthcare.

Nutritional composition analysis of plants provides essential information about their macronutrient and micronutrient content, which is crucial for understanding their dietary significance. Macronutrients include carbohydrates, proteins, and fats, essential for energy production and metabolic processes. Micronutrients, such as vitamins and minerals, play key roles in various physiological functions, including immune function, bone health, and antioxidant defense mechanisms [2]. Despite its traditional use in folk medicine, limited information is available regarding the nutritional composition of *Alternanthera paronychioides.* Analyzing its macronutrient and micronutrient content can provide valuable insights into its nutritional value and potential dietary benefits. Minerals are essential nutrients required by the human body for various physiological functions. They play crucial roles in bone formation, enzyme activation, nerve transmission, and maintaining fluid balance. Plants serve as important dietary sources of minerals, providing essential nutrients for human nutrition. However, the mineral composition of plants can vary depending on factors such as soil composition, environmental conditions, and plant species [3].

While some studies have investigated the mineral composition of certain plant species, limited information is available regarding the mineral content of *Alternanthera paronychioides.* Analyzing its mineral composition is essential for assessing its nutritional value and potential health benefits. Additionally, understanding the bio-availability of minerals from *Alternanthera paronychioides* is crucial for evaluating its contribution to meeting daily mineral requirements and promoting optimal health.

Figure 1 *Alternanthera paronychioides* (Smooth Joy Weed)

Antioxidants are compounds that inhibit oxidation processes in the body, thus protecting cells from damage caused by free radicals. Free radicals are highly reactive molecules that can damage cellular components, leading to oxidative stress and contributing to the development of various chronic diseases, including cardiovascular disorders, cancer, and neurodegenerative diseases. Plants are rich sources of antioxidants, which play a key role in their defense mechanisms against oxidative stress [4]. Assessing the antioxidant capacity of plants is essential for understanding their potential health benefits and therapeutic properties. Bioactive components are biologically active compounds present in plants that exert physiological effects on human health. These compounds may include phytochemicals, antioxidants, vitamins, minerals, and other functional constituents, which contribute to the therapeutic properties of plants.

Bioactive components play a crucial role in modulating various physiological processes, including immune function, inflammation, and metabolism [5]. Identifying and characterizing the bioactive components of *Alternanthera paronychioides* is essential for understanding its potential health benefits and therapeutic properties. These bioactive components may interact synergistically to exert beneficial effects on human health, including antioxidant, anti-inflammatory, antimicrobial, and anticancer activities. Furthermore, exploring the bioactive components of

Alternanthera paronychioides can facilitate the development of novel pharmaceuticals, functional foods, and nutraceuticals for promoting health and preventing disease.

Alternanthera paronychioides is a plant species with significant medicinal potential, yet its phytochemical composition, nutritional profile, mineral content, antioxidant capacity, and bioactive components remain largely unexplored. Comprehensive scientific studies are needed to elucidate the chemical composition and biological activities of this plant species, providing valuable insights into its therapeutic properties and potential applications in healthcare. Understanding the phytochemical composition and nutritional value of *Alternanthera paronychioides* can contribute to its utilization in traditional medicine, dietary supplementation, and pharmaceutical applications. Hence, this study investigated the phytochemical composition, nutritional contents, mineral composition and the antioxidant capacity of the ethanolic extract of *Alternanthera paronychioides.*

2. Materials and methods

2.1. Collection of Plant Material

Fresh and healthy, disease free, leaves of *Alternanthera paronychioides* were collected from the field of Crawford University, Igbesa, Ogun State in Nigeria and was authenticated at the Department of Biological Sciences by a Professional Botanist and the voucher specimen was deposited in the laboratory at the department of biochemistry. The aerial parts of fresh leaves and stem of *Alternanthera paronychioides* were washed thoroughly under running tap water and at thereafter rinsed with distilled water to remove the dirt. The leaves were air-dried for two weeks and then milled into powdery form using an electric blender. This was sieved through 1.0 mm sieve to obtain a fine powder which was kept in an airtight sterilized container with proper labeling until further use.

2.2. Plant Extraction

The extraction was carried out using soxhlet apparatus. 50 g of the plant sample was weighed and placed in the thimble which was placed in the soxhlet extractor. About 750 ml of ethanol was poured into round bottom flask, the whole setting was placed on heating mantle and gradually the ethanol was boiling and the extraction process continues for hours. The condensing unit was removed from the extraction unit and the extract was collected into a beaker. The solvent was concentrated using rotatory evaporator [6].

2.3. Qualitative Phytochemical analysis of the ethanolic extract of the leaves of *Alternanthera paronychioides.*

The ethanolic extract of Alternanthera paronychoides was analyzed for the presence of secondary metabolites such as flavonoids, tannins, steroids, saponins, steroids, terpenoids, alkaloids, terpenoids and phenols as described by [7].

2.4. Proximate Analysis of the ethanolic extracts of the leaves of *Alternanthera paronychioides.*

2.4.1. Determination of Total Ash

2g of the powdered extract was weighed into a tarred crucible, and then transferred into a furnace and the furnace was ignited for about 2-3 hours at 450oc. Then the furnace was switched off and the temperature was allowed to come down. Then the crucible was transferred into a desiccator with the aid of crucible tongs and then allowed to cool prior to weighing.

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

Where: W1 = Weight of empty crucible
W2 = Weight of original sample + crucible
W3 = Weight of Ash sample + crucible

2.4.2. Determination of Total Moisture Content

2g of the sample was weighed into already weighed aluminum drying dish and weights were recorded. The dish was transferred into the drying oven and the sample was allowed to dry for 4 hours at 105^{o}C. The sample was then cooled in the desiccator and was weighed on a weighing balance. The sample was transferred into the oven and allowed to dry for another 30mins, then cooled in a desiccator and reweighed. This experiment was repeated until constant weight is obtained.

$$\text{Moisture content (\%)} = \frac{W1-W2}{W2}$$

2.4.3. Determination of Crude Fat

2g of pre dried sample was weighed into a thimble fiber or filter paper. The boiling flask was weighed before the addition of petroleum ether. The Soxhlet apparatus was assembled and the extraction was allowed to take place for 4 hours. The boiling flask containing the extracted fat solvent was placed in an oven to remove the solvent or by use of rotary evaporator to remove the solvent. The flask was cooled in a desiccator and weighed.

$$\text{Fat on dry weight basis (\%)} = \frac{Weight\ of\ fat\ in\ sample}{Weight\ of\ dried\ sample} \times 100$$

2.5. Inductively Coupled Plasma Optical Emission Spectroscopy (ICP-OES) Heavy Metals and trace elements Analysis of the ethanolic extract of *Alternanthera paronychioides.*

Analysis of the Heavy metals and trace elements were done using the Agilent 5800 inductively coupled Plasma- Optical Emission Spectroscopy (CP-OES) equipment. Standards concentrations for heavy metals and trace elements were used for the internal calibration equipment for the analysis.

2.6. GC-MS (Gas Chromatography-Mass Spectrometry) Analysis

The Gas Chromatography-Mass Spectrometry was carried out at Nigerian Institute of Medical Research, Lagos on the plant extracts according to the methods of Rukshana et al [8]. The first step of GCMS was done by injecting the sample into the injection port of the Gas chromatogram (GC). The GC instrument vaporizes the sample and then separates and analyses the various components. Each component produces a specific spectral peak that may be recorded on a paper chart electronically. The time elapsed between elution and injection is called the "retention time". Differences between some compounds were identified using the Retention time. The peak is measured from the base to the tip of the peak.

3. Results

3.1. Qualitative Phytochemical screening

The qualitative phytochemical screening of the ethanolic extract of *Alternanthera paronychioides* is presented in table 1. The result of qualitative phytochemical screening indicated the presence of flavonoids, tannins, steroids, reducing sugar and phenolics while anthraquinone was absent.

Table 1 Phytochemical Screening of the ethanolic extracts of extracts of the leaves of *Alternanthera paronychioides.*

S/N	Constituents	Test Results
1.	Tannins	+
2.	Flavonoids	+
3.	Steroids	+
4.	Reducing sugar	+
5.	Phenolics	+
6.	Anthraquinone	-

Key: +: Presence of bioactive compounds; -: Absence of bioactive compounds

3.2. Proximate Analysis of the ethanolic extract of *Althernanthera paronychioides.*

The results for the nutritional composition of the ethanolic extract of *Alternanthera paronychioides* is shown in Table 2.

Table 2 Proximate Analysis of the ethanolic extract of *Alternanthera paronychioides*

Moisture	Ash	N.P. E	Crude fat	Crude fiber	Carbohydrate
0.38%	19.57%	20.22%	2.3%	66.49%	1.5%

3.3. Inductively Coupled Plasma Optical Emission Spectroscopy (ICP-OES) Heavy Metals and trace elements Analysis of the ethanolic extract of *Alternanthera paronychioides.*

The analysis of heavy metals and trace elements is shown in table 3. Elemental composition analysis revealed the presence of about 72 different elements.

Table 3 Elemental composition of *A. paranychioides*

ELEMENTS	CONCENTRATION (mg/ml)
Ag	0.135777
Al	2.156182
Au	0.077237
Ca	67.290324
Cu	0.138369
Fe	29.852172
K	552.81 1602
Li	3.089781
Mg	202.769354
Mn	1.076848
Na	25.806539
Ni	0.133928
P	9.949794
Pb	0.090166
S	0.097969
Si	22.895015
Sn	0.203463
Cr	0.145924
Be	0.000166
Zn Sb	0.293575 0.091927

3.4. Gas Chromatography Mass Spectrometry Analysis of the Ethanolic Extract of Alternanthera paronychioides.

The GC-MS Chromatogram of the ethanolic extract of the leaves *A. paronychioides* presented in Figure 1 revealed thirty-four peaks. This shows that thirty-four different phytocompounds were present in the extracts. The names and molecular weight of the compounds are shown in Table 4.

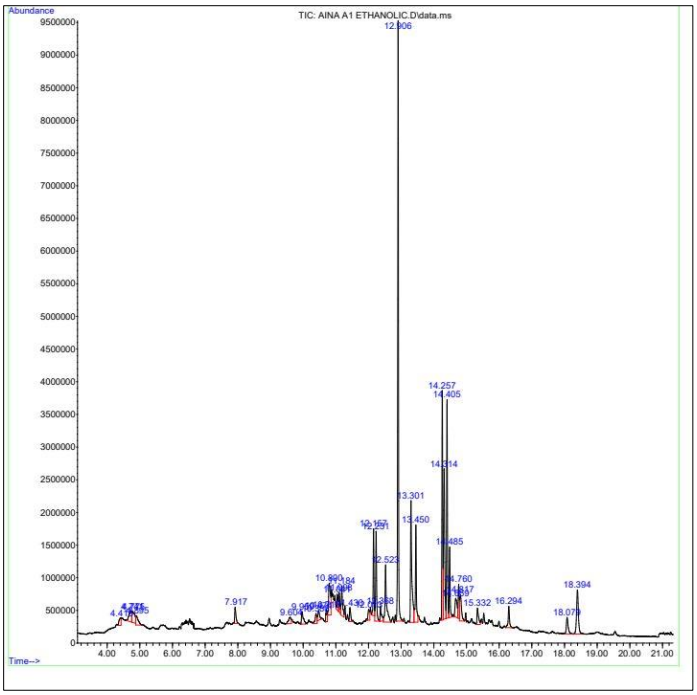

Figure 1 GC-MS ANALYSIS of the ethanolic extract of the leaves of *Alternanthera paronychioids.*

Table 4 Bioactive compounds result from GC-MS spectral analysis of Ethanolic Extract of *Alternanthera paronychioides*

Peak time	Retention time (RT)	Area %	Molecular Formula	Compounds
1	4.415	0.64	$C_6H_{11}O_S$	2-Mercapto-allyl-ester
2	4.741	1.23	$C_6H_6O_2$	Benzoic acid
3	4.775	1.38	$C_3H_6O_2S$	2-Mercaptopropanoic acid
4	4.895	0.97	$C_6H_{14}O_2$	1-Propanol 3-[(2-hydroxyethyl)]
5	7.917	0.88	$C_{10}H_{20}O_2$	Decanoic acid
6	9.604	0.71	$C_{12}H_{24}O$	(6E,8E)-Dodecadienal
7	9.959	1.03	$C_9H_{18}O_2$	8-Nonenoic acid
8	10.388	0.79	$C_9H_{16}O$	1- Cyclohexyl-2-buten-1-ol
9	10.474	0.75	$C_{18}H_{36}$	9-octadecene
10	10.715	0.68	C_4H_6O	3-buten-2-one
11	10.800	2.65	$C_6H_8O_2$	Spiro [2.2] pentane-1-carboxylic acid
12	11.041	0.90	C_6H_6O	Methyl-2-Furanyl)
13	11.098	0.96	C_6H_{10}	1,4-Hexadiene
14	11.184	1.73	$C_{12}H_{24}$	Cyclododecane
15	11.430	0.79	C_2H_4O	Oxirane
16	12.013	0.79	$C_{10}H_{16}O$	Dihydronopol
17	12.157	3.08	$C_{20}H_{34}$	Neophytadiene
18	12.231	3.84	$C_{18}H_{38}$	6,10,14 trimethylpentadecane
19	12.368	0.91	$C_{20}H_{34}$	Neophytadiene

20	12.523	3.86	$C_{18}H_{33}O$	2-(9,12-Octadecadienyloxy)
21	12.906	20.64	$C_{16}H_{32}O_2$	Hexadecanoic acid
22	13.301	7.09	$C_{14}H_{28}O_2$	Tetradecanoic acid
23	13.450	4.35	$C_8H_{16}O_2$	ethyl ester
24	14.257	8.17	$C_{18}H_{32}O_2$	9,12-Octadecadienoic acid
25	14.314	7.66	$C_{18}H_{30}O_2$	9,12,15- octadecatrienoic acid
26	14.405	8.17	$C_{20}H_{40}O$	Phytol
27	14.485	2.66	$C_{19}H_{38}O_2$	Methyl stearate
28	14.669	1.75	$C_{18}H_{34}O_2$	Linoelaidic acid
29	14.760	1.47	$C_{18}H_{32}O_2$	Linoleic acid
30	14.817	2.09	$C_{10}H_{14}$	Cyclooctene, 3-ethenyl
31	15.332	1.15	$C_{18}H_{34}O_2$	11,13-Dimethyl-12-tetradecen-1-ol acetate
32	16.294	1.28	$C_{21}H_{40}O_2$	4,8,12,16-Tetramethyl heptadecan-4-olide
33	18.079	1.34	$C_{22}H_{44}O_2$	Docosanoicacid
34	18.394	3.62	$C_{24}H_{38}O_4$	Bis(2-ethylhexyl) Phthalate

3.5. *Invitro* antioxidant capacity assay for the ethanolic extract of Alternanthera paronychioides.

The results showing the antioxidant capacity of the ethanolic extract of *A. paronychioides* is shown in table 5.

Table 5 *Invitro* antioxidant assay for the ethanolic extract of *A. paronychioides*

Phytochemicals	Total Flavonoids mg QE/g	Total Phenol mg GAE/g	DPPH radical Scavenging activity (IC_{50})µM	Total antioxidant
Concentrations	0.983±0.002	0.187±0.005	0.185±0.005	1.869±0.011

Data are expressed as mean ± standard deviation of triplicate sample.

4. Discussion

Phytochemical analysis plays a pivotal role in unraveling the chemical composition of medicinal plants, providing insights into their potential health-promoting properties. The findings from this study demonstrate the rich phytochemical and nutritional potential of the ethanolic extract of *Alternanthera paronychioides* (EEAP), confirming its status as a valuable medicinal plant. The qualitative phytochemical screening revealed the presence of several secondary metabolites, including flavonoids, tannins, steroids, reducing sugars, and phenolics as shown in Table 1. These compounds are known for their significant pharmacological effects, particularly antioxidant, anti-inflammatory, and antimicrobial properties. The absence of anthraquinone which is often associated with laxative effects, suggests a favorable profile for therapeutic use. Flavonoids have been reported to modulate enzyme activity, inhibit tumor cell proliferation, and induce apoptosis in cancer cells, making them promising candidates for cancer prevention and therapy [9]. Phenolic compounds possess potent antioxidant properties and play a crucial role in mitigating oxidative stress-induced cellular damage [10]. These compounds scavenge free radicals, chelate metal ions, and inhibit lipid peroxidation, thereby preserving cellular integrity and function [11].

The proximate analysis highlighted the emphasized the nutritional potential of *A. paronychioides* as shown in Table 2. Notably, the extract contained substantial levels of crude fiber (66.49%), ash (19.57%), and a notable amount of crude fat (2.3%). These values suggest that the plant may serve as a good dietary supplement. The high fiber content implies potential benefits for digestive health, while the ash content indicates a rich mineral profile, confirmed by elemental analysis via ICP-OES.

Elemental composition analysis revealed the presence of over 70 different elements, including essential macro and micro-minerals such as potassium (552.81 mg/ml), magnesium (202.77 mg/ml), calcium (67.29 mg/ml), iron (29.85 mg/ml), and zinc (0.29 mg/ml). These elements play vital roles in numerous physiological functions, such as enzymatic activities, oxygen transport, neuromuscular function, and bone development [12]. The presence of trace elements like antimony, tin, chromium, and manganese further adds to the therapeutic potential of the extract. However, the detection of potentially toxic elements such as lead and nickel, though in low concentrations, underscores the need for dosage regulation in any future applications. Copper contributes to the formation of red blood cells and collagen, while manganese acts as a cofactor for antioxidant enzymes and bone metabolism [13; 14]. Iron (Fe) plays a crucial role in electron transport chains, which are essential for energy production and various metabolic processes within plant cells. Iron-containing proteins, such as ferredoxins, cytochromes, and iron-sulfur clusters, participate in redox reactions, transferring electrons between molecules. These electron transport chains are integral to ATP synthesis, the production of reducing equivalents for biosynthetic reactions, and the detoxification of reactive oxygen species (ROS) [15]. Both plants and animals require the metal nickel. Nickel is required in trace amounts for the production of red blood cells and the control of lipid composition in tissues. However, at high concentrations, it turns poisonous and leads to serious illnesses such skin irritation, liver and heart failure, vision loss, and weight loss [16]. According to the experimental results, the plant samples' Ni concentration ranged from 0.133928mg/ml, which is low and safe for consumption. When it comes to the metabolism of fat, cholesterol, and glucose, chromium is essential. Insufficient amounts of it lead to hyperglycemia, increased body fat, and a drop in sperm count; in excess, it can be harmful and cause cancer. The plant's Cr concentrations were discovered to be within the safe and low limit of 0.145924. The nutritional significance of these minerals in *Alternanthera paronychioides* lies in their potential to address micronutrient deficiencies, particularly in populations with limited access to diverse food sources. Incorporating *Alternanthera paronychioides* into the diet can enhance mineral intake and support overall health and well-being. This aligns with current dietary guidelines emphasizing the consumption of nutrient-rich plant-based foods [17].

GC-MS analysis confirmed the presence of thirty-four bioactive compounds such as 9, 12, 15-octdecatrienoic acid also known as α-linolenic acid(ALA), phytol, neophytadiene, methyl stearate, 1,2,3,4-butanetetrol, Propionic acid, 2-mercaptoallyl ester, dihydronopol, phytol, isophytol among others. Many of these compounds are reported to exhibit antioxidant, anti-inflammatory, anticancer, and antimicrobial activities. α-linolenic acid is an essential polyunsaturated omega-3 fatty acid with known health-promoting properties. ALA is crucial in human nutrition and has been associated with anti-inflammatory and cardioprotective effects 8]. Propionic acid is a simple carboxylic acid, while the 2-mercaptoallyl ester moiety is characterized by its sulfur-containing mercapto group, which is commonly associated with antimicrobial and antioxidant properties [19]. Sulfur-containing compounds in plants play an important role in defense mechanisms, contributing to the plant’s ability to resist microbial attacks and oxidative stress. Furthermore, the presence of the allyl group suggests that the compound could also influence the plant's aroma, potentially enhancing its appeal to pollinators or contributing to its deterrence of herbivores. The wide range of bioactive molecules present in EEAP suggests its potential use in the development of nutraceuticals and functional foods.

Furthermore, the antioxidant potential of the extract was evident in the DPPH scavenging assay, where EEAP exhibited a low IC50 value of 0.185 ± 0.005 μM. This indicates a high free radical scavenging ability, which may contribute to the prevention of oxidative stress-related diseases such as cancer, cardiovascular disorders, and neurodegenerative conditions.

Finally, the data obtained in this study are consistent with the traditional uses of *A. paronychioides* in managing conditions such as gout, arthritis, diabetes, and hyperuricemia. The presence of key phytochemicals, nutritional elements, and potent antioxidant activity lends scientific credence to these traditional claims and positions the plant as a promising candidate for further pharmacological and nutraceutical exploration.

5. Conclusion

This study has comprehensively evaluated the phytochemical, nutritional, elemental, and antioxidant properties of the ethanolic extract of *Alternanthera paronychioides*. The extract was found to be rich in bioactive compounds such as flavonoids, tannins, and phenolics, and displayed significant antioxidant capacity. Nutritional profiling revealed high levels of crude fiber and essential minerals, supporting its use as a dietary supplement. The identification of over thirty bioactive compounds via GC-MS underscores its therapeutic potential. Given these findings, *A. paronychioides* stands out as a plant of medicinal and nutritional importance. It offers potential for development into functional foods, dietary supplements, and herbal pharmaceuticals. However, further studies involving toxicity assays, dose standardization, and clinical trials are necessary to validate its safety and efficacy in human health applications. The plant's rich phytochemical and elemental profile, combined with strong antioxidant activity, make it a compelling subject for future research in drug development and nutraceutical science.

Compliance with ethical standards

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Disclosure of conflict of interest

The authors declare no competing interests. This manuscript has not been submitted to, nor is under review at another journal or other publishing venue.

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