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COMPREHENSIVE PHYTOCHEMICAL, NUTRITIONAL, MINERAL AND ANTI-NUTRITIONAL EVALUATION OF *BOERHAVIA DIFFUSA LINN.* ROOTS FOR MEDICINAL AND NUTRACEUTICAL APPLICATIONS

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ABSTRACT

Background: Plant-based medicines constitute the basis of many modern pharmaceuticals, and numerous traditional medicinal plants continue to attract scientific interest due to their therapeutic potential. *Boerhavia diffusa* Linn. is an important medicinal plant extensively used in the Ayurvedic system for the management of various ailments. **Objective:** The present study was undertaken to evaluate the qualitative and quantitative phytochemical profile, proximate composition, nutritional value, mineral content, and anti-nutritional factors of *Boerhavia diffusa* Linn. to substantiate its medicinal and nutraceutical importance. **Methods:** Aqueous, hydroalcoholic, and chloroform extracts of *Boerhavia diffusa* Linn. were subjected to qualitative phytochemical screening and quantitative estimation of major bioactive constituents. Proximate analysis was carried out to determine moisture content, fiber, bulk density, ash values, and extractive values. Nutritional assessment included estimation of carbohydrates, proteins, fats, and vitamins, along with mineral composition (macro- and micro-elements) and anti-nutritional factors. **Results:** Phytochemical screening revealed the presence of alkaloids, tannins, flavonoids, saponins, terpenoids, and phenolic compounds, whereas cardiac glycosides were absent in all extracts. Quantitative analysis showed higher concentrations of flavonoids (7.15 g/100 g) and phenols (5.35 g/100 g) compared to alkaloids (0.533 g/100 g). Proximate analysis indicated a high total ash content (21.70%), reflecting a rich mineral profile. Nutritional evaluation revealed appreciable carbohydrate (12.84 mg/g) and protein (6.42 mg/g) contents with low fat levels (2.05 mg/g). Mineral analysis identified magnesium (138.2 mg/100 g) as the predominant element. **Conclusion:** The comprehensive evaluation confirms that *Boerhavia diffusa* Linn. is rich in bioactive phytochemicals, essential nutrients, and minerals, with acceptable levels of anti-nutritional factors. These findings support its traditional medicinal use and highlight its potential as a standardized natural drug and nutraceutical for future pharmacological and clinical studies.

KEYWORDS: *Boerhavia diffusa Linn.;* Phytochemical analysis; Proximate composition; Nutritional evaluation; Mineral analysis; Medicinal plant.

INTRODUCTION

For centuries**,** plants have served as an invaluable source of inspiration for the discovery of novel therapeutic agents. Plant-derived medicines have made significant contributions to human health and well-being and continue to form the basis of many modern pharmaceuticals. Despite advances in synthetic chemistry and biotechnology, traditional medicine based

on plant extracts remains a vital component of global healthcare systems, providing primary health coverage for more than 80% of the world's population, particularly in developing countries.[1,2,3&4] *Boerhavia diffusa Linn*. (Punarnava or red spiderling), a medicinal plant of the family Nyctaginaceae, is a key component of several Ayurvedic and traditional ethnomedical formulations, with its name signifying rejuvenation and renewal. Its therapeutic importance is well documented in classical texts such as the *Charaka Samhita* and *Sushruta Samhita*. The whole plant, particularly the roots, is widely used by indigenous and tribal communities in India and in Unani medicine for treating jaundice, ascites, inflammatory disorders, asthma, and piles. It is also valued for its diuretic, hepatoprotective, anti-inflammatory, anti-asthmatic, appetizing, and alexiteric properties, and as an antidote for rat poisoning. Extensive phytochemical, pharmacological, experimental, and clinical studies have validated its traditional uses, identifying diverse bioactive compounds that underscore its potential in modern drug development.[5 & 6] Pharmacological studies show that *Boerhavia diffusa Linn*. Possesses diverse bioactivities, including diuretic, antifertility, immunomodulatory, anti-inflammatory, antidiabetic, antiviral, antimicrobial, hepatoprotective, antimetastatic, and antioxidant effects.[7,8&9]

Phytochemical investigations of *Boerhavia diffusa Linn*.have revealed the presence of several bioactive compounds, notably alkaloids such as punarnavine, along with amino acids, flavonoids, rotenoids, lignans, and glycosides, which are believed to contribute to its medicinal efficacy.[10] Despite extensive research on its pharmacological and phytochemical properties, limited information is available regarding the nutritional composition and antinutritional factors of this species. In this context, the present investigation aims to evaluate the nutritional and antinutritional components of *Boerhavia diffusa Linn*. Such an assessment is essential to understand its potential as a nutritionally beneficial plant in addition to its established medicinal value, thereby supporting its broader application in functional foods and health-related interventions.

MATERIALS AND METHODS

Collection of root of the plant: The whole roots of *Boerhavia diffusa Linn.* were collected from a naturally growing population in the Yercaud foothills, Salem District, Tamil Nadu, India. The plant material was authenticated based on standard taxonomic characters as described in regional floras. The collected roots were thoroughly washed with distilled water to remove adhering soil and extraneous matter. The cleaned samples were shade-dried at room temperature for two weeks to prevent degradation of thermo labile constituents. After complete drying, the plant material was coarsely powdered using an electric blender. The powdered sample was transferred to airtight sample tubes and stored under refrigerated conditions until further nutritional and antinutritional analyses were performed.[11]

Plant (root) extraction: Root extraction of *Boerhavia diffusa Linn.* was carried out using three different solvent systems, namely aqueous (distilled water), hydroalcoholic, and chloroform solvents, to ensure the extraction of a wide range of polar and non-polar phytoconstituents. Dried root powder (100 g) was macerated separately with 500 mL of each solvent for 12 hours at room temperature with intermittent shaking to enhance solvent penetration and extraction efficiency. The resulting extracts were filtered using Whatman No. 1 filter paper to remove insoluble plant debris. The filtrates thus obtained were used for qualitative phytochemical analysis.

Phytochemical profile (Qualitative and Quantitative methods): Qualitative phytochemical screening of the root extracts of *Boerhavia diffusa Linn.* was performed to detect the presence of major classes of secondary metabolites using standard procedures.[12&13] These analyses were carried out to identify phytoconstituents such as alkaloids, flavonoids, tannins, saponins, phenolics, glycosides, and terpenoids.

Quantitative phytochemical analyses were subsequently conducted to estimate the concentrations of selected bioactive constituents, including alkaloids, saponins, tannins, total phenolics, and flavonoids, following established and widely accepted protocols.[14&15] The quantitative estimation provided insights into the relative abundance of these phytochemicals, which are known to contribute significantly to the biological and therapeutic potential of the plant root.

Proximate analysis

Proximate analysis of the powdered root sample of *Boerhavia diffusa Linn.* was carried out to determine its physicochemical characteristics, including moisture content, bulk density, foaming index, and total ash content. In addition, ash-related parameters such as acid-soluble and acid-insoluble ash, water-soluble and water-insoluble ash, sulphated ash, as well as extractive values including water-soluble and alcohol-soluble extractives, were evaluated. All analyses were performed in accordance with the standard methods and protocols prescribed by the Association of Official Analytical Chemists (AOAC).[16&17]

Elemental analysis

Elemental analysis of the powdered root sample of *Boerhavia diffusa Linn.* was carried out to determine its macro- and micro-mineral composition. The sample was subjected to wet acid digestion using a nitric acid–perchloric acid mixture. Briefly, an accurately weighed quantity of the powdered sample was digested with the acid mixture and allowed to stand for 24 hours to ensure complete mineralization of organic matter. Following digestion, the solution was filtered through Whatman No.

42 filter paper, and the clear filtrate was made up to a known volume with distilled water. The resulting solution was then analyzed for mineral elements using Atomic Absorption Spectroscopy (AAS) under standard operating conditions.[18&19]

Biochemical analysis: The nutritional composition of *Boerhavia diffusa Linn.* root powder was assessed by estimating the major macronutrients, including carbohydrates, lipids, and proteins, using standard analytical protocols.[20,21&22] Carbohydrate content was determined following the phenol-sulfuric acid method,[20] lipid content was estimated by Soxhlet extraction using petroleum ether as the solvent,[21] and protein content was quantified by the Kjeldahl method for total nitrogen determination.[22]

In addition, the levels of essential vitamins were measured, including ascorbic acid (Vitamin C), thiamine (Vitamin B1), and tocopherol (Vitamin E), using established spectrophotometric and chromatographic techniques.[23 & 24] These analyses provided a comprehensive evaluation of the nutritional potential of *Boerhavia diffusa Linn*, contributing to its possible application as a functional food or nutraceutical agent.

Anti-nutritional analysis

The anti-nutritional constituents of *Boerhavia diffusa Linn*. root powder were evaluated to assess the presence of bioactive compounds that may interfere with nutrient absorption. Specifically, saponins and tannins were quantified using standard analytical methods [25 & 26]. These analyses provided insights into the potential antinutritional impact of the plant while complementing the nutritional evaluation, thereby contributing to a comprehensive understanding of its dietary value.

RESULTS AND DISCUSSION

Phytochemical profile: The qualitative phytochemical screening of *Boerhavia diffusa Linn.* root extracts revealed the presence of a variety of bioactive compounds, with their distribution dependent on the solvent used. The hydroalcoholic extract showed the highest diversity, containing alkaloids (+++), flavonoids (+++), terpenoids (++), tannins (++), phlobatannins (+), coumarins (++), steroids (+++), and phenolic compounds (++), while glycosides were absent in all extracts. The chloroform extract selectively yielded steroids (++), coumarins (++), saponins (++), alkaloids (+), flavonoids (++), and phenolics (++), with other phytochemicals either absent or present in trace amounts. The aqueous extract mainly contained polar compounds, including alkaloids (++), tannins (++), steroids (+++), and phenolic compounds (++), whereas flavonoids, terpenoids, phlobatannins, saponins, coumarins, and glycosides were either weakly present or absent. Overall, the hydroalcoholic extract proved most effective in extracting a broad spectrum of phytochemicals, highlighting its potential for pharmacological applications.

Table 1: Phytochemical Constituents of *Boerhaavia diffusa Linn.*

S. No	Phytochemicals	Test	Hydroalcoholic Extract	Chloroform extract	Water (Aqueous) extract
1	Alkaloid	Dragendorff's test Mayer's test	+++ -	++ +	++ +
2	Flavonoid	Shinoda test	+++	++	-
3	Terpenoid	Salkowski test	++	-	+
4	Tannin	FeCl3 test	++	-	++
5	Phloba tannin	HCl test	+	-	-
6	Saponin	Chloroform &H2SO4 test	-	++	-
7	Coumarin	Alkaline test	++	++	-
8	Steroid	Liebermann Burchard test	+++	++	+++
9	Glycosides	Molish's test	-	-	-
10	Phenolic compounds	Ferric chloride test	++	++	++

The quantitative estimation of major phytochemicals in *Boerhavia diffusa Linn* roots revealed that flavonoids (7.15g/100g) and phenolic compounds (5.35g/100g) were present in the highest concentrations, followed by saponins (2.13g/100g), tannins (1.15g/100g), and alkaloids (0.533g/100g).[27] These results indicate that the plant is a rich reservoir of bioactive compounds, which may contribute to its diverse pharmacological activities, including antioxidant, anti-inflammatory, and antimicrobial effects. Flavonoids and phenolics are well known for their free radical scavenging and protective effects,[28] whereas saponins and tannins exhibit antimicrobial, antitumor, and anti-inflammatory properties. Alkaloids, although present in lower amounts, play a significant role as natural defense molecules in plants, providing resistance against predators and parasites, and are also associated with therapeutic benefits. Collectively,[29] the abundance and diversity of these phytochemicals suggest that *Boerhavia diffusa Linn.* possesses considerable potential as a medicinal and nutraceutical plant. The presence of these diverse phytochemical constituents suggests that *Boerhavia diffusa Linn.* may serve as a potential medicinal agent with analgesic, antispasmodic, antibacterial, anticancer,

anti-inflammatory, and antioxidant properties. The detailed phytochemical profile highlights the species' dual value, not only as a therapeutic plant but also as a nutritionally rich and safe source of bioactive compounds. This underscores its potential for use both in traditional medicine and as a natural supplement for enhancing antioxidant intake and promoting overall health.

Proximate analysis: The results of the proximate composition are shown in Table 2. The proximate analysis showed the moisture content of *Boerhavia diffusa Linn.* is 76.50% (w/w). It indicates a low shelf life of the fresh plant and hence long storage would lead to spoilage due to its susceptibility to microbial attack. This supports the practice of storage in dry form by users. Moisture content is among the most vital and mostly used measurement in the processing, preservation and storage of food.[16&19]

Table 2: Proximate and Nutrient Composition in *Boerhaavia. diffusa Linn.*

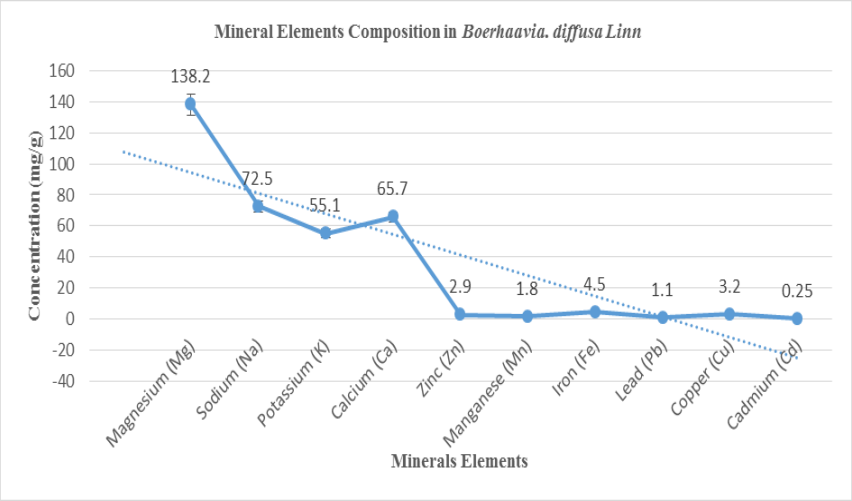
Parameters	**Concentration** (%) / g·ml^{-1}
Moisture %	76.50%
Fibre %	2.80%
Bulk density g/ml	0.38 g/ml
Foaming index %	95%
Total ash content %	21.70%
Acid soluble ash %	17.80%
Acid insoluble ash %	0.70%
Water soluble ash %	5.00%
Water insoluble ash %	14.70%
Sulphated ash	1.20%
Alcohol soluble extractive %	7.00%
Water soluble extractive %	15.80%

The proximate and nutrient analysis of *Boerhavia diffusa Linn*. roots indicates high moisture (76.5%), moderate fiber (2.8%), and substantial mineral content, reflecting its nutritional and medicinal value.[16 & 19] Bulk density, foaming index, ash, and extractive values highlight the presence of bioactive compounds such as saponins and soluble phytochemicals relevant for pharmacological and formulation purposes.[30 & 31] Collectively, these parameters support the traditional use of *Boerhavia diffusa Linn* as a safe nutraceutical and provide a baseline for quality control in herbal preparations.

Elemental analysis (Macro and Micro Elements)

Table 3: Proximate and Nutrient Composition in *Boerhaavia. diffusa Linn.*

S.No:	**Mineral Element**	**Concentration (mg/g)**	**Category**
1	Magnesium (Mg)	138.2	Macro
2	Sodium (Na)	72.5	Macro
3	Potassium (K)	55.1	Macro
4	Calcium (Ca)	65.7	Macro
5	Zinc (Zn)	2.9	Micro
6	Manganese (Mn)	1.8	Micro
7	Iron (Fe)	4.5	Micro
8	Lead (Pb)	1.1	Heavy metal
9	Copper (Cu)	3.2	Heavy metal
10	Cadmium (Cd)	0.25	Heavy metal

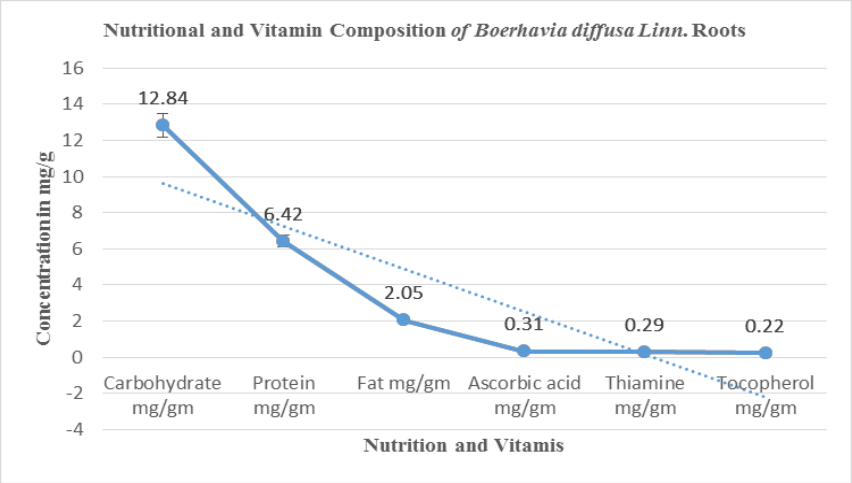


The mineral profile of *Boerhavia diffusa Linn.* roots (Table 3) demonstrates the presence of essential macro and micro-elements important for human health. Magnesium was the predominant macromineral, followed by calcium, sodium, and potassium, supporting roles in enzymatic activity, electrolyte balance, bone health, and cardiovascular function. The micro-elements iron, zinc, and manganese were present in appreciable amounts, indicating contributions to hemoglobin synthesis, antioxidant defense, and metabolic processes. Heavy metals such as lead and cadmium occurred only in trace concentrations, suggesting minimal toxicity and safe consumption within permissible limits. Overall, this balanced mineral composition substantiates the traditional medicinal use of *Boerhavia diffusa Linn* and highlights its potential as a nutraceutical resource.[16&19]

Biochemical analysis

Table 4: Nutritional and Vitamin Composition of *Boerhavia diffusa Linn.* Roots.

Carbohydrate mg/gm	12.84
Protein mg/gm	6.42
Fat mg/gm	2.05
Ascorbic acid mg/gm	0.31
Thiamine mg/gm	0.29
Tocopherol mg/gm	0.22



The nutritional and vitamin profile of *Boerhavia diffusa Linn.* roots (Table 4) indicates the presence of essential macronutrients and vitamins contributing to its medicinal and dietary value. The relatively high carbohydrate content (12.84 mg/g) suggests its role as an energy source, while the appreciable protein level (6.42 mg/g) supports metabolic and tissue repair functions.[32&33] The low lipid content (2.05 mg/g) is nutritionally advantageous and characteristic of medicinal roots.[34] The presence of vitamins such as ascorbic acid, thiamine, and tocopherol enhances the antioxidant and metabolic potential of the plant, supporting its traditional use and highlighting its promise as a functional food and nutraceutical resource.[35]

Anti-nutritional analysis: Anti-nutritional analysis of *Boerhavia diffusa Linn.* roots revealed moderate levels of tannins (16 mg/g) and saponins (1.59%), which are known to influence nutrient bioavailability. Saponins may reduce intestinal absorption of glucose and cholesterol, yet they also exhibit hypocholesterolemic effects that support cardiovascular health (Francis et al., 2002; Sparg et al., 2004). Tannins can form insoluble complexes with proteins, carbohydrates, and lipids, leading to reduced digestibility when consumed in excess (Chung et al., 2003). However, anti-nutrients generally pose minimal risk in a diversified diet. Their levels can be significantly reduced through processing methods such as cooking, soaking, fermentation, and malting (Hotz & Gibson, 2007; Gemede & Ratta, 2014). The concentrations observed in *B. diffusa* were comparable to those in common edible plants and not considered harmful (Chakraborty & Eka, 2010). Overall, the moderate presence of these compounds does not compromise the nutritional or medicinal value of *Boerhavia diffusa Linn.*

CONCLUSION

The present investigation provides a comprehensive evaluation of *Boerhavia diffusa Linn.* roots with respect to their phytochemical, proximate, nutritional, mineral, and anti-nutritional composition. Qualitative and quantitative analyses confirmed the presence of diverse bioactive phytoconstituents, particularly flavonoids and phenolic compounds, which are known to contribute significantly to antioxidant, anti-inflammatory, and therapeutic properties. The proximate analysis revealed high moisture and ash contents, indicating substantial mineral richness and supporting the plant's traditional medicinal relevance. Nutritional profiling demonstrated appreciable levels of carbohydrates and proteins with low fat content, along with essential vitamins, highlighting its value as a functional food ingredient. Mineral analysis showed dominance of essential macro- and micro-elements, especially magnesium, while toxic heavy metals were present only in trace, permissible amounts. Although moderate levels of tannins and saponins were detected, their concentrations were not considered harmful and can be reduced through conventional processing methods. Overall, the findings scientifically validate the traditional use of *Boerhavia diffusa Linn.* and underscore its potential as a safe, nutritionally rich, and pharmacologically valuable medicinal plant, providing a strong basis for its standardization and future nutraceutical and therapeutic applications.

Competing Interests: The authors declare that they have no competing interests.

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