Comparative Nutrient Content of *Andrographis paniculata* and *Boerhavia diffusa* of Semi-Arid Region of Rajasthan

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Abstract: The present study aimed to compare the nutrient composition of different plant parts (root, stem, and leaf) of *Andrographis paniculata* and *Boerhaavia diffusa* collected from the semi-arid region of Rajasthan. Proximate constituents, including carbohydrates, crude protein, organic matter, nitrogen-free extract (NFE), and selected mineral elements (phosphorus, calcium, sodium, and potassium), were analyzed to evaluate their nutritional significance. The findings indicate that *B. diffusa* displays nutrient specialization, with roots and stems serving as major storage organs, whereas *A. paniculata* exhibits a comparatively uniform nutrient profile and superior mineral richness, particularly in its foliage. These differences may influence the nutritional and medicinal applications of the two species and provide scientific support for their traditional therapeutic use.

Keywords: *Andrographis paniculata*, *Boerhaavia diffusa*, Nutrient composition, Mineral content, Phytochemical analysis, Medicinal plants, Semi-arid region, Rajasthan.

Introduction: -

Medicinal plants continue to have significant importance in the everyday lives of those living in emerging nations of Asia and Africa, including India. Medicinal plants function as both complements and alternatives to current medical treatments, which are often insufficiently accessible, while also improving the health and safety of local populations. These plants serve essential functions in everyday life and are intricately linked to many social, cultural and economic occurrences related to life, aging, disease and death. Medicinal plants are used for the treatment and diagnosis of illnesses and infections. Historically, plants have served as abundant supplies of effective and safe medicinal compounds (Russell-Smith et al. 2006). The World Health Organization (WHO) defines traditional medicine as the comprehensive amalgamation of knowledge and practices that can be systematically articulated or employed in the prevention and resolution of physical, mental, or social imbalances, relying solely on empirical experience and observations transmitted across generations, either orally or in written form. Approximately 75–90% of the rural population globally (excluding Western nations) depends on traditional medicine as their only healthcare system. The preference for ancient systems is not just attributable to poverty, which limits access to costly modern pharmaceuticals; rather, these systems are more culturally acceptable and fulfill psychological requirements in a manner that contemporary medicine does not (Fassil Kibebe 2001). Ethnomedicinal methods are considered a possible foundation for the creation of safe and effective therapies.

India has a rich history of traditional healthcare systems; nevertheless, research on traditional medicinal plants (TMP) has been relatively scarce in relation to the nation's multiethnic, cultural and forum variety. The primary phytochemical constituents found in medicinal plants include tannins, alkaloids, saponins, cardiac glycosides, steroids, terpenoids, flavonoids, phlobatannins, anthraquinones and reducing sugars. According to the WHO, the primary healthcare of the majority of populations in poor countries relies on traditional medicines, mostly derived from natural plant products (Vines 2004). The populace of Rajasthan, the largest state of India, uses traditional medicine in both rural and urban settings. Nonetheless, there is an absence of reports detailing the phytochemical composition and its broader pharmacological applications in the folk medicine of several traditional medicinal plants in Rajasthan particularly Hanumangarh. Therefore, the present study focuses on the phytochemical variation in different parts—leaf, stem and root—of two selected medicinal plants, *Boerhaavia diffusa* and *Andrographis paniculata*.

Material and Methods: -

Phytochemical analyses were carried out on selected medicinal plant species to determine the presence and concentration of major biochemical constituents (Titus et al., 2024).

1. The **crude protein** content of the samples was estimated using the Micro-Kjeldahl method as outlined by AOAC (1990).
2. The **nitrogen-free extract (NFE)** was calculated indirectly by subtracting the sum of moisture, crude protein, crude fat, ash, and crude fiber percentages from 100% (Isong and Idiong, 1997).
3. The **carbohydrate** content was determined according to the method of Onwuka (2005).

4. The proximate composition, including **organic matter**, was analyzed following the standard procedures described by AOAC (2005).
5. For mineral analysis, 5 g of powdered, oven-dried plant material was digested in concentrated nitric acid (HNO_3). The digests were quantitatively transferred into a 50 mL volumetric flask and made up to volume with distilled water. A blank digest was processed in the same way for reference. The concentrations of minerals such as **phosphorus, calcium, sodium, and potassium** were determined using atomic absorption spectrophotometry (Perkin Elmer AAnalyst 700), with results expressed as mg/100 g dry weight of sample.

Result: -

The comparative analysis of chemical composition in different parts (root, stem, and leaf) of *Andrographis paniculata* and *Boerhaavia diffusa* revealed significant variation in the content of carbohydrates, crude protein, organic matter, nitrogen free extract (NFE), and minerals (phosphorus, calcium, sodium, and potassium).

1. **Carbohydrates:** Carbohydrate levels were relatively high in the stem of *B. diffusa* (75.56%) compared to all parts of *A. paniculata*, where the stem also showed the highest value (49.05%). The root of *B. diffusa* contained comparatively lower carbohydrate content (31.22%), while the leaf exhibited the least (10.56%). In *A. paniculata*, carbohydrate content was more balanced across plant parts (38.42–49.05%), with stem tissues showing maximum accumulation. This suggests that stems of both species serve as a principal storage site for carbohydrates, although the difference is more pronounced in *B. diffusa*.
2. **Crude Protein (CP):** Protein content showed remarkable interspecific and inter-organ variation. *B. diffusa* root exhibited an exceptionally high crude protein value (37.46%), whereas other parts of this species contained much lower amounts (6.78% in stem, 2.26% in leaf). In contrast, *A. paniculata* displayed moderate CP content across its parts, with the leaf (5.66%) showing relatively higher protein compared to the root (4.12%) and stem (3.33%). These findings indicate that *B. diffusa* root could be a richer source of protein, while *A. paniculata* maintains a more uniform but lower protein distribution.
3. **Organic Matter (OM):** Organic matter values were highest in the stem of *A. paniculata* (52.38%) and lowest in the stem of *B. diffusa* (2.18%). Interestingly, *B. diffusa* root showed a moderate OM content (21.25%), while its leaf contained

12.82%. In *A. paniculata*, OM ranged between 42.54–52.38%, consistently higher than in *B. diffusa*. This suggests that *A. paniculata* is comparatively richer in organic constituents, whereas *B. diffusa* stems are relatively poor in this respect despite being carbohydrate-rich.

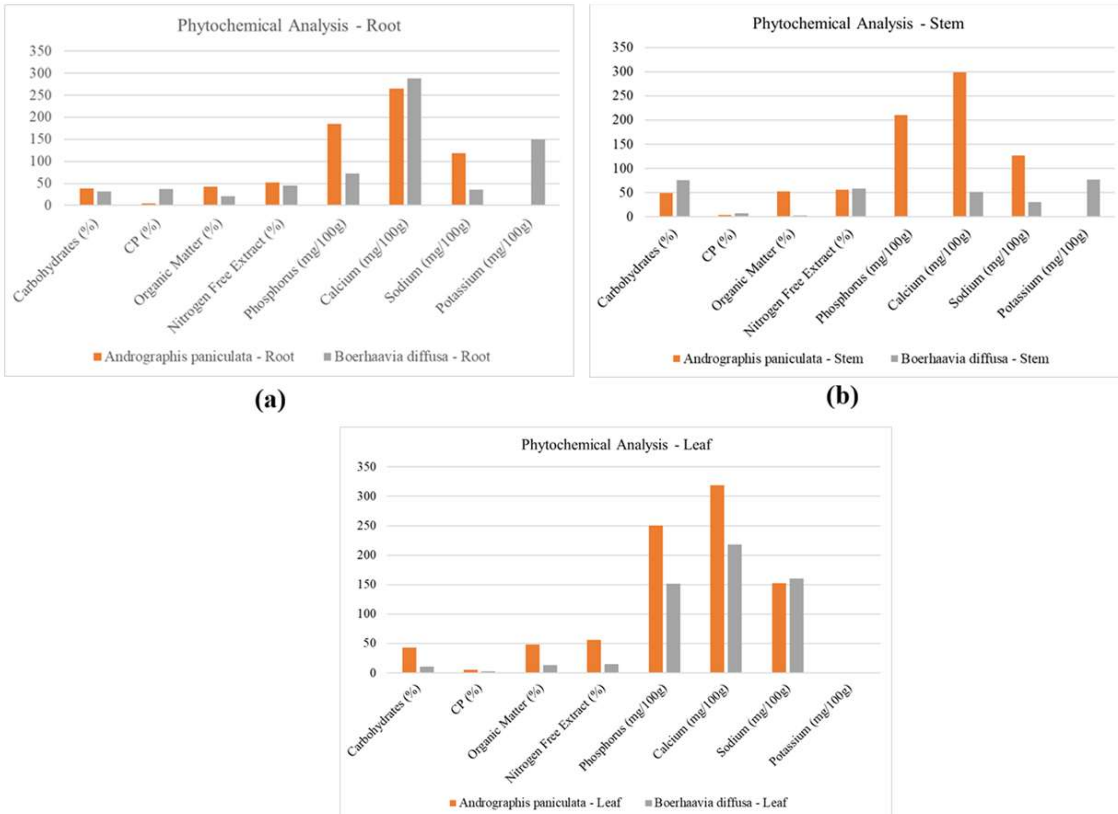
4. **Nitrogen Free Extract (NFE):** NFE was highest in *B. diffusa* stem (58.45%), indicating high soluble carbohydrate content. The lowest NFE was recorded in the leaf of *B. diffusa* (14.52%). In *A. paniculata*, NFE values remained between 52.15–56.12%, again showing more balanced distribution across parts. This pattern reinforces the observation that *B. diffusa* exhibits extreme variability, with its stem being carbohydrate-rich and leaf comparatively nutrient-poor, while *A. paniculata* maintains moderate consistency.
5. **Mineral Content:** Variation in mineral content was observed as follows:

- **Phosphorus:** *A. paniculata* leaf had the highest phosphorus content (250.13 mg/100g), while *B. diffusa* stem showed the lowest (0.50 mg/100g).
- **Calcium:** *A. paniculata* leaves (318.62 mg/100g) were again superior, though *B. diffusa* roots (288 mg/100g) also contained substantial calcium.
- **Sodium:** Maximum sodium was found in *A. paniculata* leaves (152.50 mg/100g), whereas *B. diffusa* root and stem contained relatively low sodium (35.29 mg/100g and 30.29 mg/100g respectively).
- **Potassium:** The most striking difference was observed in potassium levels—*B. diffusa* root had an extraordinarily high concentration (149.9 mg/100g), far exceeding any part of *A. paniculata* (maximum 1.05 mg/100g in root). This suggests a strong species-specific accumulation of potassium in *B. diffusa* roots, which could be a key chemotaxonomic and nutritional marker.

Table 1: Chemical composition of *A. paniculata* and *B. diffusa*

Plant	Part	Carbohydrates (%)	CP (%)	OM (%)	NFE (%)	P (mg/100g)	Ca (mg/100g)	Na (mg/100g)	K (mg/100g)
Andrographis paniculata	Root	38.42	4.12	42.54	52.15	185.26	265.74	118.35	1.05
	Stem	49.05	3.33	52.38	56.12	210.15	298.23	126.42	0.89
	Leaf	42.8	5.66	48.46	55.89	250.13	318.62	152.5	0.93
Boerhaavia diffusa	Root	31.22	37.46	21.25	45.72	72.8	288	35.29	149.9
	Stem	75.56	6.78	2.18	58.45	0.5	51.4	30.29	76.45
	Leaf	10.56	2.26	12.82	14.52	151.45	218.24	160.21	0.86

Fig 1: Phytochemical analysis of *Andrographis paniculata* and *Boerhaavia diffusa* – *(a)* root; (b) stem; (c) leaf



(a) **(b)** **(c)**

The results of the present phytochemical investigation of *Andrographis paniculata* and *Boerhaavia diffusa* are broadly consistent with earlier reports, while also providing novel insights into their nutritional specialization across different plant parts. Our study confirmed that *A. paniculata* leaves are particularly rich in essential minerals such as phosphorus, calcium, and sodium, alongside moderate carbohydrate and protein levels, aligning with the findings of **Puranik et al. (2012)**, who also reported high concentrations of phosphorus (250.13 mg/100g), sodium (152.50 mg/100g), and calcium (318.62 mg/100g) in the leaves. Similarly, **Sharma and Chauhan (2019)** observed that *A. paniculata* leaves contained maximum mineral concentrations (Ca, Na, Fe, Mn) compared to other herbs, which supports our observation of its foliage being mineral-dense. The antioxidant and phytochemical richness reported by **Owoade et al. (2021)** and **Ademiluyi et al. (2016)-**including flavonoids, saponins, and tannins-further validates the nutritional and medicinal value of *A. paniculata* leaves demonstrated in our analysis.

Our study highlighted the remarkable specialization of *B. diffusa*, where the roots are highly proteinaceous (37.46%) and rich in potassium, while the stem functions as the principal carbohydrate reservoir (75.56%), though with limited organic matter. These observations are in close agreement with **Khalil and Iqbal (2017)**, who reported significantly higher carbohydrate levels in aerial parts and elevated protein content in roots of *B. procumbens* (a congener of *B. diffusa*). Likewise, **Majgaine and Verma (2017)** emphasized the nutritive value of *B. diffusa* in terms of high protein and mineral content, corroborating our findings that its roots serve as an excellent protein and mineral source. However, our study diverges from **Ujowundu et al. (2008)**, who found *B. diffusa* leaves to be moderately rich in carbohydrate (10.56%) and vitamins (notably vitamin C and B-complex), whereas our results suggest that the leaves are nutritionally less significant compared to roots and stems. This discrepancy could be due to differences in environmental conditions, plant age or analytical methodologies.

The distinct partitioning of nutrients observed in our study adds a new dimension to existing knowledge. While previous research has largely emphasized the phytochemical constituents of leaves, particularly in *A. paniculata* **(Ademiluyi et al., 2016; Puranik et al., 2012)**, our comparative profiling highlights that roots and stems of *B. diffusa* are equally, if not more, nutritionally valuable. The high protein content in roots and carbohydrate accumulation in stems align with **Khalil and Iqbal (2017)**, yet our study provides a more detailed comparison of mineral distribution across parts, underscoring the role of potassium and phosphorus as key differentiating elements. Furthermore, the relatively nutrient-poor profile of *B. diffusa* leaves, as observed in our study, contrasts with the mineral and vitamin-rich leaves of *A. paniculata*, thus establishing complementary nutritional roles between the two species. Overall, the findings reaffirm earlier reports that both species are pharmacologically and nutritionally significant but contribute differentially: *A. paniculata* through its mineral-rich foliage, and *B. diffusa* through its protein-rich roots and carbohydrate-dense stems. By situating our results within the context of previous studies, it becomes evident that phytochemical diversity across plant parts provides the biochemical foundation for their wide-ranging ethnomedicinal applications.

Conclusion: -

The comparative evaluation of *Andrographis paniculata* and *Boerhaavia diffusa* demonstrated significant variation in nutrient composition among different plant parts. *Boerhaavia diffusa* exhibited pronounced nutritional specialization, with roots serving as rich sources of crude protein and potassium, while stems accumulated the highest levels of carbohydrates and nitrogen-free extract. In contrast, *Andrographis paniculata* maintained a more balanced nutrient distribution and was particularly rich in phosphorus, calcium, and sodium, especially in its leaves. The results suggest that *B. diffusa* roots and stems, and *A. paniculata* leaves, represent the most nutritionally valuable plant parts. These findings support previous reports on the medicinal importance of both species and provide additional evidence for their potential use as sources of nutritionally and pharmacologically important compounds. The study highlights the importance of plant-part-specific utilization and contributes to the scientific validation of these medicinal plants from the semi-arid region of Rajasthan.

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