International Journal for Multidisciplinary Research (IJFMR)
E-ISSN: 2582-2160 ● Website: www.ijfmr.com ● Email: editor@ijfmr.com

Phytochemical Profiling of Root and Leaf Specimens Collected from Diverse Agro-Climatic Zones of India

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Abstract:
To understand the phytochemical variations across different ecological zones is essential for evaluating the medicinal reliability and chemotypic stability of plant species. This study investigates the qualitative phytochemical composition of root and leaf specimens collected from four distinct agro-climatic zones in India: Zone 1 (Jammu, Western Himalayan Region), Zone 4 (Samastipur, Middle Gangetic Plains), Zone 9 (Ujjain, Western Plateau and Hills), and Zone 10 (Bangalore, Southern Plateau and Hills). Standard biochemical assays were performed to determine the presence of alkaloids, tannins, saponins, steroids, phenols, and flavonoids using NaOH and $FeCl_3$ methods. Results revealed complete uniformity across all samples, with alkaloids, tannins, saponins, steroids, phenols, and flavonoids (NaOH) present in both roots and leaves from all zones. Flavonoids detected via $FeCl_3$ were uniformly absent. The findings demonstrate remarkable chemotypic stability across diverse ecological conditions, supporting the species' reliability as a medicinal resource and encouraging further quantitative and chromatographic investigations.

Keywords: Phytochemicals; Alkaloids; Flavonoids; Chemotypic stability; Agro-climatic zones.

Introduction:

Plants produce a variety of secondary metabolites that contribute to their therapeutic value. These phytochemicals, including alkaloids, phenolics, flavonoids, tannins, steroids, and saponins, play significant roles in human health due to their antioxidant, antimicrobial, anti-inflammatory, and cytoprotective properties (Panche *et al.*, 2016). However, the quantity and composition of phytochemicals may vary geographically due to climatic, soil, and ecological differences (Gobbo-Neto & Lopes, 2007).
Understanding phytochemical stability across eco-regions is crucial for standardizing herbal drugs, ensuring quality control, and supporting pharmacognostic identification. Plants displaying minimal variation in their phytochemical composition across environmental gradients are considered chemotypically stable and suitable for medicinal use (Kaur & Arora, 2015).
The present study compares phytochemical patterns in root and leaf samples collected from four geographically distinct agro-climatic zones in India. Using well-established biochemical assays, we analyzed the presence of major phytochemical groups and assessed whether ecological variations influence phytochemical expression.

Materials and Methods:

Plant specimens (roots and leaves) were collected from the following agro-climatic zones:
Zone 1 (R1): Jammu – Western Himalayan Region
Zone 4 (R2): Samastipur – Middle Gangetic Plains
Zone 9 (R3): Ujjain – Western Plateau and Hills
Zone 10 (R4): Bangalore – Southern Plateau and Hills
All samples were collected during the same season to minimize phenological variation. Fresh samples were washed with distilled water and shade-dried for 7–10 days. Dried samples were powdered using a mechanical grinder and stored in airtight containers.
Preparation of Extracts: Five grams (5 g) of powdered root or leaf material was macerated in 50 mL of distilled water for 24 hours with intermittent shaking. The extracts were filtered and used for biochemical assays.
Qualitative Phytochemical Screening: Phytochemical tests viz. Alkaloids (Mayer's and Wagner's reagents), Tannins, Saponins, Steroids, Phenols, Flavonoids (NaOH and $FeCl_3$ test) were conducted following standard protocols described by Harborne (1998), Trease & Evans (2009), and Kokate (2010).

Results:

Phytochemical Composition in Root Samples: Results of all root samples collected from the four agro-climatic zones is presented in table 1 showed a uniform phytochemical profile, with consistent presence of alkaloids, tannins, saponins, steroids, phenols, and NaOH-detectable flavonoids. These metabolites appeared in all samples, indicating stable biosynthetic pathways unaffected by regional environmental differences. Alkaloids, tannins, saponins, and steroids were clearly identified through characteristic reactions in standard phytochemical tests, while phenols also showed strong positive coloration. Flavonoids detected via the NaOH method were present in all roots, suggesting predominance of flavones or flavonols, whereas the $FeCl_3$ method yielded negative results for all samples, indicating absence of catechol-type flavonoids. Overall, the results confirm high chemotypic stability and consistent phytochemical expression across root samples from all geographic zones.

Table 1. Phytochemical profile of root samples

Phytochemicals	R1	R2	R3	R4
Alkaloids	+	+	+	+
Tannins	+	+	+	+
Saponins	+	+	+	+
Steroids	+	+	+	+
Phenols	+	+	+	+
Flavonoids (NaOH)	+	+	+	+
Flavonoids ($FeCl_3$)	–	–	–	–

Phytochemical Composition in Leaf Samples: Results of leaf samples is presented in table 2 exhibited the same phytochemical pattern observed in roots, showing consistent presence of alkaloids, tannins, saponins, steroids, phenols, and NaOH-reactive flavonoids across all four zones. All leaf extracts produced characteristic reactions in standard tests, confirming uniform biosynthesis of major metabolite groups in aerial tissues. Similar to roots, NaOH-based flavonoid tests were positive in all samples, while $FeCl_3$-

based flavonoid detection remained uniformly negative, indicating the absence of catechol-type flavonoids. The identical phytochemical results between roots and leaves across diverse ecological regions demonstrate strong metabolic consistency and support the species' chemotypic stability.

Table 2. Phytochemical profile of leaf samples

Phytochemicals	R1	R2	R3	R4
Alkaloids	+	+	+	+
Tannins	+	+	+	+
Saponins	+	+	+	+
Steroids	+	+	+	+
Phenols	+	+	+	+
Flavonoids (NaOH)	+	+	+	+
Flavonoids ($FeCl_3$)	–	–	–	–

Discussion:

The uniform presence of all major phytochemicals across four diverse ecological zones indicates exceptional chemotypic stability. Environmental factors such as altitude, rainfall, UV exposure, and soil type typically affect secondary metabolite accumulation (Gobbo-Neto & Lopes, 2007). However, in this study, the identical phytochemical pattern suggests that genetic regulation may dominate environmental influence. This stability is significant for medicinal applications, ensuring consistent phytopharmacological properties irrespective of cultivation region. The universal presence of alkaloids suggests strong therapeutic potential, as these compounds exhibit antimicrobial, analgesic, anti-arrhythmic, and neuroactive properties (Singh *et al*., 2020). Phenolic compounds are known for their antioxidant capacity, free-radical scavenging activity, and antimicrobial effects (Bhat *et al*., 2013). Tannins also contribute to wound healing and anti-inflammatory responses. Saponins are valued for cholesterol-lowering, antifungal, hemolytic, and immunomodulatory actions (Oleszek *et al*., 2020). Their presence suggests possible protective biological activities. Plant steroids play roles in membrane stabilization and have anti-inflammatory properties (Patel *et al*., 2012). The NaOH method detected flavonoids in all samples, confirming the presence of flavones, flavonols, or chalcones important antioxidant compounds (Panche *et al*., 2016). The absence of flavonoids in the $FeCl_3$ test indicates lack of catechol-type flavonoids or leucoanthocyanins. This demonstrates that the species primarily synthesizes a specific subset of flavonoid classes, highlighting a stable biosynthetic pathway. The observed uniform phytochemical composition indicates feasibility of nationwide cultivation without loss of therapeutic quality. Chemotypic stability is especially valuable for pharmaceutical industries aiming for consistent raw-material quality (WHO, 2002).

Conclusion:

This study provides comprehensive evidence of phytochemical uniformity in root and leaf samples collected from four agro-climatic zones in India. All samples contained alkaloids, tannins, saponins, steroids, phenols, and flavonoids detectable by NaOH, while $FeCl_3$-detectable flavonoids were absent. The chemotypic stability across diverse ecological settings suggests that the species is a reliable source of phytochemicals for medicinal and industrial applications.

References:

1. Bhat, R., Kannan, A., & Karim, A. A. (2013). Phytochemical constituents and antioxidant activity of various extracts of Punica granatum leaves. Journal of Medicinal Plants Research, 7(7), 454–460.
2. Gobbo-Neto, L., & Lopes, N. P. (2007). Plant metabolism and environmental stress: Plant natural products and secondary metabolism. Brazilian Journal of Pharmacognosy, 17(4), 679–685.
3. Harborne, J. B. (1998). Phytochemical methods: A guide to modern techniques of plant analysis (3rd ed.). Chapman & Hall.
4. Kaur, M., & Arora, S. (2015). Variability in phytochemical content of medicinal plants under environmental stress. Journal of Applied Research in Medicinal and Aromatic Plants, 2(3), 65–72.
5. Kokate, C. K. (2010). Practical pharmacognosy. Vallabh Prakashan.
6. Obadoni, B. O., & Ochuko, P. O. (2001). Phytochemical studies and comparative efficacy of crude extracts of some homeostatic plants. Global Journal of Pure and Applied Sciences, 8(2), 203–208.
7. Oleszek, W., Stochmal, A., & Janda, B. (2020). Saponins and their biological activities. Phytochemistry Reviews, 19, 1505–1523.
8. Panche, A. N., Diwan, A. D., & Chandra, S. R. (2016). Flavonoids: An overview. Journal of Nutritional Science, 5, e47.
9. Patel, D. K., Kumar, R., & Umashankar, M. (2012). Phytosterols: A review on pharmacological and nutritional importance. International Journal of Pharmaceutical Sciences and Research, 3(2), 360–366.
10. Singh, A., Sharma, N., & Verma, R. (2020). Pharmacological properties of plant alkaloids: A review. Asian Journal of Pharmacology, 10(1), 13–19.
11. Trease, G. E., & Evans, W. C. (2009). Pharmacognosy (16th ed.). Saunders Elsevier.
12. World Health Organization. (2002). WHO guidelines on good agricultural and collection practices (GACP) for medicinal plants. WHO Press.