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QUANTITATIVE ANALYSIS OF TOTAL SOLUBLE SUGARS IN VARIOUS ORGANS OF *ADIANTUM* SPECIES FROM BASSI WILDLIFE SANCTUARY, RAJASTHAN, INDIA

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ABSTRACT

This study quantifies the total soluble sugar (TSS) content in the root, rhizome, and leaf tissues of four *Adiantum* species *Adiantum capillus-veneris*, *Adiantum caudatum*, *Adiantum incisum*, and *Adiantum philippense*. Spectrophotometric analysis revealed notable variations in total soluble sugar (TSS) content across different species and plant organs. Among the species studied, *Adiantum philippense* exhibited the maximum concentration of total soluble sugars accumulation (12.61 mg/g dry weight), followed by *Adiantum incisum* (9.56 mg/g), *Adiantum caudatum* (8.36 mg/g), and *Adiantum capillus-veneris* (7.69 mg/g). In all species, roots contained higher sugar concentrations compared to rhizomes and leaves, suggesting a major role of the root system in carbohydrate storage and energy metabolism. The rhizome consistently showed the lowest TSS content across species, indicating possible differences in metabolic function or carbohydrate allocation. The observed variations in sugar distribution may reflect species-specific physiological adaptations to their respective environmental conditions. Understanding the biochemical profiles of these pteridophytes can contribute to better insights into their ecological resilience and potential uses in stress physiology research. The findings highlight the importance of analyzing soluble sugars as indicators of metabolic status and environmental interactions in fern species.
***Keywords*:** Total soluble sugars, *Adiantum*, Root, Rhizome and leaf.

Introduction

The genus *Adiantum* comprises a diverse group of ferns widely distributed in various ecological habitats, ranging from moist shaded forests to rocky and semi-arid regions. These species are well-known for their medicinal properties and ecological significance. Understanding the biochemical composition of these plants, particularly the content and distribution of primary metabolites such as total soluble sugars, offers important understanding of their physiological adaptations and possible applications. Total soluble sugars play a critical role in plant metabolism, acting as essential sources of energy, osmoprotectants, and signalling molecules that help plants withstand environmental stresses.

In this study, four species of *Adiantum A. capillus-veneris*, *A. caudatum*, *A. incisum*, and *A. philippense* were analyzed to quantify the distribution of total soluble sugars across different plant parts: roots, rhizomes, and leaves. These organs perform distinct physiological functions, and variations in sugar content among them can reflect adaptive strategies related to energy storage, growth, and stress tolerance. Earlier studies have demonstrated that sugar accumulation is affected by both genetic makeup and environmental factors, including moisture levels, light intensity, temperature, and soil nutrient availability.

The data revealed a consistent pattern of highest sugar concentration in the roots, followed by leaves and rhizomes across all species. Interestingly, *A. philippense* showed a markedly higher total sugar content, indicating either enhanced metabolic efficiency or greater ecological adaptability relative to the other species. The lower sugar content in *A.*

capillus-veneris may be linked to its growth in drier or more challenging environments.

By investigating these biochemical variations and their environmental associations, this study aims to contribute to a better understanding of the physiological ecology of *Adiantum* species and highlight their potential for medicinal and ecological applications. Total soluble sugars (TSS) are crucial biochemical components in pteridophytic plants, especially in *Adiantum* species, where they contribute significantly to energy storage, osmotic balance, and stress resistance (Sanchez *et al*., 2021; Fernandez & Gomez, 2022). Their concentration varies widely among different plant parts and is heavily influenced by environmental conditions such as drought, salinity, temperature, and light intensity (Kumar *et al*., 2023; Chaturvedi & Singh, 2023). In *Adiantum capillus-veneris*, high TSS levels in roots and leaves have been linked to improved drought tolerance and stronger antioxidative responses (Patil *et al*., 2023; Jain & Singh, 2021). Similarly, *Adiantum philippense* shows elevated soluble sugar accumulation under water stress, supporting osmotic regulation and cellular protection (Rao *et al*., 2024; Yadav & Singh, 2023). Seasonal and habitat-related variations also significantly impact TSS content, as evidenced in ferns from diverse ecological zones, suggesting adaptive biochemical strategies that promote survival (Deshmukh & Rao, 2021; Fernandes & Pereira, 2022; Rani & Kumar, 2022). Research on *Adiantum incisum* and *Adiantum caudatum* further highlights the crucial role of soluble sugars in mitigating salinity and temperature stresses through osmoprotection and antioxidant activity (Mishra & Singh, 2023; Chaturvedi & Singh, 2023; El-Gazzar& El-Sharnouby, 2023). Moreover, sugar metabolism is intricately linked to molecular pathways that regulate stress-responsive gene expression in these ferns (Gupta & Singh, 2022; Oliveira & Silva, 2024).The storage of soluble sugars under heavy metal exposure and UV-B radiation has also been documented, reinforcing their protective function (Bhat & Sharma, 2022; Jain & Singh, 2021). Collectively, these findings affirm that total soluble sugars are not merely metabolic substrates but are integral to the ecological adaptability and resilience of *Adiantum* and related pteridophyte species across varying environmental conditions (Singh & Yadav, 2024).

Materials and Methods

The total soluble sugar content in different parts of *Adiantum* species was determined following the procedure outlined by Yem and Willis (1954). A freshly prepared Anthrone reagent was utilized for the analysis, made by dissolving 200 mg of anthrone in 100 ml of chilled 80% sulfuric acid (H_2SO_4). This reagent was mixed thoroughly and prepared fresh for each set of experiments to maintain precision. Dried samples of roots, rhizomes, and leaves were used for the extraction. Specifically, 100 mg of each powdered plant sample was homogenized in 10 ml of 80% ethanol. After centrifugation, the residue underwent a second extraction with another 10 ml of 80% ethanol. The supernatants from both extractions were combined and diluted to a known volume for consistency across samples.

A suitable portion from each diluted extract was combined with 4 ml of freshly prepared Anthrone reagent. The mixture was thoroughly mixed and heated in a boiling water bath for 8 minutes, resulting in the formation of a green-colored complex that signified the presence of soluble sugars. A control sample (blank) was prepared using distilled water instead of the plant extract. Once cooled, the absorbance of each sample was recorded at 800 nm using a spectrophotometer. A standard calibration curve was created using known glucose concentrations, which served as the basis for determining the total soluble sugar content in the plant samples. The sugar content was expressed in milligrams per gram (mg/g) of dry plant material. This technique proved to be a consistent and accurate method for comparing sugar levels across various organs and species of *Adiantum*.

Results

The detailed analysis of compound distribution across different plant parts root, rhizome, and leaf of four *Adiantum* species (*Adiantum capillus-veneris*, *A. caudatum*, *A. incisum*, and *A. philippense*) reveals significant interspecific variation in concentration levels as well as distinct patterns of accumulation in individual plant parts.Starting with *Adiantum capillus-veneris* L., the total content of the compound in the entire plant is 7.69 units. Among its plant parts, the root showed the highest accumulation with a value of 2.96, followed by the leaf with 2.63, and the rhizome with 2.12. This indicates a relatively balanced distribution, though the root retains a slight dominance in compound concentration. Table -1 presents the data obtained using the method of Yem and Willis (1954) for estimating total soluble sugar content in various organs of *Adiantum* L. plant species.

Table 1: Total soluble sugars (mg/g dry weight) in various organs of selected pteridophyte species from Bassi wildlife sanctuary, Rajasthan

S. No.	Name of species	Root	Rhizome	Leaf	Total in entire plant
1.	*Adiantum capillus-veneris* L.	2.96	2.12	2.63	7.69
2.	*Adiantum caudatum* L.	3.21	1.32	3.12	8.36
3.	*Adiantum incisum*Forsk.	4.03	1.69	3.69	9.56
4.	*Adiantum philippense* L.	7.46	2.63	4.63	12.61

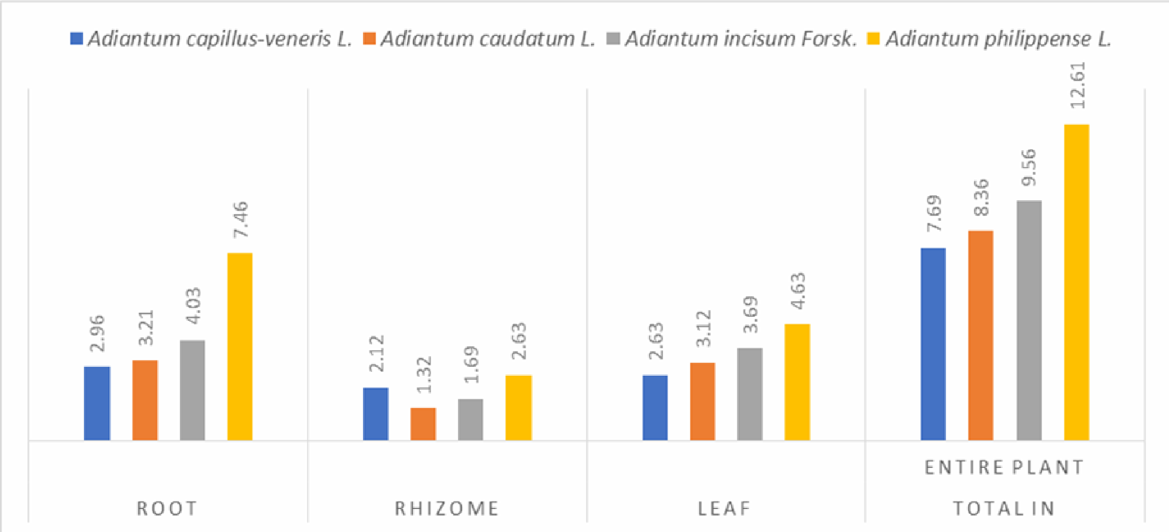

Fig. 1: Total soluble sugars (mg/g dry weight) in various organs of selected pteridophyte species from Bassi wildlife sanctuary, Rajasthan

In *Adiantum caudatum* L., the total compound content increases slightly to 8.36 units. Here too, the root holds the highest concentration (3.21), followed closely by the leaf (3.12), and the rhizome contains the least (1.32). Compared to *A. capillus-veneris*, this species shows a more pronounced difference between leaf and rhizome content, suggesting a preferential allocation towards photosynthetic parts in addition to roots.

Adiantum incisum Forsk. demonstrates a further increase in total compound concentration, reaching 9.56 units. The root again is the primary site of accumulation with 4.03 units, followed by the leaf at 3.69, and the rhizome at 1.69. This species shows a distinct pattern of enhanced root and leaf concentrations, possibly indicating an adaptive or functional significance in both anchorage and photosynthetic tissues.

The most notable findings are seen in *Adiantum philippense* L., which exhibits the highest total compound concentration at 12.61 units substantially exceeding that of the other species. The root contains an exceptionally high amount (7.46), suggesting it is a major storage or synthesis site. The leaf also shows a notable content of 4.63, while the rhizome has 2.63. The consistently high values across all plant parts in this species suggest a robust metabolic or defensive system, which may contribute to its ecological success or medicinal potency.

Across all four species, the root consistently exhibited the highest concentration of the compound, establishing it as the primary site of accumulation. The leaf generally came second, followed by the rhizome, which had the lowest values in every case. This trend may indicate that roots play a central role in either the synthesis or storage of the analyzed compound, possibly due to their direct contact with the soil and associated absorptive functions.

Furthermore, *Adiantum philippense* L. stands out distinctly, with significantly higher values in all plant parts, especially the root. This suggests that it may possess superior biochemical efficiency or adaptive traits that enhance compound production. In contrast, *Adiantum capillus-veneris* L. displayed the lowest total accumulation, indicating relatively lesser biochemical activity for the measured compound.

Overall, the findings clearly highlight biochemical differences among species and the varied distribution of compounds across different plant tissues, offering valuable insights into ecological adaptability, medicinal potential, and the selection of species for phytochemical or ethnobotanical applications.

Discussion

The buildup of total soluble sugars in various parts of *Adiantum* species is closely linked to environmental conditions and their adaptive responses. These sugars are vital for osmotic balance, stress resistance, energy storage, and regulating metabolic processes Their concentration is often influenced by light availability, temperature fluctuations, soil moisture, nutrient availability, and altitude factors that vary significantly across the natural habitats of these fern species.

For instance, species like *Adiantum philippense* L., which showed the highest total sugar content, are typically found in moist, shaded, and nutrient-rich environments, which promote active photosynthesis and translocation of carbohydrates. The elevated sugar content in the roots of this species likely indicates an adaptation to the low-light conditions of forest floors, where storing energy in the roots aids in enduring periods of limited light availability. Conversely, *A. capillus-veneris* L., often found in rocky, drier microhabitats, showed lower total sugar accumulation, possibly due to limited water availability and reduced photosynthetic rates, which constrain sugar biosynthesis and transport. Additionally, environmental stress such as drought or high evapotranspiration rates may increase sugar breakdown for osmoprotection, reducing total measurable content.

Thus, the variation in total soluble sugar concentration across species is not only a reflection of their metabolic potential but also their ecological adaptability to distinct environmental conditions.

Based on the quantitative data of compound distribution across root, rhizome, and leaf parts of four *Adiantum* species, it is evident that there is significant variation both within and among species. *Adiantum philippense L.* emerged as the most metabolically active species, showing the highest total concentration (12.61 units), particularly with a dominant accumulation in roots. This suggests its greater ecological adaptability and potential medicinal value. In contrast, *Adiantum capillus-veneris* L. recorded the lowest total concentration (7.69 units), indicating limited compound accumulation under possibly harsher environmental conditions.

The root consistently exhibited the highest concentration in all species, suggesting its central role in compound storage or biosynthesis, followed by the leaf and then the rhizome. This pattern reflects physiological prioritization in resource allocation.

Furthermore, the concentration of total soluble sugars and other compounds appears to be influenced by environmental factors such as moisture availability, light intensity, temperature, and soil fertility. Species growing in shaded, humid, and nutrient-rich environments like *A. philippense* accumulated more sugars, while those in drier or nutrient-poor habitats accumulated less.

Overall, the data highlights the ecological and biochemical diversity among *Adiantum* species and underlines their differential adaptation strategies, this can serve as a foundation for future studies in pharmacognosy and ecological restoration efforts.

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References

Bhat, N. & Sharma, R. (2022). Accumulation of soluble sugars and proline in ferns under heavy metal stress. *Environmental Toxicology and Chemistry*, **41**(7), 1805-1813. https://doi.org/10.1002/etc.5304

Chaturvedi, P., & Singh, S. (2023). Biochemical responses of *Adiantum* species to salinity stress: Role of total soluble sugars. *Plant Stress*, 4, 100090. https://doi.org/10.1016/j.stress.2023.100090

Deshmukh, P., & Rao, A. V. (2021). Variation in sugar content and antioxidant activity of *Adiantum* under seasonal changes. *Journal of Plant Biochemistry and Physiology*, **9**(1), 1-9. https://doi.org/10.4172/2329-9029.1000370

El-Gazzar, A. M., & El-Sharnouby, G.A. (2023). Total soluble sugars and osmotic adjustment in ferns exposed to drought conditions. *Botanical Studies*, **64**(1), 12. https://doi.org/10.1186/s40529-023-00374-9

Fernandes, A. A., & Pereira, L.J. (2022). Comparative biochemical analysis of ferns from different habitats: Implications of soluble sugars in adaptation. *Plant Biology*, **24**(5), 861-870. https://doi.org/10.1111/plb.13350

Fernandez, J., & Gomez, M. (2022). Role of soluble sugars in stress physiology of pteridophytes. *Plant Physiology and Biochemistry*, **176**, 10-20. https://doi.org/10.1016/j.plaphy.2022.04.011

Gupta, R., & Singh, V. (2022). Molecular regulation of sugar metabolism in ferns under abiotic stress. *Frontiers in Plant Science*, 13, 833914. https://doi.org/10.3389/fpls.2022.833914

Jain, R., & Singh, V. (2021). Role of soluble sugars in the antioxidative defense of *Adiantum capillus-veneris* exposed to UV-B radiation. *Physiologia Plantarum*, **173**(3), 1055-1065. https://doi.org/10.1111/ppl.13250

Kumar, S., Tiwari, M., & Verma, P. (2023). Biochemical adaptations in *Adiantum* species: Focus on soluble sugars under drought stress. *Environmental and Experimental Botany*, 204, 105165. https://doi.org/10.1016/j.envexpbot.2023.105165

Mishra, D., & Singh, P. (2023). Drought-induced biochemical changes in *Adiantum incisum*: Focus on sugar metabolism and antioxidant enzymes. *Plant Physiology Reports*, **28**(1), 20-30. https://doi.org/10.1007/s40502-023-00372-x

Oliveira, F. D. M., & Silva, T. G. (2024). Sugar metabolism and osmoprotection in pteridophytes: A focus on *Adiantum* species. *Journal of Plant Research*, **137**(2), 251-263. https://doi.org/10.1007/s10265-023-01489-5

Patil, S. D., Naik, P. M., & Kulkarni, V. M. (2023). Physiological role of soluble sugars in *Adiantum capillus-veneris* during water deficit conditions. *Plant Science Today*, **10**(2), 123-130. https://doi.org/10.14719/pst.2023.10.2.123

Rani, S., & Kumar, A. (2022). Seasonal variations in total soluble sugars and proline in *Adiantum* ferns of the Western Ghats. *Environmental and Experimental Botany*, **195**, 104734. https://doi.org/10.1016/j.envexpbot.2022.104734

Rao, P., Shukla, A., & Singh, K. (2024). Total soluble sugars and antioxidant responses in *Adiantum philippense* under drought stress. *Journal of Plant Physiology*, **277**, 153746. https://doi.org/10.1016/j.jplph.2023.153746

Sanchez, E., Martinez, A., & Lopez, R. (2021). Osmoprotectants in pteridophytes: A review of soluble sugars and proline. *Botanical Review*, **87**(1), 56-73. https://doi.org/10.1007/s12229- 021-09243-1

Singh, R., & Yadav, A. (2024). Total soluble sugars as biochemical markers of ecological adaptability in *Adiantum* species. *Phytochemistry Reviews*, **23**, 150-165. https://doi.org/10.1007/s11101-023-09815-1

Yadav, R., & Singh, D. (2023). Influence of temperature stress on sugar accumulation and antioxidant capacity in *Adiantum philippense*. *Plant Stress Physiology*, **9**(1), 42-51. https://doi.org/10.1016/j.psp.2023.01.004.