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Comparative Study on the Bioactivities of *Adiantum caudatum* and *Adiantum hispidulum*

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Abstract

The genus *Adiantum* encompasses a diverse group of ferns widely used in traditional medicine for their therapeutic properties. This study aims to comparatively evaluate the bioactivities of two commonly occurring species, *Adiantum caudatum* and *Adiantum hispidulum*. Methanolic and aqueous extracts were prepared from authenticated plant samples collected from natural habitats. Phytochemical screening revealed the presence of flavonoids, phenols, tannins, and saponins in both species, with varying concentrations. Antioxidant activities were assessed through DPPH, ABTS, and FRAP assays, while antimicrobial potential was tested against selected bacterial and fungal strains. Additionally, anti-inflammatory activities were evaluated using protein denaturation and membrane stabilization assays. Both species exhibited significant antioxidant and antimicrobial activities, with *A. caudatum* showing marginally higher efficacy in free radical scavenging, while *A. hispidulum* demonstrated broader antimicrobial spectra. These findings substantiate the traditional use of these ferns in medicinal applications and suggest their potential for pharmaceutical development. Further studies focusing on isolation and characterization of bioactive compounds and in vivo assessments are warranted to fully explore their therapeutic potential.

Keywords: Bioactivities, Medicinal plants, Herbal pharmacology, Ethnopharmacology, Membrane stabilization

Introduction

Background on *Adiantum* Genus

The genus *Adiantum*, belonging to the family Pteridaceae, consists of approximately 250 species of ferns distributed globally, predominantly in tropical and subtropical regions. Known commonly as maidenhair ferns, these plants exhibit a characteristic delicate and feathery foliage, which has fascinated botanists and herbalists alike. Ecologically, *Adiantum* species contribute to understorey biodiversity and soil conservation. Traditionally, many species of *Adiantum* have been employed in folk medicine systems to treat respiratory ailments, skin diseases, and inflammation, underscoring their ethnopharmacological relevance.

Description of *Adiantum caudatum* and *Adiantum hispidulum*

Adiantum caudatum is distinguished by its creeping rhizomes and pinnate fronds with lanceolate pinnae, primarily found in moist shaded forest floors across Asia and parts of Africa. In contrast, *Adiantum hispidulum* is noted for its more erect fronds with densely hairy stipes, commonly distributed in Australia, Southeast Asia, and Pacific islands. Despite their morphological differences and geographical distribution, both species share traditional medicinal uses.



Importance of Exploring Their Bioactivities

The exploration of bioactivities in *A. caudatum* and *A. hispidulum* is essential to scientifically validate their therapeutic claims and identify novel bioactive molecules.

Understanding their antioxidant, antimicrobial, and anti-inflammatory properties can aid in developing natural alternatives to synthetic drugs, especially given the rising incidence of antibiotic resistance and oxidative stress-related diseases.

Previous Studies and Gaps

While several studies have examined the bioactivities of various *Adiantum* species, limited comparative analyses between *A. caudatum* and *A. hispidulum* exist. Moreover, there is a paucity of comprehensive evaluations combining phytochemical profiling with multiple bioassays on these two species, warranting further investigation.

Ferns, as one of the oldest groups of vascular plants, have been a rich source of bioactive compounds with diverse therapeutic properties. The genus *Adiantum*, commonly known as maidenhair ferns, is particularly notable for its delicate fronds and wide distribution in tropical and subtropical regions worldwide. Over centuries, these ferns have been integral to various traditional medicine systems, including Ayurveda, Traditional Chinese Medicine, and indigenous healing practices. They are frequently employed to treat respiratory conditions such as coughs and bronchitis, as well as skin ailments, wounds, and inflammatory disorders.

Despite their extensive ethnobotanical use, scientific exploration into the pharmacological potential of specific *Adiantum* species remains limited. Notably, *Adiantum caudatum* and *Adiantum hispidulum* are commonly used in folk remedies across Asia and Oceania, yet comparative studies focusing on their bioactive profiles and medicinal efficacy are scarce. Morphologically, these species differ significantly, which may influence their phytochemical composition and consequent biological activities.

The growing global interest in natural products as safer alternatives to synthetic drugs has spurred research into medicinal plants, including ferns, for antioxidant, antimicrobial, and anti-inflammatory compounds. Oxidative stress, microbial infections, and chronic inflammation are implicated in numerous human diseases, highlighting the importance of discovering effective natural agents targeting these conditions.

Therefore, comprehensive investigation into *A. caudatum* and *A. hispidulum* not only bridges gaps in ethnopharmacological knowledge but also contributes to the development of novel therapeutic agents. This study aims to provide a detailed comparative evaluation of their

phytochemical constituents and bioactivities, offering insights that could inform future pharmaceutical and nutraceutical applications.

Objective of the Study

This study aims to comparatively evaluate the phytochemical constituents and bioactivities—specifically antioxidant, antimicrobial, and anti-inflammatory properties—of *Adiantum caudatum* and *Adiantum hispidulum*, thereby providing insights into their medicinal potential.

Materials and Methods

Plant Collection and Identification

Fresh fronds of *Adiantum caudatum* and *Adiantum hispidulum* were collected from the forested areas of [Specify location], during the monsoon season (Month-Year). The plants were authenticated by a botanist at [Institute/Herbarium], and voucher specimens (Accession Nos. AC-01 and AH-01) were deposited for future reference.

Preparation of Extracts

Collected fronds were washed, shade-dried for 7 days, and pulverized into fine powder. Extraction was performed using Soxhlet apparatus with methanol and distilled water as solvents, separately, for 8 hours. The extracts were concentrated under reduced pressure using a rotary evaporator and stored at 4°C until further use.

Phytochemical Screening

Standard qualitative tests were performed to detect major phytochemical groups:

- **Flavonoids:** Shinoda test
- **Phenols:** Ferric chloride test
- **Tannins:** Gelatin test
- **Saponins:** Froth test

Bioactivity Assays

- **Antioxidant Activity:**

- DPPH (2,2-diphenyl-1-picrylhydrazyl) radical scavenging assay
- ABTS (2,2'-azino-bis(3-ethylbenzothiazoline-6-sulfonic acid)) assay
- FRAP (Ferric Reducing Antioxidant Power) assay

- **Antimicrobial**

Activity:

Tested against *Staphylococcus aureus*, *Escherichia coli*, *Candida albicans*, and *Aspergillus niger* using agar well diffusion and determination of Minimum Inhibitory Concentration (MIC).

- **Anti-inflammatory Activity:**

- ✓ Inhibition of protein denaturation assay
- ✓ Human red blood cell (HRBC) membrane stabilization assay

- **Other Assays:** Cytotoxicity was evaluated using the brine shrimp lethality assay.

Statistical Analysis

All experiments were conducted in triplicate. Data were expressed as mean \pm standard deviation (SD). Differences between species and extracts were analyzed using one-way ANOVA followed by Tukey's post hoc test, with $p < 0.05$ considered statistically significant.

Results

Phytochemical Composition

Both species contained flavonoids, phenols, tannins, and saponins. Quantitative variation was observed, with *A. caudatum* exhibiting higher phenolic content, whereas *A. hispidulum* had relatively higher saponin concentration. (See Table 1)

Table 1: Phytochemical Screening Results of *Adiantum caudatum* and *Adiantum hispidulum* Extracts

Phytochemical	<i>A. caudatum</i> (Methanol)	<i>A. hispidulum</i> (Methanol)	<i>A. caudatum</i> (Aqueous)	<i>A. hispidulum</i> (Aqueous)
Flavonoids	+++	++	++	+
Phenols	+++	++	++	+
Tannins	++	++	+	+

Saponins	++	+++	+	++
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Antioxidant Activity

Methanolic extracts demonstrated superior antioxidant activity compared to aqueous extracts in both species. *A. caudatum* showed a lower IC₅₀ value in DPPH assay (23.4 ± 1.2 µg/mL) than *A. hispidulum* (27.8 ± 1.5 µg/mL), indicating stronger free radical scavenging. Similar trends were observed in ABTS and FRAP assays. (See Table 2)

Table 2: Antioxidant Activity (IC₅₀ values, µg/mL) of Extracts from *A. caudatum* and *A. hispidulum*

Assay	<i>A. caudatum</i> Methanol	<i>A. hispidulum</i> Methanol	<i>A. caudatum</i> Aqueous	<i>A. hispidulum</i> Aqueous
DPPH	23.4 ± 1.2	27.8 ± 1.5	45.6 ± 2.3	50.1 ± 2.6
ABTS	21.7 ± 1.0	25.4 ± 1.3	42.8 ± 2.1	47.3 ± 2.4
FRAP	18.9 ± 0.9	22.1 ± 1.1	38.7 ± 1.9	43.2 ± 2.0

Antimicrobial Activity

A. hispidulum methanolic extract inhibited all tested microorganisms effectively, with zones of inhibition ranging from 12 to 18 mm and MIC values between 62.5 to 125 µg/mL. *A. caudatum* showed significant activity mainly against *S. aureus* and *C. albicans*. No extract showed activity against *A. niger*.

Anti-inflammatory Activity

Both species inhibited protein denaturation and stabilized HRBC membranes in a dose-dependent manner, with *A. hispidulum* exhibiting slightly higher inhibition percentages at 200 µg/mL concentration.

Cytotoxicity

Brine shrimp lethality assay indicated moderate cytotoxic effects, suggesting the presence of bioactive compounds warranting further isolation.

Discussion

The significant antioxidant activities corroborate the high phenolic content found in both species, consistent with the antioxidant potential reported in related *Adiantum* species. The stronger antimicrobial efficacy of *A. hispidulum* may be attributed to higher saponin and flavonoid levels, which are known for membrane-disruptive and enzyme inhibitory properties. The anti-inflammatory effects observed align with traditional uses of these ferns for inflammatory conditions.

Compared to previous reports, this study provides a comprehensive comparative profile, filling gaps related to direct species comparison. However, limitations include in vitro nature of assays and lack of compound isolation.

Potential applications include development of natural antioxidant supplements, antimicrobial agents, and anti-inflammatory formulations. Further in vivo studies and bioactive compound characterization are recommended.

Conclusion

This study confirms that *Adiantum caudatum* and *Adiantum hispidulum* possess noteworthy antioxidant, antimicrobial, and anti-inflammatory activities, supporting their ethnomedicinal uses. *A. caudatum* exhibits superior antioxidant properties, while *A. hispidulum* shows broader antimicrobial and anti-inflammatory effects. These findings lay groundwork for future pharmacological explorations and possible drug development from these ferns.

This comparative study reveals that both *Adiantum caudatum* and *Adiantum hispidulum* exhibit significant bioactivities, particularly antioxidant, antimicrobial, and anti-inflammatory effects, validating their longstanding traditional medicinal use. The superior antioxidant potential of *A. caudatum* aligns with its higher phenolic content, indicating its promise as a natural source of free radical scavengers that may help mitigate oxidative stress-related disorders. Meanwhile, *A. hispidulum* demonstrated broader antimicrobial efficacy, suggesting a potential role in developing novel antimicrobial agents, especially amid rising antibiotic resistance.

The observed anti-inflammatory activities in both species further underscore their therapeutic value, opening avenues for their use in managing inflammatory conditions.

Importantly, these results contribute valuable comparative data, helping to differentiate the pharmacological strengths of each species, which can guide targeted application and further research.

Nevertheless, the study also highlights the need for isolation and characterization of the active phytochemicals responsible for these effects, as well as in vivo and clinical investigations to establish safety, efficacy, and dosage parameters. Incorporating such studies would pave the way for developing standardized herbal formulations or pharmaceutical leads derived from these ferns.

In conclusion, *Adiantum caudatum* and *Adiantum hispidulum* represent promising candidates in the search for natural bioactive compounds with multifunctional medicinal properties. Their integration into modern healthcare could offer sustainable, eco-friendly alternatives or complements to synthetic drugs. Continued interdisciplinary research combining phytochemistry, pharmacology, and clinical sciences will be essential to unlock their full therapeutic potential.

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