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REVIEW ARTICLE

Phytochemical and Therapeutic Insights into the Family Pteridaceae: A Review

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ABSTRACT

Pteridophytes, the non-seeded vascular cryptogams, dominated terrestrial vegetation about 350 million years ago and represent the second-largest component of the world flora, with over 250 genera and nearly 12,000 species. Within this group, the family Pteridaceae comprises 53 genera and about 950 species, making it the second-largest family of pteridophytes. Members of this family are widely recognized for their medicinal and therapeutic potential, largely due to the presence of diverse secondary metabolites. Phytochemical investigations reveal that many Pteridaceae species produce bioactive compounds of relevance in agriculture, veterinary, and human medicine. These metabolites are associated with antioxidant, antimicrobial, anti-inflammatory, and other pharmacological properties, making them promising candidates for novel drug development. Despite their potential, phytochemical studies on Pteridaceae remain scattered and underexplored. This review synthesizes existing qualitative studies on the phytochemistry of Pteridaceae, highlighting their pharmacological significance, trends in research, and gaps that warrant further investigation.

Keywords: Pteridaceae; Pteridophytes; Phytochemicals; Secondary Metabolites; Therapeutic Potential

INTRODUCTION

Pteridophytes, comprising ferns and lycophytes, are non-seeded vascular cryptogams that originated in the Silurian period more than 350 million years ago. They dominated terrestrial vegetation during the Carboniferous period but later declined in abundance. Today, pteridophytes are widely distributed, particularly in mountainous regions and moist, shady habitats, and represent about 305 genera with more than 12,000 species worldwide[1]. Beyond their evolutionary and phylogenetic significance, they form an important yet often overlooked component of biodiversity.

Traditionally, pteridophytes have been valued for their diverse economic uses. They serve as sources of food, fodder, biofertilizers, and insect repellents, and have long been employed in folk medicine[2–4]. In Chinese, Indian, and Iranian systems of traditional medicine, various ferns are prescribed for the treatment of multiple ailments[5,6]. Historical accounts further highlight their relevance: Theophrastus (327–287 BC) and Dioscorides (50 AD) documented the use of several pteridophytes as potent herbal formulations. This legacy of traditional usage has inspired modern pharmacological investigations into their medicinal value.

The therapeutic potential of pteridophytes lies in their secondary metabolites, or phytochemicals- naturally occurring bioactive compounds that contribute to plant defense and provide numerous health benefits in humans[7,8]. More than 4,000 phytochemicals have been cataloged to date, including alkaloids, flavonoids, tannins, phenolics, steroids, terpenoids, amino acids, and fatty acids[9,10]. These metabolites are known for their antioxidant, antimicrobial, anti-inflammatory, antimutagenic, and anticancer properties, making them key contributors to novel drug discovery and development[11,12]. Notably, ferns also produce certain unique phytochemicals not found in higher plants[13].

According to the World Health Organization (WHO), more than 80% of the global population relies on plant-based traditional medicines for primary health care needs[14]. With increasing awareness of the safety, accessibility, and cost-effectiveness of natural products, research on phytochemical composition has gained momentum in recent years. The family Pteridaceae, comprising about 53 genera and 950 species, is one of the largest families of pteridophytes and is widely recognized for its medicinal potential. However, despite their rich diversity and traditional importance, phytochemical investigations on Pteridaceae remain limited and fragmented. The present review aims to synthesize available qualitative phytochemical studies on the family Pteridaceae, with emphasis on their therapeutic relevance, pharmacological properties, and research gaps that warrant further exploration.

METHODOLOGY

A comprehensive literature survey was conducted to compile qualitative information on the phytochemistry and therapeutic potential of Pteridaceae species. Scientific databases including PubMed, Scopus, Web of Science, and Google Scholar were searched for relevant publications between 1950 and 2025. The search strategy employed keywords such as "Pteridaceae," "ferns," "phytochemicals," "secondary metabolites," and "medicinal properties." Only peer-reviewed articles published in English were considered. Studies were screened for relevance and data were extracted regarding species identification, phytochemical composition, and reported pharmacological or therapeutic activities. The extracted information was synthesized qualitatively, emphasizing trends across species, common and unique phytochemicals and their associated bioactivities. Unstructured or redundant data were reorganized into structured tables and figures to facilitate comparison and highlight research gaps within the family Pteridaceae.

PHYTOCHEMICAL INSIGHTS FROM PTERIDACEAE

Phytochemistry of Actiniopteris

The genus *Actiniopteris* has been extensively investigated for its diverse phytochemical constituents. *Actiniopteris radiata*, a species widely distributed in Pakistan and southern India, has been subjected to extractions with methanol, ethanol, aqueous, and petroleum ether solvents. These studies consistently reveal the presence of alkaloids, flavonoids, phenols, terpenoids, tannins, saponins, glycosides, and cardiac glycosides, with variations depending on the solvent used. Unique metabolites such as resins and betacyanins have also been reported, highlighting the biochemical richness of this fern. Methanol extracts are particularly rich in alkaloids, flavonoids, and tannins, while ethanol enhances the yield of glycosides and cardiac glycosides. Petroleum ether extractions, in contrast, largely emphasize terpenoids and steroids. These findings point to *A. radiata* as a chemically versatile species with significant pharmacological promise.

Phytochemistry of Cheilanthes

Several Cheilanthes species from the Western Ghats of India demonstrate a broad spectrum of bioactive compounds. Methanol extracts from *C. farinosa, C. anceps, C. tenuifolia*, and *C. albomarginata* consistently yield alkaloids, flavonoids, tannins, phenolic compounds, steroids, and triterpenoids. In addition, anthraquinones, amino acids, and reducing sugars have been detected, indicating substantial metabolic diversity. The occurrence of triterpenoids and anthraquinones in *C. albomarginata* and *C. anceps* suggests species-specific phytochemical signatures. *Cheilanthes bicolor*, analyzed using a wide range of solvents, revealed carbohydrates, proteins, phenols, and tannins as major groups. Collectively, *Cheilanthes* exhibits strong phytochemical potential, particularly for compounds with antioxidant, antimicrobial and anticancer properties.

Phytochemistry of Pityrogramma

The golden fern *Pityrogramma calomelanos* has been studied for its rich phytochemical profile. Aqueous and ethanol extracts of fronds, stems, and rhizomes from Kanyakumari indicate the presence of tannins, flavonoids, phenols, quinones, coumarins, terpenoids, steroids, saponins, and glycosides. Notably, betacyanin, a pigment rarely reported in higher plants, was consistently observed, suggesting potential applications in natural dye production and antioxidative therapeutics. The phytochemical uniformity across solvents indicates metabolic stability in this genus.

Phytochemistry of *Pteris*

The genus *Pteris* represents one of the most extensively explored groups within Pteridaceae. Methanol extracts from *P. confusa, P. vittata, P. argyreae, P. biaurita, P. multiaurita*, and *P. cretica* consistently reveal steroids, alkaloids, flavonoids, phenols, tannins, triterpenoids, saponins, amino acids, and sugars. Regional studies further confirm these results; for instance, *P. biaurita* from North Bengal was reported to contain cardiac glycosides and cholesterol in addition to the usual classes of metabolites. Comparative analyses show that *P. vittata* and *P. biaurita* exhibit broader chemical diversity than *P. multiaurita* and *P. argyreae*. Importantly, *P. cretica* has been found to harbor polyphenols and saponins in both leaves and rhizomes, supporting its ethnomedicinal applications in Iran.

Phytochemistry of Adiantum

Species of *Adiantum*, such as *A. lunulatum* and *A. venustum*, are chemically versatile and widely utilized in traditional medicine. Methanol and aqueous extracts reveal tannins, saponins, flavonoids, steroids, terpenoids, proteins, carbohydrates, and xanthoproteins. Solvent variation strongly influences the results: aqueous extractions highlight carbohydrates and phenols, while ethanol and methanol increase yields of flavonoids, steroids, and glycosides. The repeated detection of phlobatannins, glycosides, and volatile oils across studies suggests strong pharmacological potential, particularly in antimicrobial and antioxidant therapy.

Phytochemistry of Hemionitis

Hemionitis arifolia, a species native to the Western Ghats, has been subjected to extensive phytochemical analysis with solvents ranging from methanol to petroleum ether. Major bioactive compounds include phenols, flavonoids, glycosides, tannins, steroids, carbohydrates, saponins, and coumarins. Methanol and ethanol are particularly effective in extracting a broad range of secondary metabolites. Comparative solvent-based extractions highlight the presence of unique compounds such as xanthoproteins and cardiac glycosides, expanding the therapeutic scope of this fern.

Phytochemistry of Acrostichum and Ceratopteris

Mangrove-associated ferns like *Acrostichum aureum* and aquatic forms such as *Ceratopteris thalictroides* represent distinct phytochemical reservoirs. *A. aureum* has been shown to contain phenols, proteins, glycosides, steroids, saponins, terpenoids, and flavonoids, depending on solvent polarity. *C. thalictroides*, meanwhile, demonstrates an exceptionally broad profile including steroids, quinones, anthraquinones, coumarins, catechins, glycosides, xanthoproteins, tannins, and sugars. These findings highlight the metabolic adaptability of aquatic and semi-aquatic Pteridaceae members.

COMPARATIVE PHYTOCHEMISTRY ACROSS GENERA

The synthesis of findings across Pteridaceae reveals several trends

Core metabolites such as alkaloids, flavonoids, tannins, phenols, terpenoids and saponins are consistently reported across nearly all genera. Unique metabolites** include betacyanin in *Pityrogramma*, anthraquinones in *Ceratopteris*, and cholesterol in *Pteris biaurita*. Solvent influence is clear, with methanol and ethanol consistently yielding richer phytochemical profiles compared to aqueous and petroleum ether extractions. Geographical variation also plays a role, as species from Western Ghats, Pakistan, Iran, and North Bengal show slight differences in phytochemical composition.

Pharmacological Relevance and Research Gaps

These phytochemical findings strongly support the ethnomedicinal uses of Pteridaceae species, particularly in antimicrobial, antioxidant, anti-inflammatory, and anticancer applications. However, most studies remain preliminary, limited to qualitative screening. Few efforts have been made to isolate, characterize, or validate individual compounds through bioassays or clinical trials. Future research should adopt advanced metabolomic and biotechnological approaches to validate the therapeutic claims associated with Pteridaceae.

CONCLUSION

The Pteridaceae family demonstrates remarkable phytochemical diversity, encompassing a wide array of bioactive compounds with potential pharmacological applications. Comparative analyses across species and solvents reveal both common and unique metabolites, highlighting the importance of these ferns in drug discovery. Despite their established use in traditional medicine, Pteridaceae species remain underexplored in modern pharmacological research. Comprehensive profiling, coupled with bioactivity-guided fractionation, holds promise for unlocking novel therapeutic leads from this ancient lineage of vascular plants.

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