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The Cultural and Healing Worth of Pteridophytes: An Ethnobotanical Impression

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Abstract

Pteridophytes, one of the ancient plant groups, have been utilized in the ethnic and therapeutic practices of many cultures. They comprise lycophytes and ferns. These primitive "vascular cryptogams" are much more than decorative plants from the evolutionary past; pteridophytes have been used multifariously in customary medications as a valuable constituent of ethnobotany. Apart from therapeutic uses, these plants are used as sacrament plants, foods, homely items, and culturally distinct symbols all through Asia, Africa, Europe, and America. For centuries, species like *Adiantum capillus-veneris*, *Drynaria quercifolia*, *Pteris multifida*, and *Selaginella bryopteris* have been employed in conventional medical systems like Unani, Ayurveda, and Traditional Chinese Medicine. Currently, many indigenous peoples still use locally grown species of pteridophytes for daily nutrition and useful remedies. Regardless of their widespread cultural presence, these plants are still less studied in contemporary materia medica. However, an array of bioactive chemicals with antimicrobial, antioxidant, anti-inflammatory, and anticancer potentials have recently been found. This review reveals the perpetual implication of pteridophytes and gives importance to the need to sustain traditional knowledge, lift the sustainable use, and explore their potential in upcoming drug invention by amalgamating global ethnobotanical acquaintance with modern scientific understandings.

Keywords: Pteridophytes, Ethnobotany, Traditional Medicine, Indigenous Knowledge, Cultural Uses, Biodiversity Conservation

1. Introduction

J.W. Harshberger established the term "ethnobotany" in 1895 to classify the study of the intricate relationships that occur amongst plants and humans, particularly in ecological, cultural, and social circumstances. Ethnobotany, which was primarily demarcated as the study of plants used by native and ethnic societies, has developed into a multidisciplinary discipline that cartels traditional acquaintance with modern methods of resource management, biodiversity safety, and viable development. Exploring the ecological, figurative, ceremonial, and socio-economic characteristics of human-plant interactions goes beyond merely registering plant uses[1-3].

With fossil records going back to the Silurian period, i.e., more than 400 million years ago, these primitive vascular cryptogams represent some of the most primitive land-dwelling flora on earth. They display a staggering diversity of morphological and physiological variations that allow them to establish in terrestrial, epiphytic, xeric, and aquatic environments with about 10,500 species reported worldwide. Their placement amid bryophytes and spermatophytes, marks a pivotal alteration toward the progress of vascular tissues, dominant sporophytic generations in their life cycle, and, in certain groups (Lycophytes), the rise of heterospory—an initiation to the progression of seeds that makes them evolutionary very significant[4-6].

Since pteridophytes tend to grow almost all over the world, several ethnic groups in Asia, Africa, Europe, and America have been able to incorporate these plants deeply into their customs. Their ethnobotanical impact holds ritualistic practices, food uses, ecological functions, and medicinal uses. For more than two millennia, pteridophytes have been used as therapeutic plants in various ethnic medicinal systems. The medicinal capacities of species like *Adiantum capillus-veneris*, *Marsilea minuta*, and *Selaginella bryopteris* are described in ancient Indian texts like 'Charaka Samhita' and 'Sushruta Samhita'. Akin to this, ferns like *Lygodium japonicum*, *Selaginella tamariscina* and *Pteris multifida* are valued for their hemostatic, decontaminating, and anti-inflammatory qualities in Unani Ayurveda, and Traditional Chinese Medicine. For instance, in Unani medicine system, *Adiantum capillus-veneris* is used to treat respiratory and urinary ill conditions, which reflects its worth in various cultural healing philosophies[7].

Pteridophytes have been assimilated into daily life, food systems, and rituals by aboriginal and ancestral populations around the ecosphere, who have established rich ethnomedicinal traditions including them. In South Asia and Southeast Asia, species like *Diplazium esculentum* are used as nutraceuticals and medicines, and epiphytic ferns species like *Drynaria quercifolia* and *Nephrolepis cordifolia* are used in treatments for skeletal related problems, respiratory diseases, and reproductive conditions[8]. Ferns also have several cultural uses besides their medicinal uses: in some ethnic societies, they are used as body beautifications, ornamentals, protecting talismans, and bioresources for insulation. Since a large percentage of this traditional knowledge is passed down vocally, it is inclined to decline in the face of modernization and altering cultural customs[9].

Compared to angiosperms, pteridophytes have been used for a long time, but their incorporation into contemporary pharmacology is still quite limited. However, current studies are highlighting their bioactive potential more and more, finding substances with anti-inflammatory, diuretic, anticancer, antioxidant, and antimicrobial qualities. This increasing interest highlights the necessity of methodically recording and assessing the traditional knowledge about pteridophytes in order to promote conservation and support their potential role in future drug discovery[10].

This review summarizes ethnobotanical acquaintance from around the world regarding the cultural, medicinal, and ecological value of vascular cryptogams. It explores their phytochemical and pharmacological potential, highlights their traditional uses in various societies, and emphasizes the value of conserving ethnobotanical knowledge systems for long-term use and further scientific research.

2. Literature Search Strategy

A comprehensive literature survey was conducted to compile ethnobotanical and medicinal information on pteridophytes. Relevant peer-reviewed research articles, review papers, ethnofloristic surveys, books, theses, and reports were retrieved from major scientific databases, including Scopus, Web of Science, PubMed, Google Scholar, JSTOR, and ScienceDirect. Additional information was sourced from classical ethnobotanical texts and regional floras.

3. The Review's Objectives

The accumulated knowledge of indigenous and local communities regarding the use of plants for food, medicine, and cultural customs is known as ethnobotanical knowledge. Because of migration, habitat loss, modernization, and the deterioration of oral traditions, this knowledge is rapidly disappearing. In order to prevent irreversible cultural and biological loss and to promote the sustainable use of plant resources, many studies conducted over the past ten years have stressed the importance of recording traditional practices.

Despite being frequently disregarded in ethnobotanical literature, pteridophytes have significant ecological, cultural, and medicinal value. Their various bioactive compounds have wound-healing, antimicrobial, anti-inflammatory,

and antioxidant properties. Despite this potential, their ethnobotanical applications are still less common than those of angiosperms, highlighting the necessity of a thorough synthesis of the available data to comprehend their function in indigenous healthcare systems[11]. Therefore, this review addresses the need to: (i) maintain dwindling traditional knowledge of pteridophytes; (ii) emphasize its ethnopharmacological potential; and (iii) support conservation and sustainable utilization measures.

3.1 The Value of Ethnobotanical Research in Maintaining Conventional Knowledge

The importance of ethnobotanical research in preserving traditional knowledge before it is lost is highlighted by recent studies. Pteridophytes continue to be an essential part of primary healthcare in many tribal and rural areas for the treatment of wounds, fevers, respiratory conditions, digestive issues, and other common illnesses. In addition to providing crucial baseline data on species use, preparation techniques, and regional healthcare systems, documentation of such practices protects cultural traditions.

The pharmacological potential of pteridophytes is also revealed by ethnobotanical records. Numerous fern species that have long been used in traditional medicine have been found to have scientifically proven antioxidant, antimicrobial, anti-inflammatory, and wound-healing qualities. These documents direct bioprospecting activities and provide information for later phytochemical and pharmacological studies[12].

Additionally, by emphasizing culturally significant or heavily harvested species, ethnobotanical documentation aids in conservation planning. Sustainable-use strategies are strengthened and participatory approaches are encouraged when formal conservation frameworks are integrated with local knowledge. In general, ethnobotanical research provides a basis for protecting cultural heritage, directing the development of new drugs, and encouraging the preservation of biodiversity[13].

3.2 Worldwide Distribution

There are about 11,500 species of ferns worldwide, with tropical and subtropical mountainous areas having the highest diversity. Despite making up only around 7% of the planet's land area, eight equatorial and semitropical mountain biodiversity hotspots are home to nearly 58% of all fern species. Central America, the Caribbean, the Andean tropics, eastern Brazil, northeastern South America, Madagascar, Malesia, and East Asia are notable areas of richness. [14–17]. Climate and elevation gradients are closely correlated with fern diversity. The highest species richness is found in humid, topographically complex areas with high temperature and precipitation variability. The ecological significance of montane habitats, which make up less than 2% of the world's land area, is highlighted by the fact that nearly half of all fern species are found there[14].

3.3 Distribution by Region (India)

More than 1,000 species of pteridophytes from 67 families and 191 genera can be found in India. The main hubs of fern diversity are found in the Eastern, Western, and Himalayan regions[18]. A rich pteridophytic flora, including several rare, threatened, and endemic taxa, is supported by the nation's diverse climates, altitudes, and soil types. The Western Ghats, northeastern India, and the Himalayan belt are especially important for endemism and species richness.

3.4 Literature Review

Pteridophytes are special vascular cryptogams with distinctive foliage morphology and separate sporophytic and gametophytic generations. Approximately 1,300 species have been identified in India across major phytogeographical zones like the Himalayas, Western and Eastern Ghats, Central India, and the Andaman & Nicobar Islands, out of the approximately 13,600 extant species found worldwide[19].

As early as Theophrastus and Dioscorides' writings, the medicinal applications of pteridophytes were acknowledged. Ayurvedic, Unani, Siddha, homeopathic, and tribal medical

systems all make extensive use of them in India. Indian pteridophyte taxonomy is still based on Beddome's groundbreaking "Handbook of the Ferns of British India, Ceylon, and the Malay Peninsula" (1883).

Ferns are prized for their aesthetic qualities and are frequently used as ornamentals and horticultural plants in addition to their therapeutic uses. They are increasingly being used in landscaping and nurseries.

Pteridophytes are used as vegetables, fodder, fibers, oils, natural dyes, and fragrances, among other cultural, medicinal, and commercial uses, according to international ethnobotanical research. Their pharmacological potential is highlighted by recent research: for instance, *Drynaria fortunei* exhibits bone-strengthening properties[20], while *Diplazium esculentum* demonstrates anti-inflammatory and chemopreventive activities[21]. As interest in plant-based and alternative medicine grows, pteridophytes are emerging as promising subjects for contemporary ethnopharmacological research[22].

4. Representative Ethnobotanically Important Pteridophytes

1. ***Adiantum capillus-veneris*** **L. (Maidenhair fern)**
   - **Habit/Habitat:** Small lithophytic fern; grows on limestone rocks, cliffs, and moist ravines.
   - **Key Uses:** Paste of leaves/rhizome used for wounds, hair tonic, bronchial ailments, fever, and menstrual issues. Decoction used for childbirth support and gynecological disorders. Fresh juice used for cough and diabetes.
   - **Ethnopharmacology:** Shows bronchodilatory, anti-inflammatory, anxiolytic, and antidepressant activity.
2. ***Diplazium esculentum*** **(Retz.) Sw. (Vegetable fern)**
   - **Habit/Habitat:** Large terrestrial fern common along streams and moist slopes.
   - **Key Uses:** Popular edible fern used as seasonal vegetable; also applied for constipation, wounds, rheumatism, skin issues, fever, and pregnancy-related care.
   - **Ethnopharmacology:** Rich in polyphenols with anti-inflammatory and anticancer potential.
3. ***Selaginella bryopteris*** **(L.) Baker (Sanjeevani Booti)**
   - **Habit/Habitat:** Lithophyte of arid, rocky habitats; renowned for desiccation tolerance.
   - **Key Uses:** Cooling agent for heat stroke, remedy for diarrhea and urinary issues; decoctions used for menstrual problems and postpartum care. Culturally revered as a "life-restoring herb."
   - **Ethnopharmacology:** Exhibits antioxidant, antibacterial, and wound-healing activities.
4. ***Pteris vittata*** **L. (Chinese brake fern)**
   - **Habit/Habitat:** Lithophytic fern on limestone walls, stream margins, and disturbed habitats.
   - **Key Uses:** Decoction for dysentery, glandular swellings, fever, urinary troubles; fronds used ceremonially and as cattle-shed cushions.
   - **Ethnopharmacology:** Contains rutin and other flavonoids with antibacterial, antifungal, and anti-inflammatory effects.
5. ***Osmunda regalis*** **L. (Royal fern)**
   - **Habit/Habitat:** Moist slopes near waterfalls, swamps, and humid soils.
   - **Key Uses:** Rhizome decoction used as abortifacient and for menstrual disorders; leaf paste for birth control; also used for rheumatism, wounds, and renal issues.
   - **Ethnopharmacology:** Traditionally used for musculoskeletal disorders and internal inflammations.
6. ***Lygodium flexuosum*** **(L.) Sw. (Climbing fern)**

- **Habit/Habitat:** Moist forest edges, hedges, and stream banks.
- **Key Uses:** Treats menorrhagia, dysmenorrhea, infertility, arthritis, jaundice, skin infections, and leprosy. Widely used in rituals (e.g., Nira festival, Kerala).
- **Ethnopharmacology:** Known for anti-inflammatory, antimicrobial, and wound-healing effects.

7. ***Equisetum ramosissimum*** **Desf. (Horsetail)**
   - **Habit/Habitat:** Moist, sandy-alluvial soils; often in open to semi-shaded areas.
   - **Key Uses:** Used for fertility, kidney stones, skin issues, fractures, urinary troubles, hypertension, and digestive ailments.
   - **Ethnopharmacology:** Contains apigenin, kaempferol, quercetin, terpenes, and sterols with strong antioxidant and diuretic properties.
8. ***Marsilea quadrifolia*** **L. (Water Clover)**
   - **Habit/Habitat:** Ponds, paddy fields, and shallow wetlands.
   - **Key Uses:** Paste for cold, cough, skin issues; used for fever, dysentery, urinary disorders, neurological problems, and as famine food.
   - **Ethnopharmacology:** Rich in flavonoids and novel polyphenols; shows antioxidant and neuroprotective potential.
9. ***Cyathea gigantea*** **(Wall. ex Hook) (Tree fern)**
   - **Habit/Habitat:** Moist valleys, evergreen forests, stream sides.
   - **Key Uses:** Caudex paste used for wounds, pain relief, diabetes management, gynecological issues, and indigestion. Pith (tashe) consumed as supplementary famine food.
   - **Ethnopharmacology:** Contains saponins, triterpenes, sterols, and oleanolic acid with antimicrobial, anti-inflammatory, and antidiarrheal effects.
10. ***Nephrolepis cordifolia*** **(L.) Presl (Ladder fern)**
    - **Habit/Habitat:** Moist areas near water; roadside fern with creeping rhizomes and tubers.
    - **Key Uses:** Tubers used for indigestion, ulcers, fever, jaundice, dehydration, and wounds. Rhizome extract used in traditional female sterilization practices.
    - **Ethnopharmacology:** Exhibits antihypertensive, antidiabetic, antimicrobial, and hepatoprotective properties.
11. ***Cheilanthes farinosa*** **(Forssk.) Kaulf. (Silver fern)**
    - **Habit/Habitat:** Dry, rocky crevices; lime-rich soils.
    - **Key Uses:** Extract used for menstrual issues, fever, ulcers, eczema, stomach pain, wounds, and veterinary infections. Stipes used for crafting ear/nose ornaments.
    - **Ethnopharmacology:** Fresh fronds show antibacterial activity; root paste effective for skin inflammations.
12. ***Drynaria quercifolia*** **(L.) J.Sm. (Oak-leaf fern)**
    - **Habit/Habitat:** Epiphytic fern of humid tropical forests.
    - **Key Uses:** Rhizome paste for heart problems; fronds used for typhoid, inflammation, migraine, and gastric issues; acts as expectorant and antiseptic.
    - **Ethnopharmacology:** Noted for antibacterial and anti-inflammatory effects.

5. Pteridophytes' Secondary Metabolites:

Secondary metabolites are organic compounds that perform essential ecological tasks but do not

directly aid plant growth or reproduction. In pteridophytes, they aid in defense, allelopathy, UV protection, and environmental adaptation. These compounds enhance stress tolerance, mediate interactions between microbes and plants, and significantly boost the medicinal value of ferns. They help plants adapt to biotic and abiotic stresses, such as herbivory, pathogens, intense light, temperature fluctuations, salt, and drought, according to Bennett and Wallsgrove[23].

5.1 Principal Ecological Roles

Ferns and related plants protect themselves through a combination of chemical and physiological strategies. Phytoecdysteroids help defend against herbivorous insects by disrupting their growth and development, while tannins reduce palatability and discourage feeding. Some ferns also exhibit allelopathy, releasing bioactive compounds into the surrounding soil that suppress the growth of neighboring plants and reduce competition. In addition, harmful UV-B radiation is absorbed by epidermal flavonoids, which act as natural sunscreens and protect plant tissues from ultraviolet damage.

5.2 Saccharides

Cyanogenic glycosides release hydrogen cyanide upon tissue damage, deterring herbivores by inhibiting cytochrome c oxidase[24]. They are mainly reported in *Pteridium* species and *Microgramma vacciniifolia*. Prunasin is the most common cyanogenic glycoside in ferns[25].

5.3 Terpenoids

Terpenoids, which are biosynthesized from isoprene units, represent a diverse class of secondary metabolites in ferns and include mono-, sesqui-, di- and triterpenes, as well as carotenoids. Among them, phytoecdysteroids act as analogues of insect moulting hormones and disrupt normal insect development, contributing to plant defense[26]. Saponins, reported in *Adiantum* species, impart a bitter taste that deters herbivory[27]. Carotenoids such as β-carotene, common in members of Dryopteridaceae, play an essential role in light harvesting and protect photosynthetic tissues from photo-oxidative damage[28]. Sesquiterpenes, particularly pterosins found in *Pteris* species, are of notable pharmacological interest due to their reported antitumor, cytotoxic, antidiabetic, and anti-obesity activities[29], and they also participate in microbial interactions while providing antioxidant, anti-inflammatory, and neuroprotective benefits[30].

5.4 Alkaloids

Although alkaloids are relatively rare in true ferns, they are abundant in fern allies, particularly members of the Lycopodiaceae. Notable examples include huperzine A from *Huperzia serrata*, a potent acetylcholinesterase inhibitor that has been widely investigated for the treatment of Alzheimer's disease[31]. Related compounds such as huperzines A, B, and R exhibit strong neuroprotective properties[32], while lycodine derivatives are known for their antimicrobial activity[33]. In addition, hordenine, an alkaloid found in some lycophytes, mimics the action of dopamine and epinephrine and influences cardiovascular as well as metabolic responses[34].

5.5 Phenolic Compounds

Phenolic compounds are the most widespread secondary metabolites in ferns, where they function as powerful antioxidants, UV protectants, and antimicrobial agents[35]. Among these, caffeic and chlorogenic acids are known for their anti-inflammatory and cardioprotective effects, while tannic and gallic acids—classified as hydrolysable tannins—exhibit strong antioxidant, astringent, and wound-healing properties[34]. The high abundance of phenolics also helps explain why many phenolic-rich ferns successfully thrive in high-altitude environments, as these compounds enhance tolerance to intense ultraviolet radiation[36].

5.6 Flavonoids

Flavonoids, a diverse group of ~4000 polyphenols, show strong antioxidant, anti-inflammatory, antibacterial, and anticancer activities[37]. *Dryopteris* species possess flavonoids with cytotoxic effects on ovarian, liver, breast, and lung cancer cell lines[11, 38].

6. Pteridophytes' Biological Activities

To adapt to terrestrial stressors like UV radiation, pathogens, and herbivores, pteridophytes developed a variety of biochemical pathways. They produce a variety of bioactive compounds, such as flavonoids, steroids, phenolics, alkaloids, and terpenoids[39], thanks to their lengthy evolutionary history. Antioxidant, antibacterial, anti-diabetic, antitumor, antifungal, antiseptic, and anti-inflammatory qualities are provided by these substances[40]. Calaguline[41] and Huperzine A/B are two notable examples.

6.1 Antioxidant Characteristics

Many ferns have strong radical-scavenging activity due to their high polyphenol content[42]. These antioxidants reduce oxidative stress, which is associated with aging, cancer, atherosclerosis, and cardiovascular diseases. Significant antioxidant activity is exhibited by species such as *Drynaria*, *Davallia*, *Dicranopteris*, *Marsilea*, *Equisetum*, *Pteris*, and *Sellaginella*[43]. Antioxidants aid in preventing reactive oxygen species-induced damage to proteins, lipids, and DNA[44].

6.2 Antimicrobial Characteristics

Alkaloids, flavonoids, tannins, and glycosides found in the epidermal glands of pteridophytes prevent the growth of microorganisms[45–48]. *Adiantum*, *Lygodium*, *Pteris*, *Christella*, *Salvinia*, and *Ceratopteris* species have been shown to exhibit antibacterial activity against both Gram-positive and Gram-negative bacteria[49]. *Cheilanthes* and *Marsilea* species exhibit antifungal effects[50]. *Blechnum orientale*, *Woodwardia, Lygodium*, *Asplenium*, *Microsorum*, *Pteris*, and *Selaginella*[51] are among the ferns that exhibit antiviral activity.

6.3 Anti-inflammatory Characteristics

Inflammation and cellular damage are caused by an excess of reactive oxygen species. Phenolics, flavonoids, diterpenes, and tannins derived from ferns aid in reducing inflammatory reactions and neutralizing free radicals[52].

6.4 Anticancer Properties

Fern phytochemicals reduce oxidative stress, inhibit angiogenesis, modulate the cell cycle, and prevent metastasis, all of which have anticancer and apoptosis-inducing effects. Serratenediol, lycopodine, and lycojaponicumin analogs from Lycopodium species exhibit significant anticancer potential[53, 54].

7. Pharmaceutical Products

Huperzine A, a reversible acetylcholinesterase inhibitor isolated from *Huperzia serrata*, has gained considerable attention for its potential in the treatment of Alzheimer's disease and has also been used traditionally to manage conditions such as swelling, fractures, and organophosphate poisoning[55, 56]. Another notable compound, calaguline, extracted from *Polypodium* leaves, exhibits anti-inflammatory and anti-proliferative activities by inhibiting NF-$\varkappa$B activation[57, 58].

8. Preservation and Ecological Use

Because pteridophytes require steady, humid microclimates, habitat disruption quickly lowers their populations[59]. The following are major threats: pollution and invasive species; habitat loss, deforestation, and land-use change; overharvesting for medicinal and ornamental purposes; and climate change that modifies moisture regimes. Epiphytic ferns usually destroy their host trees hence numerous species are currently classified as endangered or vulnerable[60].

9. Conservation Strategies

These strategies may be *In situ* i.e., preservation of microclimate-dependent ecosystems, and protection of habitats and establishment of protected areas, or *Ex situ* by *in vitro* culture and cryopreservation of gametophytes and sporophytes; living collections; spore banking[61]. DNA banks, germplasm, and botanical gardens are other supportive strategies[62].

9.1 Ecological Harvesting

This procedure meant to create controlled harvesting procedures; to encourage agroforestry for the production of medicinal ferns; to involve local populations and provide incentives for sustainable practices; and to develop mechanisms for certifying materials sourced responsibly[63].

9.2 Indigenous Knowledge

Ethnobotanical study, bioprospecting, cultural recognition, and biodiversity conservation are all aided by the documentation of traditional usage[64, 65].

10. Future Prospects and Conclusion

Pteridophytes have long served traditional medicine for treating inflammation, infections, and tumors. Despite this, their phytochemistry and pharmacology remain underexplored compared to angiosperms. Most species have not yet been chemically profiled or bioassayed. Future studies should concentrate on the following areas: isolating and characterizing novel bioactive compounds; comprehending biosynthetic pathways; creating phytopharmaceuticals through computational drug design; combining biochemical research with ethnobotanical knowledge; and sustainable conservation and cultivation to stop biodiversity loss. Pteridophytes protection guarantees the survival of ecologically significant species and maintains access to essential therapeutic resources.

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Author contributions

SS –Research concept and design, **S** –Collection and assembly of data, Data analysis and interpretation, writing the article, **SS, S** – Critical revision and final approval of the article.

Data Availability

Not Applicable.

Conflicts of interest

The authors declare that there are no conflicts of interest related to this article. No ethical issues

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