

International Journal of Advanced Biochemistry Research



ISSN Print: 2617-4693
ISSN Online: 2617-4707
NAAS Rating (2026): 5.29
IJABR 2026; SP-10(6): 1611-1615
www.biochemjournal.com
Received: 27-04-2026
Accepted: 30-05-2026

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An updated review of pharmacological, and phytochemical potency of *Aleuritopteris bicolor*

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DOI: <https://www.doi.org/10.33545/26174693.2026.v10.i6Ss.8889>

Abstract

Aleuritopteris bicolor is a terrestrial fern widely distributed across the Himalayan and Southeast Asian regions and has long been used in traditional medicinal systems such as Ayurveda and Unani. The plant has attracted increasing scientific interest because of its diverse phytochemical composition and pharmacological activities. This review provides a comprehensive overview of the ethnomedicinal uses, phytochemical constituents, and pharmacological potential of *A. bicolor*. Literature indicates that the fern contains several bioactive compounds, including flavonoids, phenolics, coumarins, saponins, glycosides, and terpenoids. Advanced analytical techniques such as LC-MS have identified specific metabolites such as chlorogenic acid, quercetin derivatives, kumatakenin, and the sesterterpenoid and cheilanthetetraol. Experimental studies demonstrate that extracts of *A. bicolor* possess strong antioxidant activity (DPPH $IC_{50} \approx 9.87 \mu\text{g/mL}$), significant anti-inflammatory effects in carrageenan-induced paw-oedema models, analgesic properties in hot-plate tests, antibacterial activity against both gram-positive and gram-negative bacteria, and α -amylase inhibitory potential, suggesting antidiabetic activity. Recent studies have also reported cytotoxic effects against hepatocellular carcinoma cell lines. These pharmacological activities support the traditional ethnomedicinal use of the plant for treating wounds, fever, diarrhoea, and gastrointestinal disorders. Overall, *A. bicolor* represents a promising source of bioactive compounds with potential pharmaceutical applications. Further detailed mechanistic studies and clinical investigations are required to fully explore its therapeutic potential.

Keywords: *Aleuritopteris bicolor*, ethnomedicine, phytochemicals, antioxidant, bioactive compounds, medicinal ferns

Introduction

Aleuritopteris, also referred to as Silver or Lip Ferns, is a genus with significant morphological variation, especially in frond arrangement, which has historically resulted in a variety of taxonomic divisions in both the Eastern and Western Hemispheres^[1]. The genus, which has about 40 species, is known for its distinctive farinose indumentum and propensity for mostly xeric habitats^[2]. Recent molecular phylogenetic investigations generally maintain *Aleuritopteris* as a separate genus, despite some taxonomic ambiguity, especially with regard to its differentiation from *Cheilanthes*^[1]. The small to medium-sized terrestrial fern *Aleuritopteris bicolor* belongs to the Pteridaceae family and is indigenous to South and Southeast Asia, including India, Nepal, Bangladesh, Sri Lanka, Myanmar, Laos, Malaysia, and Indonesia^[3, 4]. William Roxburgh first identified the species as *Pteris bicolor* in 1844, but it has since undergone multiple taxonomic changes. It was first classified under *Cheilanthes* and *Hemionitis* before Fraser-Jenkins moved it to *Aleuritopteris* in 2009^[7]. It generally inhabits in dry forests, rocky slopes and scrublands. It's bipinnate fronds, which often have a silvery farinosa covering on the underside, help prevent loss, and it flourishes in exposed, xeric conditions. In addition to being valued aesthetically for its striking leaf, *A. bicolor* helps to stabilise soil and colonise damaged areas. Because of its distinctive bicoloured appearance, it is commonly referred to as "Silver Fern". Due to its wide distribution and taxonomic complexity, it is an important species for floristic and ecological studies in the region^[3, 4, 7]. In addition to *A. bicolor*'s ecological significance in soil stabilisation and the colonisation of disturbed habitats, recent phytochemical studies have revealed the presence of several bioactive constituents, such as flavonoids, phenolic compounds, coumarins, saponins, glycosides, and terpenes^[8, 9]. Numerous important compounds, such as chlorogenic acid, quercetin derivatives, kumatakenin, and

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cheilanthetetraol, a new sesterterpenoid, have been identified by improved LC-MS research, highlighting the plant's wide phytochemical features [8]. These phytochemicals are associated with a variety of pharmacological properties, including antioxidant, anti-inflammatory, antibacterial, antidiabetic, analgesic, and cytotoxic effects against hepatocellular carcinoma cells [9, 10]. Strong free-radical scavenging activity (DPPH $IC_{50} \approx 9.87 \mu\text{g/mL}$), notable analgesic activity (up to 38.89% increase in response time in the hot-plate test), significant anti-inflammatory effects (36.44% reduction in carrageenan-induced paw oedema at 500 mg/kg), and α -amylase inhibitory activity ($IC_{50} \approx 59.31 \mu\text{g/mL}$), which may have hypoglycemic effects [8, 10]. Traditional Indian and Nepalese

medical systems have long utilised this fern to treat diarrhoea, wounds, fever, and gastritis. These ethnomedicinal applications are supported by recent pharmacological studies [6, 9]. *A. bicolor*'s role as a hardy fern in rocky environments and its increasing importance as a source of natural medicinal agents make it a valuable species for ecological and biomedical research [8-10]. Because of its ethnomedicinal importance and emerging pharmacological potential, *A. bicolor* has attracted considerable attention in natural product research. This short review aims to summarize current knowledge on the plant's ethnomedicinal uses, phytochemical constituents, and pharmacological activities while identifying future research directions.

Taxonomy and Classification

Kingdom	Plantae	
Plant Name	<i>Hemionitis bicolor</i>	-
Family	Pteridaceae	-
Synonyms	<i>Aleuritopteris bicolor</i>	<i>Cheilanthes bicolor</i>
Common Name	Silver fern	Tattoo fern
Chemical constituents	Flavonoids	Alkaloids
	Saponins	
Genus	Hemionitis	-
Specific epithet	bicolor	-

Geographical Distribution

Numerous nations in Southeast Asia and the Indian subcontinent, such as India, Nepal, Bangladesh, Sri Lanka, Myanmar, Laos, Malaysia, and Indonesia, have *Aleuritopteris bicolor* [3, 5, 7]. Reports from several Indian regions, such as Andhra Pradesh, Maharashtra, Odisha, Madhya Pradesh, and the Himalayan foothills, show that it can adapt to a wide range of climatic zones [3, 10]. Generally, it is located on rocky hill slopes, dry woodlands, open scrublands, and disturbed terrains. This fern thrives in xeric (dry) environments, which are unsuitable for many fern species [2, 5]. It may colonise exposed rocky settings because of its fronds, which are often covered in a silvery farinose layer on the abaxial surface as a response to intense sunlight and limited water availability [5]. From an ecological perspective, *A. bicolor* serves as a pioneer species that promotes vegetation succession in delicate environments and maintains soil on rocky slopes [7, 10]. The topographical distribution of *Aleuritopteris bicolor* was shown in Figure 1.

1.3 Chemical constituents

Phytochemical analysis of *Aleuritopteris bicolor* has identified a wide range of bioactive substances that support its therapeutic potential. In addition to particular components like chlorogenic acid, quercetin derivatives, kumatakenin, and cheilanthetetraol (a novel sesterterpenoid), studies have revealed the presence of flavonoids, phenolic compounds, glycosides, saponins, tannins, coumarins, and triterpenes [4, 11, 13]. These phytochemicals are well known for their potent antioxidant, anti-inflammatory, analgesic, antibacterial, antidiabetic, and cytotoxic qualities [14, 17]. These pharmacological properties corroborate the traditional use of this fern in ethnomedicine to treat wounds, diarrhoea, gastritis, and fever in several parts of South Asia [13-14]. Therefore, *A. bicolor* provides scientific evidence for its ethnomedicinal applications and is a potential source of natural therapeutic agents due to its rich phytochemical composition. The chemical structure of the

active compounds present in *Aleuritopteris bicolor* were shown in Table 1.

Pharmacological activities of *Aleuritopteris bicolor*

Extracts from *Aleuritopteris bicolor* were discovered to have a number of pharmacological properties that are supported by both experimental and ethnomedical studies. With the results displayed in this review, several studies showed varying pharmacological activity.

Antioxidant Activity

Several *in vitro* experiments have demonstrated *Aleuritopteris bicolor* extracts' remarkable antioxidant capacity. In the DPPH experiment, the ethanolic extract showed exceptionally strong free radical scavenging activity with an IC_{50} value of about $9.87 \mu\text{g/mL}$, indicating a significant capacity to neutralise reactive oxygen species. The extract's remarkable performance in ferric reducing antioxidant power (FRAP) and ABTS radical scavenging assays further supported its antioxidant capacity. Flavonoids and phenolic compounds, such as derivatives of quercetin and chlorogenic acid, are primarily responsible for this activity. By providing hydrogen atoms or electrons to free radicals, these compounds stabilise them and shield cellular macromolecules from oxidative damage. The plant's antioxidant capacity supports its traditional use in oxidative stress-related ailments such as inflammation and metabolic problems [4, 11, 13].

Anti-Inflammatory and Analgesic Effect

The carrageenan-induced paw oedema model has been used to evaluate the anti-inflammatory qualities of *A. bicolor* in experimental animals. Paw oedema was suppressed by roughly 36.44% when the ethanolic extract was given at a dose of 500 mg/kg body weight, indicating a significant decrease in the initial inflammatory response. The analgesic potential was also assessed using the hot-plate test; treated animals showed a 38.89% increase in reaction time,

indicating an enhanced pain threshold. These effects may be caused by flavonoids, coumarins, and triterpenoids, which suppress inflammatory mediators, including prostaglandins and cytokines. These findings offer scientific support for the fern's traditional use in the treatment of oedema, pain, and inflammatory disorders^[13].

Antibacterial Activity

The antibacterial qualities of *A. bicolor* extracts have been evaluated against several dangerous bacterial species. Methanolic and ethanolic extracts moderately to significantly inhibited both Gram-positive bacteria, such as *Bacillus subtilis* and *Staphylococcus aureus*, and Gram-negative bacteria, such as *Escherichia coli* and *Pseudomonas aeruginosa*. Zones of inhibition ranging from 12 to 20 mm have been reported, depending on the extract amount. This antibacterial activity is mostly caused by phytochemicals such as tannins, saponins, flavonoids, and phenolic compounds that can harm microbial cell walls, block enzymatic systems, and disrupt bacterial metabolic pathways. These traits suggest that *A. bicolor* may be a naturally occurring antibacterial agent^[14].

Antidiabetic Activity

Studies on glucose absorption and α -amylase inhibitory tests have demonstrated the antidiabetic potential of *A. bicolor*. The extract effectively inhibited α -amylase with an IC₂₀ value of around 59.31 μ g/mL, suggesting that it may slow down the digestion of carbohydrates and reduce postprandial glucose levels. Additionally, *in vitro* glucose absorption tests demonstrated improved glucose utilisation in treated samples. These findings are consistent with the presence of flavonoids, phenolics, and glycosides, all of which are known to regulate insulin signalling pathways and carbohydrate metabolism. These results thus provide scientific support for the fern's traditional use in the treatment of diabetes and hyperglycemia^[16].

Cytotoxic and Anticancer Activity

A recent phytochemical study has identified several bioactive sesterpenoids and flavonoid derivatives from *A. bicolor*, including cheilanthetetraol. These compounds have been demonstrated to have cytotoxic effects on Hepatocellular carcinoma (HepG2) cell lines *in vitro*, and cell viability studies have shown moderate inhibitory action. The anticancer effect is believed to be mediated by mechanisms such as oxidative stress regulation, cell growth suppression, and apoptosis induction. These findings highlight *A. bicolor*'s potential as a source of innovative anticancer medicines made from natural ingredients^[14].

Ethnomedicinal Validation

A. bicolor has long been used in traditional South Asian medicine to treat inflammatory conditions, fever, gastritis, diarrhoea, and wounds. Local communities regularly use the plant paste topically to treat wounds and drink decoctions to treat digestive disorders, according to ethnobotanical surveys^[3, 7, 8]. By providing scientific support for these

ancient methods, contemporary phytochemical and pharmacological research has closed the gap between ethnomedicine and modern pharmacological research. The summary of pharmacological activities of *Aleuritopteris bicolor* was shown in Table 2.

Table 1: Chemical structure of the active compounds present in *Aleuritopteris bicolor*.

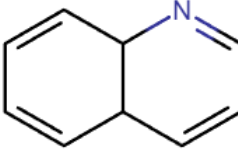
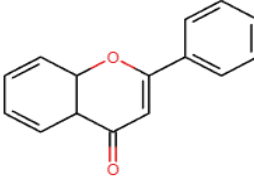
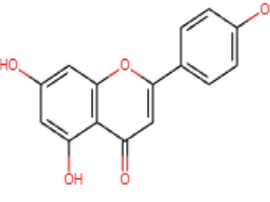
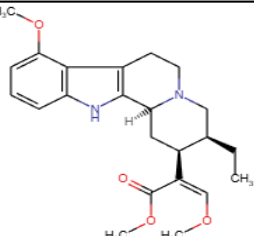
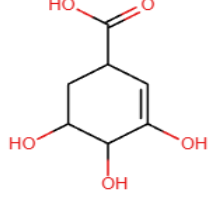
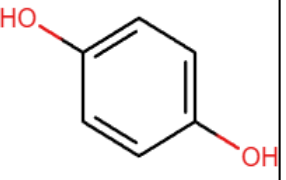
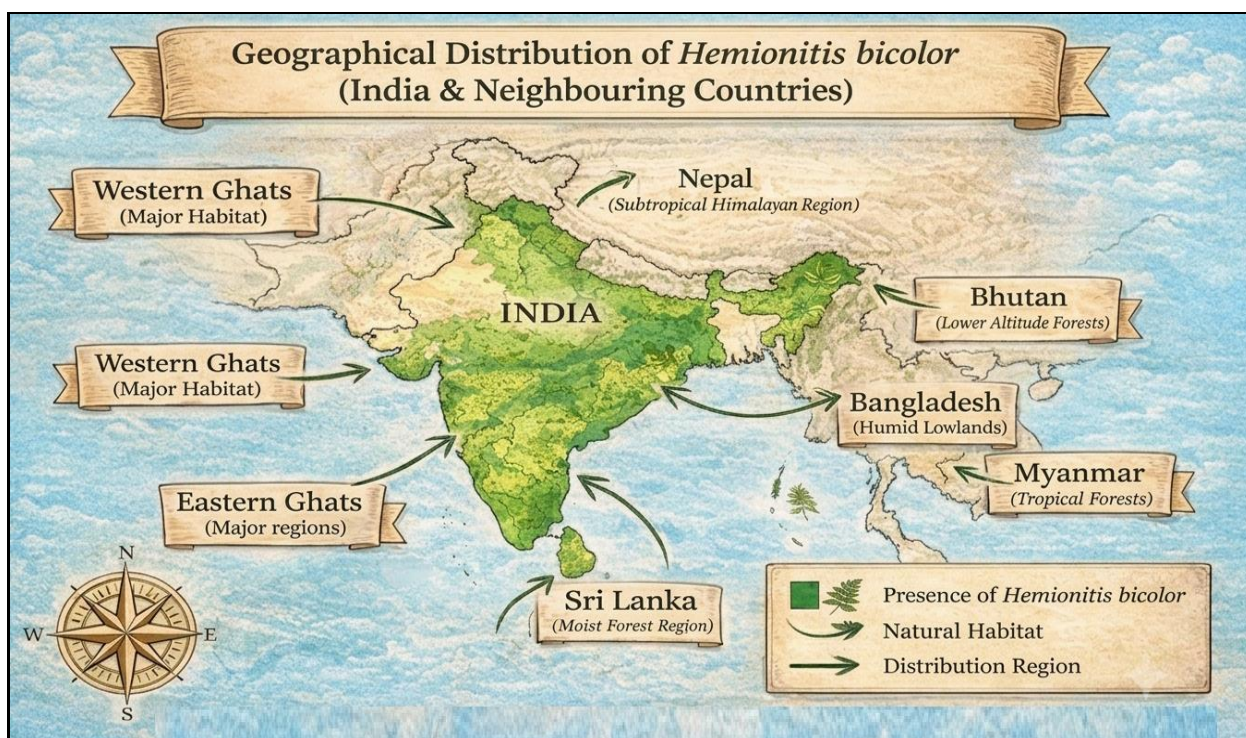
S. No.	Chemical name	Chemical Structure
1.	Alkaloid	 Quinoline
2.	Flavonoid	 Flavonoid
3.	Phenolic compound	 Phenolic compound
4.	Saponin	 Saponin
5.	Tannin	 Tannins
6.	Glycoside	 Hydroquinone

Table 2: Summary of pharmacological activities of *Aleuritopteris bicolor*.

Activity	Key Findings	Phytochemical Constituents	References
Antioxidant Activity	Strong free radical scavenging in DPPH ($IC_{50} \approx 9.87 \mu\text{g/mL}$), ABTS, and FRAP assays	Flavonoids, phenolics (quercetin derivatives, chlorogenic acid)	[12, 13]
Anti-inflammatory & Analgesic	36.44% inhibition of carrageenan-induced paw oedema; 38.89% increase in hot-plate reaction time	Flavonoids, coumarins, triterpenoids	[13, 14]
Antibacterial Activity	Inhibition zones (12–20 mm) against <i>S. aureus</i> , <i>B. subtilis</i> , <i>E. coli</i> , and <i>P. aeruginosa</i>	Tannins, saponins, flavonoids, phenolic compounds	[11, 13]
Antidiabetic Properties	α -amylase inhibition ($IC_{50} \approx 59.31 \mu\text{g/mL}$); improved glucose uptake in vitro	Flavonoids, phenolics, glycosides	[12, 14]
Cytotoxic/Anticancer	Cytotoxicity against HepG2 cell lines; apoptosis induction and proliferation inhibition	Sesterterpenoids (cheilanthetetraol), flavonoid derivatives	[13]
Ethnomedicinal Validation	Traditionally used for wounds, gastritis, diarrhoea, and fever; applied externally and consumed as decoctions.	Broad phytochemical spectrum supporting traditional use	[2-4]

**Fig 1:** Topographical distribution of *Aleuritopteris bicolor*.

Conclusion

Aleuritopteris bicolor is a medicinal fern with considerable ethnomedicinal relevance and promising pharmacological properties. Scientific studies confirm its antioxidant, anti-inflammatory, antibacterial, antidiabetic, and cytotoxic activities, largely attributed to its rich phytochemical composition. Despite encouraging experimental evidence, further studies, including mechanistic investigations and clinical evaluations, are necessary to validate its therapeutic potential and facilitate the development of novel phytopharmaceutical agents.

Declarations

Funding

No funding was received for conducting this study.

Competing interests

The authors declare that they have no competing interests.

Author contributions

MS: literature search and manuscript preparation, SK: graphical abstract and manuscript editing, PS: supervision, manuscript review and final approval.

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