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Anatomy, phytochemical analysis and medicinal uses of *Pteris vittata* L.

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Abstract Most of the diversity studies are focused in flowering plants and ferns and fern allies are almost neglected group of Plants are found in diverse parts of the world. Pteridophytes form a conspicuous flora and represent the earliest vascular land plants. More than 12,000 species of pteridophytes are estimated and distributed along different biogeographical regions of India. From the survey of literature, research shows that geographical description, morphological characters and uses of various plant species have been studied by many researchers however investigations on anatomical characters of various plants of pteridophytes are scanty or fragmentary. In the present work an effort has been made on *Pteris vittatta* L. a pteridophyta species of family Pteridaceae that commonly distributed in South Gujarat region, India. Mainly morphological, anatomical, phytochemical and medicinal uses of this plant is evaluated. Additionally, the secondary metabolites like saponins, flavonoids, alkaloids and phenolic compounds were analyzed quantitatively. The internal characteristics of the plant that were found to be significant in taxonomy, pharmacognosy, and the active principal compounds that were isolated from the chosen fern will be utilized in future medical applications.

Keywords: Pteridaceae, *Pteris vittate* L., Anatomy, Pharmacognosy, Medicinal Plant

Introduction

Pteridophytes, which encompass ferns and their allies, are ancient vascular plants found worldwide (Jones, 1987). Originating in the mid-Palaeozoic era, they're dubbed 'plant reptiles' and intrigue botanists for their unique foliage and various attributes (Dudani *et al*., 2013). India, a mega biodiversity country, hosts approximately 13,000 species of vascular plants, including around 1000 species of ferns and fern allies (Benniamine *et al.*, 2008). Southern Gujarat, Maharashtra, Goa, Karnataka, Kerala, and Tamil Nadu are the major states of the Western Ghats, a global biodiversity hotspot with a wealth of pteridophyte diversity. (Manickam and Irudayaraj, 1992; Nayar and Daniel, 1986). Pteridophyte diversity of Gujarat state is carried out by few researchers

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and reported 36 species from the state (Shah and Vaidya, 1964; Nayar and Devi, 1964; Inamdar and Shah, 1967; Dudani and Gavali, 2016; Rajput *et al.,* 2016; Kachhiyapatel *et al.,* 2017) In a past years *Ophioglossum malviae* introduced as world's smallest terrestrial pteridophyte and three more species as new record for the pteridophyte flora of Gujarat state (Patel and Reddy, 2018). In recent years in the realm of pteridophte the discovery of new species is ongoing. Recent investigation shave identified several new species including *Drynaria deuansavanhii* (Polypodiaceae) and *Hemionitis khammouanensis* (Pteridaceae) in Laos. Information regarding the habitats and provisional IUCN conservation assessments are also provided (Vongthavone *et al*., 2025).

The Chinese ladder brake *Pteris vittata* L., native to China and belonging to the family Pteridaceae, is extensively naturalized globally (Hall, 1970). It thrives across diverse regions from Asia to Europe and Africa (Wahid *et al*., 2015). Earlier studies indicated that the plant is cultivated, but the present research aligns with the findings of Rajput *et al*. (2016), which suggest that the plant is widely distributed. Recent investigations confirm its abundant presence in South Gujarat, particularly in regions such as Daman, Ahwa, Don, Kaprada, Dharampur, Vansda, Waghai, and the hilly areas of Wilson Hills. This fern primarily thrives in moist habitats, particularly along riverbanks in the region.

Medicinal importance

In India, traditional medicine draws from systems such as Ayurveda, Siddha, and Unani, which are embraced by diverse tribal communities. Medicinal plants are essential to humanity for healthcare since the dawn of civilization. The medicinal uses of certain pteridophytes and ferns in India have been documented by researchers in past years (Nair, 1959; Benjamin and Manickam, 2007). Additionally, pteridophytes have been valued economically for more than 2000 years, with these plants serving as significant sources of food and medicine. *Pteris vittate* L. has also a unique characteristic of heavy metal accumulation such as arsenic (hyper accumulator of arsenic) (Singh *et al.,* 2015; Srivastava *et al*., 2010). Extensive work has explored arsenic phytoextraction with the fern *Pteris vittate* L. (Danh *et al*., 2014; Fayiga and Saha, 2016; Xie *et al*., 2009) as an in-situ alternative to soil excavation-based arsenic remediation methods (Tack and Meers, 2010; Wan *et al*., 2016; Matzen *et al.,* 2022). However, very few literatures providing information about the medicinal uses of this plant as demulcent, hypertensive tonic and also having antiviral, antioxidant and antimicrobial activity (Kumari *et al*., 2011; Benjamin and Manickam, 2007; Jain, 2023). According to Singh *et al.* (2008), young fronds have long been used as an astringent. The cooked rhizomes are consumed as a tonic, and their

decoction is used to treat diarrhea (Wahid *et al*., 2015). In India, glandular swellings are treated using a thin paste prepared from fresh rhizomes and leaves (Rout *et al.,* 2009).

From the literature survey, it is evident that detailed anatomical characteristics of various plant organs and phytochemical profiling of *Pteris vittata* L. are scarce or incomplete. The present investigation is intended to fill this gap by providing comprehensive information on the morphology, anatomy of the organs of selected plant, along with phyto-chemical analysis and exploration of its medicinal uses.

Material and methods

Collection of botanical material

Plant materials of *Pteris vittate* L. were collected from Wilson hill area located at the 25km away from Dharmpur Taluka of District Valsad, Gujarat, India for the present study. The plants had been carefully checked with the help of different Floras (Rajput and Raole, 2015; Manickam and Irudayaraj, 1992). After authentication of Plant *Pteris vittata* L. collected in bulk and washed with running tap water to remove adhering dirt's.

Anatomical studies

The detailed micro characters were investigated by free hand sectioning of various plant organs like rhizomatous stem, root, rachis and leaflets. The sections were stained by safranin, fast green and mounted in 50% glycerine for observation (Berlyn and Miksche, 1976). The microphotographs were taken on Cilika Microscope, version 1.16 (Germany) at SN Gene lab, Surat.

Epidermal studies

The epidermal peels were taken from the adaxial and abaxial surfaces of the leaflet's lamina using delicate forceps in order to study the epidermal cells, stomata, and trichomes. They were then stained with either Safranine or Delafield's hematoxylin and preserved in glycerine (Berlyn and Miksche, 1976).

Phytochemical analysis

The extraction process followed the methods outlined by Harborne (1973), Trease and Evans (1989), Kokate *et al*. (1998), and Khandelwal (2005).

The various solvent extracts of *Pteris vittata* L. were use for the preliminary phytochemical analysis of different secondary metabolites like carbohydrates, steroids, triterpenoids, amino acids, flavonoids, tannins, saponins, phenols, alkaloids, and resins.

Ten grams (10 g) of air-dried and finely powdered plant material was subjected to extraction using appropriate solvents selected on the basis of polarity. Extraction was performed by Soxhlet extraction. In Soxhlet extraction, the sample was continuously extracted with solvent until the siphon tube solvent became colourless, indicating complete extraction. The extracts were filtered through Whatman No. 1 filter paper to remove plant debris. The filtrates were concentrated by evaporation of solvents under reduced pressure using a rotary evaporator or on a water bath at controlled temperature. The resulting crude extracts were dried, weighed to calculate percentage yield, transferred to labelled airtight containers, and stored at low temperature for further phytochemical analysis.

The phytochemicals which are present in the various solvent extracts of the selected fern were determined and quantified by the standard procedures as given below. The collected plant material was thoroughly washed under running tap water to remove extraneous matter and finally rinsed with distilled water. The material was shade-dried at room temperature to prevent the degradation of thermolabile compounds and then powdered using a mechanical grinder. The powdered sample was stored in airtight containers until further use.

Qualitative phytochemical analysis

Steroids and triterpenoids were detected by the Salkowski test, in which 2 ml of extract was treated with chloroform followed by the addition of concentrated sulphuric acid; the appearance of a reddish-brown colour at the interface indicated a positive result.

Carbohydrates were detected using Fehling's test by adding equal volumes of Fehling's solution A and B to the extract and heating; formation of a brick-red precipitate confirmed the presence of reducing sugars.

Alkaloids were identified by Dragendorff's test, where the extract was treated with Dragendorff's reagent; the appearance of an orange or reddish-brown precipitate indicated a positive reaction.

Phenolic compounds were detected by adding Folin–Ciocalteu reagent to the extract followed by sodium carbonate; the development of a blue coloration confirmed their presence.

Flavonoids were identified using the alkaline reagent test, in which sodium hydroxide was added to the extract; the formation of an intense yellow colour that disappeared upon acidification indicated the presence of flavonoids.

Tannins and catechins were detected by adding ferric chloride solution to the extract; a blue-black or greenish coloration indicated tannins, while catechins were identified by the absence or presence of characteristic colour reactions.

Saponins were detected using the foam test by vigorously shaking the extract with distilled water; persistent froth formation indicated a positive result.

Anthraquinones were tested using Borntrager's test, in which the extract was treated with benzene followed by ammonia solution; a pink or red coloration in the ammoniacal layer indicated a positive result.

Amino acids were identified by the xanthoproteic test through the formation of a yellow coloration upon treatment with concentrated nitric acid.

Proteins were detected using the Biuret test, where the extract was treated with copper sulphate and sodium hydroxide; the formation of a violet colour confirmed the presence of proteins.

Resins were detected by the turbidity test, in which turbidity upon addition of distilled water indicated a positive reaction.

Glycosides were identified by the Keller–Killiani test through the formation of a brown ring at the interface after adding glacial acetic acid, ferric chloride and concentrated sulphuric acid.

All tests were performed following standard protocols described by Harborne (1973), Trease and Evans (1989), Kokate *et al.* (1998) and Khandelwal (2005). The results are summarized in Table 1.

Quantitative phytochemical analysis

Quantitative estimation of alkaloids, flavonoids, phenolics, saponins and tannins was carried out using standard spectrophotometric procedures as described by Harborne (1973), Trease and Evans (1989) and Khandelwal (2005). The results are presented in Table.2.

Statistical analysis

Phytochemical analysis was repeated three times with 5 replicates for each treatment, and data are represented as means and standard errors (SEs). Means were analyzed using one-way analysis of variance (ANOVA, $\alpha = 0.05$), and significant means were further analyzed by Tukey's test using Past software (v4.03).

Results

Plant morphology

A perennial or seasonal herb. Frond pinnate with terminal pinnae similar to lateral ones. Stipe green, scaly throughout, light yellow to pale brownish **(**Figure 1A, B). Roots are brown in colour and mostly arise from the lower surface of rhizomes (Figure 1C). Rhizomes short, erect or sub-erect; densely clothed with narrow scales. Young scale green while mature one pale brownish. Pinnae numerous, middle pinnae longer, gradually reduced towards base while upper ones slightly reduced. Pinnae linear, sessile and oblique, base broadly cordate and somewhat dilated. Apex acuminate, acutely and shortly toothed, edges without sori, vein thin, nearly at right angles to the costa, usually forked near the base not anastomosing except in sori distinct on both surfaces. Sori forms continuous line throughout pinnae margin (Figure 1D).

Plant anatomy

Young Root

The main parts of the young root are epidermis, cortex and stele. The epidermis is unilayred and made up of tubular or oval cells with thin cell wall. Cortex is divided into outer and inner cortex. Outer cortex is narrow and parenchymatous. Several parenchyma cells of outer cortex contain tannin. Inner cortex is made up of thick wall fibers. Cell wall of fibers are highly thick due to deposition of lignin (Figure 1E). Endodermis and pericycle are unilayered. The endodermal cells are more or less rectangular or tubular. Their cell wall is thick due to the deposition of lignin and suberin. The cells of the pericycle are rectangular and smaller than the endodermal cells, and their cell wall is thin. In the center, haplostele is present where xylem is surrounded by phleom. Xylem is diarch, protoxylem is exarch. Pith is absent, central part is occupied by the metaxylem (Figure 1F). Root hairs are many, filiform or fibrilar and unicellular (Figure 2A).

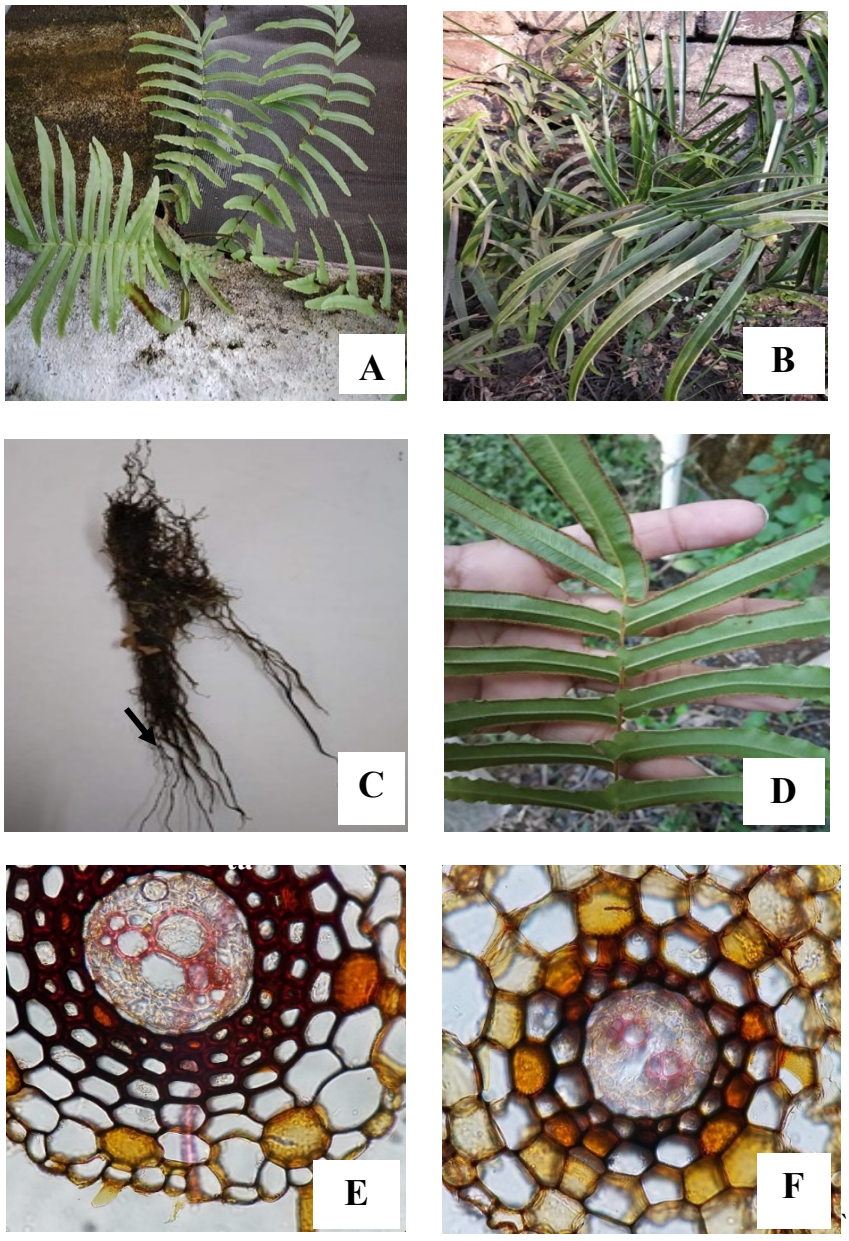

Figure 1. *Pteris vittata* in natural habitat and Anatomical identification of the plant: (A and B) Plant with rhizome, (C) Root, (D) Pinnae, (E and F) Transverse section of young root. (ta–tannin). (Magnification- A and C- 800X, B and E- 400X, F and D- 480X)

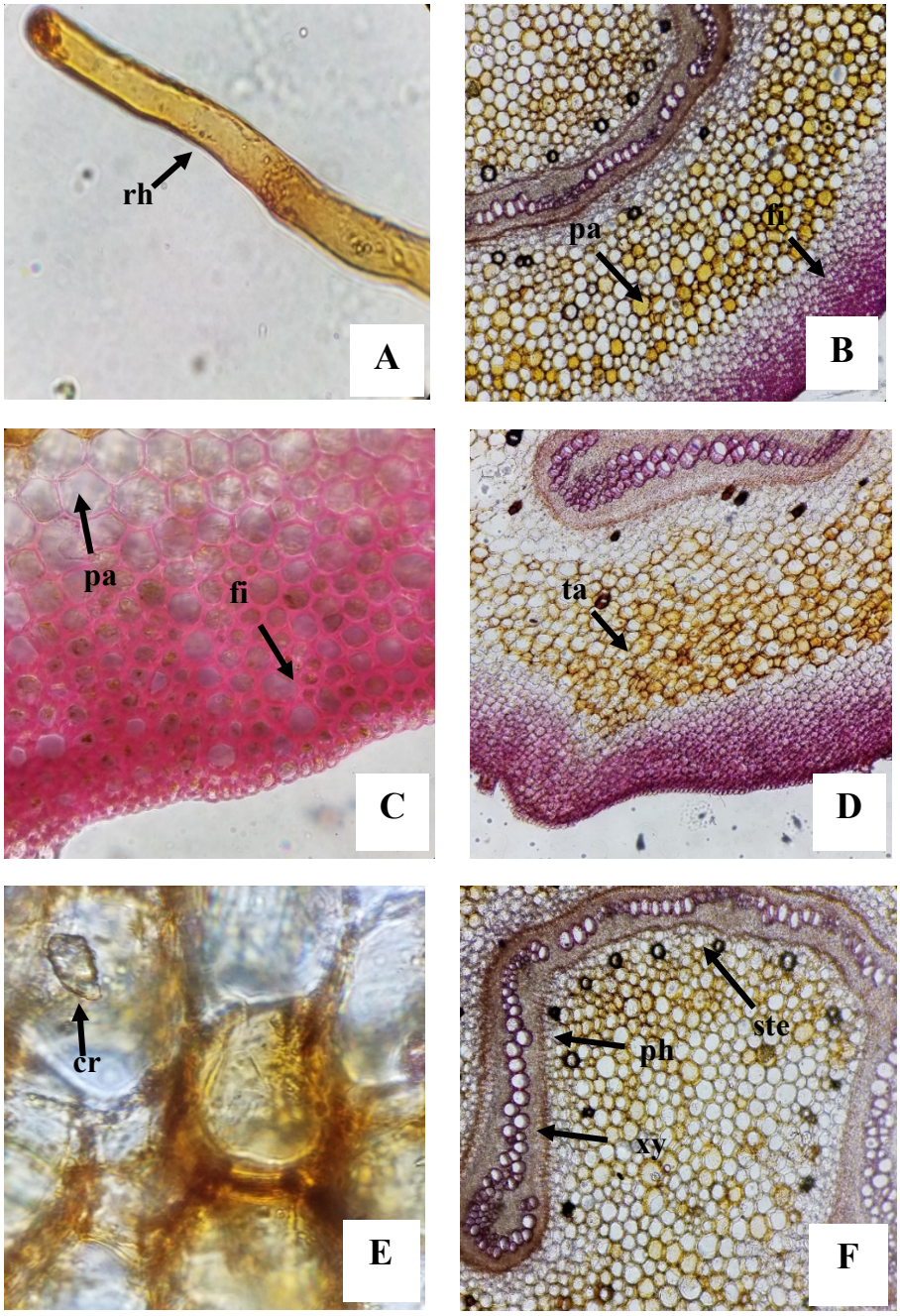

Figure 2. Anatomical identification of *Pteris vittata*: (A-F). Transverse section of- (A) Root, (B-F) Rhizome, (co – cortex, fi – fibers, pa – parenchyma, ph – phloem, rh - root hair, ste – stellate, ta – tannin, xy - xylem). (Magnification- A and B- 400X, C- 480X, D- 400X, E- 480X, F- 400X)

Rhizome

Anatomical studies of rhizome show epidermis, hypodermis, cortex and stele (Figure 2B). The epidermis is consisted of a single layer of thin-walled, compactly arranged rectangular cells. The Hypodermis is many layered and composed of thick wall polygonal fibers with deposition of lignin on their walls (Figure 2C). Cortex is large, parenchymatous. Many cortical cells exhibit deposition of tanniniferous content (Figure 2D). Rectangular crystals of calcium oxalate are observed in certain cortical cells (Figure 2E). Horse - shoe shape solenostele is found in the inner region of rhizome in which xylem is surrounded by phloem and protoxylem is exarch. Pith is large and parenchymatous. Parenchyma cells of pith contain tannin similar to the cortical cells (Figure 2F).

Rachis

The structure of rachis resembles to rhizome. The main internal parts of the rachis are epidermis, hypodermis, cortex and stele. The epidermis is unilayered and composed of rectangular cells, similar to the epidermis of the rhizome. A thick and slightly wavy cuticle is present on the outer surface of the epidermis. The hypodermis is sclerenchymatous and smaller than that of the rhizome. The cortex is large and made up of many parenchymatous cells. Some of these cells contain tanniferous content (Figure 3A, B). The stele is solenostele, similar to rhizome with exarch protoxylem **(**Figure 3A). Certain parenchyma cells of pith contain tannin (Figure 3A, B).

Midrib

The epidermal cells of midrib are rectangular and thick walled. A thick and wavy cuticle is observed on the epidermis. The hypodermis on adaxial and abaxial site is made up of fibers which are polygonal in shape and thick walled. Cortex is parenchymatous (Figure 3C**)**. The inner region of midrib has plano convex vascular bundle in which xylem is V shaped and is surrounded by phloem. The protoxylem are present in the distance ends of the arms of V shaped xylem (Figure 3C, D).

Lamina of leaf let

Lamina is isobilateral. The adaxial and abaxial epidermis are unilayered. The adaxial epidermis is made up of tubular and thin-walled cells. A cell of the abaxial epidermis is rectangular or oval in the shape and smaller than the cells of the adaxial epidermis. The cuticle on both epidermises is wavy and comparatively thicker in the adaxial epidermis. A mesophyll is homogeneous and made up of chlorenchyma cells, which are loosely arranged with large intercellular spaces. Vascular bundles of the lamina are smaller in size. Each vascular bundle has a central xylem which is surrounded by a small amount of phloem (Figure 3E, F).

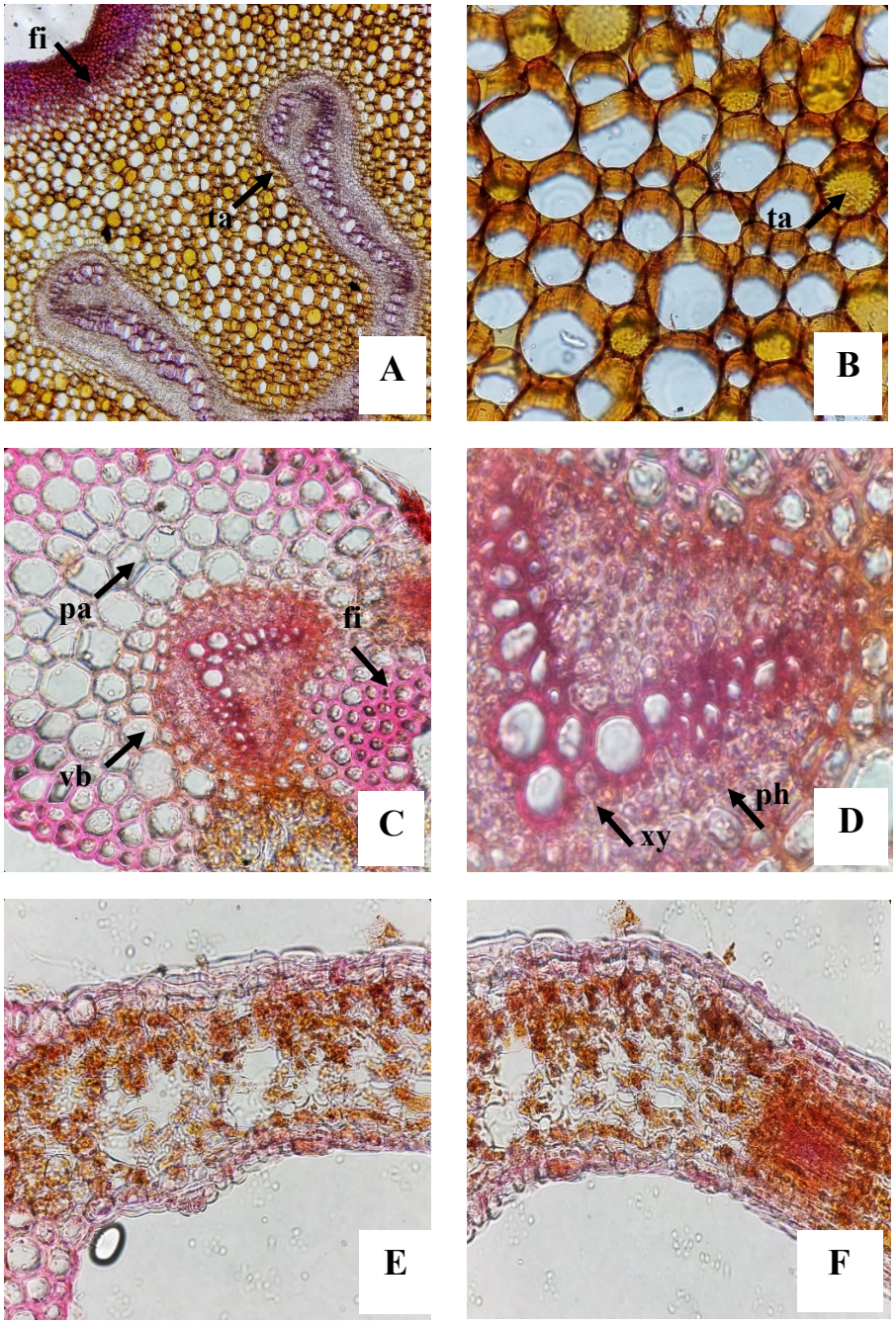

Figure 3. Anatomical identification of *Pteris vittata*: (A-F) Transverse section of- (A and B) Rachis, (C and D) Midrib, (E and F) Lamina of leaflet. (fi – fibers, pa – parenchyma, ph – phloem, ta – tannin, vb – vascular bundle, xy – xylem). (Magnification- A and C- 400X, B and D- 480 X, E and F- 400X)

Epidermal studies

Stomata are absent in the adaxial surface. Plant is hypo-stomatic. The epidermal cells have highly sinuous cell wall (Figure 4A). In the lower epidermis stomata are anomocytic where subsidiary cells are absent around the guard cells. The guard cells are surrounded by normal epidermal cells (Figure 4B).

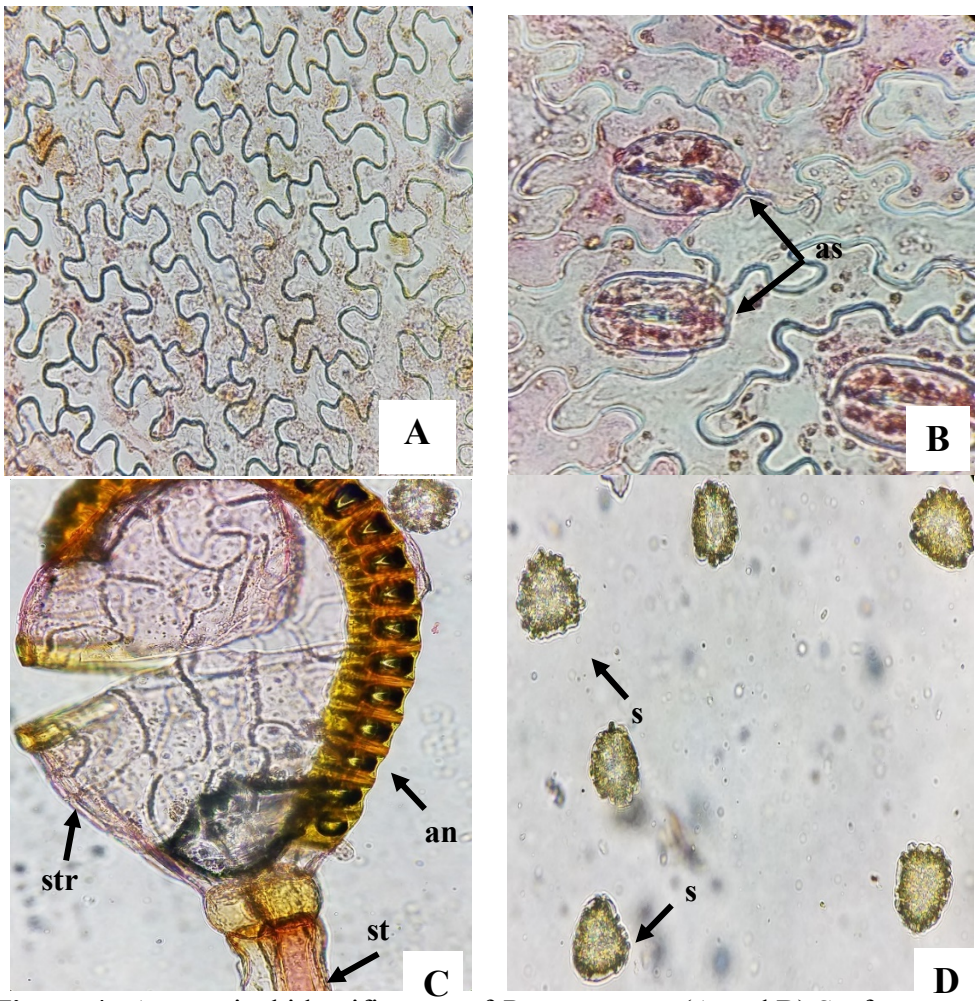

Figure 4. Anatomical identification of *Pteris vittata*: (A and B) Surface view of abaxial epidermis of lamina of leaflet, (C) Sporengium, (D) Spores. (an – annulus, as – anomocytic stomata, s – spores, st – stalk, str –stromium). (Magnification- A-D- 480X)

Spores

The sorus is of continues type. It is protected by the indusium formed by the margin pinna. The sporangium has thick-walled annulus and stromium of

thin-walled cells (Figure 4C). The spores are roughly triangular in shape and has tri radiate mask (Figure 4D).

Phytochemical profiling

Various substances like alkaloids, flavonoids, saponins, tannins, anthroquinones, steroids, reducing and non-reducing sugars, triterpenoids and amino acids are some classes of phytochemicals, and they were screened from selected fern. These active compounds are used to cure various ailments and also show anticancer, antioxidants and anti-inflammatory activities. Hence the qualitative analysis was performed to assess the groups present in various extracts. The aqueous and methanolic extracts showed positive results for ten phytochemical tests. The chloroform extract exhibited positive reactions for eight phytochemical constituents, while the petroleum ether extract showed seven positive tests (Table 1). Steroids and triterpenoids, reducing and non-reducing sugars, alkaloids, phenolic compounds, flavonoids, saponins and tannins were detected in all four extracts. Amino acids and proteins were present in aqueous and methanolic extracts but absent in chloroform and petroleum ether extracts. Glycosides were detected in aqueous, methanolic and chloroform extracts but were absent in petroleum ether extract.

Table 1. Preliminary phytochemical analysis of *Pteris vittata* in different extracts

Compounds	Test	Aqueous extract	Methanol extract	Chloroform Extract	Petroleum ether extract
Steroids & Triterpenoids	Salkowski	√	√	√	√
Reducing and non-reducing sugar	Fehling's	√	√	√	√
Alkaloids	Dragendroff's	√	√	√	√
Phenolic compounds	Folin-Ciocalteu reagent	√	√	√	√
Flavonoids	Alkaline reagent	√	√	√	√
Catechins	Ferric chloride	×	×	×	×
Saponins	Foam	√	√	√	√
Tannins	Ferric chloride	√	√	√	√
Anthraquinones	Borntrager's	×	×	×	×
Amino acids	Xanthoproteic	√	√	×	×
Resins	Turbidity	×	×	×	×
Protein	Biuret	√	√	×	×
Glycoside	Keller killani	√	√	√	×

√ - Present, ×- Absent

Quantitative phytochemical analysis

The number of various phytochemicals of *Pteris vittata* was quantitatively determined by standard procedures. The extract of *Pteris vittata* demonstrated different amounts of phytochemicals. Among the investigated five components, flavonoids were highest in comparison with the other components, followed by alkaloids and phenolic substances (Table 2). The proportion of tannin and saponin were relatively low concerning other three compounds.

Table 2. Quantitative analysis of phytochemicals in *Pteris vittata*

Phytochemicals	Amount mg/gm
Alkaloids	13.10 ± 0.20 b
Flavonoids	15.20 ± 0.30 a
Phenolics	11.45 ± 0.15bc
Saponins	09.40 ± 0.35 c
Tannins	06.30± 0.15 d

*Values represent mean ± SE. Means (n = 15) followed by same letter in each column are not significantly different ($p \leq 0.05$) according to Tukey's test.

Quantitative estimation of phytochemicals in *Pteris vittata* revealed variation in the amount of different bioactive constituents (Table 2). Among the five phytochemicals analyzed, flavonoids were found to be highest among all i.e., 15.20 ± 0.30 mg g^{-1}. After this, the second most quantity was recorded for alkaloids which were 13.10 ± 0.20 mg g^{-1}, while the phenolic compounds were slightly less (11.45 ± 0.15 mg g^{-1}). While the amounts were lower for saponins (9.40 ± 0.35 mg g^{-1}) and tannins (6.30 ± 0.15 mg g^{-1}). This was also supported by statistical analysis where the Tukey's test indicated significant differences ($p \leq 0.05$) among the groups of phytochemicals estimated in the present study. It suggested that the quantity of flavonoid was significantly higher than other compounds.

Discussion

The morphological characteristics observed in *Pteris vittata* L., including pinnate fronds, linear pinnae and continuous marginal sori protected by a false indusium, are consistent with diagnostic features of the genus *Pteris* reported in earlier taxonomic studies and fern floras, which emphasize marginal sori and frond morphology as key discriminating traits in pteridophytes. Anatomical traits such as thick-walled epidermal cells and hypodermis also align with general anatomical patterns seen in other fern species where structural reinforcement is common in frond support tissues.

The anatomical organization of the young root in the present study shows a differentiated cortex with an outer parenchymatous region and an inner zone of thick-walled lignified fibres, which corresponds well with typical fern root anatomy. Similar cortical differentiation and haplostelic stele with exarch protoxylem have been reported in several members of Pteridaceae, indicating a conserved structural pattern among terrestrial ferns (Bower, 1928; Eames, 1936). The absence of pith and the occupation of the central region by metaxylem are also characteristic features of many fern roots. The occurrence of abundant unicellular root hairs observed in the present study has been reported earlier in pteridophytes and is considered important for efficient absorption and anchorage (Sporne, 1966; Ogura, 1972).

The observation on type of stele varies from species to species of *Pteris*. In the species selected for the current work has soleno-stele. Similar type of stele is noted in *Pteris grandiflora* Blanco., *Pterispellucida* C. Presl., *Pteris dentate* Forssk*., Pteris biaurita* L. *Pteris dactylina* Hook., *Pteris heteromorpha* Fee. (Bower, 1928; Suissa, 2020) While *Pteris wallichiana* C. Presl., *Pteris speciosa* Kuhn., *Pteris decurrens* C. Presl. and *Pteris podophylla* Sw. differs from this as it is characterized by polycyclic solenostele (Suissa, 2020). In contrast to the above-mentioned species, *Pteris cretica* is characterized by a dictyostele type of stele, in which the vascular cylinder is dissected into a network of discrete vascular strands (meristeles) due to overlapping leaf gaps — a condition typical of many advanced members of *Pteris* (Bower, 1928; Eames, 1936; Sporne, 1966; Microbenotes, 2024).

The rachis anatomy of *Pteris vittata* observed in the present investigation exhibits a solenostelic vascular system with exarch protoxylem, closely resembling the stelar organization of the rhizome. This observation is in agreement with the description of rachis anatomy in the genus *Pteris* reported by Punetha (1990), who emphasized the continuity of stelar patterns within the genus. Similar anatomical correspondence between rhizome and rachis has also been documented in several fern taxa and reflects structural continuity in vascular organization from subterranean to aerial organs (Bower, 1928). The occurrence of tanniniferous contents in the cortical and pith cells of the rachis observed in the present study has been reported in other species of *Pteris* and allied genera, where such inclusions are regarded as taxonomically significant and potentially associated with protective or defensive functions (Ogura, 1972; Suissa, 2020).

The midrib structure observed in the present study, characterized by thick-walled epidermal cells, a well-developed hypodermis of fibrous cells and a plano-convex vascular bundle with V-shaped xylem surrounded by phloem, corresponds with earlier anatomical descriptions of fern fronds. A similar

organization of the midrib in *Pteris vittata* L. was discovered by Bondada *et al*. (2006) supporting the consistency of vascular and mechanical tissue arrangement in the species. In another study comparable vascular configurations in the midrib have been documented in several species of *Pteris*, where well-developed mechanical strengthening tissues contribute to lamina support (Eames, 1936; Sporne, 1966). The position of protoxylem at the distal ends of the xylem arms observed in the present study represents a common feature of fern vascular bundles and further supports uniformity in frond anatomy within the genus.

The lamina of *Pteris vittata* observed in the present study is isobilateral, with undifferentiated mesophyll and small vascular bundles embedded within the mesophyll tissue. Similar laminar organization with undifferentiated mesophyll has been reported in several fern species and differs from the dorsiventral condition commonly observed in angiosperms (Ogura, 1972). The present observations are in agreement with the findings of Kumar *et al.* (2019) and Balaji *et al.* (2011), who also reported an undifferentiated mesophyll in the lamina of *Pteris* species. In contrast, Bondada *et al.* (2006) described the lamina of *Pteris vittata* L. as dorsiventral. Such variation in lamina structure reported by different workers may be attributed to environmental conditions, developmental stage or methodological differences, as mesophyll differentiation in ferns is known to be less distinct and variable (Sporne, 1966).

The epidermal study revealed a hypostomatic leaf with anomocytic stomata restricted to the abaxial surface, which is consistent with earlier reports on fern epidermal characteristics. Anomocytic stomata are widely distributed among pteridophytes and are considered primitive in nature (Metcalfe and Chalk, 1950). The presence of highly sinuous anticlinal walls in epidermal cells has also been documented in several fern taxa and may contribute to mechanical flexibility of the lamina (Pant and Khare, 1970). Such epidermal features are useful in taxonomic identification and pharmacognostic evaluation. The present study supports to the investigation of Bondada *et al*. (2006) who suggested that plant is a hypostomatic, and this condition is due to an adaptation to reduce water loss by transpiration process of leaves.

The continuous marginal sori observed in the present study, protected by a false indusium formed by the reflexed pinna margin, are typical diagnostic features of the genus *Pteris*. Similar soral arrangements have been described in classical taxonomic literature and are considered important for generic delimitation (Bower, 1928). The presence of sporangia with a well-developed annulus and thin-walled stomium conforms with standard leptosporangiate fern characteristics. The triangular spores with a triradiate mark recorded in the present study are consistent with spore morphology described for *Pteris* species and support earlier palynological observations (Tryon and Lugardon, 1991).

Phytochemical profiling

Phytochemical screening plays an important role in understanding the medicinal potential of plants by identifying the presence of bioactive compounds. In the present study, the qualitative phytochemical profile observed in the methanolic extract of *Pteris vittata* shows close similarity with earlier reports on the genus *Pteris*.Similar type of results for phytochemical test were noted in methanol extract in different 5 species of genus *Pteris viz., Pteris. argyreae*, *Pteris confusa*, *Pteris vittata*, *Pteris biaurita* and *Pteris multiaurita* by Gracelin *et al.* (2013) and Wahid *et al*. (2015). The ethanolic and aqueous extracts of this plant reveal the presence of flavonoids, carbohydrates, phenolic compounds and sterols. Ganesan and Xu (2014). investigated the phytochemical composition of *Pteris cretica* and its significance for maintaining good health benefits, including antioxidant properties. The plant was found to contain various plant derived compounds with potential therapeutic applications. Preliminary phyto-chemical investigations of petroleum ether extract manifest the appearance of alkaloids, steroids, terpenoids, tannins, flavonoids, carbohydrates, saponins and phenolic compounds and the absence of proteins, amino acid and glycosides. Similar parameters of phytochemical compounds of petroleum ether extract were reported by Kanthal *et al*. (2023).

Quantitative phytochemical analysis

Similar type of work was carried out by Gracelin *et al*. (2013) in *Pteris vittata*, in which results were slightly lower than the present study. Jain (2023) also studied quantification of these five components in *Pteris vittata* and obtained the results similar to the present investigation.

The rich phenolic and flavonoid content of *Pteris vittata* were also observed by Singh *et al*. (2015) and indicates strong antioxidant properties. Surveys have also indicated, its antigenotoxic, antioxidant, and antiproliferative effects (Kaur *et al*., 2021), as well cytotoxic activity and involvement in autophagic pathways (Mohany *et al*., 2023).

Quantitative estimation of phytochemicals in the present study shows results comparable with earlier investigations on *Pteris vittata*. Similar quantitative analysis was carried out by Gracelin *et al*. (2013) in *Pteris vittata*, although the reported values were slightly lower than those observed in the present investigation. Jain (2023) also quantified these five phytochemical components in *Pteris vittata* and reported results that closely agree with the present findings. The comparatively higher levels of phenolic and flavonoid compounds recorded in the present study are supported by earlier reports, where

Pteris vittata was shown to possess rich phenolic and flavonoid content (Singh *et al.,* 2015), suggesting strong antioxidant potential. Additionally, several studies have reported biological activities of *Pteris vittata*, including antigenotoxic, antioxidant and antiproliferative effects (Kaur *et al.,* 2021), as well as cytotoxic activity and involvement in autophagic pathways (Mohany *et al.,* 2023), further supporting the medicinal relevance of the phytochemicals identified in this species.

In the present study various micro characters of all the organs were investigated which are useful in authentications of organ or material used as drugs or for the preparation of pharmaceuticals. Thus, these microcharacters have importance in Pharmacognosy. Moreover, the investigated microcharacters can be utilized taxonomically in the identification of species. This study will serve as an indispensable resource for establishing diagnostic criteria essential for crafting a comprehensive monograph of *Pteris vittata* L. The phytochemical analysis shows the presence of important substances like alkaloids, flavonoids, saponins, steroids, resins etc. which suggest the utility of plants in Ayurveda. Presence or absence of particular types of Phyto-constituents in the plant of the interest may be helpful, partly in the evolution of analytical profile and in the differentiation of contravention plants. The current research examined the pteridophyte *Pteris vittata*, which was found to contain various bioactive compounds. Its rich phenolic and flavonoid content suggests strong antioxidant potential, supporting its use as a medicinal plant in healthcare products targeting aging and chronic diseases.

The study documents the rich wealth of indigenous knowledge and usage of medicinal plants for the use of various diseases and also these research high points the likelihood of continued research with this plant and spotlight some sectors where more research efforts could be directed. This also underlines the potentiality for future studies on drug screening and the need for sustentation of biodiversity and traditional ecological knowledge practices.

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Conflict of interest

The author has no conflict of interest.

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