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Research Article

PRELIMINARY PHYTOCHEMICAL SCREENING OF SOME PTERIDOPHYTES FROM DISTRICT SHOPIAN (J & K)

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ABSTRACT

Objectives: The main objective of the present study was to ascertain the presence of different phytoconstitutents in the water, methanol, ethanol and acetone extracts of 34 species of pteridophytes by qualitative screening methods.

Methods: The plant extracts were evaluated for the presence of secondary metabolites such as alkaloids, glycosides, flavonoids, proteins, carbohydrates, terpenoids, resins, saponins, phenolic compounds and tannins phlobatannins and volatile oils following standard methods.

Results: The analyses indicated that 34 (100%) species contained carbohydrates and proteins and free amino acids, 27 (79.41%) flavonoids, 26 (76.47%) phenolic compounds and tannins, 24 (70.58%) glycosides, 23 (67.64%) terpenoids, 22 (64.70%) saponins, 18 (52.94%) volatile oils, 15 (44.11%) alkaloids, 12 (35.29%) phlobatannins and only 3 (8.82%) species tested positive for resins.

Conclusion: The results revealed the occurrence of several bioactive constituents which could be exploited for their potential applications for medicinal purposes. Among the solvents, water and ethanol revealed maximum number of phytochemicals than methanol and acetone.

Keywords: Pteridophytes, Phytochemicals, Extraction, Solvent, Screening.

INTRODUCTION

The plant kingdom is a treasure house of potential drugs and in the recent years there has been an increasing consciousness about the grandness of medicinal plants. Drugs from the plants are easily accessible, inexpensive, safe, and efficient and have fewer consequences. According to world health organization (WHO), more than 80% of the world's population relies on traditional medicines for their primary health care requirements. Since times immemorial plants and their parts (barks, leaves, flowers, roots, fruits, seeds etc) have been essential element of phytomedicines [1]. An understanding of the chemical constituents of plants is a prerequisite for their use in medicine and also for the synthesis of complex chemical substances [2].

With the increased anxiousness concerning human health, longevity and eco-friendly life style, a sharp increase has been witnessed in the health supplement markets during the last few decades. Although, synthetic drugs have immediate efficacy but many studies reported their side effects such as carcinogenesis [3]. Consequently, the preference of natural drugs has increased speedily worldwide [4]. Pteridophytes existed from Paleozoic era and they have faced many stochastic disturbances that led them to adapt to many serious changes of environment [5]. Hence, ferns are expected to comprise numerous effective secondary metabolites than other plants. Many useful phytochemicals or secondary metabolites for instance, alkaloids, flavonoids, phenols, steroids, triterpenoids, varied amino acids and fatty acids have been reported in the ferns [6]. Besides, they also contain unique phytochemicals, yet not found in higher plants [7]. Pteridophytes are resistant to microbial infection which may be one of the crucial factors for their evolutionary success and the fact that they lasted for more than 350 million years [8]. Ferns co-existed with human beings for years and influenced millions of human lives as traditional medicinal cures or treatments for ascarid disease, bleeding, trauma, burning, diarrhea, cold, and many more in some countries [9]. In the recent past, many traditional medicinal ferns were analyzed and reported to have various bioactivities, such as antioxidant [10], antitumor [11] and anti-HIV [12], antimicrobial [13], anti-inflammatory [14], and antiviral [15]. Nowadays there is global renaissance of medicinal plants research and great emphasis is being laid on exploring bioactive compounds and biological activities of plants owing to the natural origin, cost effectiveness and lesser side effects [16]. Therefore, in the present work, a qualitative phytochemical investigation was carried out in 34 pteridophyte plant species of south-western region of Kashmir valley to explore their medicinal value.

MATERIALS AND METHODS

Procurement of plant materials and extraction

The plant materials for the present study were collected from district Shopian of Kashmir valley, Jammu and Kashmir, India. The identity of collected specimens was authenticated by Dr. H. C. Pandey (Scientist D) and Brijesh Kumar from Botanical Survey of India, Northern Circle, Dehradun and voucher specimens are deposited at the herbarium of Botany department, Jamia Hamdard New Delhi. The plant materials used for phytochemical screening were thoroughly washed off under running tap water to get rid of all the debris and soil and then shade dried at room temperature for two weeks. The air-dried plant material was finely grounded and packed in self seal air tight polythene bags for further use. The plant extracts were prepared by standard methods [17]. 30 grams of each plant powder was soaked in 250 ml of water, ethanol, methanol and acetone for 48 h at room temperature. Each mixture was stirred every 12 hour using a sterile glass rod. The extract was filtered through Whatman No. 1 filter paper. The filtrates so obtained were concentrated by evaporating excessive solvents using a boiling water bath. The residues were then stored in cool and dry place for further analysis using the standard procedures [18], [19], [20].

Phytochemical Screening

The tests performed for the phytochemical screening are listed below.

1) Tests for alkaloids

Dragendroff's test: To 1ml of extract, 2ml of Dragendroff's reagent is added. Orange red precipitate is formed indicating the presence of alkaloids.

Wagner's test: To 1ml of extract, 1ml of Wagner's reagent is added. The formation of reddish brown precipitate indicates the presence of alkaloids.

Mayer's test: To 1ml of extract, 2ml of Mayer's reagent is added. Formation of dull white precipitate demoed the presence of alkaloids.

2) Tests for glycosides

Keller- Killiani test: 1ml of glacial acetic acid containing traces of ferric chloride and 1ml of concentrated sulfuric acid, 1ml of extract was added carefully. Appearance of brown ring at the interface shows the presence of glycosides. A violet ring may also appear below the brown ring.

Legal's test: To 1ml of extract, 1ml of pyridine, freshly prepared sodium nitroprusside and sodium hydroxide were added. Formation of pink to red color indicates presence of glycosides.

Borntrager's test: To 1ml of extract, 1ml of benzene and 0.5ml dilute ammonia solution were added. A reddish pink color indicates the presence of glycosides.

Baljet test: To 1ml of extract, 1ml of sodium picrate is added. Appearance of yellow to orange color detects the presence of glycosides.

3) Test for carbohydrates

Molisch's test: 1ml of extract was treated with few drops of Molisch's reagent (α-naphthol, 20% in ethyl alcohol). Then about 1ml of concentrated sulfuric acid was added belatedly along the sides of the tube. Formation of violet color indicates the presence of carbohydrates.

Fehling's test: 1ml of Fehling's A (Copper sulphate in distilled water) and 1ml of Fehling's B (Potassium tartarate and sodium hydroxide in distilled water) reagents were mixed and boiled for minute. Then equal volume of test solution was added to the above mixture. The solution was heated in a boiling water bath. Brick red precipitate was observed, indicating the presence of carbohydrates.

4) Tests for proteins and free amino acids

Xanthoproteic test: 1ml of extract was treated with 1ml of concentrated nitric acid solution. Formation of yellow color indicates the presence of proteins.

Ninhydrin test: 2ml of extract was treated with 1ml of Ninhydrin solution. The mixture was boiled on a water bath. Appearance of blue to purple color shows the presence of amino acids.

5) Test for Phenolic compounds (Phenolic Cpds) and tannins

Ferric chloride test: To 1ml of extract, 1ml of 5% ferric chloride (prepared in ethanol) solution was added. Blue black or dark green color appeared.

Lead acetate test: On addition of lead acetate solution to the extract white precipitate appeared.

Dilute HNO3 test: On addition of dilute HNO3 solution to the extract reddish color appeared.

6) Tests for flavonoids

Shinoda test: To 1ml of extract, few drops of concentrated HCl were added. To this solution 0.5 gram of magnesium turnings were added. Observance of pink coloration indicated the presence of flavonoids.

Lead acetate test: To the 1ml of extract, lead acetate solution was added. Formation of yellow precipitate showed the presence of flavonoids.

Ferric chloride test: To 1ml of extract, 1ml of ferric chloride (5% in water) was added. Formation of brown color confirmed the presence of flavonoids.

7) Tests for saponins

Foam test: 1ml of extract was shaken vigorously with 20ml of distilled water for 5- 10 minutes in graduated cylinders. Formation of one centimeter layer of foam indicated the presence of saponins.

Honey comb test: To the 5ml of extract, few drops of sodium bicarbonate were added and shaken well. Honey comb like frothing confirmed the presence of saponins

8) Test for volatile oils

NaOH-HCl test: 2ml of extract solution was shaken with 0.1ml of dilute sodium hydroxide and a small quantity of dilute HCl. A white precipitate was formed with volatile oils.

9) Test for phlobatannins

1ml of extract was boiled with 1% aqueous HCl. The formation of red precipitate indicated the presence of phlobatannins.

10) Tests for terpenoids

Trichloroacetic acid test: To 1ml of extract, 2ml of trichloroacetic acid was added. Formation of colored precipitate showed the presence of terpenoids.

Salkowski test: 1ml of extract was mixed with 2ml of chloroform and concentrated sulphuric acid was added carefully along the sides of tube to form a layer. A reddish brown coloration of the interface was formed to indicate positive results for the presence of terpenoids.

11) Tests for resins

Turbidity test: Distilled water (5ml) was added to the extract. The occurrence of turbidity showed the presence of resins.

RESULTS AND DISCUSSION

In the present study 34 pteridophyte species were screened for the phytochemical constituents. Screening was performed with acetone, ethanol, methanol and aqueous extracts of the plants that make up a total of 136 extracts. In this preliminary study, carbohydrates, proteins and free amino acids were detected in all extracts analyzed. Out of 136 tested extracts, 89 extracts showed the presence of flavonoids. Next to that, 86 extracts tested positive for glycosides. Terpenoids and phenolic compounds and tannins were detected in 79 and 74 extracts respectively. Volatile oils were observed in 45 extracts and 40 extracts showed occurrence of alkaloid in the crude extracts of the investigated plants. Phlobatannins showed their presence in 34 extracts, saponins in 32 extracts and resins only in 9 extracts. Out of 34 pteridophytes species, flavonoids are present in 27 (79.41%); phenolic compounds and tannins in 26 (76.47%); glycosides in 24 (70.58%); terpenoids in 23 (67.64%); saponins in 22 (64.70%); volatile oils in 18 (52.94%); alkaloids in 15 (44.11%); phlobatannins in 12 (35.29%) and resins were detected only in 3 (8.82%) species. Similarly, maximum numbers of phytochemicals are reported in *Diplazium maximum, Asplenium trichomanes and Adiantum venustum,* and least number in *Polystichum discretum* and *Dryopteris blanfordii*. Among the solvents, water and ethanol revealed more phytochemicals than methanol and acetone, whereas aqueous extracts showed highest and acetone extracts revealed least number of phytoconstitutents. The results of preliminary photochemical screening are summarized in Table 1.

Plants produce secondary metabolites not simply to adapt to their environment but also to resist themselves against several environmental stresses and also for the process of co-evolution with various interacting organisms [21]. The secondary metabolites produced against the various adverse environmental conditions are flavonoids, alkaloids, polyphenols, terpenoids, quinones, steroids, polysaccharides etc [22]. The pteridophytes, comprising ferns and fern allies, are one of the oldest land plant groups on the earth and constitute a vast group of vascular cryptogams. Many ferns were used for medicinal purposes by the early Greeks and Romans and through the middle ages. Dioscorides, a first century botanist, mentioned the use of spleenwort for healing maladies of the spleen, and the generic name '*Asplenium*' hint at this early practice [23]. Although, there are some studies on phytochemistry and pharmacology of some fern and fern allies, yet most of the species of this group remained unexplored for phytoconstitutents. Therefore, in the present study 34 pteridophyte species were screened for the phytochemical constituent utilizing four different solvents and their distribution within species is shown by the pie chart (Fig. 1).

Table 1: Qualitative phytochemical analysis of extracts of pteridophyte species in different solvent system

S. No	Plant Name	Solvents	Alkaloids	Glycosides	Carbohydrate	Proteins & free amino acids	Resins	Saponins	Phenolic Cpds & Tannins	Volatile Oils	Terpenoids	Flavonoids	Phlobatannins
1	***Adiantum venustum***	Water	-	-	+	+	-	+	+	-	+	+	+
		Ethanol	+	-	+	+	-	-	+	-	-	+	+
		Methanol	+	+	+	+	-	-	+	-	+	+	+
		Acetone	+	+	+	+	-	-	+	-	+	+	+
2	***Asplenium adiantum-nigrum***	Water	-	+	+	+	-	+	+	+	+	-	+
		Ethanol	-	+	+	+	-	-	+	+	+	-	+
		Methanol	-	-	+	+	-	-	+	-	+	-	+
		Acetone	-	+	+	+	-	-	-	+	-	-	-
3	***Asplenium pseudofontanum***	Water	-	+	+	+	-	+	+	-	-	+	-
		Ethanol	-	+	+	+	-	-	+	+	-	+	-
		Methanol	-	+	+	+	-	-	+	+	-	+	-
		Acetone	-	+	+	+	-	-	-	+	-	+	-
4	***Asplenium septentrionale***	Water	-	+	+	+	-	-	-	-	+	+	-
		Ethanol	-	+	+	+	-	-	-	-	+	+	-
		Methanol	-	+	+	+	-	-	-	-	+	+	-
		Acetone	-	+	+	+	-	-	-	-	-	+	-
5	***Asplenium trichomanes***	Water	-	+	+	+	-	+	+	-	+	+	+
		Ethanol	+	+	+	+	-	-	+	-	+	+	+
		Methanol	+	+	+	+	-	-	-	-	-	+	+
		Acetone	+	+	+	+	-	-	-	-	-	+	+
6	***Athyrium atkinsonii***	Water	-	-	+	+	-	-	+	-	-	+	-
		Ethanol	+	-	+	+	-	-	+	+	-	+	-
		Methanol	+	-	+	+	-	-	-	+	-	+	-
		Acetone	+	-	+	+	-	-	+	-	-	-	-
7	***Athyrium attenuatum***	Water	-	+	+	+	-	-	+	-	+	+	+
		Ethanol	-	+	+	+	-	-	+	-	+	+	+
		Methanol	-	+	+	+	-	-	-	-	+	+	-
		Acetone	-	+	+	+	-	-	+	-	+	-	+
8	***Athyrium mackinnonii***	Water	-	-	+	+	-	+	-	-	+	+	-
		Ethanol	+	-	+	+	-	-	-	-	+	-	-
		Methanol	+	-	+	+	-	-	-	-	+	+	-
		Acetone	+	-	+	+	-	-	-	-	+	-	-
9	***Athyrium wallichianum***	Water	-	-	+	+	-	-	-	+	+	+	+
		Ethanol	+	+	+	+	-	-	-	+	+	+	+
		Methanol	+	+	+	+	-	-	-	-	+	+	-
		Acetone	+	+	+	+	-	-	-	-	+	-	-
10	***Azolla cristata***	Water	-	+	+	+	-	-	+	-	-	+	-
		Ethanol	-	+	+	+	-	-	+	+	-	-	-
		Methanol	-	-	+	+	-	-	+	+	-	+	-
		Acetone	-	+	+	+	-	-	-	-	-	-	-
11	***Coniogramme affinis***	Water	-	+	+	+	-	+	-	+	-	+	-
		Ethanol	-	+	+	+	-	-	-	+	-	-	-
		Methanol	-	+	+	+	-	-	-	+	-	+	+
		Acetone	-	+	+	+	-	-	-	+	-	+	+
12	***Cystopteris fragilis***	Water	-	-	+	+	-	-	+	+	+	-	-
		Ethanol	-	-	+	+	-	-	+	-	-	+	-
		Methanol	-	-	+	+	-	-	+	+	+	+	-
		Acetone	-	-	+	+	-	-	-	-	+	+	-
13	***Deparia acuta***	Water	-	+	+	+	-	+	+	-	+	-	-
		Ethanol	+	-	+	+	-	-	-	-	+	-	-
		Methanol	+	+	+	+	-	+	+	-	+	-	+
		Acetone	+	+	+	+	-	-	+	-	+	-	+
14	***Deparia allantodioides***	Water	-	+	+	+	+	+	-	-	-	-	-
		Ethanol	+	-	+	+	+	-	-	-	-	-	-
		Methanol	+	-	+	+	+	+	-	-	-	-	-
		Acetone	+	+	+	+	-	-	-	-	-	-	-
15	***Diplazium maximum***	Water	-	+	+	+	+	+	+	+	+	+	+
		Ethanol	+	+	+	+	+	-	+	+	+	-	-
		Methanol	-	+	+	+	+	+	-	-	+	+	+
		Acetone	-	+	+	+	-	-	-	-	+	-	-
16	***Diplazium sibiricum***	Water	-	-	+	+	-	+	+	+	+	+	+
		Ethanol	-	-	+	+	-	-	+	+	+	+	+
		Methanol	-	-	+	+	-	-	-	+	-	+	+
		Acetone	-	-	+	+	-	-	+	-	+	-	+
17	***Dryopteris blanfordii***	Water	-	-	+	+	-	+	-	-	-	+	-

		Ethanol	-	-	+	+	-	+	-	-	-	+	-
		Methanol	-	-	+	+	-	-	-	-	-	+	-
		Acetone	-	-	+	+	-	-	-	-	-	+	-
18	***Dryopteris barbigera***	Water	-	+	+	+	-	+	+	-	-	+	-
		Ethanol	-	+	+	+	-	-	+	-	+	+	-
		Methanol	-	+	+	+	-	+	+	-	+	+	-
		Acetone	-	+	+	+	-	-	+	-	+	+	-
19	***Dryopteris nigropaleacea***	Water	-	-	+	+	-	+	+	-	-	-	-
		Ethanol	+	-	+	+	-	-	+	-	-	-	-
		Methanol	+	-	+	+	-	+	+	-	-	-	-
		Acetone	+	-	+	+	-	-	+	-	-	-	-
20	***Dryopteris ramosa***	Water	-	+	+	+	-	+	-	+	+	+	-
		Ethanol	-	+	+	+	-	-	-	+	+	+	+
		Methanol	-	+	+	+	-	-	-	-	+	+	+
		Acetone	-	+	+	+	-	-	-	-	+	-	+
21	***Dryopteris xanthomelas***	Water	-	+	+	+	-	+	+	-	+	-	-
		Ethanol	-	+	+	+	-	+	+	+	+	-	-
		Methanol	-	+	+	+	-	+	+	+	+	-	-
		Acetone	-	+	+	+	-	-	-	-	+	-	-
22	***Equisetum arvense***	Water	-	+	+	+	-	+	+	+	-	+	-
		Ethanol	+	+	+	+	-	-	+	+	-	+	-
		Methanol	-	+	+	+	-	-	+	+	-	+	-
		Acetone	+	+	+	+	-	-	-	+	-	+	-
23	***Gymnocarpium dryopteris***	Water	-	+	+	+	-	+	+	+	+	-	-
		Ethanol	+	+	+	+	-	-	+	+	+	+	-
		Methanol	+	+	+	+	-	-	-	+	+	+	-
		Acetone	+	+	+	+	-	-	-	-	+	-	-
24	***Onychium cryptogrammoides***	Water	-	+	+	+	-	-	-	-	+	+	-
		Ethanol	+	+	+	+	-	-	+	-	+	+	-
		Methanol	+	+	+	+	-	-	+	-	+	-	-
		Acetone	-	+	+	+	-	-	-	-	-	+	-
25	***Osmunda claytoniana***	Water	-	-	+	+	-	+	+	+	+	+	-
		Ethanol	-	+	+	+	-	-	-	-	-	+	-
		Methanol	-	+	+	+	-	-	+	+	+	+	-
		Acetone	-	+	+	+	-	-	-	-	+	+	-
26	***Phegopteris connectilis***	Water	-	-	+	+	-	+	-	-	+	+	+
		Ethanol	-	-	+	+	-	-	+	-	+	+	+
		Methanol	-	-	+	+	-	-	+	-	+	+	-
		Acetone	-	-	+	+	-	-	+	-	-	+	-
27	***Polystichum bakerianum***	Water	-	-	+	+	-	-	-	-	+	+	-
		Ethanol	+	-	+	+	-	-	+	+	+	+	-
		Methanol	+	-	+	+	-	-	+	+	+	+	-
		Acetone	+	-	+	+	-	-	+	-	-	-	-
28	***Polystichum discretum***	Water	-	-	+	+	-	-	+	-	-	-	-
		Ethanol	-	-	+	+	-	-	+	-	-	-	-
		Methanol	-	-	+	+	-	-	-	-	-	-	-
		Acetone	-	-	+	+	-	-	-	-	-	-	-
29	***Polystichum prescottianum***	Water	-	-	+	+	-	-	-	-	+	+	-
		Ethanol	+	+	+	+	-	-	-	-	+	+	-
		Methanol	+	+	+	+	-	-	-	-	+	+	-
		Acetone	-	+	+	+	-	-	-	-	+	+	-
30	***Polystichum yunnanense***	Water	-	+	+	+	-	+	+	+	-	+	-
		Ethanol	-	+	+	+	-	-	+	+	-	+	-
		Methanol	-	+	+	+	-	-	+	-	-	-	-
		Acetone	-	+	+	+	-	-	+	-	-	+	-
31	***Pseudophegopteris levingei***	Water	-	+	+	+	-	+	-	-	+	+	-
		Ethanol	-	+	+	+	-	-	+	-	+	+	-
		Methanol	-	+	+	+	-	-	+	-	+	+	-
		Acetone	-	+	+	+	-	-	-	-	+	+	-
32	***Pteridium aquilinum***	Water	-	-	+	+	+	+	+	-	-	-	+
		Ethanol	+	-	+	+	+	-	+	+	-	-	+
		Methanol	+	-	+	+	+	-	+	+	-	-	+
		Acetone	+	-	+	+	-	-	+	-	-	-	-
33	***Pteris cretica***	Water	-	+	+	+	-	+	+	+	+	+	-
		Ethanol	-	+	+	+	-	-	+	+	+	+	-
		Methanol	-	+	+	+	-	+	-	+	-	+	-
		Acetone	-	+	+	+	-	-	-	-	+	-	-
34	***Salvinia natans***	Water	-	+	+	+	-	-	+	-	+	+	-
		Ethanol	-	+	+	+	-	-	+	-	+	+	-
		Methanol	-	+	+	+	-	-	-	-	+	+	-
		Acetone	-	+	+	+	-	-	-	-	+	+	-

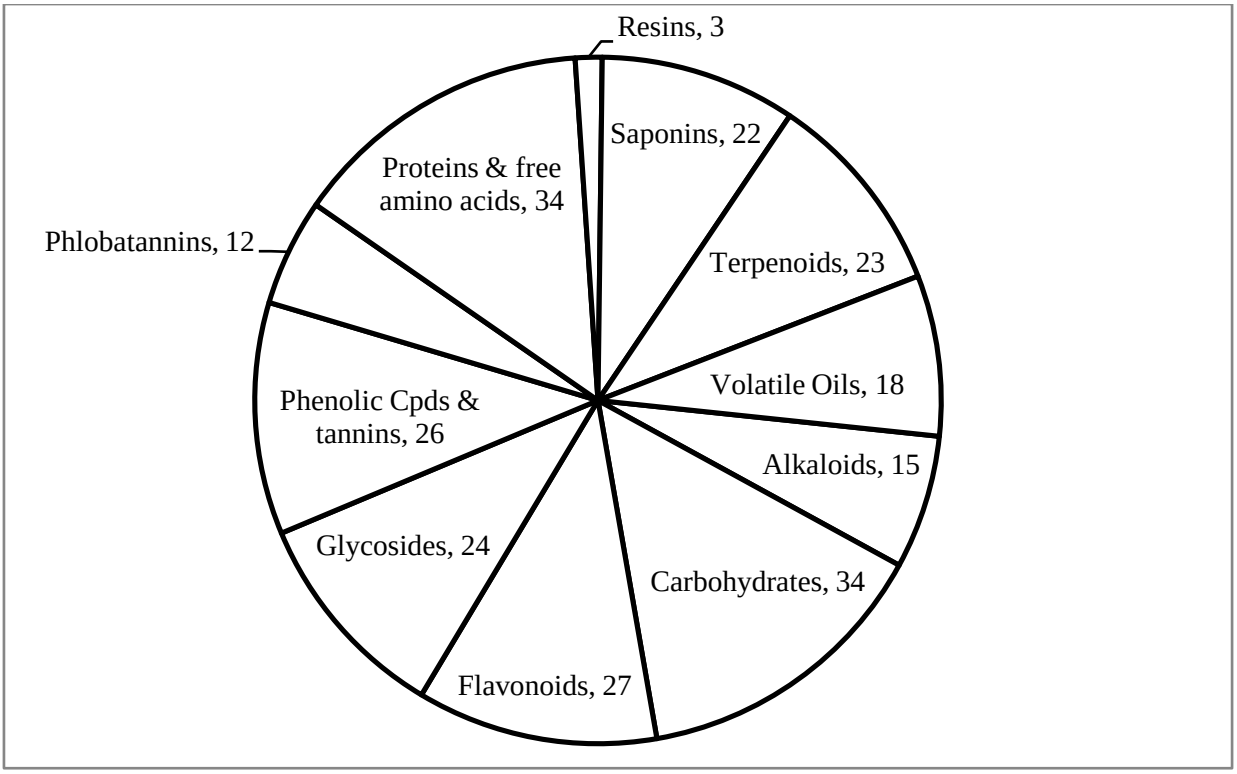

Fig. 1: Distribution of phytochemicals within species

Preliminary phytochemical screening showed the presence of proteins and carbohydrates in all the plants investigated, whereas only 15 species have shown the presence of alkaloids. Nearly 10, 000 different alkaloids have been isolated from plants, of which cocaine, atropine and curare are some noteworthy alkaloids. They act on the nervous system as stimulators or sometimes as poisons. Some earlier studies have also reported the presence of alkaloids in pteridophytes like *Pteridium aquilinum* [24], *Adiantum venustum* [25] and *Equisetum arvense* [26]. Out of 34 species, 24 have depicted positive tests for Glycosides. Glycosides are a class of molecules which play crucial roles in combating a number of dreadful diseases, especially heart diseases. Literature survey has also revealed the presence of glycosides in *Asplenium adiantum-nigrum* [27], *A. septentrionale* [28], *A. trichomanes* [29], *Equisetum arvense* [26], *Pteridium aquilinum* [30] and *Salvinia natans* [31]. Saponins are used for industrial as well as for pharmacological purposes and are beneficial to humans in many ways including treating a variety of diseases and have antibiotic, insecticidal and antifungal properties [32]. They are also used as mild detergents and in intracellular histochemical staining. In the present study, 22 species have confirmed the presence of saponins. There are several earlier reports that also support the presence of saponins in various ferns species, like *Pteridium aquilinum* [33], *Adiantum venustum* [34] and *Equisetum arvense* [26]. In nature, terpenoids play a crucial role in plant-environment interactions including plant-plant, plant-pathogen, plant-insect and plant-animal interactions [35]. Now-a-days, terpenoids are commercially employed in an immense number of industrial products such as flavoring agents, pharmaceuticals, insecticides, perfumes and anti-microbial agents [36]. In our study, 23 species have revealed the presence of terpenoids. 27 species screened for flavonoids are positive to these metabolites. Flavonoids exhibit anti-allergic, anti-inflammatory, anti-microbial, anti-cancer, anti-neoplastic, anti-oxidant and vasodilator activities. Moreover, they are able to regulate the activity of enzymes and affect the behavior of many cell systems. *Pteridium aquilinum* [24], *Equisetum arvense* [26], *Asplenium septentrionale* [28], *Adiantum venustum* [37] are some of the fern species in which flavonoids have been reported in the past. Similarly, phenolic compounds possess a variety of biological properties such as anti-oxidant, anti-apoptosis, anti-carcinogenic, anti-inflammation, anti-aging, anti-atherosclerosis, cardiovascular protection as well as inhibition of proliferation activity [38]. Besides, phenolic compounds also contribute to quality and nutritional value in terms of modifying color, taste, aroma and flavor. They are also involved in plant defense mechanisms to scavenge reactive oxygen species [39]. Tannins also exhibit potential antiviral, antibacterial and free radical scavenging properties. In the present study, 26 species showed the presence of phenolic compounds and tannins. Phlobatannins were detected only in 12 species. 18 species have shown the presence of volatile oils. Earlier studies also reported the presence of volatile oils in *Equisetum arvense* [40], *Pteridium aquilinum* [41] and *Asplenium septentrionale* [42]. Only three species, *Deparia allantodioides, Diplazium maximum* and *Pteridium aquilinum* showed presence of resins. Past studies revealed their presence just in *Equisetum giganteum* [43], which indicate that resins are rare among pteridophytes. The survey of published literature has revealed that the pteridophytes have not received much attention with regard to phytochemical analysis. The present study, therefore, is an attempt to make some advancement in this direction.

CONCLUSIONS

The study revealed the presence of many medicinally active constituents in 34 species investigated, suggesting that several pteridophyte species have the potential to synthesis useful metabolites. Numerous evidences gathered in earlier studies also confirmed the presence of bioactive phytochemicals in pteridophytes. Compared to flowering plants, pteridophytes have not received the attention that they deserve with regards to phytochemical analysis. The results obtained in the present study are encouraging and will give impetus for further research on phytochemical screening and extraction of pteridophytes in other parts of India.

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