



Pteridophytes as a Potential Treasury of Anticancer Agents

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Abstract: Human has been interacting with plants from the beginning of human existence. Plants have provided humans with basic needs such as sustenance, firewood, livestock feed, and wood. Approximately there are over 3 million vascular plants on the earth. As the first vascular plants, pteridophytes are an ancient lineage, and human beings have been exploring and using taxa from this lineage for over 2000 years because of their beneficial properties. About 13,600 species of ferns are distributed in worldwide. In India, Himalayas, Western and Eastern Ghats, and Pachmarhi Biosphere Reserve are major distribution of pteridophytes. They remain underexplored in ethno botanical aspects, than any other vascular plants despite being regarded as a valuable component of healthcare. Cancer is one of the leading causes of death and globally the numbers of cases on cancer are increasing gradually. Among the anticancer drugs, about 50% come from natural products as isolated or semisynthetic or related synthetic compounds and plants represent important source of these substances. Among all the pteridophytes examined, taxa from the Polypodiaceae, Pteridaceae, Davalliaceae and Aspleniaceae contain more anticancer compounds like taxol, *Vinca* alkaloids, camptothecin, podophyllotoxins etc.

Keywords: Anticancer, pteridophytes, ethno botany, Western-Ghats, alkaloids

Cancer is a group of diseases characterized by the uncontrolled growth and spread of abnormal cells. There are many types of cancer including lung, breast, prostate and colon cancer. Risk factors for cancer include smoking, excessive alcohol consumption, exposure to chemicals and toxins, certain infections and inherited genetic mutations. Symptoms of cancer include fatigue, pain, changes in the skin and unexplained weight loss. Treatment options for cancer consists surgery, radiation therapy, chemotherapy and targeted therapy. Early detection

and prevention are keys to managing cancer and improving outcomes.

Pteridophytes are a group of vascular plants that include ferns, horsetails and club mosses. They have been used in traditional medicine for centuries, and several species have been found to have medicinal properties. Some of the medicinal pteridophytes are the following. Maidenhair fern (*Adiantum capillus-veneris*): The fronds of the ferns have been traditionally used to treat respiratory problems such as asthma, bronchitis and coughs. Horsetail (*Equisetum arvense*): It has been

traditionally used to treat a variety of ailments including kidney and bladder problems, wounds and bone fractures. Club moss (*Lycopodium clavatum*): The fern is used to treat a variety of conditions including diarrhea, indigestion and rheumatism. Ferns have been found to have potential anticancer properties. Some studies have shown that compounds found in ferns such as flavonoids and polysaccharides, can inhibit the growth of cancer cells and induce apoptosis in certain types of cancer cells. Additionally, they have also been found to have antiinflammatory and antioxidant properties, which may also contribute to their potential as anticancer agents. However, more research is needed to fully understand the mechanisms of action and potential therapeutic uses of ferns in cancer treatment. Some studies have shown that extracts from certain ferns have the ability to inhibit the growth of cancer cells in lab tests. However, more research is needed to determine the effectiveness and safety of these plants in humans. Some examples of ferns that have been studied for their potential anticancer properties include *Dryopteris crassirhizoma*, *Polypodium leucotomos* and *Pteris cretica*.

1. Anticancer compounds in pteridophytes

Plants including pteridophytes are most common source of anticancer agents like apigenin, chrysoeriol, luteolin and tricetin as well as their O-glycosylated or C-glycosylated forms. A majority of the anticancer activity of ferns is reported to be attributed to phenolic compounds, particularly flavonoids and their O-glycosides. In vivo as well as in vitro flavonoids are powerful antioxidants with anticancer properties. Flavonoids from different ferns show both of these properties. Amentoflavone found in Psilotaceae and its monomer apigenin is prim-

arily contained in this family of plants has only been discovered that biflavonoids occur in Osmundaceae and Cyatheaaceae so far. Flavonols are the main constituents of Ophioglossaceae. Several flavonoids derived from ferns along with their O-glycosides can be found in most plant kingdoms. These are quercetin and kaempferol; the flavanone naringenin; the flavones apigenin, isoorientin, tricetin, vicenin-2 and vitexin; and the 3-deoxyanthocyanins, apigenidin and luteolinidin etc. Among the mechanisms by which they work are a reduction in DNA polymerase activity, suppression of NF- κ B, decreasing of Bcl-2 expression as well as suppression of MMP-1, p38 MAPK and c-Jun N-terminal kinase.

2. Anticancer plants in pteridophytes

2.1. *Microsorium* Link

Microsorium belongs to family Polypodiaceae, is a terrestrial epiphytic fern. Rhizomes are long or short creeping. Rhizome scales are clathrate, squarrose or appressed. Fronds are monomorphic or dimorphic and articulated to short stalks called phyllopodia. Laminae are undivided, variously lobed or deeply pinnatifid. Veins are reticulated, areoles with free included veinlets. Sori are round or slightly elongate, superficial or impressed into the lamina and bulging on upper surface. Paraphyses absent or sometimes present as simple uniseriate hairs. Spores are monoletate, bilaterally symmetrical, granulate to tuberculate.

Anticancer activities: The genus includes two important species that shows anticancer properties. *M. pustulatum* uses by people of Dayak Tribes in Central Kalimantan for antitumour medicines. Hexane extract of *M. pustulatum*

latum rhizomes is potential to inhibit tumour growth in mice (Neneng et al., 2020). *M. grossum* has been used to cure liver cancer (Petard & Raau, 1972; Defilppis et al., 1988).

2.2. *Drynaria* (Bory) J.Sm.

It is commonly known as 'Basket fern' which are epiphytes or lithophytes coming under family Polypodiaceae with creeping, branched and densely scaly rhizome. Scales are dark brown, linear or lanceolate and acuminate at end. Fronds are dimorphic, sterile and fertile. Sterile bracket fronds are simple; leaf lamina is elliptic in outline, cordate at base. Fertile fronds are simply pinnate; stipes grooved above, rounded beneath; leaf lamina is broadly elliptic in outline. Sori are dark brown, many on vein endings. Sporangial capsule is subglobose. Spores are brown, ellipsoid with spinous perine.

Anticancer activities: *D. fortunei* is used in Traditional Chinese medicine "Gu-Sui-Bu" against cancer (Punzon et al., 2003). *D. quercifolia* shows anticancer property against lung and prostate cancer cells through Brine Shrimp lethality bioassay (Milan et al., 2013)

2.3. *Aglaomorpha* Schott

Aglaomorpha is a member of the Polypodiaceae and is related to the oak fern which is found in the wild throughout Northern Europe. The natural habitat is in Indochina, Taiwan and the southern islands of Japan. Plants are epiphytic, epilithic or terrestrial. Rhizome is thick, shortly to long creeping. Scales on rhizome are appressed or spreading and margins are toothed or ciliated. Fronds not articulate, monomorphic, usually internally dimorphic, sessile with a dilated base, frond bases

imbricate or separate, forming individual nests. Fertile parts similar to sterile or usually narrower. Sori are small, in rows along connecting veins or veinlets, or distinctly enlarged to form soral patches between midrib and margin. Sporangia are glabrous or sometimes with acicular hairs. Spores are with spines or small globules.

Anticancer activities: In the Chinese traditional medicine system, "Gusuibu" has been used for its anticancer and antiinflammation activity. It is prepared from the rhizomes of various ferns, namely *A. coronans* (Cai et al, 2004; Chang et al., 2007a)

2.4. *Phlebodium* (R.Br.) J.Sm.

They are epiphytic ferns, with a creeping, densely hairy or scaly rhizome bearing fronds at intervals along its length. Rhizome is broad with densely toothed scales. The fronds are evergreen, persisting for 1-2 years and pinnatifid. Apex of pinnae attenuate and acuminate. Leaf lamina is glabrous on underside. The sori or groups of spore cases, sporangia, are borne on the back of the frond.

Anticancer activities: *P. decumanum* has been used for anticancer and ulcer treatment. Extracts of the species show anticancer activity. Testing of HL-60 and MCF-7 cells shows the inhibition of proliferation and the induction of cell death. Western blot and FACS analyses elucidate the underlying mechanisms (Punzon et al., 2003).

2.5. *Polypodium* L.

They are terrestrial or epiphytic ferns, with a creeping, densely hairy or scaly rhizome bearing fronds at intervals along its length. The species differs in size, general appearance and

in the character of the fronds which are evergreen. The sori or groups of sporangia are borne on the back of the frond; they are globose and naked, not covered with a membrane.

Anticancer properties: *P. nipponica* is an anticancer plant by testing in vivo two stage carcinogenesis on mouse skin papillomas. *P. formosanum*, *P. vulgare*, *P. fauriei* and *P. virginianum* contain triterpenes with oxygenated functional group which reduce the inhibitory effects on EBV-EA activation. This strongly suggests that these compounds are strong anticancer promoters (Konoshima et al., 1996).

2.6. *Pteris* Gled. Ex Scop.

The genus *Pteris* belongs to family Pteridaceae is a terrestrial herb. Rhizome is erect with dense scales, and scales are lanceolate, entire and pale brown in colour. Leaves are simple pinnate, pale green; stipe is long, green, scaly and grooved. Lamina is simple pinnate, pale green in colour. Pinnae are oblong, acuminate gradually reduced towards base; basal pinnae are ovate or oblong. Sori are linear along the margins, covered by translucent reflexed margins; spores are trilete, pale brown.

Anticancer properties: *P. polyphylla* and *P. multifida* contain antimutagenic factors against both picrolonic acid and benzo[a]pyrene induced mutation using the *Salmonella*/microsomal system. Each crude drug is extracted with boiling water for 2h, the method which is commonly used by Chinese people to prepare the drug for oral intake (Lee et al., 1998). From aerial part of the fern *P. multifida*, two diterpenes, entkaurane-2 beta, 16 alpha-diol and ent-kaur-16-ene-2 beta, 15 alpha-diol isolated by repeated column chromatography using

silica gel and silica gel impregnated with silver nitrate. Both compounds show a moderate cytotoxicity to Ehrlich ascites tumour cells (Woerdenbag, 1996). *P. semipinnata* shows cytotoxicity against HL-60 cell line in combination with genistein. In *P. vittata*, protoapigenone is a unique flavonoid showing potent antitumour activity against a broad spectrum of human cancer cell lines. RY10-4, a modified version of protoapigenone, manifested better anti proliferation activity in human breast cancer cell line MCF-7. The cytotoxicity of RY10-4 against MCF-7 cells is exhibited in both time and concentration dependent manners (Li et al., 1998).

2.7. *Hemionitis* L.

Hemionitis is a genus of small terrestrial, soft herbaceous ferns. Rhizomes are short creeping to erect. Thin scales intermixed with pericellular hairs present on rhizome. Fronds are somewhat dimorphic. The sterile fronds are tending to be short stalked and spreading; fertile ones long stalked and erect. Leaf blades are palmately or pedately lobed or else pinnately compound; sporangia in many superficial lines, following the course of veins throughout the lower side of fertile blades. Indusium and paraphyses are absent. Spores of *Hemionitis* are globose or tetrahedral globose, trilete and the surface cristate is echinate or tuberculate.

Anticancer activities: Leaf and rhizome of *H. arifolia* show properties of antidiabetic, antimicrobial and anticancer (Santhosh et al., 2014).

2.8. *Adiantum* L.

Adiantum is terrestrial herb with erect rhizome. Scales are lanceolate, acuminate, pale

brown coloured. Fronds are dichotomously branched. Stipe is dark brown to black in colour. Pinnules are dimidiate, obovate, elliptic or rhomboid, shortly stipitate and truncate to cuneate at base. Sterile pinnae are serrate; fertile pinnae serrate to lobed; hispid is coriaceous. Sori are along the reflexed margins, reniform, dark brown to black. Sporangial capsules are subglobose. Spores are yellow, trilete and tetrahedral.

Anticancer activities: The whole plant of *A. capillus-veneris* is anticancerous, antiviral and hypoglycaemic (Santhosh et al., 2014). Neohopane 12 ene, adianane and secoadnanane are isolated from *A. monoclamyis*, exhibit inhibitory effect on EBV-EA activation at higher concentration (Konoshima et al., 1996). Preliminary phytochemical screening and anticancer evaluation of *A. venustum* against Ehrlich Ascites Carcinoma in animal model is valuable. The findings indicate that ethanolic extract of *A. venustum* possesses significant anticancer activity and also reduces elevated level of lipid peroxidation due to the presence of terpenoids and flavonoids. Thus, ethanolic extract could have vast therapeutic application against cancer (Viral et al., 2011).

2.9. *Pityrogramma* Link

It is terrestrial herb with erect, densely scaly rhizome. Scales are brownish, linear and entire. Fronds are bipinnate. Stipe is dark-pinkish brown coloured. Lamina is triangular in outline and pinnae lanceolate, acuminate in outline. Pinnules are rhomboidal to lanceolate in shape, rachi and costa grooved above, raised below; lower surface of pinnules white crusted. Sori are acrostichoid. Sporangial capsule is globose. Spores are triangular in outline,

yellowish with pinkish thickenings.

Anticancer activities: In vitro cytotoxicity of the extracts and isolated components observed in Dalton's lymphoma ascites tumour cells (DLA cells) and Ehrlich ascites tumour cells (EA cells) using the trypan blue exclusion method (Sukumaran & Kuttan, 1991).

2.10. *Angiopteris* Hoffm.

Angiopteris belongs to family Marattiaceae. It is a terrestrial herb with erect, massive rhizome. It is densely covered with dark brown to black hairs. Fronds are bipinnate. Stipe is long and hairy. Lamina is broadly elliptic, acute in outline. Pinnae are oblong-lanceolate, acute in outline. Pinnules are oblong, acuminate, serrulate to entire and rounded at base. Costa raised above and below, veins indistinct above, prominent below, rarely forked.

Anticancer activity: For sarcoma, the leaves are crushed together with leaves of "agakai" (plant species not stated), and the sap applies twice a day (Defilpps et al., 1988).

2.11. *Davallia* Sm.

The plant rhizome is long creeping, white-waxy and appressed to substrate. Black peltate bases of rhizome scales usually persistent, and remaining portion is deciduous. Fronds are not always markedly dimorphic, and chartaceous. Stipe bearing scattered reduced scales with a minute peltate base and marginal crisped hairs. Rachis and lower surface of lamina contain scattered reduced scales. Sori present on the marginal portion, indusium often projecting beyond margin and very tightly attached along both sides.

Anticancer activities: *D. divaricata* and *D.*

solida are used in Traditional Chinese medicine and Korean folk medicine (Cui et al., 1990). *Pteridium aquilinum* and *D. cylindrica* show the anticancer potentials in A549 cells (Chiu et al., 2009; Sarker et al., 2011).

2.12. *Marsilea* Necker

It is terrestrial or aquatic herbs with long creeping rhizome. Fronds are simple and stipe is slender, glabrous or softly pubescent. Lamina is quadrifid and each lobe is obovate or obtriangular, lobed to serrate along the outer margins. Sporocarps are oblongoid; hispid is less hairy at maturity, with stalk and produced in clusters.

Anticancer activities: The methanolic extracts of *M. quadrifolia* show an antiproliferative activity with IC₅₀ value of MCF-7 cells at 39.06 µg/ml. Ethylacetate and aqueous extracts of *M. quadrifolia* exhibit antiproliferative activity with an IC₅₀ value of 47.825 and 187.5 µg/ml respectively (Uma & Pravin, 2013). Among the species, the highest percentage of tumour inhibition induce by *M. minuta* (82.32%) at 1000ppm, and significant tumour inhibition observed at 10, 100 and 1000 ppm of plant extracts on potato disc induced by *Agrobacterium tumefaciens* indicating their presence of tumour inhibitor metabolites. These metabolites may serve an important role in developing antitumour drugs for human beings, as there is a similarity between human and plant tumour formation mechanism (Sarker et al., 2011).

2.13. *Blechnum* L.

Blechnum is a terrestrial herb with suberect rhizome. Apex of rhizome is densely scaly and scales are lanceolate, pale brown, apex acuminate with entire margin. Stipes are

tufted, dark brown at the very base, pale or grey-brown above, sparsely scaly at the base and glabrous above. Lamina is falcate lanceolate, apex acuminate, base truncate, basal few pinnae pairs are sessile, slightly reduced or not, subopposite. Largest pinna oblong-lanceolate, apex acuminate, base truncate, margin apparently entire but bearing very minute pale brown spinules. veins obscure above and below, forked once or twice, free, reaching the margin; pinnae dark green, glabrous above and below; texture coriaceous. Sori linear along the costa, not reaching the base and apex, parallel, indusiate; indusia pale brown, firm, margin serrate; spores reniform, yellowish-brown, exine with faint thin, reticulate thickenings.

Anticancer activities: In the evaluation on the anticancer property of this fern, selective cytotoxicity exhibits against human colon cancer cells HT-29 and HCT-116, human colonic adenocarcinoma HT-29, human colonic carcinoma HCT-116, human breast adenocarcinoma MCF-7 and human leukemia K562 (Lai & Lim, 2010).

2.14. *Dryopteris* Adans.

The genus is terrestrial herb with erect rhizome. Dense scales are present at the apex and scales are ovate-lanceolate. The characters of lamina include ovate-lanceolate shape, bipinnatifid, acuminate apex. Primary pinnae are ascending, falcate, subopposite at the basal part of the lamina. Largest pinna ovate-lanceolate, apex acuminate, base cuneate; basal pairs usually bear an accessory branch; primary pinna of the largest frond, subopposite or alternate, anadromous below, isodromous above; basal few pairs shortly stalked, others

sessile or adnate, ovate-lanceolate, decurrent on the basal basiscopic side, apex acute, basiscopic base broadly cuneate, acroscopic base truncate or broadly cuneate, margin lobed onesixth to five-sixth way to the costules; lobes oblong, apex acute or rounded, margin entire or toothed; rachules narrowly winged on either side, shallowly grooved and dark brown above, stramineous below; veins indistinct above, slightly distinct below, up to five pairs, forked once or twice, not reaching the margin; pinnae dark green; texture herbaceous; scattered small scales borne on rachis and costa. Sori median on the veinlets; pale brown, glabrous with thin membranous border; spores dark brown, with prominently winged, irregularly folded perispore.

Anticancer activity: Fernane 9(11)-ene and 22-hydroxy hopane are the two anticancer compounds found in *D. crassirhizoma* (Konoshima et al., 1996).

2.15. *Oleandra Cav.*

Rhizome is creeping and white waxy in the older parts, and long leafless parts alternating with more or less dense clusters of very short phyllopodia. Branches usually in opposite pairs; in cross section is with weak sclerenchyma sheath and without sclerified strands; roots scattered, usually with long unbranched parts. Scales persistently covering the rhizome, peltate base appressed, with dark centre and lighter margin, acumen brown, usually recurved, with ciliate margin, apex twisted and with frizzy cilia. Fronds monomorphic; stipe with dark coloration on abaxial side, often distinctly bicolorous, with catenate hairs; lamina base truncate to rounded, apex often abruptly caudate, texture thin herbac-

eous, translucent, both surfaces densely set with catenate hairs, costa on lower surface in basal half of lamina with dark coloration, with copious long pale scales. Sori close to costa, indusium thin, glabrous or hairy. Sporangial stalk without glands below the sporangium. Spores are echinate and ridged, perispore solid.

Anticancer activity: Gammacerane is an anticancer compound present in *O. wallichii* that inhibits in vivo two stage carcinogenesis in mouse skin papillomas (Konoshima et al., 1996).

2.16. *Asplenium L.*

The genus is a terrestrial herb with creeping rhizome. Scales are brownish, clathrate, lanceolate, margins fimbriate with glandular hairs. Fronds simply pinnate; scaly beneath, sparsely above; lamina lanceolate in outline; pinnae, lanceolate, long-acuminate, crenulate, coriaceous, veins forked near the costa, veinlets again forked, not reaching the margin; terminal pinna smaller, gemmiparous. Sori are linear, reddish brown; indusia linear, paler. Sporangial capsule is globose. Spores yellowish, elliptic or planoconvex with thickly folded perine.

Anticancer activity: Two species from this genus, *A. polyodon* and *A. nidus*, have anticancer, antidiabetic and antiviral activity. (Singh, 1999; Lee et al., 2003)

2.17. *Ophioglossum L.*

Terrestrial herbs are with fleshy small, sub-globose, subterranean rhizome. Fronds bipartite; sterile blade, oblong or elliptic, obtuse or apiculate, subcoriaceous, veins anastomosing; fertile spike arising from the base of the sterile blade, oblong, acute, flattened, fleshy

with wavy margins. Sporangia globose sunken and arranged in a row on either side of the stalk.

Anticancer activity: *O. gramineum* and *Hexastylis arifolia* have anticancer, antidiabetic and antiviral activities (Singh, 1999; Lee et al., 2003)

2.18. *Pteridium Gleditsch; Scopoli*

Common bracken is herbaceous perennial plant, deciduous in winter. The large, roughly triangular fronds are produced singly, arising upwards from an underground rhizome. It dies back to ground level in autumn. The rhizome grows up to deep, because it regrows in the spring from an underground rhizome. *P. aquilinum* tends to be found in dense colonies on genetically identical fronds. In the spring as the plant enters its growing cycle, fiddle heads are first sent up from the rhizome. The density and area covered by a single rhizome maximizes that rhizome's chance of biological success when sending up new growth. The new growth presents as vertical stalks, coiled and covered in silver-gray hairs, that can be several feet in height before unfurling into fronds.

Anticancer activity: β -caryophyllene, linalool, geranial and γ -terpinene in the genus exhibit anticancer and antioxidative activities (Nwiloh et al., 2014)

2.19. *Dicranopteris Bernh.*

The genus *Dicranopteris* means two branched. Species name of *D. linearis* means narrow and parallel sided and refers to the fronds. Large fern, sprawling up to 3 metres, has characteristic forking stems growing along the ground with compound stalked fronds. The main rachis is divided into two distinct rachis

branches. Trilete shaped spores in sporangia lack indusium. The sporangia are found on the underside of lobes of the ultimate two branches.

Anticancer activities: *D. linearis* has anticancer property proved through in vitro MTT assay on MCT-7, HeLa, HT-29, HL-60, K-562 and MDA-MB-231 cell lines (Sukumaran & Kuttan, 1991).

2.20. *Sellaginella P. Beauv.*

Terrestrial herbs are with erect cylindrical green stem, branched from base. Branches are many, erecto-patent and compound. Rhizophores are in tufts towards basal portion, slender, cylindrical. Leaves pale green, green or light brownish, heteromorphic, distant on main stem, closely arranged in four rows on branches; median leaves membranous, ovate, aristate, margin dentate or denticulate; lateral leaves membranous, ovate-lanceolate, acute, proximal margin serrate at base, serrulate to towards apex; axillary leaves membranous, ovate-lanceolate, acute, oblique at base, margin dentate towards apex. Strobili are terminal, sessile; sporophylls monomorphic, spiral, ovate, aristate, oblique, dentate or denticulate. Megasporengia are towards base, microsporengia towards apex. Megaspores are orange-red, trilete, tetrahedral, papillate. Macrospores are creamy white, globose, tetrahedral, reticulate.

Anticancer activities: Bioactivity guided fractionation of the leaves of *S. willdenowii* affords three known biflavones, 4',7"-di-*O*-methylamentoflavone, isocryptomerin and 7"-*O*-methylrobustaflavone, that are significantly cytotoxic against a panel of human cancer cell lines (Silva et al., 1995). In vitro MTT assay on

human colon cancer cell lines gives idea of anticancer property of *S. lepidophyla* (Lee & Lin, 1988). *S. willdenowii*, *S. lepidophyla*, *S. labordei*, *S. moellendorffii*, *S. delicatula*, *S. tamariscina*, and *S. doederleinii* are shown to have cytotoxic and antimutagenic effects due to the presence of bioflavonoids (Silva et al., 1995; Sun et al., 1997; Lee et al, 1999). *S. moellendorffii* exhibits in vitro cytotoxic activity on human ovarian adenocarcinoma cells, cervical carcinoma (HeLa) and foreskin fibroblast (FS-5) (Lin et al., 2000; Su et al., 2000). *S. tamariscina* shows in vitro antiproliferative activity in leukemia cells (Chen et al., 2005; Gayathri et al., 2005). *S. doederleinii* induces antimutagenic activity against picronic acid induced mutation and exhibits antiproliferative activity against human cancer cells (Woo et al., 2005; Gao et al., 2007).

2.21. *Odontosoria* (C.Presl) Fee

Odontosoria from family Lindsaeaceae is terrestrial herb with creeping, branched rhizome. Dense dark brown hairs cover the rhizome. Fronds are quadripinnate and finely dissected. Stipe is long, yellow and hairy at the very base. Fronds have oblong or elliptic-lanceolate shaped lamina. Primary pinnae triangular or ovate-acuminate in outline and show alternate stalk arrangement. Secondary pinnae are rhomboid or elliptic in outline with alternate phyllotaxy. Tertiary pinnae are obovate or obtriangular in outline. Quaternary pinnae obtriangular shaped, truncate at apex, cuneate at base, entire. Sori are elliptic at the apex of the quaternary pinnae, dark brown. Sporangial capsule is subglobose and a stalk present. Spores are yellow, hyaline, smooth.

Anticancer activities: In traditional Chinese medicine, *O. chinensis*, either alone or in combi-

nation with other ingredients, is considered effective in cancer treatments, detoxification and hemostasis, resulting in its reputation as an “all-purpose antidote” (Wu et al., 2017).

2.22. *Macrothelypteris* (H.Ito) Ching

The terrestrial plant is under the family Thelypteridaceae. Creeping rhizome is with dense scales. Scales are dark brown, linear, densely acicular and hairy. Fronds are bipinnate; stipe, scaly at base; lamina ovate-lanceolate in outline, rachis grooved above, pinnae elliptic-lanceolate, acuminate; pinnules alternate, lanceolate, acuminate, cuneate to decurrent at base, thin membranous, progressively reduced to both ends, deeply lobed to costa; lobes oblong, serrate, obtuse to rounded, falcate; costules grooved above, raised below, hispid on both sides, veins pinnate, forked free. Sori are circular, yellow color present on median of veins. Sporangial capsule is subglobose. Spores are ellipsoid with thinly folded perine.

Anticancer activities: Protoapigenone is an antitumour compound isolated from root of *M. torresiana*. It is a main constituent of the total flavonoid fraction that exhibits in vitro antitumour activity against lung cancer (Huang et al., 2010).

3. Outlook

Pteridophytes, a group of plants that includes ferns and their allies, have been shown to possess various anticancer properties. Several studies have investigated the cytotoxicity of extracts and compounds derived from different parts of pteridophytes, and have found them to be effective against a range of cancer cells. Some of the mechanisms through which

pteridophytes exhibit their anticancer properties include inducing cell cycle arrest, promoting apoptosis, and inhibiting angiogenesis. Furthermore, some pteridophyte compounds have been shown to enhance the efficacy of chemotherapy drugs. Several researchers have studied the phytochemical and medicinal uses of lycophytes and ferns in recent years that demonstrate the importance of ferns and their allies in plant science fields. The medicinal uses of pteridophytes are specifically due to their antioxidant, antidiabetic, anticancer, antiviral, antiinflammatory,

wound healing, antimicrobial and anti-Alzheimer activities. The main medicinal pteridophytes belong to the following families: Davalliaceae, Equisetaceae, Lygodiaceae, Ophioglossaceae, Polypodiaceae, Psilotaceae, Pteridaceae, Salviniaceae, Selaginellaceae, Lindsaeaceae, Woodsiaceae, Aspleniaceae, Marattiaceae, Blechnaceae, Polypodiaceae and Thelypteridaceae. Present data may contribute to a better understanding of the uses of fern beyond ornamental purposes; especially those that promote the use and development for medicinal purposes.

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