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Phytochemical and Pharmacological Potential of Genus *Drynaria* (Bory) J. Sm.: A Comprehensive Review

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Abstract
The genus *Drynaria* (Bory) J. Sm. (Polypodiaceae) comprises approximately 32 species distributed across Africa, Asia and the Pacific Islands, representing diverse ecological and climatic zones. This genus has long been utilized in traditional medicine systems, where species are prescribed for the treatment of osteoporosis, bone fractures, tinnitus, inflammation, hyperlipidemia, arteriosclerosis and rheumatism. Phytochemical investigations have revealed the presence of diverse bioactive compounds including flavonoids, phenols, triterpenoids, phytosterols, chromones, furanocoumarins, lignans, tocopherols, fatty acid derivatives, phenylpropanoids and terpenoids. These constituents are associated with a wide range of pharmacological activities, such as analgesic, anti-arthritic, anticancer, anti-HIV, anti-inflammatory, antimicrobial, antioxidant, antipyretic, hepatoprotective, immunomodulatory, nephroprotective, neuroprotective, osteogenic, thrombolytic, cytotoxic and anti-obesity effects. This systematic review integrates ethnomedicinal knowledge with modern phytochemical and pharmacological evidence, highlighting the therapeutic relevance of *Drynaria* species and underscoring their potential for future drug discovery.

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INTRODUCTION

The genus *Drynaria* has been extensively utilized in traditional medicine, particularly for the treatment of bone-related disorders, inflammatory conditions, infections and bacterial diseases (Chen et al., 2021). Phytochemical studies have identified a wide spectrum of bioactive compounds, including flavonoids, triterpenoids, tannins and phenolic acids, which contribute to the genus's diverse pharmacological activities (Chen et al., 2021; Trinh et al., 2015). Recent pharmacological investigations have demonstrated the therapeutic potential of *Drynaria* species, highlighting their anti-inflammatory, analgesic, antimicrobial, osteoprotective, neuroprotective and hepatoprotective properties (Irudayaraj and Senthamarai 2004; Jeong et al., 2005; Anuja et al., 2010; Wang, 2018; Huang et al., 2023). This systematic review aims to synthesize current evidence on the medicinal value of *Drynaria*, with a focus on its phytochemical composition and pharmacological activities, thereby providing deeper insights into its potential applications in both traditional and modern medicine.

MATERIALS AND METHODS

Ethnobotanical and pharmacological data concerning the genus *Drynaria* were compiled through a systematic review of several well-established online resources, including Web of Science, Scopus, PubMed, Google Scholar, ResearchGate, Wiley Online Library, ScienceDirect, the Global Biodiversity Information Facility (GBIF) and Plants of the World Online (POWO). Information regarding phytochemicals and bioactive compounds was extracted from PubChem and the Royal Society of Chemistry's ChemSpider database. The molecular structures of key constituents were drawn and analyzed using ChemSketch (Freeware Edition, ACD/Labs), which provides precise tools for structural representation and molecular modelling. This integrated methodology strengthened the accuracy, reproducibility and reliability of the phytochemical and pharmacological information assembled for *Drynaria*.

Taxonomy:

Drynaria is a distinct genus, best recognized by the peculiar frond dimorphism *Drynaria*, commonly known as 'Basket ferns' or 'Oak leaf ferns.' The fern genus *Drynaria* belongs to family Polypodiaceae. There are 33 species in the genus *Drynaria* (Christenhusz, 2015). In India it is represented by 6 species (Rawat and Deroliya, 2024). *Drynaria coronans, D. propinqua and D. quercifolia* are cultivated in gardens. According to Rawat and Deroliya (2024) these ferns thrive well in temperate to tropical climates rich in moisture, often flourishing along watercourses with gentle sunlight exposure. Known for their elegant, green basket like fronds, they are popular for ornamental use and natural landscaping.

Drynaria (Bory) J. Sm. in Hook. Journ. Bot. 4: 60. 1841; Nayar, Bull. Nation. Bot. Gard. Lucknow no. 56.9. 1961. nom. cons., *Polypodium* subgenus *Drynaria* Clarke, Trans. Linn. Soc. Lond. II (Bot.) 1: 555 (1825); Hope, J. Bombay nat. Hist. Soc. 15: 89 (1903).

Type species: *Drynaria quercifolia* (L.) J. Sm. in Hook. Journ. Bot. 3: 398. 1841.

Distribution: Africa, Australia, China, India, Indonesia, Malaysia, Philippines, Thailand, Singapore and Sri Lanka

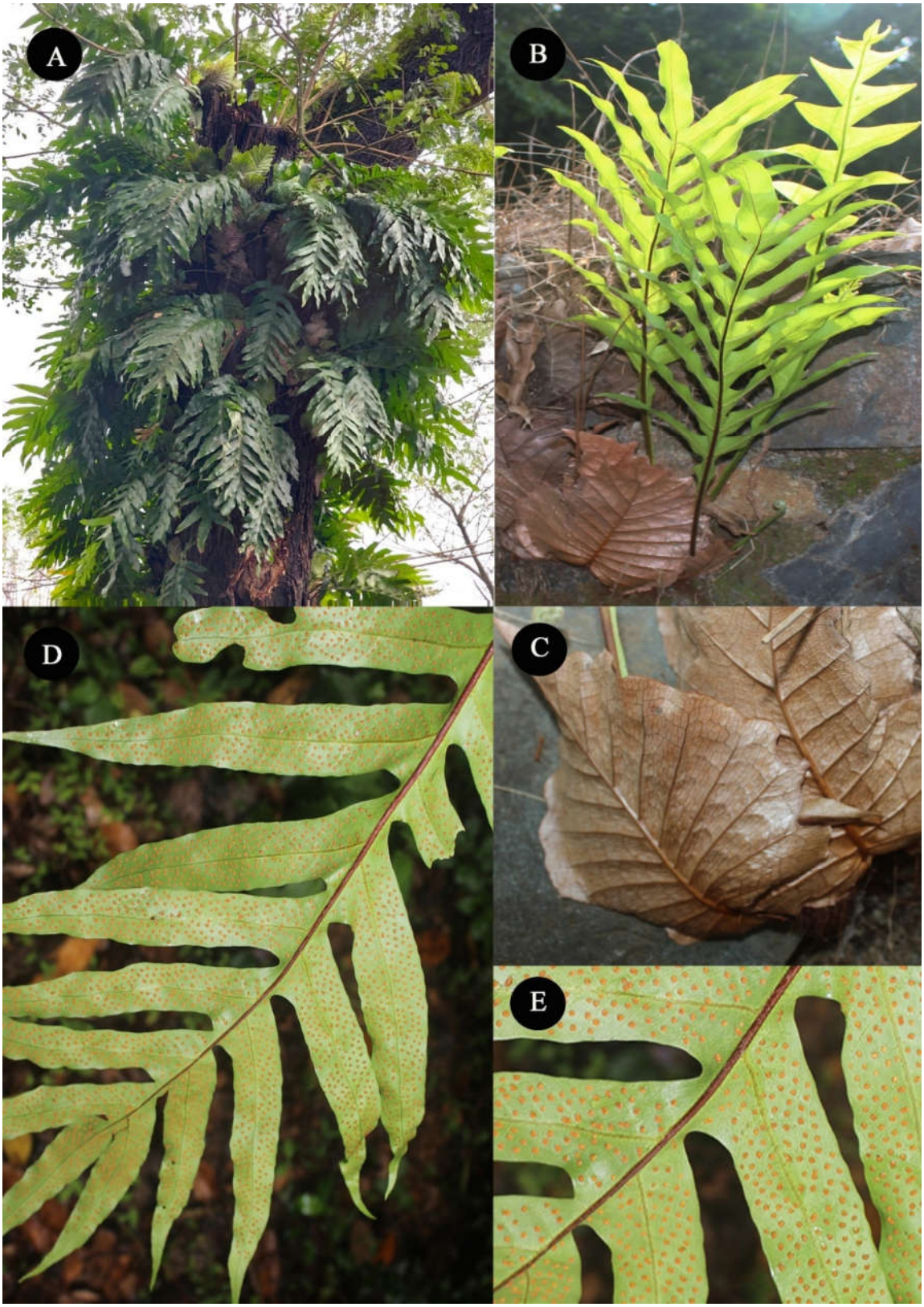

Figure 1: A, B. Habit of *Drynaria* **C.** Vegetative frond **D.** Reproductive frond **E.** enlarged reproductive frond.

Ethnobotany

Species of the genus *Drynaria* have been traditionally employed as medicinal remedies across the world, with widespread use in Southeast Asia and China. Among the different plant parts, the rhizome is particularly valued in folk medicine for the treatment of bone fractures, osteoporosis, tinnitus, rheumatic pain and respiratory ailments such as cough and tuberculosis. In addition to these ethnomedicinal applications, pharmacological investigations have revealed that *Drynaria* species possess a broad spectrum of bioactivities. A detailed account of the traditional uses of the genus is presented in **Table 1.**

Table 1: Traditional Uses of *Drynaria* Species

Name of the plant	Plant Part	Local Name	Preparation Method	Traditional use	References
D. bonii Christ	Rhizome	-	Decoction	Used for the treatment of osteoporosis, bone fractures and tinnitus.	Pham et al., 2015
	Rhizome	-	-	Used to heal bone fractures, stimulate hair growth and treat tinnitus or deafness.	Trinh et al., 2015
D. fortunei (Kunze) J. Sm	Rhizome	Gusuibu	Decoction	Used as a traditional Chinese medicine for bone healing.	Liu et al., 2001
	Rhizome	Gol-Se-Bo	Decoction	Demonstrates therapeutic potential in managing inflammation, hyperlipidemia, arteriosclerosis, rheumatism, osteoporosis, and bone resorption	Jung., 2007
	Rhizome	Gu sui bu	-	In China it used from thousands of years to treat the kidney, strengthen bones, promote fracture healing and relieve pain.	Liu et al., 2012
	Rhizome	-	Paste	Traditional Chinese medicine for treating injuries and bone fractures from falling and beating.	Zhao., 2024
	Rhizome	-	-	Used to heal bone fractures, stimulate hair growth, treat tinnitus, deafness, chronic diarrhea, low back pain and odontopathy.	Benskey and Gamble, 1996
	Rhizome	Gurar	Decoction	Used to treat cough, tuberculosis and typhoid fever	Khan et al., 2007a
D. quercifolia (L.) J.Sm.	Rhizome	Gurar	-	Used to treat tuberculosis, loss of appetite, cough, and fever.	Bhattacharya., 1990; Kirtikar and Basu., 1994
	Rhizome	Mudava atukkal	Soup	Used to treat rheumatic complaints.	Saravanan et al., 2013
	Rhizome	Bandor shoal	_	Treats typhoid, fever, cough, indigestion, jaundice, diabetes,	Chaity et al., 2016

				tuberculosis, and throat infections.	
	Fronds	Mudava atukkal	Soup	The fronds are traditionally used by Indian tribal communities to treat typhoid, jaundice, headache, cough, cholera, and skin diseases.	Modak et al., 2021

Phytochemistry

The genus *Drynaria* exhibits a rich diversity of bioactive phytochemicals, most of which are derived from the rhizomes, as reported in species such as *D. fortunei* (Kunze) J. Sm., *D. propinqua* (Wall. ex-Mett.) J. Sm. ex Bedd., *D. bonii* H. Christ., *D. quercifolia* (L.) J. Sm., and *D. roosii* Nakaike. A smaller proportion of compounds have been isolated from aerial parts, particularly the leaves. In China, the rhizome of *D. fortunei* is widely recognized in local herbal medicine under the names *D. rigidula* and *Rhizome Drynariae*. To date, approximately 190 phytochemicals have been isolated and classified according to their structural classes. Among them, flavonoids and flavone derivatives represent the most abundant group, followed by phenols and phenolic acids. Species-specific distribution has also been noted: *D. fortunei* contains the highest number of flavonoids and phenols, *D. quercifolia* is particularly rich in fatty acids and triterpenoids, while *D. bonii* and *D. propinqua* also yield flavonoids, phenols and triterpenoids. Notably, *D. roosii* contains five liglaurates, which are associated with cytotoxic activity.

Pharmacological studies on isolated compounds have demonstrated diverse biological activities, including anti-inflammatory, neuroprotective, acetylcholinesterase inhibitory, antioxidant, antibacterial, cell proliferation–promoting and anti-osteoporotic effects (Ramesh et al., 2001; Wang et al., 2016; Xu et al., 2018; Liang, 2011a; Liu et al., 2020; Trinh et al., 2020; Zhang et al., 2022; Ahn et al., 2023). Extraction of plant material has been conducted using solvents such as ethanol, methanol and petroleum ether, while compound isolation and characterization have been achieved through chromatographic and spectrometric techniques, including silica gel chromatography, Sephadex LH-20, gas chromatography–mass spectrometry (GC–MS) and high-performance liquid chromatography (HPLC). Frequently identified bioactives include naringin and neoeriocitrin (in *D. fortunei* and *D. quercifolia*) and β-sitosterol (in *D. propinqua*). Furthermore, several novel structures, such as Drynaether A and Drynachromosides A, highlight the unique phytochemical profile of the genus. Collectively, these findings emphasize the therapeutic potential of *Drynaria* species, particularly for their anti-inflammatory, antioxidant and anticancer properties. A detailed list of phytochemicals is presented in **Table 2.**

Table 2: Phytochemical compounds of genus *Drynaria*

Species	Plant Part	Class	Compounds	Biological activity	Reference
D. bonii					
1.	Rhizome	Flavonoids	Kaempferol	Osteoblast	Trinh et al., 2016
2.			Nobiletin	Antifungal, Antioxidant	Trinh et al., 2015
3.			Drynaether A	Osteoblast	Trinh et al., 2016
4.			5-Hydroxymethylfurfural	Osteoblastic	Trinh et al., 2020

5.		Phenol	Protocatechuic acid	Antifungal, Antioxidant Osteoblastic	Trinh et al., 2015; Trinh et al., 2016; Trinh et al., 2020
6.			Rutin	Osteoblastic, Antifungal, Antioxidant	Trinh et al., 2015; Trinh et al., 2020
7.			Nicotiflorin	Osteoblastic, Antifungal, Antioxidant	Trinh et al., 2015; Trinh et al., 2020
8.			Protocatechualdehyde	Antifungal, Antioxidant	Trinh et al., 2015
9.			Isoliquiritigenin	Antifungal, Antioxidant	Trinh et al., 2015
10.			3-(5-hydroxymethyl) furan-2-yl)-2-phenylacrylaldehyde	Antifungal, Antioxidant	Trinh et al., 2015
11.			Chrysophanol	Antifungal, Antioxidant	Trinh et al., 2015
12.			Linocaffein	Antifungal, Antioxidant	Trinh et al., 2015
13.		Triterpenoid	24-Methylen-cycloartan-3β-ol	Osteoblastic	Trinh et al., 2020
14.			Triphyllol	Osteoblastic	Pham et al., 2015; Trinh et al., 2020
15.			24-Methylencycloartan-3β-olt	-	Pham et al., 2015
D. fortune					
16.	Rhizome	Chromone	5,7-Dihydroxychromone-7-O-neohesperidoside	-	Ahn et al., 2023
17.			5,7-Dihydroxy-2-methyl chromone		Han et al., 2015
18.			5,7-Dihydroxy-2-hydroxymethyl chromone		Han et al., 2015
19.			Drynachromoside C		Han et al., 2015
20.			Drynachromoside D		Han et al., 2015
21.			Drynachromoside B	Osteoblast	Shang et al., 2013; Han et al., 2015
22.			Drynachromoside A	Osteoblast	Shang et al., 2013
23.			Schumanniofioside A		Han et al., 2015
24.			5-Hydroxy-2-methylchromone-7-O-rutinoside		Han et al., 2015

25.		Flavonoid	Eriodictyol	Osteoblastic activity, Cytotoxicity	Liang., 2011a; Wang et al., 2016; Xu et al., 2018; Liu et al., 2020; Zhang et al., 2022
26.			Kaempferol 3-O-rhamnoside 7-O-glucoside	-	Ahn et al., 2023
27.			Kaempferol 3-O-glucopyranoside-7-O-arabinofuranoside	-	Ahn et al., 2023
28.			Neoeriocitrin	Neuropharmacological, Cytotoxicity	Li et al., 2009; Liang, 2011a; Liu et al., 2012; Wang et al., 2018; Liu et al., 2020; Dang et al., 2022; Ahn et al., 2023
29.			Naringin	Neuropharmacological, Cytotoxicity, Osteoblastic	Liang, 2011a; Liu et al., 2012; Wang et al., 2016; Xu et al., 2018; Wang et al., 2018; Liu et al., 2020; Dang et al., 2022; Zhang et al., 2022; Ahn et al., 2023
30.			Hesperidin	-	Ahn et al., 2023
31.			Luteolin-7-O-β-D-glucoside	Cytotoxicity	Xu et al., 2018; Liu et al., 2020
32.			Astragalin	Cytotoxicity	Xu et al., 2018, Liu et al., 2020
33.			Luteolin	Neuropharmacological, Cytotoxicity, Osteoblastic	Liang, 2011a; Xu et al., 2018; Wang et al., 2018; Liu et al., 2020; Zhang et al., 2022
34.			Naringenin	Neuropharmacological, Osteoblastic	Xu et al., 2018; Liu et al., 2020; Zhang et al., 2022
35.			Naringenin chalcone	Osteoblastic	Zhang et al., 2022
36.			Kaempferol	Neuropharmacological, Cytotoxicity, Osteoblastic	Xu et al., 2018; Wang et al., 2018; Liu et al.,

					2020. Zhang et al., 2022
37.			2′,4′-Dihydroxydihydrochalcone	-	Liang, 2011a
38.			Nobiletin	Osteoblastic	Zhang et al., 2022
39.			Luteolin 7-O-β-D-glucopyranoside	-	Liang, 2011a; Sui et al., 2015
40.			Kaempferitrin	Osteoblastic	Zhang et al., 2022
41.			Cianidanol	Osteoblastic	Zhang et al., 2022
42.			Luteolin-7-glucuronide	Osteoblastic	Zhang et al., 2022
43.			Quercetin	Osteoblastic	Zhang et al., 2022
44.			Isorhamnetin	Osteoblastic	Zhang et al., 2022
45.			Dehydrodiisoeugenol	Osteoblastic	Zhang et al., 2022
46.			Eriodictyol 7-O-β-D-glucopyranoside	-	Liang, 2011a
47.			Luteolin 8-C-β-D-glucopyranoside	-	Liang, 2011a
48.			Epicatechin	-	Dang et al., 2022
49.			Cymaroside	-	Dang et al., 2022
50.			Drynaether A	Osteoblast	Trinh et al., 2016
51.			5,7,3′,5′-Tetrahydroxy-flavanone	Osteoblast	Shang et al., 2013
52.			5,7,3′,5′-Tetrahydroxy-flavanone-7-O-β-D-glucopyranoside	Osteoblast	Shang et al., 2013
53.			5,7,3′,5′-Tetrahydroxy-flavanone-7-O-neohesperidoside	Osteoblast	Shang et al., 2013
54.			(+)-Afzelechin	-	Liang et al., 2011b
55.			(+)-Catechin	-	Liang et al., 2011b
56.			(-)-Epiafzelechin		Wu and Zhao, 2005; Liang et al., 2011b
57.			4α-Carboxymethyl-(+)-catechin methyl ester	-	Liang et al., 2011b

58.			4β-Carboxymethyl- (-)-epiafzelechin methyl ester	-	Liang et al., 2011b
59.			4β-Carboxymethyl- (-)-epiafzelechin	-	Liang et al., 2011b
60.			(+)-Afzelechin-3-O-β-allopyranoside	-	Liang et al., 2011b
61.			(+)-Afzelechin-6-C-β-glucopyranoside	-	Liang et al., 2011b
62.			(-)-Epicatechin-3-O-β-D-allopyranoside	-	Liang et al., 2011b
63.			(+)-Epicatechin-3-O-β-D-allopyranoside	-	Liang et al., 2011b
64.			(-)-Epicatechin-8-C-β-D-glucopyranoside	-	Liang et al., 2011b
65.			(-)-Epiafzelechin-5-O-β-D-glucopyranoside	-	Liang et al., 2011b
66.			(-)-Epiafzelechin-3-O-β-D-allopyranoside	-	Wu and Zhao, 2005; Liang et al., 2011b;
67.			(-)-Epiafzelechin-(4β→8)-4β-carboxymethyl- (-)-epicatechin methyl ester	-	Liang et al., 2011b
68.			(-)-Epiafzelechin-(4β→8)-4α-carboxymethyl- (-)-epiafzelechin ethyl ester	-	Liang et al., 2011b
69.			Epiafzelechin-(4β→8)-4β-carboxymethyl-epiafzelechin methyl ester		Liang et al., 2011b
70.			Epicatechin-(4β→8)-epicatechin		Liang et al., 2011b
71.			(-)-Epiafzelechin-(4β→8)- (-)-epiafzelechin-(4β→8)-4β-carboxymethyl- (-)-epiafzelechin methyl ester		Liang et al., 2011b
72.			(-)-Epiafzelechin-(4β→8,2→O→7)-epiafzelechin-(4β→8)-epiafzelechin		Liang et al., 2011b
73.			5-Hydroxymethylfurfural		Ahn et al., 2023

74.		Phenol	4-Hydroxybenzoic acid		Ahn et al., 2023
75.			Gallic acid		Liang et al., 2010b; Ahn et al., 2023
76.			Protocatechuic acid	-	Liang et al., 2010b; Sui et al., 2015; Dang et al., 2022; Ahn et al., 2023
77.			Caffeic acid 4-O-β-D-glucopyranoside	-	Liang et al., 2010b; Liu et al., 2012; Ahn et al., 2023
78.			4,4'-Dihydroxy-3,3'-imino-di-benzoic acid	-	Liang et al., 2010b
79.			p-Hydroxybenzoic acid	-	Liang et al., 2010b
80.			(E)-Caffeic acid	-	Liang et al., 2010b
81.			Ethyl trans-3,4-dihydroxycinnamate (First-time)	-	Liang et al., 2010b
82.			p-Coumaric acid 4-O-β-D-glucopyranoside	-	Liang et al., 2010b
83.			Coumaric acid 4-O-β-D-glucopyranoside		Ahn et al., 2023
84.			Lavandoside		Ahn et al., 2023
85.			Trans-p-sinapoyl-β-D-glucopyranoside		Ahn et al., 2023
86.			23(S)-12-O-Caffeoyl-12-hydroxyllauric acid glycerol ester	-	Liang et al., 2010b
87.		Triterpenoid	Fern-9(11)-ene	-	Liu et al., 1999
88.			Hop-22(29)-ene	-	Liu et al., 1999
89.			Cyclolaudenol	-	Liu et al., 1999
90.			20β-Hydroxychiratan-22-one	Cytotoxicity	Liang et al., 2010a
91.		Sterol	β-Sitosterol	Cytotoxicity	Wu and Zhao, 2005; Liang, 2011a; Wang et al., 2018
92.			Daucosterol	Osteoporosis	Liang, 2011a
D. propinqua					
93.		Flavonoid	(-)-Epiafzelechin-3-O-β-D-allopyranoside	-	Liu et al., 1994
D. quercifolia					
94.		Flavonoid	Naringin	Antibacterial	Ramesh et al., 2001

95.			5-Hydroxymethylfurfural	Anti-inflammatory	Modak et al., 2021
96.		Fatty Acid	Decanoic Acid		Ragavan and Srinivasan, 2024
97.			Dodecanoic acid	Anti-inflammatory	Modak et al., 2021; Ragavan and Srinivasan, 2024
98.			Benzene-propionic Acid		Ragavan and Srinivasan, 2024
99.			Acetate		Ragavan and Srinivasan, 2024
100.			Eicosyl Acetate		Ragavan and Srinivasan, 2024
101.			Methyl Stearate		Ragavan and Srinivasan, 2024
102.			Palmitic Acid		Ragavan and Srinivasan, 2024;
103.			Stearic Acid		Ragavan and Srinivasan, 2024
104.			Propanoic Acid		Ragavan and Srinivasan, 2024
105.			Succinate		Ragavan and Srinivasan, 2024
106.			Tetradecanoic Acid		Ragavan and Srinivasan, 2024
107.		Triterpenoid	Friedelin	Antibacterial	Ramesh et al., 2001
108.			Epifriedelinol	Antibacterial	Ramesh et al., 2001
109.			β-Amyrin	Antibacterial	Ramesh et al., 2001
110.					
111.		Sterol	β-Sitosterol	Antibacterial,	Ramesh et al., 2001
112.			β-Sitosterol 3-β-D-glucopyranoside	Antibacterial	Ramesh et al., 2001
D. rigidula					
113.	leaves	Flavonoid	Kaempferitrin		Nugraha et al., 2019
114.		Sterol	Kaempferol-7-O-α-l-rhamnopyranosyl-4′-O-glucopyranoside		Nugraha et al., 2019
115.			β-Sitosterol		Nugraha et al., 2019
116.			Campesterol		Nugraha et al., 2019
117.			Stigmasterol		Nugraha et al., 2019

D. roosii					
118.	Rhizome	Liglaurates	Liglaurates A to E	Cytotoxicity	Wufuer et al., 2022
Other					
D. bonii					
119.			Ethyl β-D-fructopyranoside	-	Pham et al., 2015
120.			Drybonioside	-	Pham et al., 2015
121.			α-Tocopherol	-	Pham et al., 2015
122.			4′-Hydroxy-7-methoxyflavan	Osteoblast	Trinh et al., 2016
123.			Uracil	Osteoblast	Trinh et al., 2016
124.			Indole-3-carboxylic acid	Osteoblast	Trinh et al., 2016
D. fortune					
125.			(7′R,8′S)-Dihydrodehydrodiconiferyl alcohol 4′-O-β-D-glucopyranoside		Liang, 2011a
126.			Lariciresinol 4′-O-β-D-glucopyranoside		Liang, 2011a
127.			(-)-Secoisolariciresinol 4-O-β-D-glucopyranoside		Liang, 2011a
128.			12-O-caffeoyl-12-hydroxyldodecanoic acid methyl ester	-	Sui, 2015
129.			p-Hydroxy benzenepropanoic acid	-	Sui, 2015
130.			Caffeic acid	-	Sui, 2015
131.			3,4-Dihydroxyphenyl ethyl 8-O-β-D-allopyranoside	-	Sui, 2015
132.			5,7-Dihydroxychromone-7-neohesperidoside	Cytotoxicity	Wang et al., 2018
133.			Psoralen	Cytotoxicity	Sui. 2015; Wang et al., 2018
134.			(E)-4-O-β-D-glucopyranosyl caffeic acid	Cytotoxicity	Wang et al., 2018
135.			Protocatechoic acid	Cytotoxicity	Wang et al., 2018
136.			E-4-O-β-D-glucopyranosyl caffeic acid	-	Li et al., 2009
137.			5,7-Dihydroxychromone-7-O-rutinoside	-	Liu et al., 2012

138.			Maltol 3-O-β-D-glucopyranoside	-	Liang, 2011a
139.			Trans-cinnamic acid	Neuropharmacological	Wang et al., 2018
140.			P-coumaric acid	Neuropharmacological	Wang et al., 2018
D. quercifolia					
141.	Rhizome		Vitamin E	Anti-inflammatory	Modak et al., 2021
142.			Silane, ethenylethoxydimethyl-	Anti-inflammatory	Modak et al., 2021
143.			4H-Pyran-4-one, 2,3-dihydro-3,5-dihydroxy-6-methyl-	Anti-inflammatory	Modak et al., 2021
144.			Catechol	Anti-inflammatory	Modak et al., 2021
145.			Benzeneacetic acid	Anti-inflammatory	Modak et al., 2021
146.			Beta-D-Ribopyranoside, methyl, 3-acetate	Anti-inflammatory	Modak et al., 2021
147.			Benzenepropanoic acid, 4-hydroxy-, methyl ester	Anti-inflammatory	Modak et al., 2021
148.			1,3,4,5-Tetrahydroxycyclohexanecarboxylic acid	Anti-inflammatory	Modak et al., 2021
149.			1,2-Benzenedicarboxylic acid, bis(2-methylpropyl) ester	Anti-inflammatory	Modak et al., 2021
150.			n-Pentadecanol	Anti-inflammatory	Modak et al., 2021
151.			Hexadecanoic acid, methyl ester	Anti-inflammatory	Modak et al., 2021
152.			2-Hydroxycyclopentadecanone	Anti-inflammatory	Modak et al., 2021
153.			Dibutyl phthalate	Anti-inflammatory	Modak et al., 2021
154.			n-Hexadecanoic acid	Anti-inflammatory	Modak et al., 2021
155.			Alpha-D-Glucopyranoside, methyl	Anti-inflammatory	Modak et al., 2021
156.			n-Nonadecanol-1	Anti-inflammatory	Modak et al., 2021
157.			9,12-Octadecadienoic acid (Z, Z)-, methyl ester	Anti-inflammatory	Modak et al., 2021

158.			6-Octadecenoic acid, methyl ester, (Z)-	Anti-inflammatory	Modak et al., 2021
159.			cis-9-Hexadecenal	Anti-inflammatory	Modak et al., 2021
160.			Octadecanoic acid	Anti-inflammatory	Modak et al., 2021
161.			4,8,12,16-Tetramethylheptadecan-4-olide	Anti-inflammatory	Modak et al., 2021
162.			1-Heptacosanol	Anti-inflammatory	Modak et al., 2021
163.			Hexadecanoic acid, 2-hydroxy-1-(hydroxymethyl)ethyl ester	Anti-inflammatory	Modak et al., 2021
164.			Bis(2-ethylhexyl) phthalate	Anti-inflammatory	Modak et al., 2021
165.			9,12-Octadecadienoic acid (Z, Z)-, 2-hydroxy-1-(hydroxymethyl)ethyl ester	Anti-inflammatory	Modak et al., 2021
166.			Squalene	Anti-inflammatory	Modak et al., 2021
167.			Gamma-Tocopherol	Anti-inflammatory	Modak et al., 2021
168.			A'-Neogammacer-22(29)-ene	Anti-inflammatory	Modak et al., 2021
169.			1-Phenanthrenecarboxylic acid, 7-ethyl-..., methyl ester	Anti-inflammatory	Modak et al., 2021
170.			Ergost-5-en-3-ol, (3β,24R)	Anti-inflammatory	Modak et al., 2021
171.			Cholest-5-en-3-ol, 4,4-dimethyl-, (3β)	Anti-inflammatory	Modak et al., 2021
172.			Cholest-5-en-3-ol, 4,4-dimethyl-, (3β)-	Anti-inflammatory	Modak et al., 2021
173.			Ergosta-8,24(28)-dien-3-ol, 4,14-dimethyl-, (3β,4α,5α)	Anti-inflammatory	Modak et al., 2021
174.			Stigmast-5-en-3-ol, (3β)	Anti-inflammatory	Modak et al., 2021
175.			9,19-Cyclolanost-24-en-3-ol, (3β)-	Anti-inflammatory	Modak et al., 2021
176.			9,19-Cyclolanost-25-en-3-ol, 24-methyl-, (3β,24S)-	Anti-inflammatory	Modak et al., 2021
177.			Dimethylhexyl-tetramethyl-	Anti-inflammatory	Modak et al., 2021

			benzo[cyclohepta]indene derivative		
178.			Cyclopropa[5,6]-33-norgorgostan-3-ol derivative	Anti-inflammatory	Modak et al., 2021
179.			9,19-Cyclolanostan-3-ol, 24-methylene-, (3β)-	Anti-inflammatory	Modak et al., 2021
180.			5-(7a-Isopropenyl-4,5-dimethyl-octahydroinden-4-yl)-3-methylpent-2-en-1-ol	Anti-inflammatory	Modak et al., 2021
181.			9,19-Cyclolanostan-3-ol, 24-methylene-, (3β)-	Anti-inflammatory	Modak et al., 2021
182.			Indole		Ragavan and Srinivasan, 2024
183.			Acetamide		Ragavan and Srinivasan, 2024
184.			Butylated Hydroxytoluene		Ragavan and Srinivasan, 2024
185.			Sucrose	-	Liu et al., 1992
186.			(-)-epiafzelechin-3-O-beta-Dallopyranoside	-	Liu et al., 1992
187.			4-O-β-D-glucopyranosyl caffeic acid	-	Liu et al., 1992
188.			Beta-sitosterol-3-O-β-D-glucopyranoside	-	Liu et al., 1992
D. quercifolia					
189.	Rhizome		3,4-dihydroxybenzoic acid	Antibacterial, Cytotoxicity	Khan et al., 2007b
190.			acetyl lupeol	Antibacterial, Cytotoxicity	Khan et al., 2007b

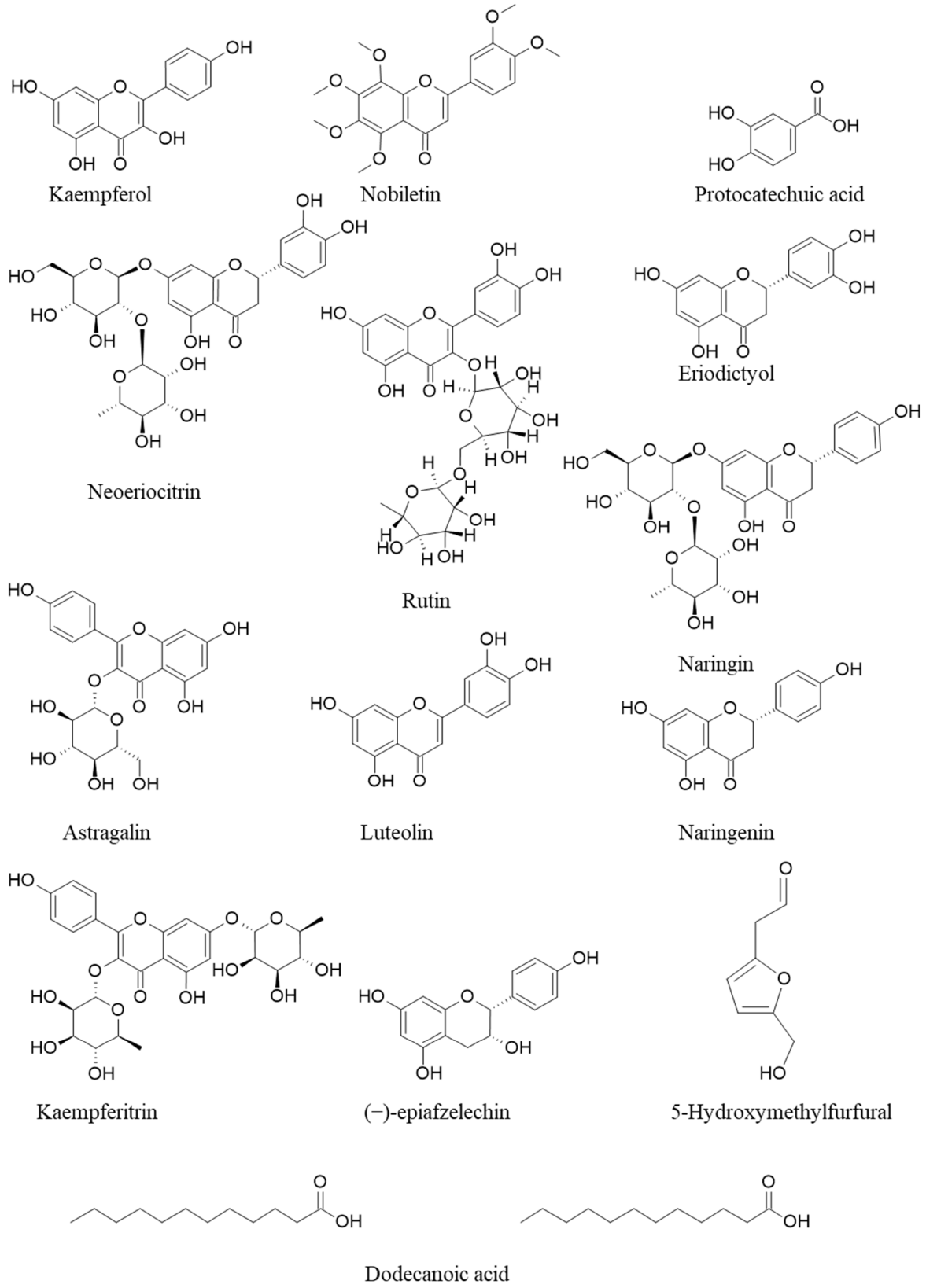

Figure 2: Chemical compounds from *Drynaria* species.

Pharmacology

Drynaria exhibits various pharmacological activities presented **in Figure 3** as below.

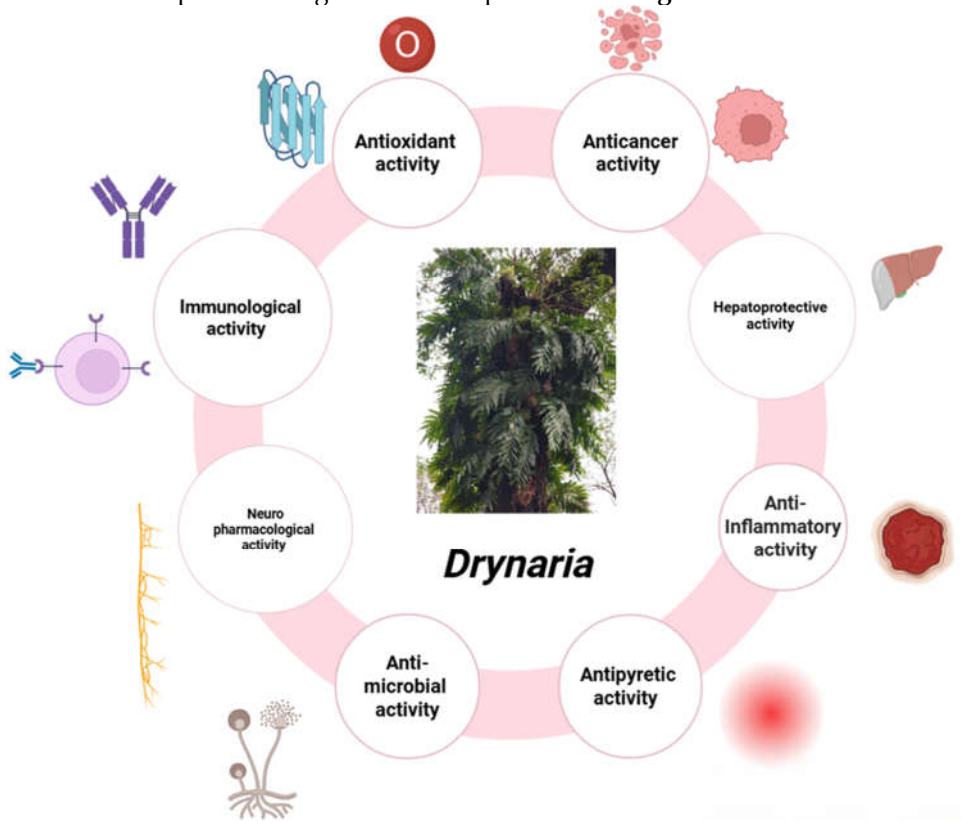

Figure 3: Pharmacological activity of *Drynaria*.

Anti- microbial activity:

The antimicrobial potential of *Drynaria* species has been widely reported across multiple extracts, plant parts and target pathogens. The methanolic rhizome extract of *D. quercifolia* demonstrated significant, dose-dependent antibacterial activity against both Gram-positive and Gram-negative bacterial strains, as assessed by the agar well diffusion assay. The strongest inhibition was observed against *Pseudomonas aeruginosa* (29 mm at 50 mg/mL), followed by *Salmonella typhi* (26 mm) and *Aeromonas hydrophila* (25 mm), while other bacterial strains showed moderate inhibition (Ramesh et al., 2001). In a related study, chloroform and *n*-butanol fractions of *D. fortunei* root demonstrated the strongest activity against oral pathogens (MIC: 0.0078–0.3125 mg/mL; MBC: 0.019–0.625 mg/mL), outperforming methanol and ethyl acetate fractions. However, the activity was relatively weak against *Streptococcus criceti*, *Aggregatibacter actinomycetemcomitans* and *Fusobacterium nucleatum* (MIC/MBC: 1.25–5 / 1.25–10 mg/mL) (Jung, 2007). Bioactive compounds have also been identified as contributing to antimicrobial activity. For example, 3,4-dihydroxybenzoic acid, isolated from the ethanolic extract of *D. quercifolia* rhizome, exhibited significant antibacterial effects against both Gram-positive and Gram-negative bacteria using disc diffusion and serial dilution assays, with MIC values ranging from 8–32 µg/mL for Gram-positive strains and 16–64 µg/mL for Gram-negative strains (Khan et al., 2007b). Consistent with this, different extracts of *D. quercifolia* rhizome displayed antibacterial activity in the order: ethanol (80%) > methanol (70%) > benzene (50%) > chloroform (40%), as assessed by the agar diffusion method (Kandhasamy et al., 2008). The antibacterial efficacy of acetone and ethanol extracts of *D. quercifolia* rhizome was further validated against urinary tract pathogens using the disc diffusion method, with amikacin serving as a standard.

The acetone extract was effective against *Enterococcus faecalis* (8 mm) and *Streptococcus pyogenes* (MZOI: 22 mm vs. 23 mm for amikacin), whereas the ethanol extract showed notable inhibition of *P. aeruginosa* (Mithraja et al., 2012). Similarly, methanolic extract of *D. quercifolia* rhizome displayed significant antibacterial activity against Gram-positive bacteria (*S. aureus*, *B. subtilis*, *S. pyogenes*; MIC: 0.31–1.25 mg/mL) and Gram-negative bacteria (*E. coli*, *P. aeruginosa*; MIC: 0.62–2.5 mg/mL), with *S. flexneri* being the least sensitive (Pandhy and Dash, 2015). Extending to other species, phytochemicals isolated from the ethanolic extract of *D. bonii* rhizome, including chrysophanol, nobiletin, protocatechualdehyde, isoliquiritigenin, rutin and drynaran, exhibited only minimal antimicrobial effects against fungi (*Fusarium oxysporum*, *Saccharomyces cerevisiae*, *Candida albicans*, *Aspergillus niger*) and bacteria (*B. subtilis*, *S. aureus*, *P. aeruginosa*, *E. coli*) with a MIC of 50 µg/mL (Trinh et al., 2015). In contrast, chloroform fractions of *D. fortunei* root showed stronger activity against periodontal pathogens (*Prevotella intermedia* and *Porphyromonas gingivalis*) in MIC/MBC checkerboard dilution and time-kill assays, with MIC/MBC values ranging from >39 to 2,500/5,000 µg/mL. The activity, although less potent than ampicillin or gentamicin (MIC/MBC: 0.25–64/0.25–64 µg/mL and 0.5–256/1–512 µg/mL, respectively), still highlighted significant antibacterial potential (Cha et al., 2017). Beyond antibacterial activity, *D. baronii* rhizome extracts, rich in flavonoids and phenolics, exhibited anti-HIV activity by inhibiting viral replication and key enzymes associated with HIV progression. The extract showed a CC_{50} of 263 µg/mL, an EC_{50} of 57 µg/mL and a selectivity index (SI) of 5, indicating mild anti-HIV potential and moderate protection against HIV-induced cytopathic effects (Chu et al., 2009).

Thrombolytic activity

The thrombolytic activity of various extracts of *Drynaria quercifolia* rhizome and fertile foliage was assessed using an *in vitro* clot lysis assay with human blood. Among the tested extracts, the methanolic extract of the rhizome exhibited the highest thrombolytic activity (38.34%), followed by the aqueous extract with moderate activity (33.32%). Fertile foliage extracts also demonstrated moderate thrombolytic potential (>25%), while the chloroform extract showed moderate activity in both rhizome and foliage (Chaity et al., 2016).

Antipyretic activity

Antipyretic activity of *Drynaria* species has been demonstrated in several experimental models. Petroleum ether and ethyl acetate fractions of *D. quercifolia* rhizome produced significant ($p < 0.05$) antipyretic effects in Wistar albino rats, reducing elevated rectal temperature after 3 hours by 38.5 ± 0.15% and 37.03 ± 0.16% at 40 mg/kg and by 88.9 ± 0.23% and 84.6 ± 0.20% at 80 mg/kg, respectively. These results were comparable to the standard drug aspirin (96.3 ± 0.10%) (Khan et al., 2007a). Similarly, methanolic extract of *D. quercifolia* rhizome exhibited dose-dependent antipyretic activity at 100, 250 and 500 mg/kg in Brewer's yeast-induced pyrexia in Wistar albino rats, with effects comparable to the standard drug paracetamol (200 mg/kg; 37.24 °C) (Janaranjani et al., 2014).

Anti-Inflammatory activity

The anti-inflammatory potential of *Drynaria* species has been extensively investigated through both *in vivo* and *in vitro* studies. Ethanolic extract of *D. quercifolia* rhizome demonstrated significant activity in Wistar albino rats, effectively inhibiting carrageenan-induced paw oedema and cotton pellet-induced granuloma formation in a dose-dependent manner, with inhibition rates of 80.00%, 83.53% and 85.88%, while the indomethacin-treated group exhibited maximum inhibition (88.24%) (Anuja et al., 2010). Similarly, methanolic extract of *D. quercifolia* rhizome produced notable anti-inflammatory effects at 2.5 hours, with paw oedema inhibition of 21%, 33% and 58% at doses of 100, 250 and 500 mg/kg b.w., respectively, compared to 40% inhibition observed with the standard drug dexamethasone (200 mg/kg b.w.) (Janaranjani et al., 2014). In another study, aqueous and methanolic extracts of *D. quercifolia* rhizome significantly reduced carrageenan-induced oedema in a dose-dependent manner ($p < 0.05$ and $p < 0.01$), with methanolic extract showing the highest activity at 150 mg/kg (Das et al., 2014). Further, methanolic extract of *D. quercifolia* demonstrated both *in vivo* and *in vitro* efficacy, with paw oedema reduction over 21

days (low and high dose groups recording 60.44 ± 1.44 mm and 58.39 ± 1.72 mm, respectively) and protein denaturation inhibition of 29 ± 6.34%, 39.6 ± 6.46% and 51.2 ± 4.41% at concentrations of 600, 800 and 1000 µg/ml (Modak et al., 2021). Beyond *D. quercifolia*, ethanolic extract of *D. fortunei* rhizome has also been evaluated for anti-inflammatory potential (Mani et al., 2024). Studies in RAW264.7 macrophages and SW1353 human chondrocytes revealed inhibition of 5-LO (85.78%) and COX-2 (56.64%), suppression of NO, LTB4 and PGE2 production, and downregulation of MMP-3 and MMP-9 in IL-1β-stimulated chondrocytes. These findings suggest a cartilage-protective effect, highlighting its potential application in osteoarthritis management (Lee and Kang, 2023).

Hepatoprotective activity

Total flavonoids of *D. fortunei* (TFRD, 125 mg/kg; Rutin 97.82%) demonstrated significant hepatoprotective activity against aflatoxin B1 (AFB1)-induced liver toxicity in chickens. Treatment with TFRD reduced intestinal permeability, enhanced villus height and goblet cell maturation by 59% and restored gut microbiota composition. Moreover, it protected hepatic tissue by modulating bile acid metabolism, while simultaneously suppressing oxidative stress, hepatic lipid accumulation and ferroptosis-related gene expression, thereby conferring protection against AFB1-induced hepatotoxicity (Huang et al., 2023).

Nephroprotective activity:

The flavonoid fraction (FF) of *Drynaria fortunei* (10 mg/kg) demonstrated significant nephroprotective activity in murine models of renal injury. In gentamicin- and mercuric chloride–induced acute renal failure as well as in 5/6-nephrectomized mice, FF treatment markedly reduced blood urea nitrogen (17.1 ± 1.0 vs. 22.7 ± 3.8 mg/dL) and serum creatinine levels (0.58 ± 0.09 vs. 0.68 ± 0.05 mg/dL). Moreover, it significantly improved survival time (116.8 ± 36.3 vs. 40.8 ± 6.9 days) and promoted tubular regeneration, indicating both functional and structural renal recovery (Long et al., 2005).

Neuropharmacological activity

The neuropharmacological potential of *Drynaria* species has been extensively investigated. Petroleum ether and ethyl acetate fractions of *D. quercifolia* rhizome exhibited significant central nervous system (CNS) depressant activity in mice, as evidenced by prolonged diazepam-induced sleep, delayed nikethamide-induced death, increased time spent in the dark, and enhanced immobility in a dose-dependent manner (50–200 mg/kg). Among the two, the petroleum ether fraction demonstrated greater potency, with no mortality observed even at 800 mg/kg, highlighting a favorable safety profile (Khan et al., 2009). An aqueous extract of *Drynaria fortunei* rhizomes was found to reverse Aβ25–35-induced axonal atrophy in cultured mouse cortical neurons (Yang et al., 2015). In a controlled cortical impact (CCI) rat model of traumatic brain injury (TBI), a decoction of *D. fortunei* rhizome (20 mg/kg, orally for 14–28 days) reduced brain damage by ~40%, improved memory and motor performance by ~35%, and alleviated anxiety and depression. The extract also modulated immune responses by downregulating pro-inflammatory IL-6 (~45%), upregulating anti-inflammatory IL-10 (~50%), restoring immune cell balance and attenuating pathological brain cell activation, with eriodictyol identified as a major bioactive constituent (Wang et al., 2016). Furthermore, fractions of *D. fortunei* rhizome were evaluated for acetylcholinesterase inhibitory activity through bio-guided fractionation using UPLC–MS/MS. The n-butanol fraction exhibited the strongest inhibitory effect (IC_{50} = 5.62 ± 0.23 µg/mL), outperforming petroleum ether (35.48 ± 9.93 µg/mL) and aqueous fractions (36.31 ± 3.68 µg/mL). Isolated flavonoid aglycones, including naringenin, eriodictyol, kaempferol and luteolin, showed markedly stronger inhibition (IC_{50} as low as 3.81 ± 0.21 µM for naringenin) compared to their glycosidic counterparts, such as astragalin, luteolin-7-O-β-D-glucoside, naringin and neoeriocitrin (Liu et al., 2020).

Immunological activity

The immunomodulatory potential of *Drynaria fortunei* was demonstrated through both cellular and humoral immune assays. In a delayed-type hypersensitivity (DTH) model, the extract produced a dose-dependent enhancement of immune responses in mice sensitized with sheep red blood cells (SRBC) and oxazolone. Humoral immunity was also stimulated, as evidenced by a

significant elevation in circulating antibody in SRBC-immunized mice. Hematological analysis revealed an increase in total WBC counts, further supporting its immunostimulatory activity. Moreover, in a cyclophosphamide-induced immunosuppression model, *D. fortunei* treatment effectively restored immune function, counteracting the suppressive effects of cyclophosphamide (Jeong et al., 2005).

Anti- obesity

The aqueous extract of *Drynaria fortunei* rhizome was evaluated for its anti-obesity potential in male C57BL/6 mice. After six weeks of treatment, the extract significantly reduced body weight, with a final mean weight of 31.85 ± 1.95 g compared to 35.50 ± 2.76 g observed in the high-fat diet (HFD) control group, demonstrating a notable weight-lowering effect (Gil et al., 2023).

Haematological studies

Haematological effects of *Drynaria* have also been investigated. Intraperitoneal administration of 3,4-dihydroxybenzoic acid, isolated from the ethanol extract of *D. quercifolia* rhizome, was evaluated in Swiss albino rats. The compound did not produce any significant alterations in haematological parameters compared to the control group. Specifically, RBC counts remained within normal ranges (control: 5.08 ± 0.07–5.16 ± 0.09; experimental: 5.10 ± 0.08–5.37 ± 0.12), while WBC counts were similarly unaffected (control: 5.86 ± 0.32–6.04 ± 0.28; experimental: 6.08 ± 0.21–6.19 ± 0.22). Platelet levels also showed no significant variation (Khan et al., 2007b).

Anti- arthritic activity

Species such as *Drynaria quercifolia* and *Drynaria fortunei* have demonstrated significant anti-arthritic potential through mechanisms involving the reduction of inflammation, protection of cartilage and promotion of bone repair. The ethanolic flavonoid extract of *D. fortunei* rhizome was evaluated in a Collagen-Induced Arthritis (CIA) model in Wistar rats, established via subcutaneous injection of bovine type II collagen. The treatment resulted in a significantly higher trabecular area percentage and trabecular number, along with a significantly reduced resolving power in comparison to the control group ($P < 0.05$) (Gao et al., 2013). Similarly, the aqueous extract of *D. quercifolia* (100 and 200 mg/kg body weight) produced a dose-dependent reduction in elevated enzyme levels ($P < 0.05$ to $P < 0.001$) relative to arthritic controls. Notably, this effect was comparable to indomethacin (2 mg/kg) in a model of arthritis induced by 0.1 ml of Freund's Complete Adjuvant (Sigma–Aldrich) (Saravanan et al., 2013).

Osteoblastic activity

Ethanolic extract of *Drynaria bonii* rhizome, fractionated into hexane, chloroform, ethyl acetate and methanol, demonstrated stimulatory effects on MG-63 osteoblastic cell proliferation, with the methanol fraction showing the highest activity, increasing proliferation by 6.16% at 0.01 mg/mL (Trinh et al., 2016). Subsequently, Trinh et al., (2020) isolated 24-methylen-cycloartan-3β-ol, triphyllol and protocatechuic acid from *D. bonii* rhizome, which enhanced MG-63 proliferation by 7.68–11.18% at 100 µg/mL in MTT assays. In parallel, flavonoid fractions of *D. fortunei* significantly promoted bone defect healing in rat bone marrow stromal cells (BMSCs) via the p38 MAPK pathway, with medium-dose treatment (0.22 $g \cdot kg^{-1} \cdot d^{-1}$) achieving optimal bone repair. This was evidenced by higher X-ray scores (~8–10 vs. ~4–5 in controls), BV/TV ratios (~40–50% vs. ~20–25%), 2–3-fold increases in osteoblast counts, ~70–80% reduction in fibrous tissue and marked upregulation of BMP-2 (~3–4-fold) and RUNX-2 (~2.5–3-fold). Enhanced BMSC proliferation, alkaline phosphatase (ALP) activity and mineralized nodule formation (~1.5–3-fold increases) further confirmed strong osteogenic potential (Sun et al., 2021). Total flavonoids of *D. fortunei* (TFDR) ameliorated glucocorticoid-induced osteoporosis (GIOP) in rats by significantly improving femoral bone mineral density (0.300 ± 0.023 g/cm^2, $p < 0.01$) and bone microarchitecture through upregulation of OC, OPG, BMP-2 and PINP (Zhang et al., 2022). Likewise, TFRD and its major flavonoids—neoeriocitrin, naringin and naringenin—enhanced IDG-SW3 cell viability by 20–30%, suppressed RANKL and SOST expression by 40–50% and improved trabecular bone parameters (BV/TV ↑15–25%, Tb.Th ↑10–20 µm, Tb.Sp ↓15–20 µm), along with 10–12% increases in bone mineral density, without hepatic or renal toxicity in osteoporotic rats (Jin et al., 2022). Supporting these results, TFRD (0.22 g/kg/day) significantly

improved bone remodeling in rat femoral defect models, promoting continuous bone formation, cortical bone reconstruction and increased expression of BMP-2, VEGF and CD31, thereby enhancing both osteogenesis and angiogenesis (Zhao et al., 2022). Combination therapy of TFRD with metformin in ovariectomized rats further improved bone quality, with ~15–20% increases in BMD, ~25% rise in BV/TV, ~20% increase in Tb. N and ~15% decrease in Tb.Sp, accompanied by ~30% elevation of serum PINP, ~35% reductions in CTX-1 and TRAP and ~20% improvement in femoral strength (Jiang et al., 2023). Most recently, TFRD was shown to enhance cranial bone repair in rat defect models, validated through micro-CT, histological, and ELISA analyses, with network pharmacology and molecular assays implicating TGF-β–mediated osteogenesis. Serum profiling identified 27 active compounds, while *in vitro* studies confirmed enhanced BMSC proliferation and differentiation (Zhao et al., 2024). Collectively, these findings highlight *D. bonii* and *D. fortunei* flavonoids as potent stimulators of osteoblast proliferation, osteogenesis and bone regeneration, supporting their potential as therapeutic agents for osteoporosis and bone defect repair.

Antioxidant activity

An aqueous extract of *Drynaria fortunei* rhizome was evaluated for its antioxidant potential against reactive oxygen species (ROS) in rat osteoblasts using a cytometric assay. The extract significantly reduced intracellular ROS levels in a concentration-dependent manner, showing reductions of 35% at 10 µg/mL ($p = 0.003$) and 50% at 100 µg/mL ($p = 0.001$) (Liu et al., 2001). Similarly, Chang et al., (2012) investigated the antioxidant activity of methanolic extract of *D. fortunei* rhizome using multiple in vitro assays. In the HRP–Luminol–H_2O_2 system, the extract exhibited strong activity with an IC_{50} of 2.9 ± 0.3 µg/mL. In contrast, moderate activity was observed in the $CuSO_4$–Phen–Vc–H_2O_2 assay (IC_{50} = 27.7 ± 1.0 µg/mL) and the Luminol–H_2O_2 assay (IC_{50} = 9.2 ± 2.5 µg/mL). In another study, Das et al., (2014) evaluated the antioxidant activity of methanolic and aqueous extracts of *D. quercifolia* rhizome using superoxide scavenging, DPPH radical scavenging and reducing power assays. The methanolic and aqueous extracts exhibited IC_{50} values of 42.93 µg and 67.20 µg for superoxide scavenging, 53.60 µg and 66.20 µg for DPPH radical scavenging and 42.83 µg and 41.05 µg for reducing power, respectively. Both extracts demonstrated dose-dependent activity, although their efficacy was lower compared to the standard ascorbic acid (IC_{50} = 4.30 µg). Furthermore, the methanolic extract of *D. quercifolia* rhizome demonstrated significant free radical scavenging activities. It showed potent DPPH (EC_{50} = 18.54 ± 0.70 µg/mL) and ABTS (EC_{50} = 29.80 ± 0.70 µg/mL) scavenging activity, along with notable hydroxyl radical (EC_{50} = 37.60 ± 0.41 µg/mL), nitric oxide (EC_{50} = 42.40 µg/mL) and hydrogen peroxide (EC_{50} = 32.80 ± 1.89 µg/mL) scavenging effects. These results were comparable to the standard antioxidant butylated hydroxytoluene (BHT) (Jinu et al., 2014). Consistently, Trinh et al., (2015) investigated the antioxidant potential of isolated compounds from the ethanolic extract of *D. bonii* rhizome using the DPPH radical scavenging assay. Protocatechuic acid, protocatechualdehyde and rutin exhibited strong antioxidant activities, with SC_{50} values of 13.12, 4.87 and 25.00 µg/mL, respectively. Prasanna and Anuradha (2015) demonstrated that the methanolic extract of *D. quercifolia* rhizome exhibited a dose-dependent antioxidant effect. In the DPPH radical scavenging assay, maximum inhibition of 49.58 ± 0.03% was observed at 150 µL, with lower activities of 22.71 ± 1.00% and 17.13 ± 0.16% at 100 µL and 50 µL, respectively. Similarly, the ferric reducing antioxidant power (FRAP) assay confirmed a concentration-dependent response, with the highest reducing activity at 300 µg (2.78 ± 0.01 µM/mg), followed by 200 µg (0.44 ± 0.005 µM/mg) and 100 µg (0.27 ± 0.01 µM/mg). Moreover, Tan and Lim (2015) investigated the antioxidant activities of methanolic extracts of rhizomes and fronds from *D. quercifolia*, *D. rigidula* and *D. sparsisora*. Among the tested samples, *D. quercifolia* fronds exhibited the highest total phenolic content (TPC: 2939 ± 469 mg GAE/100 g), free radical scavenging activity (FRS: IC_{50} = 0.09 mg/mL) and ferric reducing power (FRP: 17.5 mg GAE/g). In contrast, *D. sparsisora* rhizomes outperformed its fronds in FRS, while lipid peroxidation inhibition (LPI) remained comparable across all extracts (≥50%). The ferrous ion chelating (FIC) assay, however, revealed weak secondary antioxidant

activity in all species. Chaity et al., (2016) evaluated the antioxidant activity of methanolic and aqueous extracts from the rhizome and fertile foliage of *D. quercifolia*. In the DPPH assay, the aqueous rhizome fraction showed the highest activity (IC_{50} < 15 µg/mL) with an antioxidant activity index (AAI) of 1.77. In the H_2O_2 scavenging assay, the aqueous fractions of rhizome and foliage exhibited IC_{50} values of 77.36 ± 2.2 and 90.33 ± 4.1 µg/mL, respectively. The ABTS assay revealed the strongest activity in the aqueous rhizome fraction (IC_{50} = 23.29 ± 1.85 µg/mL), while the FRAP assay confirmed the highest reducing capacity in the same fraction (42.36 ± 1.36 µmol Fe^{2+}/g). Chu et al., (2009) evaluated the antioxidant activity of a herbal extract of *D. baronii* using electron-spin resonance spectroscopy. The extract demonstrated effective superoxide ion scavenging (IC_{50} = 40 µg/mL) and moderate hydroxyl radical scavenging (IC_{50} = 1500 µg/mL). Interestingly, it also enhanced the superoxide scavenging capacity of vitamin C.

Anticancer activity

The anticancer potential of *Drynaria* species has been explored through in vitro studies. An herbal extract of *D. baronii* exhibited weak cytotoxicity (CC_{50} > 400 µg/mL) against normal cell lines (HGF, HPC, HPLF) and tumor cell lines (HSC-2, HSC-3, HSC-4, Ca9-22, NA, T98G, HL-60), showing only slight tumor specificity. Its primary activity appeared to be free radical scavenging, as demonstrated by superoxide (IC_{50} = 40 µg/mL) and hydroxyl radical (IC_{50} = 1,200 µg/mL) inhibition, as well as enhanced synergistic scavenging with vitamin C. In addition, the extract displayed weak anti-HIV activity (SI = 5), suggesting that radical scavenging rather than direct cytotoxicity underlies its antitumor effect (Chu et al., 2009). Complementing these findings, an aqueous extract of *D. fortunei* rhizome demonstrated antiproliferative activity against breast cancer cells. Using CellTiter-Glo assay and cell cycle analysis, the extract dose-dependently reduced MDA-MB-231 cell viability, with maximum inhibition observed at 1,000 µg/mL. It further suppressed colony formation in soft agar at concentrations of 100–5,000 µg/mL and induced G1-phase cell cycle arrest at 300–800 µg/mL, highlighting its potential to inhibit cancer cell proliferation and tumorigenic capacity (Telang et al., 2024).

Cytotoxicity

The *Drynaria* genus has been extensively investigated for its cytotoxic and anticancer potential, with extracts and isolated compounds exhibiting apoptosis induction, proliferation suppression, and modulation of cancer-related pathways. Notably, the flavonoid fraction of *D. fortunei* protected against gentamycin-induced ototoxicity in guinea pigs by decreasing inner hair cell damage (2%, $p < 0.05$) and maintaining auditory thresholds comparable to controls (Long et al., 2004). Similarly, *D. fortunei* enhanced the proliferation of human osteo precursor cells (OPC-1) at concentrations of 10–120 µg/mL, with maximal stimulation observed at 120 µg/mL, although higher doses were inhibitory (Jeong et al., 2005). Acute toxicity assessments of *D. quercifolia* rhizome fractions (petroleum ether and ethyl acetate) revealed no mortality up to 800 mg/kg, supporting their safety profile (Khan et al., 2009). In cancer models, the isolated compound 20β-hydroxychiratan-22-one from *D. fortunei* exhibited strong cytotoxicity against Hela, PC-13 and HepG2 cells with IC_{50} values of 2.92, 1.08 and 2.45 µM, respectively (Liang et al., 2010a). Furthermore, nine compounds from *D. fortunei* rhizome, including naringin, neoeriocitrin, kaempferol, luteolin and protocatechuic acid, demonstrated neuroprotective effects by promoting PC12 cell proliferation under Aβ25–35-induced injury without exerting cytotoxicity (Wang et al., 2018). Likewise, ethanolic extracts of *D. fortunei* rhizome exhibited no cytotoxicity in RAW264.7 macrophages and SW1353 chondrocytes, maintaining >90% viability even at 100 µg/mL (Lee and Kang, 2023). In contrast, ethanolic extracts of *D. roosii* rhizome displayed notable cytotoxicity against multiple cancer cell lines (A549, HeLa, HepG2, MCF-7, HCT-116), with superior potency against HeLa cells (IC_{50} 0.06–0.34 µM), surpassing the standard drug adriamycin (IC_{50} 1.49 µM) and optically pure (+)-1 and (+)-2 enantiomers showing enhanced activity (Wufuer et al., 2022). Additionally, methanolic extracts of *D. quercifolia* leaves, fractionated into petroleum ether, carbon tetrachloride, chloroform and aqueous fractions, exhibited moderate cytotoxicity in the brine shrimp lethality assay, with LC_{50} values ranging from 7.61 to 15.83 µg/mL compared to the standard vincristine sulfate (Runa et al., 2013).

Collectively, these findings underscore the anticancer potential of *Drynaria* species, while also highlighting their selective cytotoxicity and favorable safety margins.

CONCLUSION

The *Drynaria* genus, predominantly distributed across Southeast Asia, particularly in China and India, comprises mostly epiphytic species thriving in warm and humid forest ecosystems. Traditionally, members of this genus have been employed in ethnomedicine for the treatment of osteoporosis, bone fractures, tuberculosis, rheumatic disorders and as stimulants for hair growth, often administered as decoctions or soups prepared from rhizomes and fronds. Phytochemical investigations reveal that *Drynaria* species, especially *D. fortunei*, *D. quercifolia* and *D. bonii*, are rich in flavonoids, phenols, triterpenoids, fatty acids, chromones, and sterols, with flavonoids being the major bioactive constituents. These compounds largely underpin the reported pharmacological properties, including anti-inflammatory, antioxidant, neuropharmacological, anticancer, cytotoxic and osteogenic effects. Importantly, *Drynaria* species have demonstrated a relatively safe therapeutic profile in preclinical studies, supporting their potential as candidates for herbal drug development. However, further clinical investigations are imperative to validate their efficacy, optimize dosage regimens and establish standardized formulations for human use. With growing global interest in natural medicine, *Drynaria* holds promise as a valuable source of effective phytotherapeutics for diverse health conditions.

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Author contributions
AVL was responsible for writing, data collection and compilation. SPD critically reviewed and revised the manuscript as required. SBP and PVP, MMA, SMP reviewed the manuscript. SAD provided supervision, technical guidance and final editing. All authors read and approved the final version of the manuscript.

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Declarations
Ethical statement
This study did not involve any experiments on human participants or animals conducted by the authors

Conflict of interest
All authors declare that they have no conflict of interest.

REFERENCES

Ahn, J. S., and Whang, W. K. (2023). The Development and Validation of Simultaneous Multi-Component Quantitative Analysis via HPLC–PDA Detection of 12 Secondary Metabolites Isolated from *Drynariae Rhizoma*. *Separations*, *10* (12), 601.

Anuja, G. I., Latha, P. G., Suja, S. R., Shyamal, S., Shine, V. J., Sini, S. and Rajasekharan, S. (2010). Anti-inflammatory and analgesic properties of *Drynaria quercifolia* (L.) J. Smith. *Journal of Ethnopharmacology*, *132* (2), 456-460.

Bensky, D., & Gamble, A. (1996). *Chinese herbal medicine: Materia medica*. Eastland Press, 2 (1), 1–1000.

Bhattacharya, S. (1990). *Chiranjib Banoushadi*. Calcutta, India: Anand Publishing Ltd., 10 (1), 223–226.

Cha, J. D., Jung, E. K., Choi, S. M., Lee, K. Y., and Kang, S. W. (2017). Antimicrobial activity of the chloroform fraction of *Drynaria fortunei* against oral pathogens. *Journal of oral science*, *59* (1), 31-38.

Chaity, F. R., Khatun, M., & Rahman, M. S. (2016). *In vitro* membrane stabilizing, thrombolytic and antioxidant potentials of *Drynaria quercifolia* L., a remedial plant of the Garo tribal people of

Bangladesh. *BMC complementary and alternative medicine*, *16*, 1-9.

Chang, C. L., Lin, C. S., & Lai, G. H. (2012). Phytochemical characteristics, free radical scavenging activities, and neuroprotection of five medicinal plant extracts. *Evidence-based Complementary and Alternative Medicine*, *2012* (1), 984295.

Chen, S. Q., Liang, W., Zhang, X. M., Li, X., Zhan, Z. L., Guo, L. P., and Gao, W. Y. (2021). Research progress on chemical compositions and pharmacological action of *Drynariae Rhizoma*. *Zhongguo Zhong Yao Za Zhi= Zhongguo Zhongyao Zazhi= China Journal of Chinese Materia Médica*, *46* (11), 2737-2745.

Christenhusz, M.J.M (2015) New combinations in Drynaria (Polypodiaceae subfam. Polypodioideae) Phytotaxa 230 (3): 299–300.*http://dx.doi.org/10.11646/phytotaxa.230.3.11*

Chu, Q., Satoh, K., Kanamoto, T., Terakubo, S., Nakashima, H., Wang, Q., and Sakagami, H. (2009). Antitumor potential of three herbal extracts against human oral squamous cell lines. *Anticancer Research*, *29* (8), 3211-3219.

Dang, Y., Xu, W., Song, Q., Huang, C., Wang, B., Chen, C., and Yang, Y. (2022). Quality characteristics of *Drynariae Rhizoma* from different origins based on multi-index component quantitative analysis. *Chinese Journal of New Drugs*, 31 (17)1736-1746.

Das, B., Choudhury, M. D., Dey, A., Talukdar, A. D., Nongalleima, K. H., and Deb, L. (2014). Antioxidant and anti-inflammatory activity of aqueous and methanolic extracts of rhizome part of *Drynaria quercifolia* (L.) J. Smith.) J. Smith. *International Journal of Pharmacy and Pharmaceutical Sciences,* 6 (6), 43-49., 6 (6), 43-49.

Gao, H. L., Xiao, L. B., Zhang, Z. F., Ouyang, G. L., Huang, X. X., Li, N. L., and Xie, J. (2013). Experimental study on effect of *rhizoma drynariae* flavone on bone destruction of collagen inducted arthritis rat. *Zhongguo gu Shang= China Journal of Orthopaedics and Traumatology*, *26* (9), 764-767.

Gil, T. Y., Park, J., Park, Y. J., Kim, H. J., Cominguez, D. C., and An, H. J. (2023). *Drynaria* rhizome water extract alleviates high-fat diet-induced obesity in mice. *Molecular Medicine Reports*, *29* (2), 30.

Han, L., Zheng, F., Zhang, Y., Liu, E., Li, W., Xia, M., and Gao, X. (2015). Triglyceride accumulation inhibitory effects of new chromone glycosides from *Drynaria fortunei*. *Natural product research*, *29* (18), 1703-1710.

Huang, S., Lin, L., Wang, S., Ding, W., Zhang, C., Shaukat, A., and Liu, F. (2023). Total flavonoids of *rhizoma drynariae* mitigates aflatoxin B1-induced liver toxicity in chickens via microbiota-gut-liver axis interaction mechanisms. *Antioxidants*, *12* (4), 819.

Irudayaraj, V., and Senthamarai, R. (2004). Pharmacognostical studies on a medicinal fern, *Drynaria quercifolia* (L.) J. Sm. (Polypodiaceae: Pteridophyta). *Phytomorphology*, *54* (3-4), 193-200.

Janaranjani, B., Prasanna, G., and Chitra, M. (2014). Anti-inflammatory and antipyretic activities of *Drynaria quercifolia* rhizome in rats. *International Journal of Pharmaceutical Sciences Review and Research,* 29 (1), 57-61.

Jeong, J. C., Lee, B. T., Yoon, C. H., Kim, H. M., and Kim, C. H. (2005). Effects of *Drynariae rhizoma* on the proliferation of human bone cells and the immunomodulatory activity. *Pharmacological research*, *51* (2), 125-136.

Jiang, N., Jin, H., Yang, K., Zhang, Z., Xu, W., Chen, X., and Xu, H. (2023). The mechanism of metformin combined with total flavonoids of *Rhizoma Drynariae* on ovariectomy-induced osteoporotic rats. *Biomedicine and Pharmacotherapy*, *165*, 115181.

Jin, H., Jiang, N., Xu, W., Zhang, Z., Yang, Y., Zhang, J., and Xu, H. (2022). Effect of Khan *and Pharmacotherapy*, *153*, 113379.

Jinu, U., Thayumanavan, T., Singh, T. B., & Sasikumar, J. M. (2014). In vitro antioxidant capacity of the fern, *Drynaria quercifolia* (L) SM, rhizome extract. *Int J Pharm Pharm Sci*, *6*(7), 413-416.

Jung, E. K. (2007). Antimicrobial activity of extract and fractions from *Drynaria fortunei against* oral bacteria. *Journal of Bacteriology and Virology*, *37*(2), 61-68.

Kandhasamy, M., Arunachalam, K. D., and Thatheyus, A. J. (2008). *Drynaria quercifolia* (L.) J. Sm: A potential resource for antibacterial activity. *African Journal of Microbiology Research*, *2*, 202-205.

Khan, A., Haque, E., Mukhlesur Rahman, M., Mosaddik, A., Abdul Alim Al-Bari, M., and Rahman, M. (2007a). Antipyretic activity of rhizome of *Drynaria quercifolia*. in rabbit. *Pharmaceutical biology*, *45*(4), 312-315.

Khan, A., Haque, E., Mukhlesur, R. M., Mosaddik, A., Rahman, M., & Sultana, N. (2007b). Isolation of antibacterial constituent from rhizome of *Drynaria quercifolia* and its sub-acute toxicological studies. *Journal of Faculty of Pharmaceutical Sciences.* 5 (4), 201-2011

Khan, A., Haque, E., Rahman, B. M., and Rahman, M. (2009). Neuropharmacological Effect of the Rhizome of *Drynaria quercifolia* in Mice. *Iranian journal of pharmacology and therapeutics,* 8 (1), 23-27.

Kirtikar, K. R., and Basu, B. D. (1994). *Indian medicinal plants*. Dehra Dun, India: Dehra Dun Publisher Ltd., 4 (2), 2745–2746.

Lee, S. G., and Kang, H. (2023). Anti-inflammatory and human chondrocyte protective effect of *Drynariae rhizoma* extract. *Tropical Journal of Pharmaceutical Research*, *22* (12).

Li, X. H., Xiong, Z. L., Yu, M., Lu, X., Yu, X., and Li, F. (2009). High performance liquid chromatographic fingerprints of ethanol and cyclohexane extracts of *Rhizoma Drynariae* and quantitative analysis of index components based on principal component analysis. *Chinese Journal of Chromatography*, *27* (4), 453-457.

Liang, Y. H., Wang, W., Yu, S. W., Ye, M., He, X. H., Gong, N. B., and Guo, D. A. (2010a). A new chiratane type triterpenoid from the rhizomes of *Drynaria fortunei*. *Fitoterapia*, *81* (8), 988-991.

Liang, Y. H., Ye, M., Zhang, L. Z., Li, H. F., Han, J., Wang, B. R., and Guo, D. A. (2010b). Two new phenolic acids from *Drynariae Rhizoma*. *Yao xue xue* bao= Acta Pharmaceutica Sinica, 45 (7), 874-878.

Liang, Y. H. (2011a). Lignans and flavonoids from rhizome of *Drynaria fortunei*. *Zhongcaoyao*, 25-30.

Liang, Y. H., Ye, M., Yang, W. Z., Qiao, X., Wang, Q., Yang, H. J., and Guo, D. A. (2011b). Flavan-3-ols from the rhizomes of *Drynaria fortunei*. *Phytochemistry*, *72* (14-15), 1876-1882.

Liu, S. Q., Xiao, Z. Y., and Feng, R. (1992). Chemical constituents of Drynaria *propinqua* (Wall) J. Sm. *Zhongguo Zhong yao za zhi= Zhongguo Zhongyao Zazhi= China Journal of Chinese Materia Medica*, *17* (12), 737-9.

Liu, S. Q., Xiao, Z. Y., and Feng, R. (1994). A flavonol glycoside from *Drynaria propinqua*.

Liu, Z., Lu, A., Zhang, Q. H., and Zhang, L. (1999). Research on petroleum ether extract of Rhizoma Drynariae. *Zhongguo Zhong yao za zhi= Zhongguo zhongyao zazhi= China journal of Chinese materia medica*, *24* (4), 222-255.

Liu, H.-C., Chen, R.-M., Jian, W.-C., and Lin, Y.-L. (2001). Cytotoxic and antioxidant effects of the water extract of the traditional Chinese herb Gusuibu (*Drynaria fortunei*) on rat osteoblasts. *Journal of the Formosan Medical Association, 100* (6), 383–388.

Liu, H., Zou, S., Qi, Y., Zhu, Y., Li, X., and Zhang, B. (2012). Quantitative determination of four compounds and fingerprint analysis in the rhizomes of *Drynaria fortunei* (Kunze) J. Sm. *Journal of natural medicines*, *66*, 413-419.

Liu, M. Y., Zeng, F., Shen, Y., Wang, Y. Y., Zhang, N., and Geng, F. (2020). Bioguided isolation and structure identification of acetylcholinesterase enzyme inhibitors from drynariae rhizome. *Journal of Analytical Methods in Chemistry*, *2020* (1), 2971841.

Long, M., Smouha, E. E., Qiu, D., Li, F., Johnson, F., and Luft, B. (2004). Flavanoid of *Drynaria fortunei* protects against gentamicin ototoxicity. *Phytotherapy Research: An International Journal Devoted to Pharmacological and Toxicological*

Evaluation of Natural Product Derivatives, *18* (8), 609-614.

Long, M., Qiu, D., Li, F., Johnson, F., and Luft, B. (2005). Flavonoid of *Drynaria fortunei* protects against acute renal failure. *Phytotherapy Research: An International Journal Devoted to Pharmacological and Toxicological Evaluation of Natural Product Derivatives*, *19* (5), 422-427.

Mani, H., Baisel, A., Ravikumar, M., Saravanakumar, R., Maheshwari, P., Vivek, P. and Romauld, S. (2024). Synergistic effect of plant extracts from *Delonix elata*, *Hygrophila auriculata*, and *Drynaria quercifolia* against inflammation. *Oxidation Communications, 47* (4).

Mithraja, M. J., Irudayaraj, V., Kiruba, S., and Jeeva, S. (2012). Antibacterial efficacy of *Drynaria quercifolia* (L.) J. Smith (Polypodiaceae) against clinically isolated urinary tract pathogens. *Asian Pacific Journal of Tropical Biomedicine*, *2* (1), S131-S135.

Modak, D., Paul, S., Sarkar, S., Thakur, S., & Bhattacharjee, S. (2021). Validating potent anti-inflammatory and anti-rheumatoid properties of *Drynaria quercifolia* rhizome methanolic extract through in vitro, in vivo, in silico and GC-MS-based profiling. *BMC complementary medicine and therapies*, *21*, 1-20.

Nugraha, A. S., Wangchuk, T., Willis, A. C., Haritakun, R., Sujadmiko, H., and Keller, P. A. (2019). Phytochemical and pharmacological studies on four Indonesian epiphytic medicinal plants: *Drynaria* rigidula, *Hydnophytum formicarum*, *Usnea misaminensis*, and *Calymperes schmidtii*. *Natural Product Communications*, *14* (6), 1934578X19856792.

Padhy, R., and Dash, S. K. (2015). Antibacterial evaluation of methanolic Rhizome extract from an in vivo and in vitro grown Pteridophyte, *Drynaria quercifolia* (Linn.) J. Smith. *Asian J Pharm Clin Res*, *8* (4), 130-138.

Pham, T. N. T., Mai, Đ. T., Huynh, T. M. N., & Le, T. D. (2015). Drybonioside, a new glucoside from the *Drynaria bonii* H. Christ Rhizomes. *Natural Product Research*, *29*(2), 137-140.

Prasanna, G., & Anuradha, R. (2015). Evaluation of in vitro antioxidant activity of rhizome extract of *Drynaria quercifolia* L. *International Journal of ChemTech Research*, *8*(11), 183-187.

Royal Botanic Gardens, Kew. (2025). *Drynaria* (Bory) J. Sm. Plants of the World Online. https://powo.science.kew.org/taxon/urn:lsid:ipni.org:names:328217-2

Ragavan, M. L., and Srinivasan, H. (2024). Therapeutic potential of dietary phytochemicals from *Drynaria quercifolia* to modulate gut microbiome: an in-silico approach. *Journal of Biomolecular Structure and Dynamics*, 42(21), 11508-11520.

Ramesh, N., Viswanathan, M. B., Saraswathy, A., Balakrishna, K., Brindha, P., and Lakshmanaperumalsamy, P. (2001). Phytochemical and antimicrobial studies on *Drynaria* quercifolia. *Fitoterapia*, *72*(8), 934-936.

Rawat, V. K. and Deroliya, P. K. (2024) Taxonomic study of the genus *Drynaria* (bory) j. Sm. (Polypodiaceae) in North-East India. Indian Fern J. 41(2): 239-248.

Runa, J. F., Hossain, M., Hasanuzzaman, M., and Ali, M. R. (2013). Investigation of phenolic profiles, cytotoxic potential and phytochemical screening of different extracts of *Drynaria quercifolia* J. Smith (leaves). *Advanced* Pharmaceutical Bulletin, 3(2), 465.

Saravanan, S., Mutheeswaran, S., Saravanan, M., Chellappandian, M., Paulraj, M. G., Raj, M. K., and Duraipandiyan, V. (2013). Ameliorative effect of *Drynaria quercifolia* (L.) J. Sm., an ethnomedicinal plant, in arthritic animals. Food and chemical toxicology, 51, 356-363.

Shang, Z. P., Meng, J. J., Zhao, Q. C., Su, M. Z., Luo, Z., Yang, L., and Tan, J. J. (2013). Two new chromone glycosides from *Drynaria fortunei*. *Fitoterapia*, *84*, 130-134.

Sui, H. F. (2015). Studies on chemical constituents of *Drynaria roosii*. *Zhongcaoyao*, 2992-2995.

Sun, W., Li, M., Xie, L., Mai, Z., Zhang, Y., Luo, L., and Jiang, Z. (2021). Exploring the mechanism of total flavonoids of

Drynariae rhizoma to improve large bone defects by network pharmacology and experimental assessment. *Frontiers in pharmacology*, *12*, 603734.

Tan, J. B. L., and Lim, Y. Y. (2015). Antioxidant and tyrosinase inhibition activity of the fertile fronds and rhizomes of three different *Drynaria* species. *BMC research notes*, *8*, 1-6.

Telang, N. T., Nair, H. B., & Wong, G. Y. (2024). Anti-proliferative effects of *Drynaria fortunei* in a model for triple negative breast cancer. *Oncology Letters*, *29* (2), 91.

Trinh, P. T. N., Tri, M. D., An, N. H., An, P. N., Minh, P. N., and Dung, L. T. (2015). Phenolic Compounds from the Rhizomes of *Drynaria bonii*. *Chemistry of Natural Compounds*, *51*, 476-479.

Trinh, P. T. N., Tri, M. D., Hien, D. C., An, N. H., Minh, P. N., An, P. N., and Dung, L. T. (2016). A new flavan from the *Drynaria bonii* H. Christ rhizomes. *Natural product research*, *30* (7), 761-767.

Trinh, P. T. N., Giang, B. L., Danh, T. T., Hung, Q. T., Van Du, C., and Tuan, N. T. (2020). Phytoconstituents of the rhizome of *Drynaria bonii* and the effect of phytoconstituents on the cell proliferation of osteoblast MG-63 cells. In *IOP Conference Series: Materials Science and Engineering* ,736 (2), 022079.

Wang, W., Li, H., Yu, J., Hong, M., Zhou, J., Zhu, L., and Wang, J. (2016). Protective effects of Chinese herbal medicine *Rhizoma drynariae* in rats after traumatic brain injury and identification of active compound. *Molecular neurobiology*, *53*, 4809-4820.

Wang F. J., Wang T. T., Xu M. Y., *et al*. (2018). Chemical constituents of *Drynaria Fortunei* and their protective effects on PC12 cell. *Chinese Pharmaceutical Journal*, 1359-1365.

Wu, X. A., and Zhao, Y. M. (2005). Isolation and indentification of chemical compounds from *Drynaria fortunei*. *Zhongguo Zhong yao za zhi= Zhongguo Zhongyao Zazhi= China Journal of Chinese Materia Medica*, *30*(6), 443-444.

Wufuer, H., Xu, Y., Wu, D., He, W., Wang, D., Zhu, W., and Wang, L. (2022). Liglaurates E, cytotoxic bis (lauric acid-12yl) lignanoates from the rhizomes of *Drynaria roosii* Nakaike. *Phytochemistry*, *198*, 113143.

Xu, Z. L., Xu, M. Y., Wang, H. T., Xu, Q. X., Liu, M. Y., Jia, C. P., and Zhang, N. (2018). Pharmacokinetics of eight flavonoids in rats assayed by UPLC-MS/MS after Oral Administration of Drynariae rhizoma extract. *Journal of Analytical Methods in Chemistry*, *2018*(1), 4789196.

Yang, Z. Y., Kuboyama, T., Kazuma, K., Konno, K., and Tohda, C. (2015). Active constituents from *Drynaria fortunei* rhizomes on the attenuation of Aβ25–35-induced axonal atrophy. *Journal of natural products*, *78* (9), 2297-2300.

Zhang, F., Li, Q., Wu, J., Ruan, H., Sun, C., Zhu, J., and Zhu, L. (2022). Total flavonoids of drynariae rhizoma improve glucocorticoid-induced osteoporosis of rats: UHPLC-MS-based qualitative analysis, network pharmacology strategy and pharmacodynamic validation. *Frontiers in endocrinology*, *13*, 920931.

Zhao, D., Fang, B., Yi, C., He, M., Zheng, J., and Li, Y. (2022). Effects of total flavonoids of *Rhizoma drynariae* on bone remodeling and expression of bone morphogenetic protein-2, vascular endothelial growth factor and CD31. *Chinese Journal of Tissue Engineering Research*, *26* (29), 4638.

Zhao, Y., Cai, X., Sun, J., Bi, W., and Yu, Y. (2024). Active components and mechanisms of total flavonoids from *Rhizoma Drynariae* in enhancing cranial bone regeneration: An investigation employing serum pharmacochemistry and network pharmacology approaches. *Journal of ethnopharmacology*, *319*, 117253.

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