Int. J. Pharm. Investigation, 2024; 14(2):273-288.
https://www.jpionline.org

Review Article

An Update on Medicinal Importance of the Plant: *Polygonum plebeium* R. Br.

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ABSTRACT

Polygonum plebeium R. Br. (Family: Polygonaceae) is commonly known as "small knotweed". It is used as a traditional medicine by many cultures across the world. In the rural communities of Shahjahanpur, Uttar Pradesh, it has long been practised to treat intestinal symptoms and pneumonia orally, while leaf powder combined with mishri is offered to treat menstruation disorders. It is abundantly found in the regions of Bangladesh, India, Pakistan, and Sri Lanka. It consists of numerous phytochemicals, such as alkaloids, essential oils, flavonoids, phenols, and tannins , and possesses a variety of pharmacological activities, including anticancer, anti-inflammatory, antioxidant, antinociceptive, cytoprotective, and neuroprotective effects. *P. plebeium* extract has a wide range of pharmacological properties and is used in the treatment of diarrhoea, eczema, inflammation, liver illness, and ringworm. In this review, a comprehensive and methodical search was performed in several prominent scientific databases, such as the Google Scholar, PubMed, Research Gate, Scopus, Science Direct, and Web of Science.

Keywords: *Polygonum plebeium*, Traditional uses, Phytoconstituents, Pharmacological effect.

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Received: 12-10-2023;
Revised: 18-12-2023;
Accepted: 03-02-2024.

INTRODUCTION

It is believed that more than 80% of the world's population prefers the use of herbal treatments for the treatment of basic ailments.[1] Over 60% of the globe's population uses traditional medicinal plants to treat various health conditions.[2] In poor countries, 80% of the population uses traditional medicinal plants for treatment of various illnesses. Herbal medicine enjoys widespread popularity globally, with particular prominence in South Asian countries such as India, Bangladesh, Pakistan, and Sri Lanka.[3] The use of herbal remedies has been widely advocated for the therapeutic management of several medical conditions. Plant resources are widely recognized as valuable natural materials for the advancement of innovative pharmaceuticals on a global scale. Herbal treatments are becoming more popular because people believe plants, being close to nature, are safer than synthetic drugs. Plants have several benefits over modern medicine, including their low cost, their ease of availability, and the fact that they cause less adverse reactions.[4] The importance of doing research in the field of medicinal plants lies in its potential to uncover new medicinal compounds derived from indigenous plant species that hold worldwide significance.[5] A diverse range of medicinal species are employed for their therapeutic properties in alleviating human ailments, as well as for applications in cosmetics, flavourings, essential oils, bittering agents, spices, sweetening agents, insect repellents, and colouring agents.[6]

Polygonum plebeium R.Br. (family: Polygonaceae), is commonly referred to as "small knotweed" in the English. The genus *Polygonum* consists of approximately 250 plant species, including both annual and perennial varieties. The plants have a broad distribution, ranging from northern temperate to tropical and subtropical regions. The plant flourishes in wet conditions, specifically in areas with low elevation near streams and rivers. *P. plebeium* is commonly observed in close proximity of rivers, canals, dried-up lakes, and cultivated rice fields. The growth of the plant is determined by the composition of clayey soil and the fluctuating levels of water logging it experiences annually.[7]

Pharmacognosy

Taxonomical classification

Root-Root

Kingdom-Plantae

Phylum-Tracheophyta

DOI: 10.5530/ijpi.14.2.35

Class-Magnoliopsida

Order-Polygonales

Family-Polygonaceae

Genus-*Polygonum*

Species-*Polygonum plebeium*

Vernacular name

P. plebeium has many different names that vary depending on the languages spoken in a specific geographical area. Here are the plant vernacular names used across Indian subcontinent (Table 1).

Botanical description

P. plebeium is a perennial herb, highly branched, that can reach a length of up to 30 cm. The stems and branches of woody plants are originating from a central base. The leaves are oblong, with a size range of 0.5-10 mm in length and 1.2-3.2 mm in width, and have smooth edges with lack of hairs. The nerves on the leaves are not prominent, and the petiole is sessile. The stipules are ciliate and have a whitish colour. Ochrea, which is a tubular sheath formed by the fusion of two stipules around a stem, measures 1-2 mm in length. It is membranous and has an ovate shape. The flowers are small, measuring approximately 0.2 mm in diameter. They are typically white, sometimes with a pinkish hue, and are found singly in the axils of the plant. They have flower-stalks that are 1.5 mm long during flowering and are typically surrounded by Ochrea. They measure approximately 1-2 mm in diameter and have very short stalks. The tepals of the plant have a total of five parts, with three outer tepals and two inner tepals. They are inverted-lance shaped, with unequal sizes. The outer tepals are slightly longer and pointed, while the inner tepals are blunter. The anther is ovoid, 2-celled, 0.2 mm long, and reddish in colour. The ovary is 3-gonous, measuring 0.5 mm in length and having a greenish colour. It is 1-loculed and contains only one ovule. The style is 3-fid, thick, and measures 0.2 mm in length. The stigma is terminal and subcapitate, appearing pinkish in colour. The net lets are sharply trigonous, measuring 0.1 mm in diameter, and possess a persistent style. They have a shiny and glabrous appearance. The stamens consist of five filaments that are long and have a broadened base, and they are all of equal length. The ovary is small and has a trigonous shape, characterized by three styles and capitate stigmas. The nuts are small, ranging from 1.0 to 1.75 mm in length. They have a circular to ovate shape and appear shiny, black, and devoid of hair. The period of flowering and fruiting occurs from October to March.[8]

Cultivation and Propagation

P. plebeium is favourably grown in conditions ranging from full sun to partial shade. The soil conditions in which this species grows are best when they are moist and cultivated, but they can tolerate some drought. This plant species also flourishes well-drained; with a maximum altitude range of 1250 m. Propagation commonly occurs through seed or root system division.

Distribution

P. plebeium is widely distributed across several regions of world, including Australia, Bangladesh, India, Pakistan, North America and Sri Lanka. The species is indigenous to Madagascar, Pakistan, Sri Lanka, and many regions in India, including Andhra Pradesh, Assam, Daman, Goa, Gujarat, Himachal Pradesh, Maharashtra, Orissa, Tamil Nadu, and West Bengal. It is distributed in India across a wide altitudinal range, spanning from sea level to approximately 2200 m in the Himalayan region.[7]

Traditional uses

P. plebeium is reportedly used as a famine food in the tribal communities of Bihar, Jharkhand, Uttar Pradesh, and Orissa. It locally known as a Muthisag in the state of Orissa, and is utilized for the treatment of pneumonia.[9] It has been utilized in the treatment of menstruation disorders with the administration of its leaf powder in combination with mishri.[10] *P. plebeium* powder is orally administered for the treatment of pneumonia and gastrointestinal disorders. The practice of using powdered substances has been observed among the native people of the Lakhimpur region in Assam.[11] In addition to their therapeutic applications for urinary infections and digestive disorders,

Table 1: The vernacular names associated with *P. plebeium*.

Country of origin	Vernacular names
India	Bengali: Chemti Sag, Khudi Bisakamtali, Mechuya Shaak, Raniphul; English: Small Knotweed; Gujarati: Zinako Okhrad; Hindi: Chimati Saag, Lal Buti, Machechi; Kachchhi: Ratanjot; Kannada: Kempu Nela Akki, Siranige Soppu; Malayalam: Peraraththa; Manipuri: Tarakman; Marathi: Gulabi Godhadi; Mizo: Bakhate; Nepali: Balune Saag, Bethe, Latte Jhaar, Masino Pire, Sukul Jhaar; Odia: Muthisag; Sanskrit: Sarpakshee, Sarpalochana; Telugu: Chimati Kura.
Bangladesh	Chemti sag, Dubia Sag, Anjaban.
Pakistan	Hind raani.

Table 2: Traditional uses of *Polygonum plebeium*.

Part used	Geographical region	Community of people	Traditional uses	References
Whole	Orissa	Ethnic people	Treatment of pneumonia	9
Whole	Bihar, Jharkhand, Uttar Pradesh, and Orissa	Tribal people	In the tribal cultures of Bihar, Jharkhand, Uttar Pradesh, and Orissa, it is utilised as famine food.	9
Leaf	Utter Pradesh	Rural people	In the rural parts of the Shahjahanpur district of Uttar Pradesh, leaf powder mix with mishri was used to treat menstrual issues.	10
Whole	Assam	Tribal people	The powdered form is taken orally to treat pneumonia and gastrointestinal issues.	9
Root	Tamil Nadu	Rural people in Sivagangi	Apply a paste derived from *P. plebeium* roots twice a day to minimise irritation.	14
Whole	Pakistani	Pakistan people	To cure ailments like ringworm, inflammation, diarrhoea, liver illness, and pneumonia, aqueous plant extracts are used as a tonic.	17,21
Whole	Punjab	Local communities	The root decoction, leaf extract, and whole powder paste have several applications both externally and internally, such as serving as liver tonics, treating pneumonia, relieving heartburn, and facilitating regular bowel movements.	18
Whole	Rajasthan	Tribal people	Plant ash and oil are applied as topical treatments for eczema. A medicinal infusion prepared from a plant species that alleviates colic-related irritation.	20

crushed leaves have been employed for the removal of dandruff from hair and as an ingredient in perfume formulations.[12,13] The rural population of Sivagangai, Tamil Nadu, India, has employed a paste obtained from the roots of *P. plebeium* that is applied twice daily to relieve inflammation.[14] The aqueous plant extracts from *P. plebeium*, also known locally as "Hind Raani" in the Kotli district of Pakistani, have long been used as a tonic to treat pneumonia and intestinal disorders. The whole plant extract is traditionally used for its analgesic, anthelmintic, astringent, and purgative. The plant's aqueous extract is used as a tonic in the treatment of respiratory infections like pneumonia and digestive problems like diarrhoea. The whole plant juice is preferred because it has expectorant, diuretic, and vasoconstrictive properties.[15,16] In Pakistan, people residing in rural areas have traditionally utilized certain remedies for addressing a range of health concerns, such as liver illness, inflammation, dysentery, eczema, and ringworm.[17] The communities residing near the Chenab River in Punjab province, Pakistan, have utilized 129 medicinal plants, including *P. plebeium*, for the treatment of various ailments. The traditional use of *P. plebeium* includes oral administration of decoction prepared from its root and shoot, as well as consumption of leaf extract and whole plant powder. These remedies are believed to be effective in treating conditions such as galactagogue, pneumonia, liver tonic, heartburn, and promoting regular bowel movements. Additionally, the external use of *P. plebeium* paste is used in the treatment of eczema.[18] A preparation made from powdered seeds and roots is frequently consumed orally as part of traditional African practices for treating digestive disorders.[19] The native group residing in the Shekhawati region of Rajasthan, India, has traditionally consumed a decoction prepared from the plant species for the purpose of alleviating colic inflammation. Additionally, they have employed a mixture of plant ash and oil and used them topically to treat cases of eczema.[20] The traditional uses of *P. plebeium* is mentioned in Table 2.

Phytochemical uses

P. plebeium extracts have not been adequately studied for the presence of different classes of phytochemical components. However, a few studies have reported different classes of phytochemical compounds present on *P. plebeium* plant parts, including its root, flower, leaves, and whole plant. These studies have shown that *P. plebeium* has a wide range of bioactive phytoconstituents and is considered an important source of bioactive phytoconstituents. The extracts of *P. plebeium* aerial parts were determined to be phytoconstituents and found to contain essential oils, alkaloids, tannins, and flavonoids.[21] The

Table 3: List of phytochemical compounds identified in methanolic extract of *P. plebeium* whole plant by UHPLC/MS and pharmacological activity

Class of the compound	Name of the compound	Molecular weight	Molecular formula	Pharmacological activity	Reference
Flavonoid	6-Methoxytaxifolin (1)	334.0689	$C_{16}H_{14}O_8$	Anti-inflammatory	36
	5-Hydroxy-7,2',3',4',5'-entamethoxyflavone(2)	388.1158	$C_{20}H_{20}O_8$	Not reported	
	Pongamoside A(24)	440.1107	$C_{23}H_{20}O_9$	Not reported	
	Isovitexin(26)	432.1056	$C_{21}H_{20}O_{10}$	Anti-oxidant, anti-cancer, anti-inflammatory, anti-hyperalgesia, and neuroprotective effects.	37
	Myricetin 3'-rhamnoside(27)	464.0955	$C_{21}H_{20}O_{12}$	Anti-mutagenic	
	6-Hydroxyluteolin 6-sulfate(28)	381.9995	$C_{15}H_{10}O_{10}$	Not reported	
	6-Hydroxyluteolin 5-rhamnoside(29)	448.1006	$C_{21}H_{20}O_{11}$	Not reported	
	Luteolin 4'-sulfate(30)	366.0046	$C_{15}H_{10}O_9$	Antioxidant	38
	Kaempferol 4'-rhamnoside(32)	432.1056	$C_{21}H_{20}O_{10}$	Antibacterial	39
	3,5,6,7-Tetrahydroxy-4'-methoxyflavone(33)	316.0583	$C_{16}H_{12}O_7$	Not reported	
	Ombuin(34)	330.0740	$C_{17}H_{14}O_7$	Anti-inflammatory and anti-fibrotic.	40
	Kaempferol(36)	286.0477	$C_{15}H_{10}O_6$	Antioxidant, anti-inflammatory, antimicrobial, anticancer, cardio-protective, neuroprotective, antidiabetic, anti-osteoporotic, anti-estrogenic, anxiolytic, analgesic and anti allergic.	41
	Quercetin(37)	302.0427	$C_{15}H_{10}O_7$	Decreasing blood pressure, anti-hyperlipidaemia, anti-hyperglycaemia, anti-oxidant, antiviral, anticancer, anti-inflammatory, anti-microbial, neuroprotective, and cardio-protective.	42
	Rhamnetin(38)	316.0583	$C_{16}H_{12}O_7$	Antioxidant, anticancer, anti-inflammatory, antiviral and antibacterial.	43
	Quercetin-3,4'-dimethyl ether(41)	330.0740	$C_{17}H_{14}O_7$	Not reported	
	7,3',4'-Trihydroxyflavone(50)	270.0528	$C_{15}H_{10}O_5$	Antioxidant and anti-inflammatory.	44
Phenolic	Norvisnagin(6)	216.0423	$C_{12}H_8O_4$	Not reported	
	6-Galloylglucose(17)	332.0743	$C_{13}H_{16}O_{10}$	Not reported	
	Gallic acid(18)	170.0215	$C_7H_6O_5$	Antioxidant, antimicrobial, anti-inflammatory, and anticancer.	45
	3,4-Dihydroxybenzoic acid/ Protocatechuic acid(19)	154.0266	$C_7H_6O_4$	Prevents oxidative stress, inflammation and cardiac hypertrophy.	46
	1,2-Digalloyl-β-D-glucopyranose(20)	484.0853	$C_{20}H_{20}O_{14}$	Not reported	
	Lucidin-primeveroside(21)	564.1479	$C_{26}H_{28}O_{14}$	Not reported	
	Lignicol(22)	240.0667	$C_{11}H_{12}O_6$	Not reported	
	Lyoniresinol 9'-sulfate(23)	500.1352	$C_{22}H_{28}O_{11}$	Not reported	

Class of the compound	Name of the compound	Molecular weight	Molecular formula	Pharmacological activity	Reference
	3,4-Methylenedioxybenzoic acid(25)	166.0266	$C_8H_6O_4$	Not reported	
	Propioveratrone(42)	194.0943	$C_{11}H_{14}O_3$	Anti-bacterial activity.	47
	Gingerol(44)	294.1831	$C_{17}H2_6O_4$	Anti proliferative, anti-tumor, invasive, and anti-inflammatory.	48
	[6]-Gingerdiol 3-acetate(51)	338.2093	$C_{19}H_{30}O_5$	Not reported	
Carboxylic acid	3-Hydroxyadipic acid(10)	162.0528	$C_6H_{10}O_5$	Not reported	
	Erythronic acid(12)	136.0372	$C_4H_8O_5$	Anti-inflammatory	49
	6,7-dihydroxy-4-oxo-2-heptenoic acid(14)	174.0528	$C_7H_{10}O_5$	Not reported	
	cis-4-octenedioic acid(31)	172.0736	$C_8H_{12}O_4$	Not reported	
	Chelidonic acid(35)	184.0008	$C_7H_4O_6$	Analgesic and anti-microbial, intestinal anti-inflammatory.	50
Phyto compound	Xanthene-9-carboxylic acid(3)	226.0630	$C_{14}H_{10}O_3$	Neuroprotector, antitumor, antimicrobial	51
	Coriandrone C(4)	246.0528	$C_{13}H_{10}O_5$	Not reported	
	1-Hydroxypentane-1,2,5-tricarboxylic acid(7)	220.0583	$C_8H_{12}O_7$	Not reported	
	5-Acetylamino-6-formylamino-3-methyluracil(8)	226.0702	$C_8H_{10}N_4O_4$	Not reported	
	Paraxanthine(9)	180.0647	$C_7H_8N_4O_2$	Psychostimulant	52
	1-Methylxanthine(11)	166.0491	$C_6H_6N_4O$	Anti-cancer	53
	Quinic acid(13)	192.0634	$C_7H_{12}O_6$	Antioxidant, anti-diabetic, anti-cancer, anti-microbial, anti-viral, antiaging, neuroprotective, anti-nociceptive and analgesic.	54
	2,4,6,3,5-Pentahyd roxycyclohexanone (15)	178.0477	$C_6H_{10}O_6$	Antibacterial	55
	2-Deoxy-2,3-dehydro-N-acetylneuraminic acid(16)	291.0954	$C_{11}H_{17}NO_8$	Anti-diabetic	56
	(6S)-dehydrovomifoliol(39)	222.1256	$C_{13}H_{18}O_3$	Not reported	
	3-Hydroxy-5,8-megastigmadien-7-one(45)	208.1463	$C_{13}H_{20}O_2$	Not reported	
Phenolic/ Flavan	Catechin 7-O-β-D-glucopyranoside(5)	452.1319	$C_{21}H_{24}O_{11}$	Antioxidant	57
Flavan/ Phenolic	Apigeniflavan(47)	258.0892	$C_{15}H_{14}O_4$	Pancreatic cancer, Antioxidant.	58,59
Flavone	5-Hydroxy-7,8,4'-trimethoxyflavanone(49)	330.1103	$C_{18}H_{18}O_6$	Not reported	
Steroid	Bufotalin(40)	444.2512	$C_{26}H_{36}O_6$	Anti-proliferative and antimetastatic.	60
Terpenoid	Ganoderic acid H(43)	572.2985	$C_{32}H_{44}O_9$	Anti-cancer	61
Amino acid	Methyldopa(46)	211.0845	$C_{10}H_{13}NO_4$	Anti-hypertensive	62
	L-Tyrosine methyl ester(48)	195.0895	$C_{10}H1_3NO_3$	Not reported	

Table 4: List of phytochemical compounds detected in *P. plebeium* flower and pharmacological activity.

Class of compound	Name of the compound	Molecular weight	Molecular formula	Pharmacological Activity	References
Triterpenoid	Epifriedlanol(3)	428.7	$C_{30}H_{52}O$	Not reported	
	Oleanolic acid(5)	456.7	$C_{30}H_{48}O_3$	Anti-diabetic, anti-viral, anti-HIV, antibacterial, anti-fungal, anti-carcinogenic, anti-inflammatory, hepatoprotective, gastro protective, hypolipidemic and anti-atherosclerotic, as well as interfering in several stages of the development of different types of cancer.	63
	Betulinic acid(2)	456.71	$C_{30}H_{48}O_3$	Anti-inflammatory, anti-bacterial, anti-viral, anti-diabetic, anti-malarial, anti-HIV and anti-tumor.	64
Flavonoid	Guaijaverine(4)	434.3	$C_{20}H_{18}O_{11}$	Anti-cancer, anti-diabetic, antioxidant, anti-diarrheal, anti-microbial, lipid-lowering, and hepatoprotection.	65
	Rutin(7)	610.521	$C_{27}H_{30}O_{16}$	Anti-oxidation, anti-inflammation, anti-diabetic, anti-adipogenic, neuroprotective and hormone therapy.	66
	Quercetin(6)	302.236	$C_{15}H_{10}O_7$	Anti-cancer, anti-oxidant, anti-inflammatory, anti-cardiovascular, anti-aging, and neuroprotective.	67
Phytosterol	β sitosterol(1)	414.718	$C_{29}H_{50}O$	Treatment of inflammatory diseases, such as rheumatoid arthritis, inflammatory bowel diseases, multiple sclerosis, asthma, and cardiovascular diseases.	68

roots of the plant, specifically, contain important compounds such as tannin and oxymethylanthraquinone.[19] The leaves of the 15 species were collected in the catchment areas of the river Beas, Punjab. A comparative study of the secondary metabolites was investigated, among which *P. plebeium* has the highest contents of phenols (31.56 mg/g) and also reports of flavonoids, xanthophylls, and lipids.[22] Phenolic compounds possessing antioxidant effects are currently being employed in the processed food sector as a commercial operation. Another studies showed that phenolic compounds are present in almost all parts of a plant and exhibit several health benefits. It has shown antioxidant activity against oxidative stress. It is used as a nutraceuticals and functional foods.[23,24] The plant's flavonoid constituents exhibit a diverse range of activity, covering cytoprotective, antioxidant, anti-inflammatory, anticancer, antinociceptive, and neuroprotective properties.[25] The presence of tannins has also been observed in the leaves of *P. plebeium*.[26] The estimation of secondary metabolite present in the methanol extract of *P. plebeium* whole plant and its fractions was carried out using the Folin-Ciocalteu method.[21] The ethyl acetate fraction of the plant exhibited the highest concentrations of phenolic (89.38 mg/g) and flavonoid (51.21 mg/g) compounds in this study. The reference compounds utilized in this study consisted of gallic acid and quercetin. The Ultra-Performance Liquid Chromatography-Mass Spectrometry (UHPLC/MS) technique was employed to evaluate the isolation phytochemical compound present in the methanolic extract of the whole plant of *P. plebeium*. This analysis led to the detection and identification of a total of 51 components. Figure 1 displays a full list of chemical compounds, along by their corresponding molecular structures.[32]

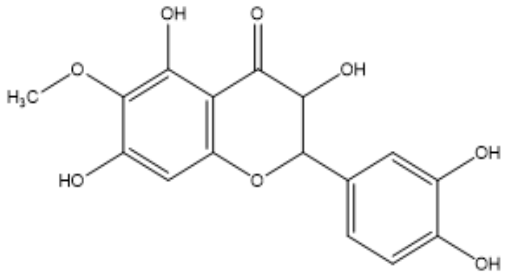
The main flavonoid components of *P. plebeium* extracts have been shown to be luteolin, isovitexin, and kaempferol derivatives. On the other hand, the principal phenolic components consist of gallic acid and its derivatives, protocatechuic acid, gingerols, and lyoniresinol 9'-sulfate.[32] A study was conducted on the flowers of *P. plebeium*, revealing the presence of seven phytochemical compounds. The phytochemical compounds included in this group are β-Sitosterol, Betulinic acid, Epifriedelanol, Guaijaverin, Oleanolic acid, Quercetin, and Rutin. Figure 2 lists major chemical compounds and their molecular structures.[27]

Mineral content

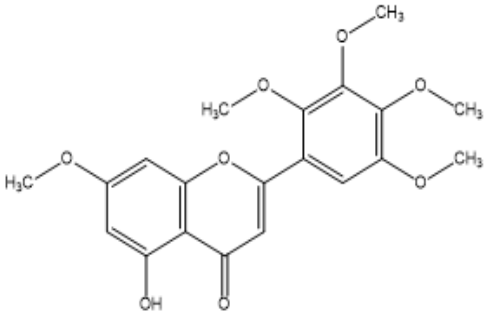
The leaves of *P. plebeium* are a good source of many different kinds of minerals; they are particularly rich in calcium, iron, magnesium, manganese, phosphorus, potassium, sulphur, and zinc. The study involved a comparative analysis of the mineral content in the leaves of 26 different species. It was observed that *P. plebeium* exhibited the highest potassium concentration (8.19

Table 5: Pharmacological activities of *Polygonum plebeium*.

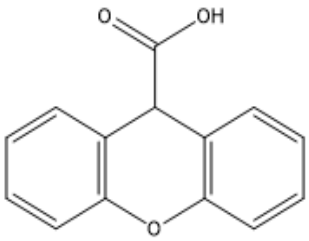
Activity	Part used	Model	Dose range	Method	Mechanism of action	Standard compound	Extract	References
Antibacterial activity	Leaves	*In vitro*	100, 50, 25 mg/mL	Agar diffusion	It inhibits the *Staphylococcus aureus.*		Ethyl acetate	29
	Leaves	*In vitro*	100, 50, 25, 12.5 and 6.2 mg/mL	Agar diffusion	It inhibits the *Pseudomonas aeruginosa.*		Ethanol	30
Anti-oxidant activity	Aerial part	*In vitro*		DPPH Nitric oxide Reducing power capacity.	It is polyphenolic and flavonoid constituents inhibit the scavenging of free radicals and the reduction of nitric oxide label, $Cu^{2+,}$ and Fe^{3+} ions.	Ascorbic acid, Gallic acid	Petroleum ether, Ethyl acetate, Methanol	21,32
Antidiabetic activity	Whole	*In vitro*		α-amylase and α-glucosidase assay.	The activity of the enzymes α-amylase and α-glucosidase are suppressed by the extract and fraction of *P. plebeium*.	Acarbose	Methanol	32
Anticholinesterase activity	Whole	*In vitro*		Cholinesterase assays	It has significant inhibitory against AChE and BChE.	Galantamine	Methanol	32
Tyrosinase activity	Whole	*In vitro*		Tyrosinase assay	The ethyl acetate fractions of *P. plebeium* exhibited the strongest anti-tyrosinase activity.	Kojic acid	Methanol	32
Cytotoxic activity	Aerial part	*In vitro*		Brine Shrimp lethality bioassay	The cytotoxic activity of *P. plebeium* may possibly be attributed to its polyphenolic and flavonoid components.	Vincristine sulphate	Petroleum ether, Ethyl acetate, Methanol	21
Anti-inflammatory activity	Whole	*In vivo*	250 mg/kg, 500 mg/kg	Carrageenan and egg albumin	The presence of *P. plebeium* secondary metabolites may be related to the inhibition of the synthesis and release of inflammatory mediators.	Ibuprofen	Methanol	34, 35
Hepatoprotective activity	Whole	*In vivo*	250 mg/kg	Carbon tetrachloride (CCl_4)	Anti-fibrotic effects are achieved by reducing α -smooth muscle actin (α-SMA), tumour growth factor beta (TGF-β), and collagen mRNA expression. Its alkaloid and flavonoid content have reduced liver inflammation and fibrosis.		Ethanol	35



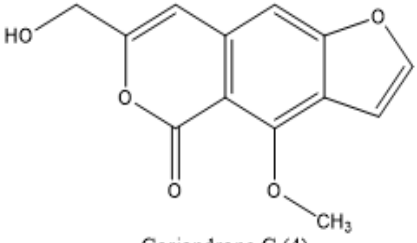
6-Methoxytaxifolin (1)



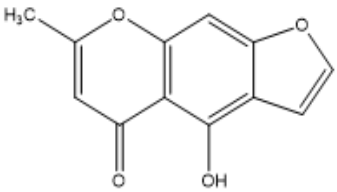
5-Hydroxy-7,2',3',4',5'-pentamethoxyflavone (2)



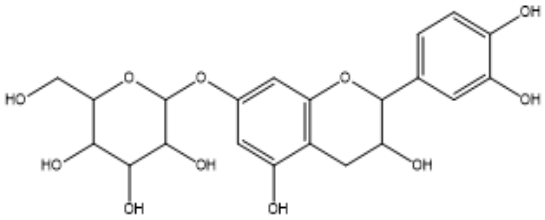
Xanthene-9-carboxylic acid (3)



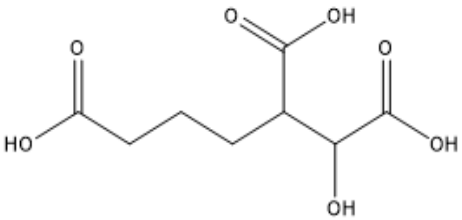
Coriandrone C (4)



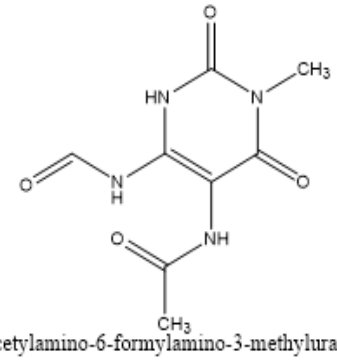
Norvisnagin (6)



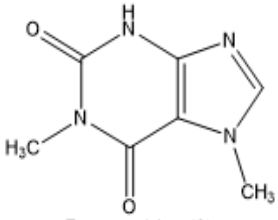
Catechin 7-O-β-D-glucopyranoside (5)



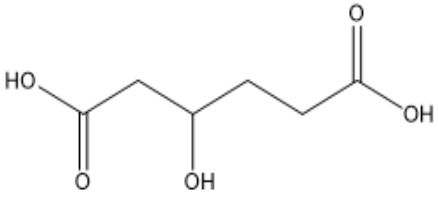
1-Hydroxypentane-1,2,5-tricarboxylic acid (7)



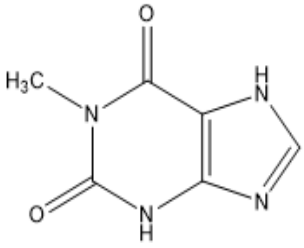
5-Acetylamino-6-formylamino-3-methyluracil (8)



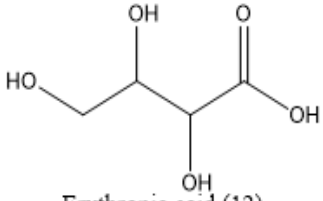
Paraxanthine (9)



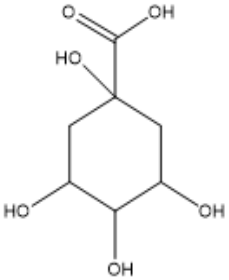
3-Hydroxyadipic acid (10)



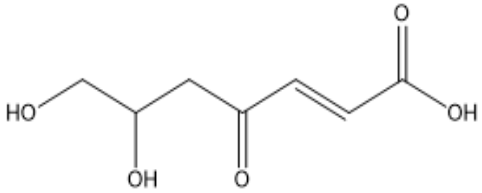
1-Methylxanthine (11)



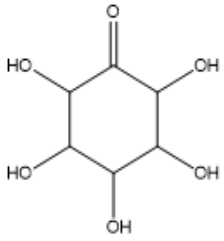
Erythronic acid (12)



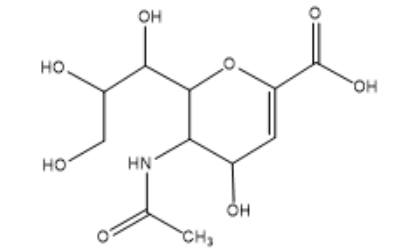
Quinic acid (13)



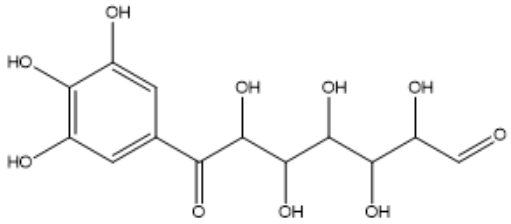
6,7-dihydroxy-4-oxo-2-heptenoic acid (14)



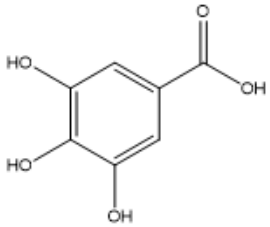
2,4,6,3,5-Pentahydroxycyclohexanone (15)



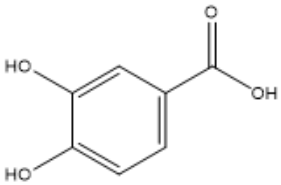
2-Deoxy-2,3-dehydro-N-acetylneuraminic acid (16)



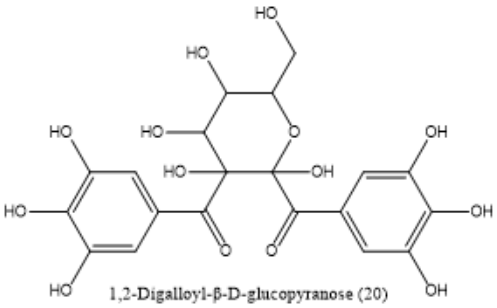
6-Galloylglucose (17)



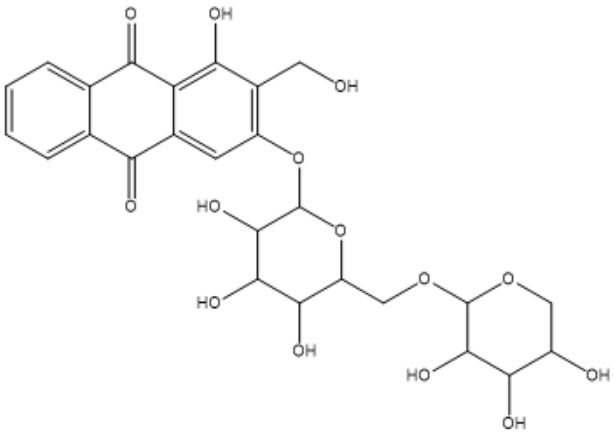
Gallic acid (18)



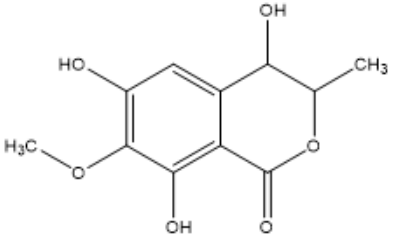
Protocatechuic acid (19)



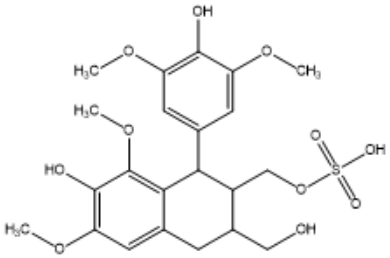
1,2-Digalloyl-β-D-glucopyranose (20)



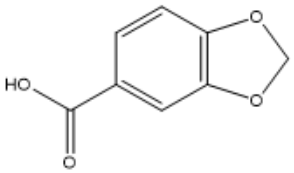
Lucidin-primeveroside (21)



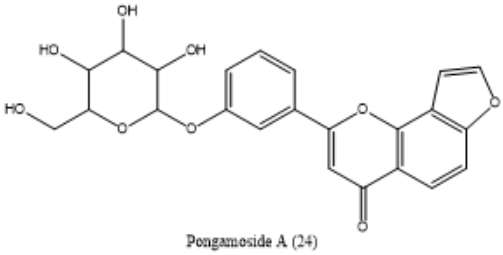
Lignicol (22)



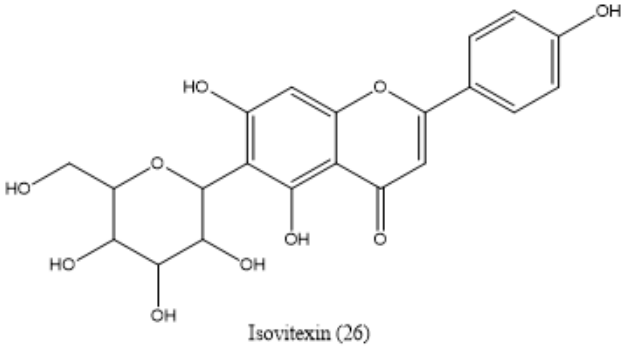
Lyoniresinol 9'-sulfate (23)



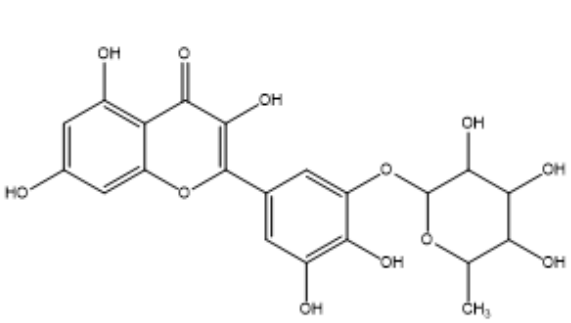
3,4-Methylenedioxybenzoic acid (25)



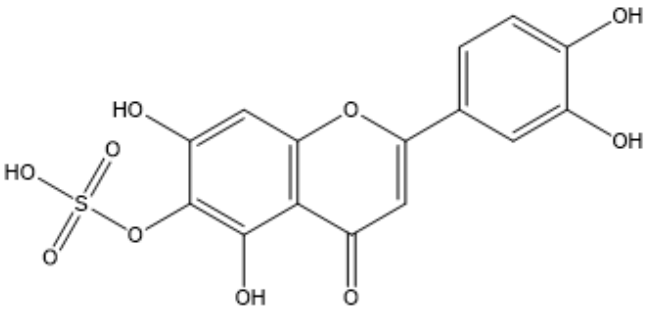
Pongamoside A (24)



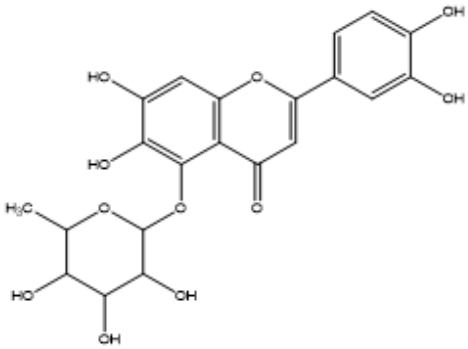
Isovitexin (26)



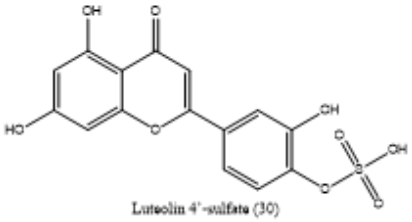
Myricetin 3'-rhamnoside (27)



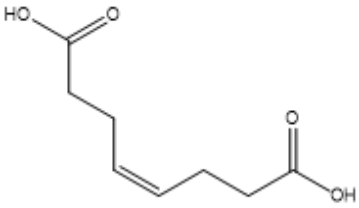
6-Hydroxyluteolin 6-sulfate (28)



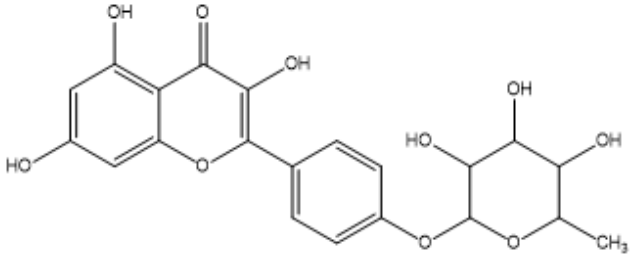
6-Hydroxyluteolin 5-rhamnoside (29)



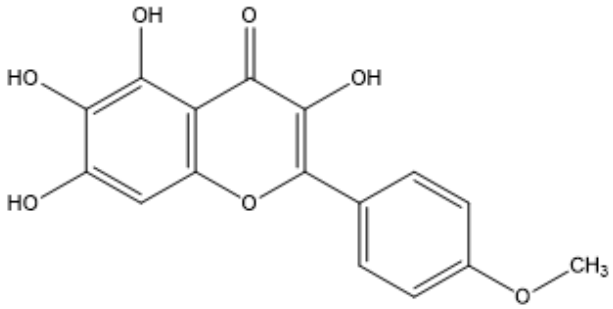
Luteolin 4'-sulfate (30)



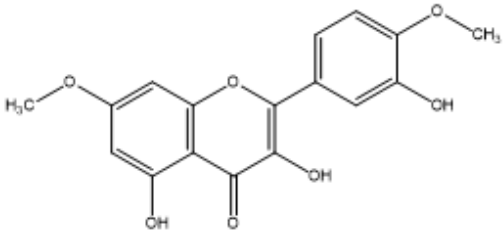
cis-4-octenedioic acid (31)



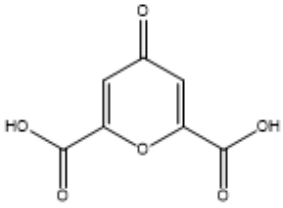
Kaempferol 4'-rhamnoside (32)



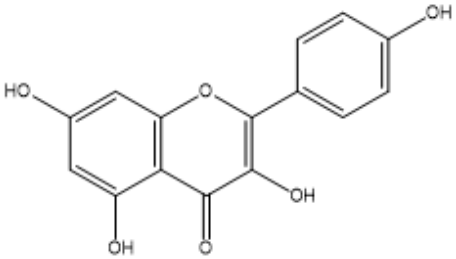
3,5,6,7-Tetrahydroxy-4'-methoxyflavone (33)



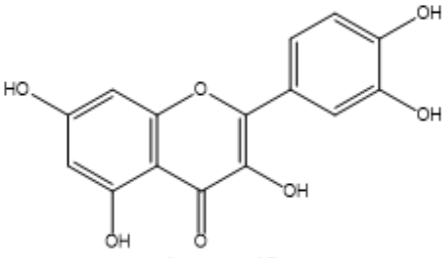
Ombuin (34)



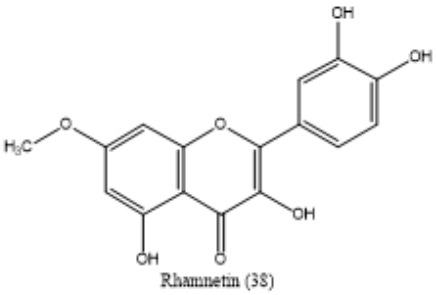
Chelidonic acid (35)



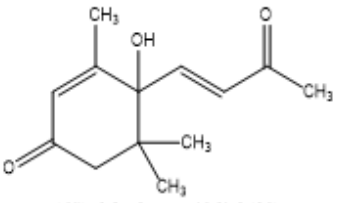
Kaempferol (36)



Quercetin (37)



Rhamnetin (38)



(6S)-dehydrovomifoliol (39)

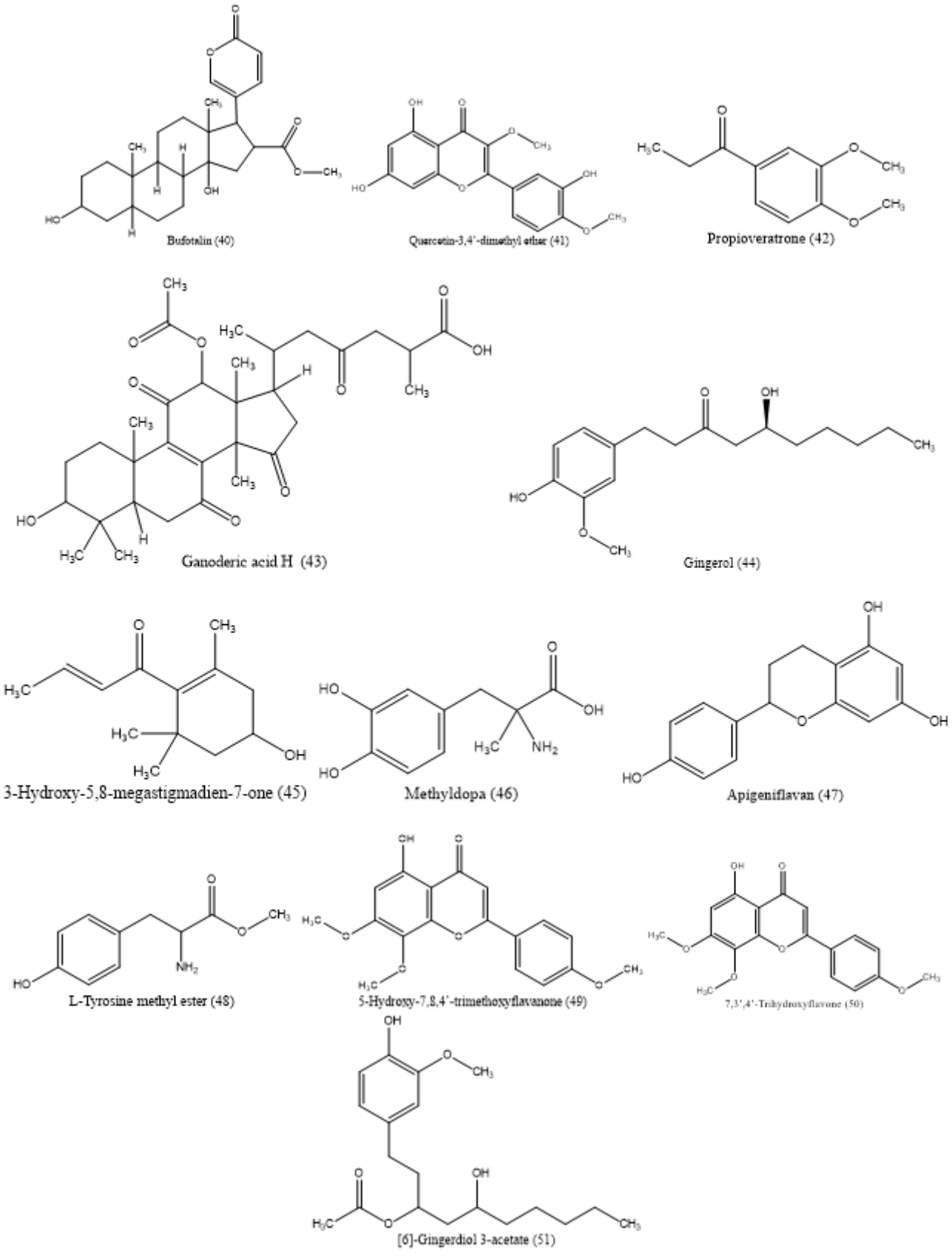


Figure 1: List of phytochemical compounds identified in methanolic extract of *P. plebeium* whole plant by UHPLC/MS.

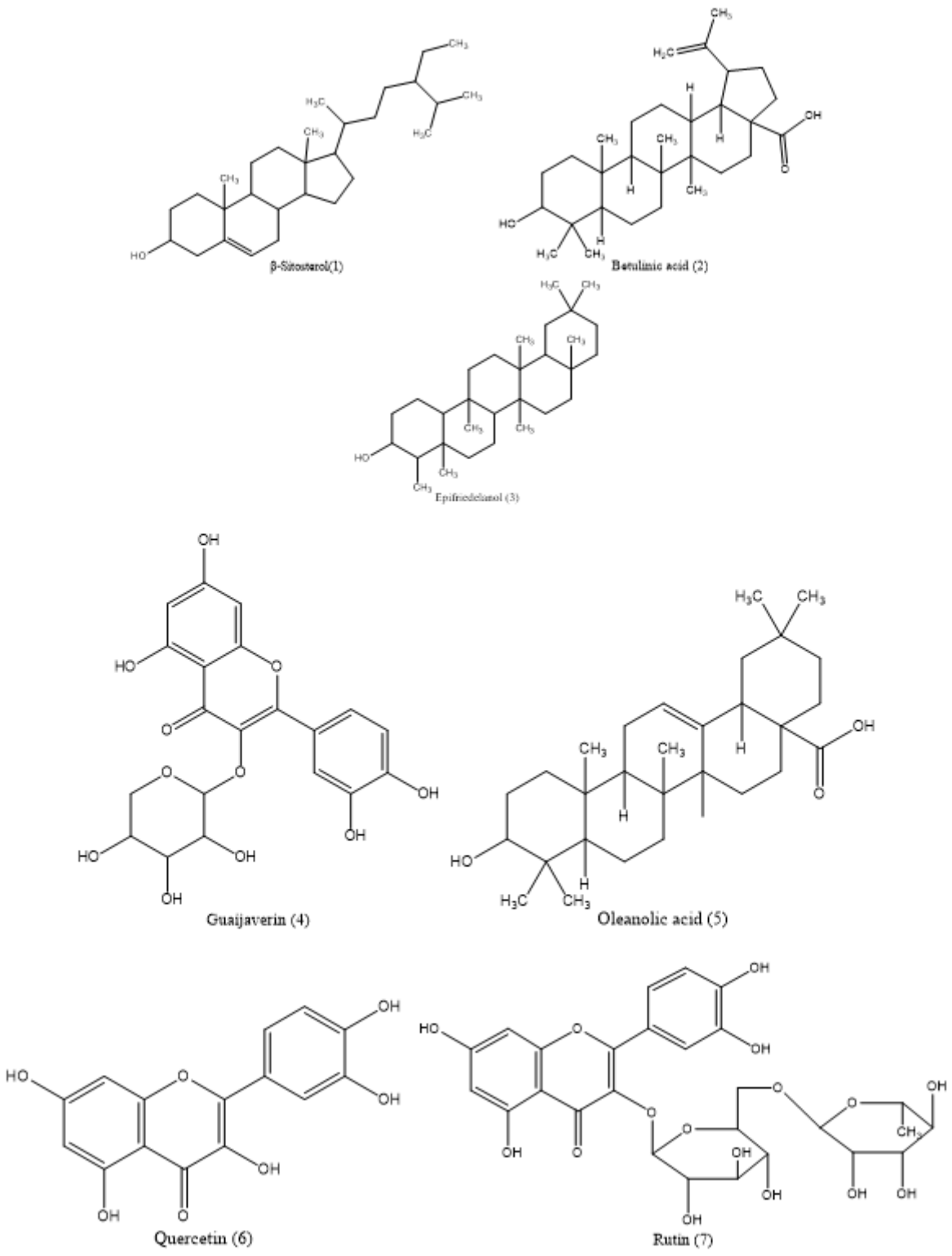


Figure 2: List of phytochemical compounds detected in *P. plebeium* flower.

mg/100 g) among all the species examined. A significant amount of minerals are contained in leaves, which have traditionally been used by indigenous people and tribes to optimize their health and food security.[27] The mineral composition of the whole plant extract was assessed using the proton-induced X-ray emission (PIXE) technique. During the analysis, the plant extract contains the minerals cobalt, copper, iron, manganese, vanadium, and zinc. The analysis also showed that the iron content had the

highest concentration (297.62 mg/L), followed by manganese, zinc, copper, and cobalt. On the other hand, vanadium was found to possess the lowest concentration (0.71 mg/L).[28] The phytochemical compounds and their pharmacological activities are mentioned in Tables 3 and 4.

Pharmacological activity

Antibacterial activity

The bacterial pathogen *Staphylococcus aureus* and *Pseudomonas aeruginosa* was isolated from a wound infection on the arm of a patient at Cleopatra Hospital in Cairo, Egypt. To assess its susceptibility, the pathogen was subjected to testing using solvent leaf extracts derived from *Euphorbia hirta* and *P. plebeium*. The study's findings revealed that the ethyl acetate extract from both plants exhibited possible antibacterial activity. To effectively combat *S. aureus* and *P. aeruginosa* resistance to bacterial infection, the phytochemical components of both plants worked synergistically.[29,30]

The use of plant extract with Silver Nanoparticles (Ag-NPs) synthesis is of particular interest because it is environmentally friendly and economical. Often, Ag-NPs are widely used in various sectors such as antibacterial research, wound healing processes, drug administration, bio sensing, cancer treatment, and solar radiation detection. The result of this study indicates that *P. plebeium*-derived Ag-NPs are more stable and have potential antibacterial action. The mechanistic approach of plant extracts with Ag-NPs is mediated by distinct pathways. Firstly, the attachment of Ag-NPs to the bacterial cell wall and membrane is followed by an increase in the rate of penetration and a modification of the signal transduction pathways. Finally, cellular-level toxicity and oxidative stress were reduced by constituents of plant extracts with Ag-NPs.[31]

Antioxidant activity

The methanol extract of *P. plebeium* and its various fractions, including hexane, ethyl acetate, and water are the subject of the investigation of its antioxidant activity. The aforementioned fraction had the strongest antioxidant capacity in the DPPH (2,2-diphenyl-1-picrylhydrazyl), ABTS (2,2-azino-bis (3-ethylbenzothiazoline-6-sulfonic acid), CUPRAC (CUPric Reducing Antioxidant Capacity), and FRAC (Ferrous reducing antioxidant capacity) assays as well. This difference was explained by the different concentrations of phenolics and flavonoids found in ethyl acetate and methanol compared to hexane and water extract. The correlation between the total amount of phenolic and flavonoid content in the extracts and their antioxidant activity is further supported by a Pearson correlation study.[32]

A study was conducted to determine the antioxidant activity of the aerial parts of *P. plebeium* using an *in vitro* technique. The results indicate that methanolic extracts exhibit the greatest level of free radical scavenging activity based on their IC_{50} value of 43.63 g/mL. The ethyl acetate extract had an IC_{50} value of 72.62 g/mL, which suggests that it was less effective at scavenging free radicals than the other extracts. The IC_{50} value of normal ascorbic acid, a commonly used antioxidant, was determined to be 18.34 g/mL. The methanolic and water extracts were found to be the most effective in scavenging nitric oxide. Researchers found that the concentrations of plant extracts increased reduction power, despite their low alkaloid content. Potential antioxidant activity was detected in the ethyl acetate and methanolic extracts. The supporting research for this study suggests that *P. plebeium* may have potential as a natural antioxidant.[21]

Anti-diabetic activity

The enzymes α-amylase and α-glucosidase are employed to provide antidiabetic effects *in vitro*. The highest result for the α-glucosidase inhibitory activity was found in water extract (1.78±0.01 mmol/g), however the highest value for the α-amylase inhibitory assay was found in hexane (0.49±0.01 mmol/g). Acarbose used as standard compound for evaluating the effect of antidiabetic activity. *P. plebeium* can be seen as a possible component to develop novel antidiabetic natural product-based medications.[32]

Anti-cholinesterase activity

The anticholinesterase-inhibiting activity of the methanolic extract of *P. plebeium* and its fractions, such as hexane, ethyl acetate, and water, was tested. The findings of the study indicate that the methanolic extract and its fraction exhibit significant inhibitory effects against Acetylcholinesterase (AChE) and Butyrylcholinesterase (BChE). When compared to the methanol extract (3.63 ± 0. 16 mg/g) and the ethylacetate fraction (3.45 ± 0.56 mg/g), the water fraction (4.03 ± 0.05 mg/g) is more effective against AChE. The hexane fraction has the lowest level of activity (3.35±0.12 mg/g) against Acetylcholinesterase (AChE). While, the hexane fraction had the higher activity against BChE, with a value of 5.62±0.27 mg/g, exceeding both the methanolic extract (1.47±0.06 mg/g) and the water fraction (0.89±0.08 mg/g) in terms of efficacy, the ethyl acetate fraction had no significant activity against Butyrylcholinesterase (BChE). The anticholinesterase inhibitory effect of the *P. plebeium* extract and its fraction towards AChE and BChE may be attributed to the presence of lipids, sterols, phenolics, and flavonoids components. Galantamine serves as a standard compound for evaluating the effects of anticholinesterases.[32]

Tyrosinase activity

The extract and fractions of *P. plebeium* exhibited anti-tyrosinase activity. In the study that was performed, several solvents were examined for their respective activities. Methanol (68.34±1.32mg/g), water (65.90±2.69mg/g), and hexane (activity not specified) showed relatively lower levels of activity. Conversely,

ethyl acetate displayed the highest level of activity, measuring at 71.89±1.44mg/g. The results of this investigation revealed that the components of the extracts had a synergistic impact. The extract and fractions of *P. plebeium* contain phytoconstituents suggest that have an impact on the reduction of melanin synthesis in the epidermis layer of the skin. The results of this study indicate that the phytochemicals found in *P. plebeium* might potentially be used in the formulation of skincare products. Kojic acid is often used as a pharmaceutical agent of reference.[32,33]

Cytotoxic activity

The cytotoxic properties *P. plebeium* of the aerial parts were investigated by using *in vitro* method. Petroleum ether, ethyl acetate, methanol, and water, were used to extract the plant's aerial parts. The extracts were also tested for their potential cytotoxicity using a Brine Shrimp lethality bioassay. Among the extracts tested in this study, water extract of the aerial part showed the greatest toxicity to Brine Shrimp nauplii, with a LC_{50} (Lethal concentration 50) value of 23.72 g/mL, while standard drug Vincristine sulphate had a LC_{50} value 2.47 g/mL. The order at which cytotoxic potential of the test samples decreased was as follows: Water extract>Petroleum ether extract>Methanolic extract>Ethyl acetate extract.[21]

Anti-inflammatory

A study was conducted to examine the anti-inflammatory properties of the methanolic extract derived from *P. plebeium* aerial parts. The efficacy of the plant's anti-inflammatory properties was assessed by *in vivo* through the method of carrageenan and egg albumin-induced rats paw oedema models. An evaluation of the plant's ability to suppress protein denaturation was conducted by quantifying the absorbance of the plant extract after treatment with bovine serum and egg albumin solutions. The methanolic extract of *P. plebeium* exhibited has demonstrated a dose-dependent inhibition of egg albumin and bovine serum albumin denaturation, with inhibitory rates of 72.9% and 67.5% respectively. In models of paw oedema induced by carrageenan and egg albumin, the plant extract significantly reduced inflammation rate of 48.7% and 40.63%. The results obtained from this investigation could potentially offer evidence of *P. plebeium* as a therapeutic intervention for inflammatory conditions. The possible anti-inflammatory activities of the *P. plebeium* methanolic extract may be partially elucidated by the presence of secondary metabolites, along with their precise mechanisms of action.[34]

Hepatoprotective activity

The hepatoprotective activity of *P. plebeium* whole plant extracts was examined in a rat model. According to a predetermined regimen, Carbon Tetrachloride (CCl_4) was administered intra peritoneally to cause liver fibrosis. CCl_4 is frequently employed in experimental research to investigate hepatic inflammation, fibrosis, and cirrhosis. The hepatoprotective efficacy of *P. plebeium* was assessed through the quantification of Alanine Transaminase (ALT), aspartate Aminotransferase (AST), and gamma-glutamyl trans peptidase (γGT) enzyme levels. The liver tissue was subjected to histological analysis, which confirmed the presence of implanted extracellular matrix and evidence of tissue necrosis. The mRNA expression of genes associated with liver fibrosis was assessed using real-time PCR. The result of the study indicates that the hepatoprotective properties of *P. plebeium* extracts mitigate liver injury generated by CCl_4 in a rat model. The aforementioned investigations collectively indicate that *P. plebeium* inhibits liver fibrosis due to its anti-inflammatory and antioxidant properties, which effectively interfere with and delay CCl_4-induced hepatic inflammation and fibrosis. This study provides evidence to endorse the utilisation of *P. plebeium* as a therapeutic intervention for individuals suffering from hepatic diseases and concomitant fibrotic conditions.[35] The pharmacological activities of *P. plebeium* shown in the Table 5.

CONCLUSION

Much scientific literatures focused on phytoconstituents and their pharmacological activity to find alternative treatments for a variety of medical conditions. According to the scientific data presented in the literature, several phytochemical components of *P. plebeium* have been used for therapeutic purposes in the management of ailments. The scientific literature presents evidence of the pharmacological activity shown by *P. plebeium*, including its hepatoprotective, antibacterial, cytotoxic, anti-inflammatory, and antioxidant. A diverse array of chemical components, including flavonoids, phenols, xanthophylls, alkaloids, tannins, and essential oils, were detected in the various plant samples. Additional research is required to determine the precise constituents accountable for those mentioned pharmacological effects. The previously mentioned results possess the potential to provide a basic framework for the execution of chemical, pharmacological, and biochemical research in the future, finally culminating in the discovery and advancement of innovative pharmaceutical substances. In the present context, it is crucial to investigate the phytochemical and pharmacological properties of these plants that have therapeutic relevance.

ACKNOWLEDGEMENT

The authors are thankful to the Shiksha 'O' Anusandhan Deemed to be University for providing continuous support and encouragement in the promotion of scientific works.

CONFLICT OF INTEREST

The authors declare that there is no conflict of interest.

ABBREVIATIONS

***P. plebeium*:** *Polygonum plebeium;* **UHPLC/MS:** Ultra-performance liquid chromatography-mass spectrometry; **PIXE:** Proton-induced X-ray emission; **Ag-NPs:** Silver nanoparticles**; DPPH:** 2,2-diphenyl-1-picrylhydrazyl; **ABTS:** 2,2-azino-bis (3-ethylbenzothiazoline-6-sulfonic acid); **CUPRAC** CUPric Reducing Antioxidant Capacity; **FRAC:** Ferrous reducing antioxidant capacity**; IC_{50}:**Half maximal inhibitory concentration**; AChE:** Acetylcholinesterase; **BChE:** Butyrylcholinesterase; **LC_{50}:** Lethal concentration 50; **CCl_4: C**arbon tetrachloride; **ALT:** Alanine transaminase; **AST:** Aspartate aminotransferase; **γGT:** Gamma-glutamyl trans peptidase; **PCR:** Polymerase chain reaction.

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Cite this article: Nayak S, Kar DM, Choudhury NSK, Dalai MK. An Update on Medicinal Importance of the Plant: *Polygonum plebeium* R. Br. Int. J. Pharm. Investigation. 2024;14(2):273-88.