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Unveiling The Potential of *Polygonum Plebeium*: From Folk Remedy to Functional Bioactive Resource

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Abstract: The review paper present comprehensive information regarding geographical distribution, habitat, botanical description, phytoconstituents, traditional uses and pharmacological activities of *Polygonum plebeium* polygonaceae family. It is a prostrate, densely branched, annual herb. It is used as edible herb as well as traditional medicine in India. It consists of numerous bioactive compounds such as alkaloids, essential oils, flavonoids, phenols and tannins. *Polygonum plebeium* used traditionally for the treatment of eczema, diarrhoea, liver disorder, inflammation and ringworm. Researchers reported their pharmacological work regarding medicinal potential of this herb. It possesses a variety of biological activity such as anticancer, anti-inflammatory, antioxidant, antinociceptive, cytoprotective, neuroprotective etc. Method was adopted to search literature about this herb in various websites, search engine and scientific databases such as Web of science, Scopus, Science Direct, Google Scholar, PubMed. There is a scope for further investigation regarding isolation of biomolecules, their efficiency and effectiveness. It requires proper study of the plants and biomolecules for their better utilization for development of herbal formulation and new dosage form in future in the field of Ayurveda.

Keywords: ***Polygonum plebeium*, Traditional uses, Phytoconstituents, Phytopharmacological screening**

I. INTRODUCTION:

It is widely believed that over 80% of the world's population prefers herbal remedies for treating common ailments, and more than 60% use traditional medicinal plants to address a range of health issues. In economically disadvantaged countries, around 80% of people depend on these natural treatments for various illnesses. Herbal medicine is extensively practiced worldwide, with notable prominence in South Asian nations like India, Bangladesh, Pakistan, and Sri Lanka. The therapeutic use of herbal remedies is strongly promoted for managing numerous medical conditions. Plant-based resources are increasingly valued as important natural ingredients in the global development of innovative pharmaceutical products.[1]

The growing popularity of herbal treatments is largely attributed to the belief that plant-based remedies, being more natural, are safer than synthetic medications. Compared to conventional drugs, medicinal plants offer several advantages, such as lower cost, greater accessibility, and fewer side effects. Research in the field of medicinal plants is crucial, as it holds the potential to discover new therapeutic compounds from native plant species with global relevance. A wide variety of medicinal plants are utilized not only for their healing properties in treating human illnesses but also in the production of cosmetics, flavourings, essential oils, spices, sweeteners, bittering agents, insect repellents, and natural colorants.

Polygonum plebeium R.Br., belonging to the family *Polygonaceae*, is commonly known as "small knotweed" in English. The *Polygonum* genus comprises around 250 species, encompassing both annual and perennial types. These plants are widely distributed, thriving in regions ranging from temperate zones to tropical and subtropical climates. *P. plebeium* typically grows in moist environments, particularly in low-lying areas adjacent to streams and rivers. It is frequently found near water bodies such as rivers, canals, dried lake beds, and in cultivated rice paddies. The plant's growth is influenced by the clay content of the soil and the seasonal variations in waterlogging conditions it encounters each year.

Pharmacognostic Classification (Taxonomy) of *Polygonum plebeium*:

- Kingdom: Plantae (Plant Kingdom)
- Phylum: Tracheophyta (Vascular plants)
- Class: Magnoliopsida (Dicotyledons)
- Order: Polygonales
- Family: Polygonaceae (Knotweed family)
- Genus: *Polygonum*
- Species: *Polygonum plebeium*[9]

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Geographical source:
Polygonum plebeium is widely distributed across various parts of the world, including Australia, Bangladesh, India, Pakistan, North America, and Sri Lanka. It is native to regions such as Madagascar, Pakistan, Sri Lanka, and several states in India, including Andhra Pradesh, Assam, Daman, Goa, Gujarat, Himachal Pradesh, Maharashtra, Odisha, Tamil Nadu, and West Bengal. In India, the species is found across a broad altitudinal range, from coastal areas at sea level up to elevations of around 2200 meters in the Himalayan region.[1,2]

(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.

Cultivation and Propagation:
Polygonum plebeium thrives in environments ranging from full sunlight to partial shade. It prefers moist, cultivated soils but is also capable of withstanding periods of drought. The plant grows well in well-drained soil conditions and is typically found at elevations up to 1250 meters. Propagation generally takes place through seeds or by dividing the root system.[21]

Botanical description:
Polygonum plebeium is a highly branched perennial herb that can grow up to 30 cm in length. Its stems and branches are woody at the base, emerging from a central point. The leaves are oblong in shape, measuring between 0.5 to 10 mm in length and 1.2 to 3.2 mm in width. They have smooth, hairless edges, and their veins are not distinctly visible. The leaves are sessile, lacking a petiole. The stipules are white and fringed with fine hairs (ciliate).[3]
The plant features an ochrea a thin, membranous, ovate sheath formed by the fusion of two stipules around the stem which is 1–2 mm long. The flowers are minute, about 0.2 mm in diameter, usually white with occasional pinkish tones, and occur singly in the leaf axils. These flowers are borne on short stalks about 1.5 mm long, typically enclosed by the ochrea. Flower diameters range from 1–2 mm, supported by very short pedicels.[3]
The flower contains five tepals arranged in two whorls: three outer and two inner. The tepals are inverted-lanceolate and vary in size, with the outer ones being slightly longer and pointed, while the inner ones are shorter and blunter. The anthers are reddish, ovoid, two-celled, and measure around 0.2 mm in length. The ovary is three-angled (trigonous), green, one-chambered, 0.5 mm long, and houses a single ovule. It is topped with a thick, three-lobed (3-fid) style that is about 0.2 mm long. The stigma is terminal, sub capitate, and pinkish in colour.
The plant produces sharply three-angled nutlets that are about 0.1 mm in diameter, shiny, hairless, and retain the persistent style. The stamens are made up of five filaments, all equal in length, with broadened bases. The ovary is small, trigonous, with three styles and rounded stigmas. The nuts are glossy, black, hairless, and measure between 1.0 to 1.75 mm in length, typically circular to ovate in shape.[1,3]

Traditional uses:
Polygonum plebeium has been traditionally used as a famine food by tribal communities in the Indian states of Bihar, Jharkhand, Uttar Pradesh, and Odisha. In Odisha, it is locally known as "Muthisag" and is used to treat pneumonia. Leaf powder mixed with *mishri* (crystallized sugar) is traditionally administered to manage menstrual disorders. The powdered form of *P. plebeium* is also taken orally to treat pneumonia and gastrointestinal conditions, a practice observed among indigenous groups in Assam's Lakhimpur region.[4]
Beyond its internal medicinal uses for urinary tract infections and digestive issues, the crushed leaves are applied to eliminate dandruff and are also included in local perfume preparations. In Sivagangai, Tamil Nadu, rural populations apply a root-based paste topically, twice daily, to reduce inflammation.
In the Kotli district of Pakistan, where it is locally referred to as "Hind Raani," the plant's aqueous extracts have long been used as a tonic for pneumonia

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and intestinal disorders. The entire plant is traditionally employed for its analgesic, astringent, anthelmintic, and purgative properties. Its juice is particularly valued for being an expectorant, diuretic, and vasoconstrictor.

In rural areas of Pakistan, *P. plebeium* is part of traditional remedies used to treat liver diseases, inflammation, dysentery, eczema, and ringworm. Among communities near the Chenab River in Punjab province, it is one of 129 medicinal plants used to treat various health problems. Traditional applications include oral use of root and shoot decoctions, leaf extract, and whole plant powder to treat conditions such as pneumonia, liver ailments, indigestion, and to support lactation and bowel regularity. A topical paste is also used to treat eczema.[18]

In African traditional medicine, powdered seeds and roots of *P. plebeium* are taken orally to relieve digestive disorders. Meanwhile, in the Shekhawati region of Rajasthan, India, a decoction made from the plant is consumed to ease colic inflammation. Additionally, a topical application made from plant ash mixed with oil is used to manage eczema. [20]

Table 2: Traditional uses of *Polygonum plebeium*.

Plant Part	Geographical region	Traditional Uses
Whole	Odisha	Treatment of pneumonia
Leaf	Bihar, Jharkhand, Uttar Pradesh and Odisha	In the tribal cultures of Bihar, Jharkhand, Uttar Pradesh, and Orissa, it is utilised as famine food.
Whole	Uttar Pradesh	In the rural parts of the Shahjahanpur district of Uttar Pradesh, leaf powder mix with mishri was used to treat menstrual issues.
Root	Assam	The powdered form is taken orally to treat pneumonia and gastrointestinal issues.
Whole	Tamil Nadu	Apply a paste derived from *P. plebeium* roots twice a day to minimise irritation.
Whole	Punjab	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.
Whole	Rajasthan	Plant ash and oil are applied as topical treatments for eczema. A medicinal infusion prepared from a plant species that alleviates colic-related irritation.

Phytochemical use:

The phytochemical profile of *Polygonum plebeium* has not yet been thoroughly explored. However, limited research has identified various classes of phytochemical compounds in different parts of the plant, including the roots, flowers, leaves, and the whole plant. These preliminary findings suggest that *P. plebeium* contains a diverse array of bioactive constituents and holds potential as a significant source of medicinally valuable phytochemicals. Studies on the aerial parts of the plant have revealed the presence of essential oils, alkaloids, tannins, and flavonoids. Specifically, the roots of *P. plebeium* have also been found to contain unique Although the phytochemical composition of *Polygonum plebeium* is not yet fully characterized, existing research indicates that the plant contains significant bioactive compounds. The roots are reported to contain tannins and oxymethylanthraquinone. In a study conducted in the Beas River catchment area of Punjab, leaves from 15 plant species were analysed for secondary metabolites, with *P. plebeium* displaying the highest phenolic content (31.56 mg/g), along with notable levels of flavonoids, xanthophylls, and lipids.[6]

Phenolic compounds, known for their antioxidant properties, are widely used in the food industry and are present throughout the plant. These compounds offer numerous health benefits, including combating oxidative stress, and are commonly incorporated into nutraceuticals and functional foods. The flavonoids in *P. plebeium* demonstrate a broad range of biological activities, such as cytoprotective, antioxidant, anti-inflammatory, anticancer, antinociceptive, and neuroprotective effects. Tannins have also been detected in the leaves.

Quantitative analysis of secondary metabolites in methanolic extracts of the whole plant

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and its fractions was performed using the Folin–Ciocalteu method. The ethyl acetate fraction showed the highest phenolic (89.38 mg/g) and flavonoid (51.21 mg/g) content, using gallic acid and quercetin as reference standards.

The primary flavonoids identified include luteolin, isovitexin, and kaempferol derivatives, while the major phenolic compounds consist of gallic acid and its derivatives, protocatechuic acid, gingerols, and lyoniresinol 9'-sulfate. Additional analysis of *P. plebeium* flowers revealed the presence of seven phytochemicals: β-sitosterol, botulinic acid, epifriedelanol, guaijaverin, oleanolic acid and quercetin.

Table -3 List of phytochemical compounds in methanolic extract of *P. plebeium* (whole plant) and their pharmacological activity

Phytochemical compound	Name of the compound	Pharmacological activity	Reference
Flavonoid	6-Methoxytaxifolin	Anti-inflammatory	10,11
	Isovitexin	Anti-oxidant, anti-cancer, anti-inflammatory, anti-hyperalgesia, and neuroprotective effects	
	Ombuin	Anti-inflammatory and anti-fibrotic	
	Luteolin-4'-sulfate	Antioxidant	
	Kaempferol	Antioxidant, anti-inflammatory, antimicrobial, anticancer, cardio-protective, neuroprotective, antidiabetic, anti-osteoporotic, anti-estrogenic, anxiolytic, analgesic and anti-allergic	
	Quercetin	Decreasing blood pressure, anti-hyperlipidaemia, anti-hyperglycaemia, anti-oxidant, antiviral, anticancer, anti-inflammatory, anti-microbial, neuroprotective, and cardio-protective	
	Rhamnetin	Antioxidant, anticancer, anti-inflammatory, antiviral and antibacterial	
Steroid	Bufotalin	Anti-proliferative and antimetastatic	13
Terpenoid	Ganoderic acid	Anti-cancer	14
Amino acid	Methyldopa	Anti-hypertensive	15
Triterpenoid	Oleanolic acid	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	14
Phytosterol	β-sitosterol	Treatment of inflammatory diseases, such as rheumatoid arthritis, inflammatory bowel diseases, multiple sclerosis, asthma, and cardiovascular diseases	16
Phenolic	Gallic acid	Antioxidant, antimicrobial, anti-inflammatory, and anticancer	6,22
	Protocatechuic acid	Prevents oxidative stress, inflammation and cardiac hypertrophy	
	Propioveratrone	Anti-bacterial activity	
	Gingerol	Anti proliferative, anti-tumour, invasive, and anti-inflammatory	
	Erythronic acid	Anti-inflammatory	17

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Carboxylic acid	Chelidonic acid	Analgesic and anti-microbial, intestinal anti-inflammatory	
	Xanthene-9-carboxylic acid	Neuroprotector, antitumor, antimicrobial	
	Paraxanthine	Psychostimulant	
	Quinic acid	Antioxidant, anti-diabetic, anti-cancer, anti-microbial, anti-viral, antiaging, neuroprotective, anti-nociceptive and analgesic	
	2-Deoxy-2,3-dehydro-N-acetylneuraminic acid	Anti-diabetic	

Pharmacological activities:

1. In vitro study

Antioxidant activity

This study examined the antioxidant activity of *P. plebeium* methanol extract and its various solvent fractions, including hexane, ethyl acetate, and water. Among these, the ethyl acetate and methanol fractions demonstrated the highest antioxidant potential, as evidenced by their performance in DPPH, ABTS, CUPRAC, and FRAC assays. These variations in antioxidant activity are attributed to the differing levels of phenolic and flavonoid compounds present in each extract, with ethyl acetate and methanol extracts containing higher concentrations than those from hexane and water. A Pearson correlation analysis further confirmed a strong relationship between the total phenolic and flavonoid content and the antioxidant effectiveness of the extracts.[5]

An in vitro study was carried out to evaluate the antioxidant activity of the aerial parts of *P. plebeium.* The findings revealed that the methanolic extract exhibited the highest free radical scavenging capacity, with an IC50 value of 43.63 µg/mL. In comparison, the ethyl acetate extract had a higher IC50 value of 72.62 µg/mL, indicating lower antioxidant effectiveness. For reference, ascorbic acid, a standard antioxidant, showed a much stronger activity with an IC50 of 18.34 µg/mL. Among the extracts, methanol and water were most effective in scavenging nitric oxide. Despite having low alkaloid content, the extracts demonstrated increased reducing power with rising concentrations. Both ethyl acetate and methanolic extracts showed promising antioxidant properties. These results support the potential of *P. plebeium* as a natural source of antioxidants.[17]

Cytotoxic activity

The cytotoxic effects of the aerial parts of *P. plebeium* were evaluated using an in vitro approach. Extracts were prepared using petroleum ether, ethyl acetate, methanol, and water. These extracts were assessed for cytotoxic activity through a Brine Shrimp lethality bioassay. Among all samples, the water extract demonstrated the highest level of toxicity against Brine Shrimp nauplii, with an LC50 (lethal concentration 50) value of 23.72 µg/mL. In comparison, the standard anticancer drug Vincristine sulfate exhibited a significantly lower LC50 value of 2.47 µg/mL. The descending order of cytotoxic potency among the tested extracts was: water extract > petroleum ether extract > methanolic extract > ethyl acetate extract.[15]

Antidiabetic activity

The antidiabetic potential of *P. plebeium* was assessed in vitro through the inhibition of the enzymes α-amylase and α-glucosidase. The water extract demonstrated the strongest α-glucosidase inhibitory activity, with a value of 1.78 ± 0.01 mmol/g, while the hexane extract showed the highest α-amylase inhibition at 0.49 ± 0.01 mmol/g. Acarbose was used as the reference standard for comparison. These findings suggest that *P. plebeium* holds promise as a natural source for the development of new antidiabetic therapies.[23]

Antibacterial activity

Staphylococcus aureus and *Pseudomonas aeruginosa,* two bacterial pathogens, were isolated from a wound infection on a patient's arm at Cleopatra Hospital in Cairo, Egypt. To evaluate their antibiotic susceptibility, the pathogens were tested with solvent-based leaf extracts from *Euphorbia hirta and P. plebeium.* The results indicated that the ethyl acetate extracts of both plants showed potential antibacterial effects. The phytochemical compounds present in the plants appeared to work synergistically to combat bacterial resistance in *S. aureus* and *P. aeruginosa*.[10]

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The synthesis of silver nanoparticles (Ag-NPs) using plant extracts has gained attention due to its eco-friendly and cost-effective nature. Ag-NPs have a broad range of applications, including antibacterial studies, wound healing, drug delivery, biosensing, cancer therapy, and solar radiation detection. Findings from this study show that Ag-NPs synthesized from P. plebeium are particularly stable and demonstrate promising antibacterial properties. The interaction between plant extracts and Ag-NPs operates through several mechanisms. Initially, Ag-NPs attach to the bacterial cell wall and membrane, enhancing penetration and altering signal transduction pathways. Ultimately, the bioactive components in the plant extracts combined with Ag-NPs help to minimize oxidative stress and cellular toxicity.[12]

Table 4: in-vitro Phytopharmacological screening of *Polygonum plebeium*

Pharmacological Activity	Method	Mechanism of action
Anti-oxidant activity	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
Cytotoxic activity	Brine Shrimp lethality bioassay	The cytotoxic activity of *P. plebeium* may possibly be attributed to its polyphenolic and flavonoid components
Antidiabetic activity	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*
Antibacterial activity	Agar diffusion	It inhibits the *Staphylococcus aureus* and *Pseudomonas aeruginosa*

2. In vivo study

Anti-inflammatory activity

A study was carried out to investigate the anti-inflammatory effects of the methanolic extract obtained from the aerial parts of *P. plebeium*. The extract's efficacy was tested in vivo using rat paw oedema models induced by carrageenan and egg albumin. Additionally, the extract's capacity to prevent protein denaturation was assessed by measuring absorbance changes in solutions containing bovine serum and egg albumin after treatment. The methanolic extract demonstrated dose-dependent inhibition of protein denaturation, with inhibition rates of 72.9% for egg albumin and 67.5% for bovine serum albumin. In the paw oedema models, inflammation was significantly reduced, showing inhibition rates of 48.7% and 40.63%, respectively. These findings suggest that *P. plebeium* methanolic extract may serve as a potential anti-inflammatory agent, likely due to the action of its secondary metabolites and their underlying mechanisms.[7]

Hepatoprotective activity

The hepatoprotective potential of whole plant extracts of *P. plebeium* was evaluated using a rat model. Liver fibrosis was induced by intraperitoneal administration of carbon tetrachloride (CCl_4), a compound commonly used in experimental studies to mimic hepatic inflammation, fibrosis, and cirrhosis. The protective effect of *P. plebeium* was assessed by measuring serum levels of liver enzymes such as alanine transaminase (ALT), aspartate aminotransferase (AST), and gamma-glutamyl transpeptidase (γGT). Histological analysis of liver tissue revealed extracellular matrix accumulation and necrosis. In addition, real-time PCR was employed to examine the expression of fibrosis-related genes. The findings indicated that P. plebeium extract significantly reduced liver damage induced by CCl_4. These results suggest that the plant's anti-inflammatory and antioxidant properties contribute to its ability to prevent and delay the progression of hepatic inflammation and fibrosis.

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Table 5: in-vivo Phytopharmacological screening of *Polygonum plebeium*

Pharmacological Activity	Method	Mechanism of action
Anti-inflammatory activity	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
Hepatoprotective activity	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

II. CONCLUSION:

Polygonum plebeium, a herbaceous species commonly found in tropical and subtropical regions, has emerged as a plant of considerable interest due to its ecological adaptability, nutritional content, ethnomedicinal value, and potential role in sustainable agriculture. Traditional practices across various cultures have long utilized this plant for treating ailments such as diarrhoea, dysentery, inflammation, and respiratory disorders, underscoring the need for modern pharmacological validation of its bioactive constituents. Nutritionally, its edible leaves contribute to dietary diversity, particularly in rural and undernourished communities.[8]

Ecologically, *P. plebeium* demonstrates remarkable resilience to abiotic stresses, such as drought and poor soil conditions, making it a promising candidate for cultivation in marginal environments. Its ability to act as a cover crop and contribute to soil health further enhances its utility in agroecological systems. Despite these promising attributes, current scientific literature on this species remains fragmented and largely anecdotal, lacking in-depth molecular, biochemical, and agronomic studies. Given global challenges such as climate change, food insecurity, and the need for alternative plant-based therapeutics, *Polygonum plebeium* stands out as an underutilized resource that merits greater attention in both scientific and policy-making circles. With targeted investment and research, this modest wild plant could play a significant role in advancing sustainable health and agricultural systems in the years to come.

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CONFLICTS OF INTEREST

The authors declare no conflicts of interest.

ABBREVIATIONS:

P. plebeium: Polygonum plebeium; 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; IC50 :Half maximal inhibitory concentration; AChE: Acetylcholinesterase; BChE: Butyrylcholinesterase; LC50 : Lethal concentration 50; CCl4 : Carbon tetrachloride; ALT: Alanine transaminase; AST: Aspartate aminotransferase; γGT: Gamma-glutamyl trans peptidase; PCR: Polymerase chain reaction.

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