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Ethnobotanical uses, phytochemistry and biological activities of *Salix tetrasperma* roxb. (Salicaceae) - A review

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Abstract
Ethnobotany is the study of relationship of people and plants. *Salix tetrasperma* Roxb.(Indian willow), belonging to the family Salicaceae, is a deciduous undershrub or a small tree found distributed in various countries such as India, China, Malaya Peninsula and Archipelago. Literatures on ethnobotanical survey highlighted medicinal and non-medicinal potential of the plant. The non-medicinal applications of the plant includes the use of plant as fodder, soil binder on embankments and fuel and in making baskets, agricultural tools, sports articles, furniture and roofing material. Different parts of *S. tetrasperma* have been used as traditional medicine. Ethnomedicinally, the plant is used to treat ailments such as diabetes, fever, piles, epilepsy, rheumatism, swellings, stones in bladder, wound, ear pain, dysentery, cough and cold. Studies on the chemical components of different parts of the plant revealed the presence of compounds such as catechol, salicin and its derivatives. The plant is found to be rich in mixtures of flavonoid and phenolic acid derivatives. The plant is shown to exhibit a range of bioactivities such as antimicrobial, antioxidant, cytotoxic, analgesic, anti-inflammatory, antipyretic, CNS activities, laxative and diuretic activity. The presence of these phytochemicals can be responsible for the therapeutic potential of *S. tetrasperma*. The plant appears to be a promising candidate for developing drugs with potential therapeutic traits.

Keywords: Plants, *Salix tetrasperma*, ethnobotany, phytochemicals, bioactivities

Introduction
Plants have been considered as important sources of human requirements such as food, shelter, clothing, decorations, tools, dyes, and medicine. The term *Ethnobotany* is defined as relationship between man and plants. Plants are an integral part of traditional medicine. It is estimated that about 80% of people still rely on traditional medicine based on plants as their primary healthcare needs (especially tribal communities and people from remote areas). Worldwide, ethnic groups encompass a vast knowledge on therapeutic potential of plants. Besides, many plants such as tulsi, turmeric and neem are used in certain religious rituals. As medicine, plants are used singly or in combination (in certain formulations) for treating several diseases or disorders including cancer. Plants are widely used in various systems of medicine such as Ayurveda, Unani, Siddha and Traditional Chinese Medicine. Medicinal plants are also used worldwide for income generation and livelihood improvement. Therapeutic potential of plants is due to the presence of secondary metabolites such as alkaloids, polyphenolic compounds including flavonoids, saponins and triterpenes which are referred as phytochemicals. Plants have provided lead compounds for developing pharmaceutical agents with several pharmacological activities. Drugs such as quinine, reserpine, aspirin, digoxin, vincristine, vinblastine and morphine are from plant origin. An immense interest in research on therapeutic potentials of plants has been triggered because of wide range of adverse effects associated with the use of synthetic drugs. A wide range of biological activities have been displayed by extracts and purified compounds from plants and formulations based on plants [1-18].

Salix tetrasperma Roxb.
The family Salicaceae includes deciduous trees with alternate leaves and catkins of small flowers. *Salix tetrasperma* Roxb. belongs to Salicaceae and is a native of Southeast Asia, India. It is commonly known as Indian willow in English, Neeruvanji in Kannada and Jalavetasa in Sanskrit. The plant is distributed in India, China, Nepal, Afghanistan, Laos,

Cambodia, Vietnam, Singapore, Myanmar, Malaya Peninsula and Archipelago. In Karnataka of India, the plant is found distributed in Bangalore, Kodagu, Hassan, Mandya, Mysore, Shimoga, Tumkur and Uttara Kannada. It is a large, well branched, deciduous undershrub or small tree (6-9m height) with silvery tomentose branchlets. The plant grows in wet and swampy places. Bark is rough with deep vertical fissures. Leaves simple, elliptic-lanceolate, to 12x3cm, dark green above and greyish white below, apex acute, margin serrate, glandular, base cuneate, peduncle long, to 5cm. Flowers in catkin, unisexual, sessile, subtended by caducous bract, achlamydeous, stamens 4-12, free, male flowers yellowish and female flowers greenish. Fruit is a 2-valved capsule, dry and dehiscent. Flowering and fruiting occurs in different months of the year at different regions [19-24]. It is used in Ayurveda, Unani and Siddha [25]. It is reported as an antitoxic plant in the Ayurvedic text Astanga Hridaya [26]. In the present review, we discussed ethnobotanical uses, phytochemistry and biological activities of *S. tetrasperma*.

Ethnobotanical uses of *S. tetrasperma*

Worldwide, plants possess medicinal and non-medicinal uses which are exploited by several communities. Non-medicinal uses of plants includes the utilization of plants as fodder, spice, repellants, fuel wood and timber, for ornamental purposes and for basket making, driving away evil spirits, construction, roofing, fences, making plough, net, ropes, mats, sports articles and musical instruments [6, 27, 28, 29]. The plant *S. tetrasperma* is well known for being utilized ethnobotanically for various purposes such as fodder, soil binder, for making agricultural utensils, baskets, sport articles and treatment of various illnesses or disorders. Detailed information of utilization of different parts of the plant for medicinal and non-medicinal purposes in various parts of the world is shown in Table 1 and Table 2 respectively.

Table 1: Ethnobotanical uses of *S. tetrasperma* (medicinal uses)

Area	Uses	Reference
Central Punjab, Pakistan	Bark is used as febrifuge	Zereen and Khan [30]
Bangladesh	Febrifuge	Sarwar [31]
Nagaland, India	Decoction of bark is used in fever	Zhasa *et al*. [32]
Tharu tribes, Himalayan Terai region of India	Bark in fever; Leaves with sugar in rheumatism, epilepsy, venereal diseases, Wild bladder stone, piles and swellings	Bajpai *et al*. [18]
Kozhenchery Taluk, Pathanamthitta District, Kerala, India	Rheumatism, Antiepileptic, Swelling, Piles, Venereal diseases, Stones in bladder	Nitheesh *et al*. [33]
Indo-Burma region, India	Bark is febrifuge	Rai and Lalramnghinglova [34]
Neelum Valley, Azad Jammu and Kashmir, Pakistan	Anodyne and febrifuge	Ahmad *et al*. [35]
Wayanad, Kerala, India	Roots are used in diabetes	Kumar and Janardhana [36]
District Bannu, Khyber Pakhtunkhwa, Pakistan	Leaves poultice to wounds, leaf juice for ear pain, roots in cough and cold, seeds in dysentery	Khan *et al*. [37]
Western Mizoram, India	Bark is used as febrifuge	Lalfakzuala *et al*. [38]
Karamar valley, district Swabi, Pakistan	Bark is used in fever and leaves for piles and rheumatism	Khalid *et al*. [39]
Meghalaya, northeast India	Bark febrifuge; dried and powdered leaves with sugar in rheumatism, epilepsy, piles, swellings, stones in bladder	Laloo *et al*. [40]
Lahaul valley, Himachal Pradesh, India	Fever	Singh *et al*. [41]
Dehradun, India	Fever	Adhikari *et al*. [42]
Jalgaon district, Maharashtra, India	Management of wounds	Chopda and Mahajan [43]

Table 2: Ethnobotanical uses of *S. tetrasperma* (non-medicinal uses)

Area	Uses	Reference
Wayanad wildlife sanctuary, Kerala, India	Twigs are used for making basket	Narayanan *et al*. [44]
Mao-Naga tribe, Manipur, India	Log of the plant is used for making traditional utensils. Plant is grown as soil binder on embankments.	Lokho and Narasimhan [45]
Agra valley Parachinar, upper Kurram agency, Pakistan	Wood is used as fuel and in making agricultural tools	Ajaib *et al*. [28]
Siran Valley, District Mansehra, Pakistan	Construction, furniture, fencing, roofing, fuel wood	Ahmad *et al*. [46]
Ashezai and Salarzai Valleys, District Buner, Pakistan	Wood	Sher *et al*. [47]
Sargodha district, Punjab, Pakistan	Ornamental	Shah *et al*. [48]
Chagharzai valley, district Buner, Pakistan	Fuel wood, timber, roofing material	Sher *et al*. [49]
Dawarian village, Neelum valley, Azad Jammu and Kashmir, Pakistan	Used as fuel, foliage is used as fodder, wood is used as making sport articles	Ahmad and Habib [50]
Himachal Pradesh, India	Used in making agricultural equipment and house construction, as timber	Kharwal and Rawat [51]
District Ghizer, Gilgit, Baltistan	Leaf is used as fodder, stem is used as fence and fuel	Jabeen *et al*. [52]
Ghulamo Timber Market Mardan, Khyber Pakhtunkhwa, Pakistan	Timber and fuel	Shah *et al*. [53]
Allai valley, district Battagram, Pakistan	Fuel and timber	Haq *et al*. [54]
Temperate zones of Pakistani Hindukush-Himalaya	Stem is used as fuel wood; leaves are used as fodder	Adnan *et al*. [55]
District Rajouri, Jammu and Kashmir, India	Shoot looped for cattle fodder	Rashid and Sharma [56]

Phytochemicals detected in *S. tetrasperma*

Studies have detected a wide range of phytochemicals in different parts of *S. tetrasperma*. The bark extract was shown to contain flavonoids, tannins and saponins [57]. The study by El-Shazly *et al.* [58] employing the techniques viz. MS, and 1D NMR (1H and 13C) and 2D NMR (H-H COSY, HSQC, and HMBC) spectral analyses revealed the isolation of β-sitosterol acetate, friedelin, 3β-friedelinol, β-amyrin, β-sitosterol, β-sitosterol-O-glucoside in addition to palmitic acid from the light petroleum fraction of methanolic extract of stem bark. Chemicals namely catechol and tremulacin were isolated from dichloromethane fraction of methanolic extract of leaves. Salicin and its derivatives tremuloidin and 2'-*O*-*p*-(*E*)-coumaroyl salicin were isolated from the ethyl acetate fraction of the methanolic extract of leaves. In a study, El-Wakil *et al.* [59] carried out identification of the chemical constituent of the defatted methanolic extract of leaves by HPLC-ESI-MS technique. The tentatively identified compounds were shown to be mixture of flavonoid and phenolic acid derivatives. The study of Virupaksha *et al.* [60] revealed the presence of phytochemicals viz. flavonoids, tannins, triterpenes, phenolic compounds, saponins, steroids and sterols in the leaves.

Biological activities of *S. tetrasperma*

Researches have been carried out to investigate various bioactivities of different parts of *S. tetrasperma*. Extracts and formulations from different parts of the plant are shown to exhibit a range of bioactivities such as antimicrobial, antioxidant, cytotoxic and other pharmacological activities. Brief information on the bioactivities of *S. tetrasperma* reported is given below.

Laxative activity: Sumanta *et al.* [61] evaluated laxative activity of two concentrations of aqueous extract of bark. An increase in the amount of fecal matter was observed in extract treated group of animals. The extract exhibited dose dependent laxative activity and the activity observed was significant and higher than that of reference standard.

Diuretic activity: Aqueous extract of bark was evaluated for diuretic activity in albino rats. The result obtained revealed dose dependent diuretic activity and a significant increase in urine volume in extract treated group was observed. The urinary levels of potassium, sodium and chloride ions were also higher in extract treated groups [61].

Analgesic activity: El-Shazly *et al.* [58] evaluated analgesic activity of extract of S. tetrasperma by acetic acid induced writhings method and showed that the extract clearly possess a pain relieving effect. In another study, Virupaksha *et al.* [60] evaluated antinociceptive activity of ethanolic and aqueous extracts of leaves by hot plate and tail flick method. A dose dependent antinociceptive activity was observed in extract treated group of animals with marked activity being displayed by ethanolic extract.

Antipyretic activity: The potential of ethanolic and aqueous extract of leaves to lower rectal temperature of rats administered subcutaneously with brewer's yeast was investigated by Virupaksha *et al.* [60]. The extract was shown to exhibit dose dependent antipyretic effect.

Antischistosomal activity: Abdel-Hameed *et al.* [62] evaluated antischistosomal activity of two concentrations (100 and 200µg/ml) of methanol extract of leaves against *Schistosoma mansoni* worms. Both concentrations of extract were shown to be ineffective in causing mortality of worms.

Insecticidal activity: The study of Islam *et al.* [63] evaluated insecticidal activity of methanol-ethyl acetate (1:9) extract of leaf, bark and root against Tribolium castaneum by surface film treatment. Root extract caused marked insecticidal potential when compared to leaf extract whereas bark extract was not effective.

Cytotoxic activity: An in vivo cytotoxic activity, in terms of cell growth inhibition (%), of methanol-ethyl acetate (1:9) extract of leaf, bark and root in EAC tumor bearing mice was assessed by Islam *et al.* [63]. Only root and bark extract showed cytotoxicity while leaf extract had no activity. In another study by Moustafa *et al.* [64], the methanolic extract of leaf was shown to exhibit cytotoxicity against the cell line HCT-116 while cell lines viz. MCF-7, HepG2 and A-549 were not affected.

Central nervous system activity: In a study, Virupaksha *et al.* [65] evaluated CNS activities of leaf extracts using neuropharmacological experimental models in mice. Locomotor activity was measured by means of actophometer and skeletal muscle relaxant effect was evaluated by using rotarod apparatus. The extracts displayed dose dependent locomotor and muscle relaxant activity.

Antioxidant activity: The study of El-Shazly *et al.*[58] showed the potential of methanolic extract of *S. tetrasperma* to scavenge DPPH radicals with an IC50 value of 94.5µg/ml. El-Wakil *et al.* [59] evaluated antioxidant activity of defatted methanol extract and fractions viz. dichloromethane, ethyl acetate, butanol and water fraction of methanolic extract of leaves. The extract and fractions exhibited total antioxidant capacity and displayed scavenging potential against DPPH and ABTS radicals. Ethyl acetate fraction was shown to contain high phenolic and flavonoid content. In another study, Kishore *et al.* [66] observed concentration dependent scavenging of DPPH radicals by hydroalcoholic extract of bark.

Anti-inflammatory activity: El-Shazly *et al.* [58] evaluated anti-inflammatory activity of *S. tetrasperma* extract by rat hind paw edema method. The activity observed was almost comparable with that of reference standard at 120mg/kg body weight. In another study, Kishore *et al.* [66] evaluated anti-inflammatory activity of hydroalcholic extract of bark by using carrageenan induced paw edema method in albino Wistar rats. The extract was shown to exhibit dose dependent and significant anti-inflammatory activity in treated group of animals when compared to control group.

Hypoglycemic activity: Chhetree *et al.* [57] determined hypoglycemic activity of bark extract in rats. Among the tested extracts, the aqueous extract revealed promising results that is comparable to that of the reference standard glibenclamide.

Antibacterial activity: The study of Abdel-Hameed *et al.* [62] did not reveal antibacterial activity of leaf extract (at 1mg/disk) against Gram positive and Gram negative bacteria as evaluated by disk diffusion method. Islam *et al.* [63] evaluated antibacterial activity by disk diffusion method of methanol-ethyl acetate (1:9) extract of leaf, bark and root

against a panel of Gram positive and Gram negative bacteria. Among extracts, bark extract exhibited prominent antibacterial activity while root extract exhibited inhibitory activity against least number of test bacteria. Leaf extract was more effect against Gram positive bacteria when compared to Gram negative bacteria. In a study by Bhatt *et al*. [67], a herbal formulation containing *S. tetrasperma* was shown to inhibit acne causing *Propionibacterium acnes* and *Staphylococcus epidermidis***.**

Antifungal activity: Deepak *et al*. [68] investigated the antisporulant effect of watery extract of *S. tetrasperma* leaves against *Sclerospora graminicola*. It was found that the extract had no inhibitory effect on zoosporangium formation of *S. graminicola*. In a study by Abdel-Hameed *et al*. [62], the leaf extract of *S. tetrasperma* was shown to be inactive against test fungi viz. *Aspergillus niger* and *Candida albicans*. More recently, Pushpavathi *et al*. [69] investigated antifungal potential of leaf extract of *S. tetrasperma* against a panel of fungi isolated from sorghum seeds. The extract exhibited marked antifungal potential against fungi and revealed >50% inhibition of all fungi except *Fusarium* sp.

Conclusions

Plants have been used in various systems of traditional medicine such as Ayurveda, Unani and Siddha. Compounds from plants have also been parts of Allopathy. An extensive survey of literatures available on *S. tetrasperma* indicated that the plant is ethnobotanically important and is widely used for various medicinal and non-medicinal purposes especially in countries viz. India, Pakistan and Bangladesh of Asian continent. Researches highlighted that the plant contains a rich variety of phytochemicals such as phenolic compounds, flavonoids, saponins, sterols and others. The plant is studied for various pharmacological activities and is reported to exhibit bioactivities such as antimicrobial, antioxidant, cytotoxic, analgesic, anti-inflammatory, and antipyretic activity. The presence of phytochemicals in plants could be responsible for the therapeutic potential (medicinal value) of plants as several investigations have revealed the pharmacological effects of pure plant ingredients. The ethnomedicinal and pharmacological properties of this plant highlights the possible utilization of the plant for drug development. Further studies can be taken up to isolate active principles present in the plant and to develop drugs effective in treatment of various diseases.

Conflicts Of Interest

None declared

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