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A COMPREHENSIVE REVIEW ON PHYTOCHEMICALS AND MEDICINAL PROPERTIES OF PUTRANJIVA ROXBURGHII WALL

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ABSTRACT

Putranjiva roxburghii Wall. is known for its medicinal properties and credited with a significant role in Ayurvedic texts as an anti-inflammatory, antipyretic, analgesic, and anti-rheumatic herb, that is also useful to treat gynaecological and fertility disorders. Almost all parts of the plant, i.e, root, stem, leaves, fruits, and seeds contain numerous secondary metabolites such as phenolics, glycosides, triterpenes, and flavonoids. The presence of these phytochemicals imparts significant therapeutic activities to the plant such as anti-hyperglycaemic, analgesic, antioxidant, anti-inflammatory, antimicrobial and antiparasitic properties, and hence, the plant parts and its extracts can be used as a cure for varied diseases, including cancer.

Keywords: Putranjiva roxburghii, Ethnobotany, secondary metabolites, medicinal properties

INTRODUCTION

Plants are known to produce various chemicals having medicinal and economical importance and hence, have long been incorporated in daily lives of humans as food, medicines, dyes, perfume, and dietary supplements (Tiwari & Rana, 2015). The plant-derived molecules, termed phytochemicals, have been increasingly sought after as potent cures for numerous diseases. The study of phytochemicals is Phytochemistry, and this mainly involves the study of chemical structures, biosynthesis, and bioactivity of the phytochemical. This usually requires its extraction from its source plant by validated extraction methods (Mendoza & Silva, 2018). The extracted phytochemicals are then evaluated for their remedial properties and consequent uses in various diseases.

Putranjiva roxburghii Wall. (syn. Drypetes roxburghii (Wall.) Hurus.), also known as Putrajeevak, has been mentioned in ancient Indian and Ayurveda texts for its medicinal values. Owing to its significant therapeutic properties, the plant is now being used in modern medicine and research.

Taxonomic position

Putranjiva roxburghii Wall. is a member of spurge family, Euphorbiaceae, and is native to tropical and South-east Asia. Its taxonomic position as elucidated by P.V. Sharma (Gupta, 2016) is as follows:

Kingdom: Plantae
Sub-kingdom: Tracheobionta
Division: Tracheophyta
Sub-division: Spermatophyta
Class: Magnoliopsida
Sub-class: Rosidae
Order: Malpighiales
Family: Euphorbiaceae/Putranjivaceae
Genus: Putranjiva

Species: P. roxburghii Wall.

Botanical description: P. roxburghii Wall. is a large spreading, evergreen tree with numerous pendant branches, and height ranging from 15-20 m (Dar et. al., 2018). The trunk is light brown to greyish in colour, bearing horizontal lenticels. The leaves are elliptical to oblong in shape, with a slightly pointed apex, dark green in colour and glabrous, arranged alternately on the branches (Gupta, 2016). The flowers are small, unisexual, greenish yellow in colour. Male flowers are found in axillary clusters, whereas female flowers are usually solitary. Fruits are rounded to elliptical drupes, with a single hard, stony seed (Murthy et. al., 2013).

Ethnobotanical uses: The plant is widely used in traditional medicinal systems to cure common ailments like fever, cold, cough, headache, and inflammations and also as a cereal and pulse preservative. Leaves are used in decoctions to treat liver disorders, rheumatic joints, eye, and throat infections and in pastes applied on for insect bites, filariasis, allergic patches and burning sensations (Wansi et. al., 2016). It is said to increase the strength of female reproductive system, cure infertility and also aid in conception. Fruits and seeds are often worn as necklaces by expecting mothers for an easy delivery (Gupta, 2016). Fruits are consumed orally as laxative and diuretic. The plant is a constituent of the herbal formulation, Lucap capsule used to treat anaemia and menstrual and post-partum disorders (Kumar, 2020). It is also used to treat azoospermia and is a constituent of the Ayurvedic formulation, Y-spur used to increase sperm count (Murthy et. al., 2013).

Secondary Metabolites of Putranjiva roxburghii Wall: The plant is known to contain a horde of phytochemicals in different parts, imparting significant medicinal value.

Phenolic compounds such as gallic acid, ellagic acid from the ethanolic extract of leaves (Gupta, 2016), caffeic acid, ferulic acid, syringic acid, vanillic acid, gentisic acid and catechin have been identified by HPLC-DAD profiling of aqueous extract of leaves (Nazli et. al., 2022). Flavonoids such as catechin, putraflavone and amentoflavone; tannins such as ellagi- and gallo-tannins (Kumar, 2020) and numerous triterpenoids such as β-amyrin, putrone, putrol, putranjivic acid, methyl putranjivate, friedelin, friedelanol, roxburgholone, putranjivadione, putric acid, roxburghonic acid, roxburghonol have been characterized from root bark, leaves, (Gupta, 2016) stem and trunk bark (Mishra et. al., 2021). Leaves are also known to contain saponin A, B, C and D (Gupta, 2016), whereas azulene, desulphonigrin and myo-inositol-4-C-methyl have been identified by GC-MS profiling (Keshav et. al., 2021). The stems are known to contain quebrachitol (QBC) and 2, 4 dihydroxy-5-(hydroxymethyl) benzoic acid (DHMBA) (Mishra et. al., 2023).

Fruits contain mannitol (Gupta, 2016) and the fruit peel is known to contain linalool, citronellal, citronellic acid, geraniol, geranyl acetate, β-bisabolene, docosenamide, caryophyllene oxide and some other constituents (Hasan et. al., 2019). The seeds are known to contain mustard oil derivatives such as isopropyl, 2-butyl and 2-methyl-butyl isothiocyanates; glucosinolates namely glucocochlearin, glucojiaputin, and glucoputranjivin (Dar et. al., 2018), which other than Brassicales, are only known to have evolved in Drypetes and Putranjiva of Euphorbiaceae (Burow et. al., 2008). The seed coat is known to contain triterpene saponins, pyranosides A-D, β-sitosterol, putranoside, putranjivoside and β-D-glucosidase (Kumar, 2020). Other than these, presence of alkaloids and glycosides have also been reported by preliminary screening of the plant extracts prepared in different solvents (Ahmad et. al., 2017; Sarath, 2019; Mane et. al., 2021).

Therapeutic activities: The plant is known to possess an array of biological activities, of which some significant ones, are briefed as follows:

Anti-inflammatory and Analgesic activity: The plant has been shown to possess remarkable anti-inflammatory and pain-relieving activities. The ether extract of leaves has been tested in rat models with carrageenin-induced paw oedema, croton oil-induced ear and anus oedema, and has shown to produce significant anti-inflammatory results; additionally, the extract has also been shown to have analgesic effects in acetic acid-induced writhing and suppress the licking activity in formalin test in mouse models (Reanmongkol et. al., 2009). The ethanolic extracts of leaves and stem have also been shown to produce anti-inflammatory effects in similar rat models (Rajahamsa et. al., 2013). The methanolic extract of seeds has also shown analgesic effects in tail flick method in mouse models (Sudarshan et. al., 2009).

Antioxidant potential: The plant has been reported to show significant antioxidant activity by numerous researchers. The aqueous extract of leaves was used to conduct the DPPH (2,2-diphenyl-1-picrylhydrazyl) assay to find its radical scavenging potential and the results showed it to be equipotent as the standard ascorbate, with a highest inhibition of 59.16% at 100µg/ml whereas for ascorbate, it was 66.4% for the same concentration (Panda et. al., 2021). Another DPPH assay was performed for n-hexane, ethyl acetate, methanol, and distilled water extracts of leaves, stems and fruits. It showed that maximum %FRSA (%Free Radical Scavenging Activity) was shown by methanolic extract of stems and aqueous extract of leaves (86 ± 0.56%) with IC50 values of 68 ± 0.43 and 149 ± 0.21 µg/mL, respectively (Nazli et. al., 2022). The ethanolic extract of fruit peel has been proved to show excellent antioxidant activity in a dose-dependent fashion with the DPPH scavenging percentages as 16.0 ± 1.3, 40.7± 0.8, and 66.7 ± 2.8 at 5, 10, and 25 µg/mL respectively (Hasan et. al., 2019).

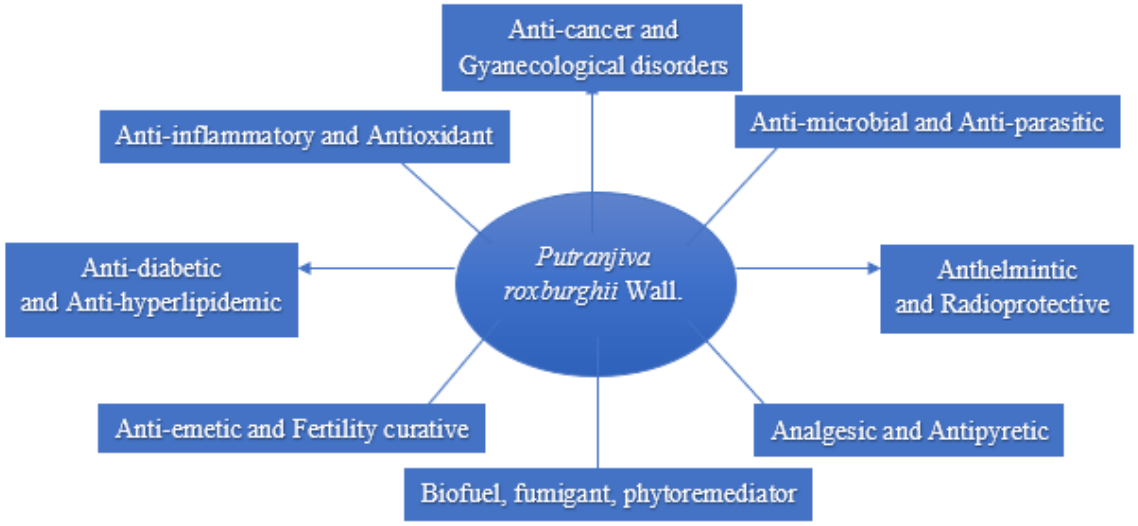

Fig. 1:
Schematic representation of beneficial properties of Putranjiva roxburghii Wall.

Anti-microbial and Larvicidal activity: Anti-bacterial activity of different parts of the plant have been reported by many workers. Silver nanoparticles synthesized from the plant's leaf extracts showed potent anti-microbial activity against Candida albicans, Candida tropicalis, Escherichia coli and Staphylococcus aureus (Ali et. al., 2015). The methanolic extract of bark was found to be effective against Streptococcus mutans, that causes dental caries (Chatterjee and Das, 2017). The ethanolic extract of fruit peel was found effective against Bacillus subtilis and Enterobacter xiangfangensis (Hasan et. al., 2019). The methanolic extract of the plant was found to be functional against Newcastle disease (ND) and avian influenza (AI) of the H5N1 subtype, the viral pathogens that cause serious respiratory infections in poultry (Abd-Alla et. al., 2019). The aqueous and methanolic extracts of leaves showed significant activity against the two fungal species causing grape rot, Alternaria alternata and Fusarium sp. (Nawaz et. al., 2020).
Strong mosquito larvicidal activity, against Anopheles stephensi Liston and Culex quinquefasciatus Say, was shown by silver nanoparticles synthesized from aqueous fruit extracts (Haldar et. al., 2013). The hydroethanolic leaf extract has shown anti-parasitic activity in the cells of promastigotes of both sensitive and resistant strains of Leishmania donovani (Keshav et. al., 2021).

Anti-diabetic and Anti-hyperlipidaemic activity: The plant is known to be used in folk medicine for diabetes mellitus, and this use has been proved by some workers. The ethanolic extract of leaves was found to exhibit a dose dependent significant anti-hyperglycaemic activity in alloxan-induced diabetic rats (Varma et. al., 2011). The ethyl acetate extract of bark has shown anti-hyperglycaemic activity in streptozotocin-induced diabetic rats, by

elevating the density of β-cells in the islets of Langerhans (Abhimanyu et. al., 2018). The plant has also been shown to combat hyperlipidaemia by showing significant activity of ethanolic and aqueous leaf extracts in Triton induced hyperlipidaemic rats (Mangalaselvan, 2019).

Anti-Cancer potential: The plant has been used in various experiments as a cytotoxic agent. The seed extract has been used to synthesize silver nanoparticles which were then used to target various cell lines such as MCF-7 cell line of human breast cancer (Nayaka et. al., 2020), HCT-116 (colon carcinoma), PANC-1 (pancreatic carcinoma), MDA-MB 231 (breast carcinoma) cell lines (Balkrishna et. al., 2020). The results showed that these nanoparticles possess significant target apoptotic activity, implying the plant's anti-cancer potential. Another study showed that the seeds contain a protein belonging to the PNP-UDP (Purine Nucleoside Phosphorylase–Uridine Phosphorylase) family, a class of plant defence and storage proteins, which was then proved to possess remarkable anti-cancer activity against breast cancer (MCF-7), prostate cancer (DU-145) and hepatocellular carcinoma (HepG2) cell lines (Verma et. al., 2022).

Fertility restorer and enhancer: The plant has been repeatedly mentioned in ancient texts for its uses in reproductive disorders and sterility and is even now used for the same in various folk medicinal systems. This has been proved by various studies conducted in animal models. The seed extract prepared by SCFE (Super Critical Fluid Extraction) using liquid CO_2 has been shown to work as a strong reverser of fertility impairment in both male and female zebrafish models (Balkrishna et. al., 2021). The dried ethanolic extract of seeds, diluted in S-TALP medium, has been evaluated in-vitro on bull semen by Computer Assisted Semen Analysis (CASA) and it has been found to show a marked increase in the motility and viability of both X and Y chromosome-bearing spermatozoa (Italiya et. al., 2023).

Other diverse activities and uses: The methanol extract of fruits and seeds have been reported to possess anthelmintic activity as they have been shown to cause paralysis and death of worms (Kumar, 2020). The plant is also known to be an anti-emetic as its aqueous extracts have proved effective in reducing the frequency of retching in CuSO4 induced emesis in four days old chicks (Mughal & Mahboob, 2013). The ethanolic extract of seeds have been shown to possess significant radioprotective activity as it delayed the death of radiation-exposed Swiss albino mice, as well as increased their survival rate (up to 40%) compared to the control group (Shastry et. al., 2014).

The seeds of the plant have been shown to contain 'putrin', a protein belonging to the family of 2S albumin seed storage proteins, that was found to possess DNase and RNase activity, along with strong anti-fungal and mild translation inhibitory activity (Tomar et. al., 2014). Another protein belonging to the thermostable family 1 of glycoside hydrolase enzymes, called PRGH1, possessing O-glucosidase and S-glucosidase activities, has been reported from seeds (Patel et. al., 2012). This protein is also known to play a crucial role in plant defence by its active participation in the hydrolysis of various toxins (Kar et. al., 2017).

The plant has been reported to have potent fumigant potential and hence, can be used as an excellent seed preservative. Essential oils from 32 plant species were evaluated against two species of fungi dominant in spoiling peanuts, Aspergillus flavus and A. niger, as well as the insect, Trogoderma granarium, of which the oil of P. roxburghii exhibited the greatest toxicity. The oil was shown to be fungicidal at its minimum inhibitory concentration (MIC) of 400 ppm and protected the peanut seeds completely for 6 months, without having any effect on their germination or further usage (Tripathi and Kumar, 2007).

The plant, especially its seeds, have been shown to be excellent sources of non-edible oil that can be used as a biofuel and also for the production of other green chemicals (Sahoo et. al., 2020). A study reported that the seed oil was found suitable for blending with diesel as much as up to 50%, without any compromise on the performance of the combustion engine. The oil was also used to produce factice, that upon blending with rubber, improved its viscosity, strength, firmness, and even made it more durable at high temperatures (Nag et. al., 1995). The seeds have also been reported to be effective as an adsorbent, after preparing them with epichlorohydrin, for removing nickel (Ni^{+2}) from contaminated laboratory water and

electroplating effluent of the lock industry, thus, proving that the plant might be a good candidate to be used for phytoremediation (Khatoon et. al., 2021).

CONCLUSION

Putranjiva roxburghii Wall. is an evergreen tree of the family Euphorbiaceae and is said to provide a wide range of therapeutic benefits, citing its mention in ancient medicine texts and extensive use in folk and tribal medicine. Phytochemical and pharmacognostical investigation of its roots, stem, leaves, fruits and seeds have revealed the presence of many secondary metabolites including phenolics, flavonoids, triterpenes, glycosides, alkaloids, saponins, and glucosinolates. The plant is known to possess excellent remedial properties such as antioxidant, anti-inflammatory, analgesic, anti-cancer, anti-bacterial, anti-fungal, larvicidal, anthelmintic, anti-emetic, anti-diabetic and anti-hyperlipidaemic activities that have been reported by various experiments. The plant can be used as a good source for biofuel production, for factice preparation and also as a preservative for stored cereals and pulses. The plant has a potential to be used as a phytoremediator.

The existence of numerous bioactive substances in the plant may be the basis for its many therapeutic and economically important characteristics. This proves why the plant has been acknowledged as an important medicinal plant, not only in ethnobotanical and folk medicines, but also as a strong candidate to be further used and researched for developing modern medicines and drugs for various diseases.

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