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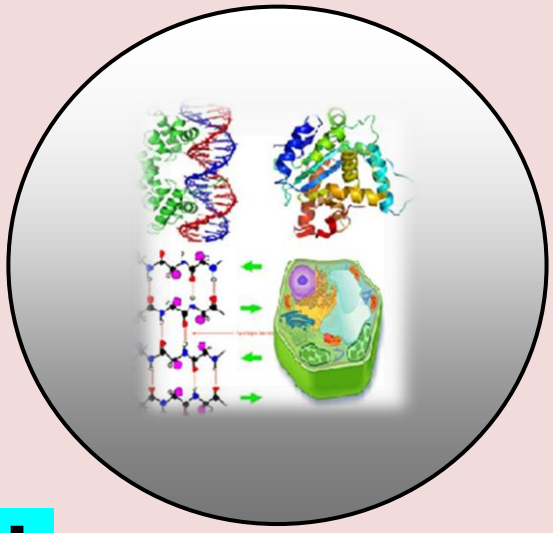

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Pinus roxburghii: Phytochemistry and Pharmacological Uses

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ABSTRACT

Medicinal plants played significant part in treatment of various human ailments. As compared to modern medicine, traditional therapy exhibited fewer side effects without high expenditure. Therefore traditional plant based therapies are in frequent use. Pinus is important genus of family Pinaceae. Mainly 3 Pinus species are found in wild in Indian Himalayas i.e. Pinus roxburghii, Pinus gerardiana and Pinus wallichiana. Of these, P. roxburghii is source of important phytoconstituents, which are beneficial in treatment of human ailments. P. roxburghii trees are reported to have wound healing, anticancer, antimicrobial and antispasmodic properties and they are important in treatment of cough, asthma, tuberculosis, hepatic ailments, genito-urinary diseases and epilepsy. This review of Pinus roxburghii takes into account information regarding its geographical distribution, prescence of phytochemical compounds and their pharmacological uses. There is requirement of conducting further research regarding bioactive compounds.

Keywords: Bioactive compounds, Diseases, Himalayas, Pharmacology and Pinus roxburghii.

INTRODUCTION

Medicinal plants have major role in alleviation of human diseases and health enhancement and maintenance. The plant based medicines are favored because of their fewer side effects and lesser cost. The phytochemical compounds isolated from plants are very useful in treating human ailments and are ingredients of some commercial medicinal formulations (Craker et al., 2007). Since ancient times India has been reported to harbour a large variety of medicinal plants and plant-dependent ayurvedic system has been famous worldwide. India is amongst twelve mega biodiversity centers having more than 45000 plant species (Aggarwal, 2014). Genus *Pinus* comes under family *Pinaceae*, which is a major family within conifers. *Pinus* has approximately 110 species found globally (Richardson et al., 2007).

The major *Pinus* species in India are *P. roxburghii (Chir pine), P. gerardiana* (Chilgoza pine), *P. wallichiana* (Blue pine)*, P. kesiya* (Khasi pine) *and P. merkussi* (Teriasserian pine), (Gamble, 1902). *P*. *roxburghii, P*. *wallichiana* and *P*. *gerardiana* are located in Himalayas, while *P. kesiya* and *P. merkussi* are native to Assam and Burma. Systematic position and local names of *P. roxburghii* in some major Indian languages, are provided in Table 1 and Table 2 respectively.

Majority of raw material for Ayurvedic and alternative therapies, are collected from Indian Himalayas. India supplies Ayurvedic, Unani and Allopathic Medicines (Samant et al., 2007, Sharma et al., 2011, Chauhan et al., 2014). *Pinus* species harbour phytochemicals which are useful in alleviation of many diseases. *P. roxburghii* has enlarged crown and its growth area ranges from Kashmir to Bhutan and Siwalik hills (Shuaib et al., 2013). In current review, discussion is done about different phytochemicals of *P. roxburghii* and their important pharmacological uses. Employing *P. roxburghii* phytoconstituents in commercial formulations has also been discussed.

PINUS ROXBURGHII

Occurrence and External Features

Pinus roxburghii, an ornamental plant, mainly occur in North-Western Himalayas. In India, it is found largely in Himachal Pradesh, Kashmir and Uttaranchal (Puri et al., 2011). *P. roxburghii* is a large tree occurring 500 to 2500 m above sea level (Khan et al, 2012). Its branches grow in whorled pattern and leaves are light green and needle like. The tree lasts for about one and half year. Bark has dark gray or reddish colour. Bitter oleo-resin is extracted from stem. The male flowers exist in cone form. Ovoid female cones occur singly or in clusters of 2-5 cones (Shuaib et al., 2013).

Table 1. Systematic Position of *Pinus roxburghii* (Kirtikar and Basu, 1999).

Kingdom	Plantae
Division	Pinophyta
Class	Pinopsida
Order	Pinales
Family	Pinaceae
Genus	*Pinus*
Species	*roxburghii*
Binomial name	*Pinus roxburghii* Sarg.

Table 2. Local Names of *Pinus roxburgii* in Different Languages (Kirtikar and Basu, 1999).

Hindi	Chir, Salla
Sanskrit	Manojna, Bhadradaru
English	Chir pine or Long leaved pine
Bengali	Saralgachha
Gujrati	Saraladeodara
Tamil	Simaidevadari
Telgu	Devadaru
Malyalam	Salla, Charalam

Phytochemical Constituents

P. roxburghii contains terpenoids, flavonoids, tannins and xanthones. The petroleum ether extract harboured friedelin, ceryl alcohol and β-sitosterol (Beri, 1970). While The methanolic extract of *P. roxburghii* bark contains xanthones; 1,5-dihydroxy-3,6,7-trimethoxy-8-dimethylallyloxy-xanthone and 1-hydroxy-3,6-dimethoxy-2-β-Dglucopyranoxanthone (Rawat et al., 2006). The bark also harboured taxifolin, kaempferol, rhamnetin, quercetin, catechin, 3,4-dihydroxycinnamic acid, 3,4-dihydroxybenzoic acid, pinosylvin, resin acid, sterols and gallocatechin (Beri, 1970, Rawat et al., 2006). Chatterjee et al. (1977) observed hexacosylferulate in *P. roxburghii*. The bark of *P. roxburghii* contains tannins (7-10 %); (Anonymous, 2003) and sugars glucose, fructose and arabinose (Ahmad et al., 1990b). The bark essential oil of *P. roxburghii* harboured pinenes, 3-carene, cambrene, longifolene, thunbergol, sylbestrene, terpineol, elemol, methyl dihydroabtate, myrcene, bornyl acetate and alpha cadinol (Kaushik et al., 2013).

P. roxburghii needles yielded colourless, volatile pine oil. Zafar et al. (2010) reported α-Pinene, β-myrcene, 3-carene, terpinyl acetate, α-terpineol, borneol acetate, α-longipinene and caryophyllene in needle essential oil. Alpha humulene, Beta-pinene, longifolene, camphene, limonene and alpha-ternene were also reported (Swales and Devi, 1979, Coppen et al., 1988). *P. roxburghii* needle wax contained hydroxyacids (Iqbal et al., 2011). Macrocyclic lactones obtained from these acids are frequently employed in perfumery. Hydroxyacids on reacting with *p*-toluenesulfonic acid generated juniperic acid (Dayal et al., 1989). Stem and needle extract of *P. roxburghii* contained resin acids (abietic acid, neoabietic acid), quercetin, catechin, taxifolin, kaempferol, myricetin, 3,4-dihydroxybenzoic acid, 3,4-dihydroxycinnamic acid, rhamnetin, pinosylvin 3-methyl ether, resveratrol and glycoside (Coppen et al., 1988, Willför et al., 2009). The seed oil of *P. roxburghii* harboured enhanced linoleic acid (Ahmad et al., 1990a) and tannins (Ahmad et al., 1989).

The wood essential oil of *P. roxburghii* contained cambrene, alpha thujene, terpinolen, alpha-pinene, sabinene, verticol, myrcene, caryophyllene and thunbergol (Kaushik et al., 2013). The oleoresin of *P. roxburghii* harboured phenolic acids and lignan. Phytocompounds such as *p*-coumaric acid, pinoresinol and ferulic acid, were also obtained (El-Shaer, 2002). Turpentine oil is manufactured from *P. roxburghii* oleoresin. The oil chiefly contained β-3-carene and α-pinene followed by β-pinene, longifolene and terpenes. It also harboured longicycline (Jadhav and Nayak, 1980, Anonymous, 2003). Diterpene rosin acids of *P. roxburghii* species harboured many acids most significantly abietic acid. Abietic acid negatively affects lipoxygenase function and possesses anti-inflammatory property (Kuchimanchi et al., 2002). During analysis of abietic acid and its methyl esters under different storage scenarios, some known compounds and many noval oxidation products were observed (Prinz et al., 2002). *Pinus* species rosin harboured 15-hydroperoxydehydroabietic acid (15-HPDA), having allergenic nature (Shao et al., 1995).

Ethnopharmacological Applications

Different tribes in Northern India employ different parts or products generated from *Pinus roxburghii* in various traditional applications. The timber from *P. roxburghii* is employed in preparing various sports goods and musical instruments, matchbox, furniture and also as house construction material. The bark paste is employed in treating burns and ulcers. The *P. roxburghii* wood oil has antiseptic, diaphoretic, aromatic and carminative properties.

It is employed as nerve tonic and in treating eye, ear, skin diseases and haemorrhages (Hussain et al., 2010). The volatile turpentine oil obtained from *P. roxburghii* is used in preparing terpene chemicals which are employed as lubricants, solvents, adhesives, in paints and varnishes and as antiseptic. It is also employed in treating chronic bronchitis (Bajracharya, 1979) and lumbago and arthritis. It is used as remedy of tooth ailments and in gangrene of lungs neuralgia (Chauhan, 1999). Resin (*Biroja*) is obtained from turpentine oil. It is used in varnish, paints, in printing inks and batteries. The *P. roxburghii* resin with ash of *Betula utilis* is used in treating sprains and damaged bones and employed in treatment of gastric trouble and worm infestation (Uniyal et al., 2006). The carbon part of charred resinous wood (*doi*) of *P. roxburghii* with mustard oil (*kajal*), is applied to eyes (Singh et al., 1990). The seeds of female cones are employed in treating tuberculosis, urinary bladder anomalies and in bronchitis (Bissa, 2008). The tannins obtained from bark are employed in leather coloring. The needle oil is employed in muscular pains (Bissa, 2008) and the grounded *P. roxburghii* needles are used in measles treatment.

Pharmacological Applications

Different phytoconstituents obtained from *P. roxburghii* have myriad of pharmacological applications (Figure 1.).

Anticancer Properties

Petroleum ether and chloroform extracts of *P. roxburghii* Sarg. exhibited significant anti-cancer activity. *P. roxburghii* cone essential oil possesses cytotoxic properties when tested on MCF-7cells (Satyal et al., 2013, Kaushik et al., 2015b).

Antioxidant and Antidyslipidemic (Lowering of Lipid Profile) Properties

The *P. roxburghii* needles extract has positive effect on high density lipoproteins (HDL)-C and its ratio with total cholesterol and reduced level of plasma lipid profile. The n-butanol part and alcoholic extract possesses significant antioxidant properties. The bark extract has also antioxidant properties (Puri et al., 2011, Sharma et. al., 2016).

Hepatoprotective Properties

The oil recovered from wood of *P. roxburghii* (applied at doses of 200, 300 and 400 mg/kg body weight) normalized significantly elevated enzymatic levels of aspartate aminotransferase, alanine aminotransferase, alkaline phosphatase and reduced levels of glutathione (GSH) and total protein in rat liver damage model, thus showing significant hepatoprotective property (Khan et al., 2012).

Antidiabetic Properties

P. roxburghii ethanolic bark extract given to diabetic rats at 100, 300 and 500 mg/kg body weight p.o. per day caused increase in body weight, reduced level of blood glucose, glycated haemoglobin, total cholesterol and serum triglycerides, thus showing antidiabetic effect. The HDL cholesterol level was enhanced in rats with extract treatment (Kaushik et al., 2015a). Compounds obtained from *Pinus* e.g. secoisoresinol, pinoresinol and cedeodarin exhibited good interaction with diabetic receptors (Kaushik et. al., 2014). *P. roxburghii* bark extract exhibited good antidiabetic activity during *in-vitro* α-amylase inhibitory assay (Kaushik et. al., 2015c).

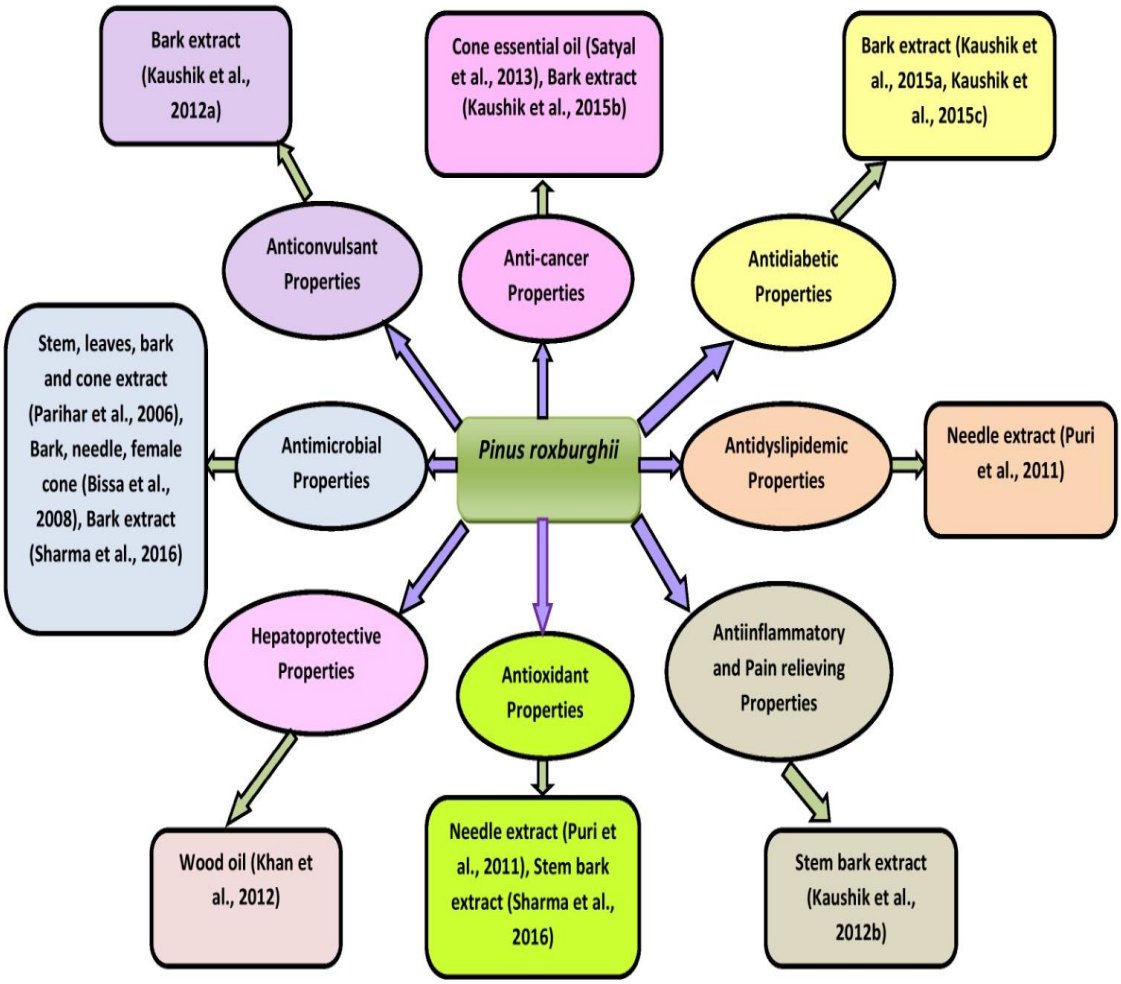

Figure 1. Pharmacological Applications of *P. roxburghii.*

Antibacterial Properties

P. roxburghii extract exhibited wide antimicrobial activity**.** The aerial parts (bark, needles and female cones) showed *antibacterial properties* against *Escherichia coli*, *Enterobacter aerogenes* and *Agrobacterium tumefaciens.* Needle extract showed good inhibitory activity against *Klebsiella pneumonia* (Bissa et al., 2008). *P. roxburghii* bark extract exhibited antimicrobial activity against *Pseudomonas aeruginosa*, *E. coli* and *Staphylococcus aureus.* Antifungal properties were exhibited against *Candida albicans* (Sharma et. al., 2016). Aqueous and alcoholic extracts from *P. roxburghii* stem, leaves, bark and cone showed growth-arresting property against *Agrobacterium tumefaciens* (Parihar et al., 2006).

Antiasthmatic Property

The anti-allergic property of *P. roxburghii* was tested employing milk-induced leukocytosis in mice and passive paw anaphylaxis in rats (*in-vivo*) while alcoholic extract of *P. roxburghii* was tested for its antiasthmatic property employing guinea pig ileum preparation (*in-vitro*), histamine-induced bronchospasm in guinea pigs and catalepsy in mice (*in-vivo*); (Kaushik et al., 2013).

Pain-relieving and Antiinflammatory Property

Alcoholic stem bark extract of *P. roxburghii* showed antiinflammatory and analgesic (pain-relieving) property when applied at 100, 300 and 500 mg/kg in mice. Polyphenolic compounds in extract were responsible for these properties (Kaushik et al., 2012b).

Anticonvulsant Activity

P. roxburghii alcoholic bark extract at 300 and 500 mg/kg body weight exhibited anticonvulsant property and was effective against partial seizures in rats (Kaushik et al*.,* 2012a).

Commercial Applications

Pinus roxburghii wood has immense commercial value. The heartwood is employed in constructing houses and furniture while the softwood has applications in preparing packaging cases and tea chest (Rajbhandari, 2001). The resin is employed in repairing ceramic pottery. It is also used in protective coatings, varnishes and printing inks. Resin yields viscous rosin oil which is used as lubricating grease. Turpentine oil from *P. roxburghii* is employed as ingredient in varnishes, thinners, soaps and disinfectants (Manandhar, 2002). The tannins obtained from bark are employed in tanneries.

Some important market products based on *P. roxburghii*

The polyherbal oil extract prepared from *P. roxburghii* oleoresin has pain-relieving and antiinflammatory properties (Azmat et al., 2006). While another marketed formulation Rumalaya gel which is manufactured from *P. roxburghii* resin, is beneficial in alleviating bone and joint pain (Rastogi et al., 2004, Sharma and Kolhapure, 2005).

CONCLUSIONS

Pinus (pine tree) is important genus of family Pinaceae. Amongst different *Pinus* species*,* mostly naturally found in different Himalayan regions in India, *P. roxburghii* is important source of various medicinally and commercially important phytoconstituents. Products obtained from *P. roxburghii*, are also used by local tribes. *P. roxburghii* wood is important economically and finds application in house and furniture construction. Pine extracts and oils have great potential as marketed formulations. The resin, turpentine oil and tannins obtained from *P. roxburghii*, have various commercial applications. Being source of pharmaceutically important compounds, *P. roxburghii* may form basis of development of novel, more efficient, cost-effective medicines without side effects in future.

Although considerable amount of information is known regarding different medicinally active phytoconstituents of *P. roxburghii* and their pharmacological properties yet further research is required on different aspects like developing novel products, their safety profile, pharmacological properties, efficacy evaluation and proper commercialization of products.

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