A Review on Himalayan Pine Species: Ethnopharmacological, Phytochemical and Pharmacological Aspects

Aditi Sharma, Lalit Sharma, Rohit Goyal

ABSTRACT

Introduction: Ever since ancient times, medicinal plants recognized as major source of therapeutics, as rescue for human diseases and maintain health. There is an exponential increase in usage of green medicines due to less cost and fewer side effects. The family Pinaceae, is largest conifer in species diversity. Pinus is the largest genus of monoecious, resiniferous, evergreen trees commonly known as Pines. Three species of pines occur wild in Indian Himalayas Pinus roxburghii, Pinus wallichiana, Pinus gerardiana. In addition, the constituents present in these plants are beneficial for the purpose of treatment of various ailments.

Methods: Information was collected from scientific journals, books, and reports via electronic search tools (Medline, Pubmed etc.)

Results: This review summarizes the existing information on three species of Pinus in relation to their pharmacognostic properties, phytochemistry, ethnopharmacology and pharmacological activities.

Key words: Pinus, Himalayas, Pinus roxburghii, Pinus wallichiana, Pinus gerardiana, Phytochemistry, Pharmacology, Ethnopharmacology.

INTRODUCTION

Medicinal plants are recognized as major source of therapeutics, throughout human history to fight illness and maintain health. The usage of natural product in treatment of diseases has been increased because of its natural source and comparatively lesser side effects as compared to the complexity in formulating chemical based drugs, as well as uprising cost has led worldwide researchers to focus on the medicinal plant research. The plant extracts possess medicinal properties and are often used as sweetening agent, colouring agent, preservatives in many medicinal formulations. India has a rich diversity of medicinal as well as aromatic plants and holds a unique place in the world in the traditional system of medicine thus called medicinal Garden of the world. India is one of the twelve mega biodiversity center having over 45000 plant species. Pinus is the most common genus of the family Pinaceae, which in turn is the largest family within the confierous. It is a large genus with over 110 species worldwide. The genus is divided into two subgenera: Strobus (Haploxylen, soft pines) and Pinus (Diploxylon, hard pines). Five species of pines are indigenous to India viz. P. roxburghii (Chir pine), P. wallichiana (Blue pine), P. kesiya (Khasi pine), P. gerardiana (Chilgoza pine) and P. merkussi (Teriassarian pine). Among all P. roxburghii, P. wallichiana and P. gerardiana are found in the Himalayas, whereas P. kesiya and P.merkussi are indigenous to Assam (India) and Burma. The Indian Himalayan region, a birthplace of Ayurveda and alternative therapies, covers about 18% of India and extends more than 2,800 km long and 220-300 km wide with altitudes of 200-8000m. India fulfills 80% demand of Ayurvedic medicine, 46% of Unani drugs and 33% of allopathic drugs. The unique climatic conditions enable a rich array of growth of various medicinally useful plants. Pinus species are important forest primarily for timber interests and source of gum oleoresins. Three species of Pinus plants are abundantly found in Himachal Pradesh i.e. Pinus roxburghii, Pinus wallichiana and Pinus gerardiana. P. roxburghii Sarg (chir pine) is a tall tree with spreading crown grows at an altitude of 450-2400m from Kashmir to Bhutan and Siwalik hills. P. wallichiana (blue pine) found at an altitude 2000-3500 m whereas P. gerardiana, commonly (Chilgoza pine) found at an altitude of 1600-3000m in district Kinnaur of Himachal Pradesh (H.P.). The present review was aimed to aware the researchers about the potential of Pinus species from Himalayas and to fully explore the scientific basis for the medicinal uses of these plant species.

Pinus roxburghii

Habitat and morphology

Pinus roxburghii Sarg. (Pinaceae) is an older terrestrial ornamental plant in the world. It is the most important pine of North Western Himalayas and an important resin and timber yielding species. In India it is found in Himachal Pradesh, Kashmir and Uttarakhand. It is a large tree with spreading crown...
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reaching 30-50 m with a trunk diameter of up to 2 m. It is found at the height of 500 to 2,500 m above sea level and grows gregariously. It is a large tree with branches in more or less whorled, bark dark gray, often reddish, deeply fissured, rough, exfoliating in longitudinally elongated plates, leaves in clusters of three, 20-30 cm, long, triquetrous, finely toothed, needle like, light green, persisting on an average for a year and half; male flowers about 1.5 cm long, arranged in the form of cones, female cones, solitary or 2-3 together, ovoid, 10-20 cm×7.5×13 cm when ripe. The tapping of the stem produces clear, transparent oleo-resin with the pungent and bitter taste. Taxonomy and common names of Pinus roxburghii Sarg are shown in Table 1.13

Phytochemical constituents

*P. roxburghii* is known to be a rich source of terpenoids, flavonoids, tannins, xanthenes other compounds shown in Table 2. Structure of different bioactive compounds is given in Figure 1a, 1b, 1c.

Ethnopharmacological uses

*Pinus roxburghii* has been widely used as a traditional remedy by the local tribes in various parts of Northern India. The wood oil is antiseptic, diaphoretic, rubefacient, aromatic and carminative in nature. It is used as a nerve tonic and expectorant and as remedy for diseases of the eye, ear, pharynx, hemorrhages, worm infestations and skin.22 The bark paste is applied in burns, scalds and ulcers. The timber is largely used for various purposes e.g., matchbox industry, sports goods, musical instruments, house building, furniture, tea chests etc. The volatile component of resin known as turpentine oil is the most important basic raw material for the synthesis of terpene chemicals widely used as adhesives, lubrication, solvents, plasticizers, paints and varnishes, antiseptic and expectorant. It is included in the Indian Pharmaceutical Codex as *Oleum terebinthininae* for treatment of chronic bronchitis.23 Turpentine oil is applied externally as rubefacient in lumbar and arthritis. It is also used as remedy for neuralgia, minor hemorrhages of tooth sockets and also recommended in gangrene of lungs.22 It is used to arrest minor hemorrhages in tooth sockets and nose. In the form of enema used in obstinate constipation. Inhalng the vapors of turpentine is useful in bronchitis. Resin (*Birotaj*) is obtained as solid residue in the distillation of turpentine oil from oleoresin. It is used for bangles, varnish, paints, polish industries, ingredient of printing inks, batteries. To heel cracks boiled resin (*khaida or leesa*) are used. The carbon is collected from the burnt resinous wood (*dai*) of *P. roxburghii* mixed with mustard oil and is made into a paste (*kajal*), which is applied inside the lower eyelids to keep the eyes clean and attractive.22 The resin mixed with the ash of *Betula utilis* is commonly applied over sprains and plastered on fractured bone for quick recovery, softent scar tissue and consumed as remedy in worm infestation and gastric trouble.24 The resin is a stimulant and used internally as stomachic and in gonorrhoea. The bark has tannins used for coloring the leather. Leaves are used in construction of roofs as "Channana". The needles of *Pinus roxburghii* are ground and mixed with water and given to patients suffering from measles. The oil obtained by the distillation of the needles is used in muscular pains and as expectorant.23 The seeds from the female cones are edible and are consumed in treatment of bronchitis, tuberculosi and urinary bladder infections.23

### Table 1: Taxonomy of Pinus roxburghii.

<table>
<thead>
<tr>
<th>Taxonomic classification</th>
<th>Synonym</th>
<th>Common names</th>
</tr>
</thead>
<tbody>
<tr>
<td>Kingdom: Plantae</td>
<td><em>Pinus longifolia</em></td>
<td>English: Long leaved Pine or chir pine</td>
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<tr>
<td>Division: Pinophyta</td>
<td></td>
<td>Hindi: Chil, Chir, Salla</td>
</tr>
<tr>
<td>Class: Pinopsida</td>
<td></td>
<td>Sanskrit: Manojna</td>
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<tr>
<td>Order: Pinales;</td>
<td></td>
<td>Gujarati name: Teliyodeodaro</td>
</tr>
<tr>
<td>Family: Pinaceae</td>
<td></td>
<td>Bengali: Saralgachhai</td>
</tr>
<tr>
<td>Genus: <em>Pines</em></td>
<td></td>
<td>Malayalam: Salla, Charalam</td>
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<tr>
<td>Subgenus: <em>Pines</em></td>
<td></td>
<td>Tamil: Simaidevadari</td>
</tr>
<tr>
<td>Species: <em>roxburghii</em></td>
<td></td>
<td>Telugu: Devadaru</td>
</tr>
</tbody>
</table>

### Table 2: Bioactive constituents in *Pinus roxburghii*.

<table>
<thead>
<tr>
<th>Part of plant</th>
<th>Bioactive constituents</th>
</tr>
</thead>
<tbody>
<tr>
<td>Needle essential oil</td>
<td>α-Pinene (22.8%), camphene (0.4%), β-pinene (14.1), A3-carene (50.6%), α-phellandrene (0.1%), α-terpine (0.4%), limonene (0.9%), β-phellandrene (0.7%), γ-terpine (0.5%), p-cymene (tr), longipine (0.2%), cyclosativene (tr), saturene (0.1%), longifolene (3.4%), β-caryophyllene (0.2%), α-terpinyl acetate (0.3%), longicyclene (0.2%), terpinolene (3.8%), reported in resin. Zhou et al 2010 reported α-Pinene (29.3%), β-myrcene (1.1%), 3-carene (14.2%), terpinyl acetate (1.0%), α-terpineol (4.5%), borneol acetate (2.2%), α-longipine (1.2%), caryophyllene (21.9%) and caryophyllene oxide (3.1%) in needle essential oil.</td>
</tr>
<tr>
<td>Wood essential oil</td>
<td>Caryophyllene (16.75), Thunbergol (16.29), 3-carene (14.95%), Cambrène (12.08%), alpha thujene (10.81%), terpinolene (7.17%), alpha pinene (4.8%), alpha caryophyllene (3.7%), sabine (3.79%), Verticil (1.84%), 4-terpineol (1.79%), myrcene (1.28%)</td>
</tr>
<tr>
<td>Bark essential oil</td>
<td>alpha pinene (31.29%), 3-carene (28.05%), Cambrène (4.86%), Longifolene (4.42%), Thunbergol (4.11), beta pinene (2.99%), sylibestrene (2.42%), terpineol (2.05%), terpinolene (2.03), terpinyl acetate (1.56%), elemol (1.46%), Methyl dihydro abtate (1.3%), myrcene (1.36%), Bornyl acetate (1.1%), alpha cadinol (1.08%)</td>
</tr>
<tr>
<td>Stem and needle extract</td>
<td>Quercetin, resin acid (abietic acid, neoabietic acid), taxifolin, catechin, quercetin derivative, taxifolin derivative, catechin and galloカテchin, kaempferol, rhamnetin isorhamnetin, myricetin, 3,4-dihydroxybenzoic acid, 3,4-dihydroxycinnamic acid, monomethyl pinosylin, dihydromonomethyl pinosylin, resveratrol, glycoside, pinoresinol, secoisolaricresinol.</td>
</tr>
<tr>
<td>Petroleum ether extract</td>
<td>Friedelin, ceryl alcohol and β-sitosterol</td>
</tr>
<tr>
<td>Bark needles wax</td>
<td>1,5-dihydroxy-3,6,7-triethoxy-8-allyloxyanthone, 1-hydroxy-3,6-dimethoxy-2-β glucopyranoxanthone, friedelin, ceryl alcohol, β-sitosterol, taxifolin, quercetin, catechin, kaempferol, rhamnetin, 3,4-dihydroxybenzoic acid, 3,4-dihydroxycinnamic acid, pinoresinol, pinosylin, resin acid, sterols, galocatechin and tannins</td>
</tr>
</tbody>
</table>

### Commercial uses

*Pinus roxburghii* is mostly a timber yielding plant and hence possess high commercial value. The heartwood of the plant is used in the making of furniture and building houses while the softwood is used in packaging cases and tea chest.26 The bark is rich in tannins and finds its application in tanneries. The resin is commonly used to repair broken ceramic
pottery. It is also used in protective coatings, varnishes and printing ink. When destructively distilled, resin produces a viscous liquid called rosin oil which is used as lubricating greases. Turpentine oil is commercially important as it is a major component in varnishes, thinners, sealing wax, soaps and disinfectants.

Pharmacological uses

Hepatoprotective Activity

Imran et al, 2012 studied hepatoprotective activity of wood oil of Pinus roxburghii at doses of 200, 300 and 400 mg/kg on rat liver damage induced by carbon tetrachloride and ethanol. The substantially elevated enzymatic levels of aspartate aminotransferase, alanine aminotransferase, alkaline phosphatase and decreased level of reduced glutathione (GSH) and total protein were significantly restored to normal levels.

Analgesic and Anti-inflammatory Activities

Alcoholic extract of Pinus roxburghii bark exhibited anti-inflammatory and analgesic activity at the doses of 100, 300 and 500 mg/kg (analgesic activity was evaluated by acetic acid-induced writhing and tail immersion tests in swiss albino mice. Acute and chronic anti-inflammatory activity was evaluated by carrageenan-induced paw oedema and cotton pellet granuloma in wistar albino rats. These activities were due to the presence of polyphenolic compounds present in the extract.

Anticonvulsant Activity

Kaushik et.al., 2012 reported alcoholic extract of Pinus roxburghii extract at doses of 100, 300 and 500 mg/kg was effective against generalized tonic-clonic and partial seizures using maximal electroshock induced seizure model in rats.

Antiasthmatic activity

The alcoholic extract of P. roxburghii was evaluated as antiasthmatic using guinea pig ileum preparation (in-vitro), histamine-induced bronchospasm in guinea pigs and catalepsy in mice (in-vivo). Anti-allergic activity of the plant was evaluated using milk-induced leukocytosis in mice and passive paw anaphylaxis in rats (in-vivo).

Antioxidant and Antidyslipidemic Activities

Pinus roxburghii needle extract possesses significant potential to lower the level of plasma lipid profile followed by a beneficial effect on high density lipoproteins (HDL) in high fat diet fed hyperlipidemic golden Syrian hamster model. Antioxidant activity of n-butanol fraction and alcoholic extract was found to be significant when assessed by trolox equivalent antioxidant capacity (TEAC) assay. Sharma et.al., 2016 described plant extract of Pinus roxburghii bark posses significant antioxidant activity against 2,2-diphenyl-1-picrylhydrazyl (DPPH) and nitric oxide assays.

Anticancer activity

Petroleum ether, ethyl acetate, chloroform and ethanol extract of Pinus roxburghii Sarg. was evaluated for anticancer activity on IMR-32 Human Neuroblastoma cancer cell line and implicit the observation that petroleum ether and Chloroform extracts having promising activity. Cone essential oil of P. roxburghii showed notable cytotoxic activity on MCF-7 cells at 100 μg/ml.

Antibacterial Activity

The plant extract shows the antimicrobial potential against a wide variety of microorganisms, Bissa et.al., 2008 studied antibacterial activity of aerial parts of Pinus roxburghii against E.coli, Enterobacter aerogenes, Agrobacterium tumefaciens. Sharma et. al., 2016 reported significant antimicrobial
activity of *Pinus roxburghii* bark extract against *Pseudomonas aeruginosa*, *Escherichia coli*, *Staphylococcus aureus* and *Candida albicans* and promising antifungal activity against *Candida albicans*. Aqueous and alcholic extracts from *P. roxburghii* stem, leaves, bark, male cone and male cone showed growth-inhibitory activity against the bacterial plant pathogen *Agrobacterium tumefaciens*. Antidiabetic activity

Ethanolic extract of *Pinus roxburghii* bark at dose of 100, 300, 500 mg/kg possesses significant antidiabetic activity in alloxan-induced-diabetic rats. In an in-silico study by Kaushik et al., 2014, it was observed that secoisoresinol, pinoresinol, and cedeodarin showed the best docking results on different diabetic receptors. In another study Kaushik et al., 2015 showed that the extracts from the bark of *Pinus roxburghii* by bioassay guided fractionation have good antidiabetic activity when tested through α-amylase inhibitory assay in-vitro.

*Pinus gerardiana* Habitat and morphology

*Pinus gerardiana*, known as the chilgoza pine, (noosa, or neoza) is a pine native to the northwestern Himalayas. There are about 29 species of pine which produce edible nuts those are utilized by indigenous tribal cultures in the world. In India, out of six species of pine, *Pinus gerardiana* is the only species which produces edible and highly nutritious nuts. This species is distributed not only in India but also in Afghanistan, Tibet, Baluchistan (Pakistan) between 2000 and 3350 m elevation. In India, it is distributed only in Himachal Pradesh (Kinnaur and Chamba Districts) and Jammu and Kashmir. The branches are slightly ascending, and usually not whorled. The bark exfoliates in irregular thin flakes, gray in colour. The leaves are needle like, stiff, dark green, and are arranged in clusters of three. Male cones are cylindrical, elongated, dark brown pointed at the tip, measure and bear a rudimentary wing. *Pinus gerardiana* is well known for its edible seeds (Chilgoza), rich in carbohydrates and proteins. These “nuts” are known and sold locally under the name of Chilgoza, “Neja” (singular) or “Neje” (plural). Chilgoza is only pine which is of immense social importance because it is an income source for tribal people in the Kinnaur district of Himachal Pradesh. They are either eaten raw or roasted and are also included as an ingredient in a variety of traditional dishes, such as breads, candies, sauces and cakes, as well as in vegetable and meat dishes. In general, pine nuts are known to be a good source of nutrients. Taxonomy and common names of *Pinus gerardiana* are given in Table 4.

**Phytochemical constituents**

The nuts are considered to be rich source of various nutrients including proteins, carbohydrates, fibers, minerals besides its higher amount of oil. Its oil is of very good quality, free of cholesterol and a rich source of fatty acids like Sieric acid (0.3%), Linoleic acid (Omega-6) (51.3 %), Linolenic acid (Omega-3) (1.5 %) Oelic acid (Omega-9) (39.7% Arachidic acid (2.1%) Palmitic acid (7.2%). Hoon et al., 2014, reported approximately 50% fat, 30% protein, 10% carbohydrate, 4% ash and 6% moisture in Pine nuts. The seeds with edible kernels are obtained from ripe cones credited with carminative stimulant and expectorant properties. Analysis of kernels possesses delicate terbinthine flavor, moisture (7.5%), protein (15.9%), fat (49.9%), carbohydrates (21.6%), fibre (2.2), and mineral matter (2.9%). On pressing kernels yielded a transparent clear oil having pale yellow. Low molecular weight components in pine nuts from *Pinus pinea* includes glucose, fructose, sucrose, and raffinose, several soluble carbohydrates, saccharides (galactose, maltose, and plantose) and cyclitols (pinitol, galactinol, galactopinitol A1, fagopyritol B1, and other glycosyl-inositosil). Most abundantly found cyclitols are chiroinositol, fagopyritol B1, and pinitol. Structure of different bioactive compounds from *Pinus gerardiana* are shown in Figure 3.

**Ethnopharmacological uses**

The cones and wood are used as timber and firewood. Branches are commonly used as roof thatching materials in houses. Wood is also used as building material and making of huts and wooden boxes. The bark of the tree is made into baskets and also into rough buckets for fetching water. Tan or green dye is obtained from the needles. The needles contain a substance called terpene, released when rain washes over the needles and it has a negative effect on the germination of some plants, including wheat. The resins are obtained by tapping the trunk, or by destructive distillation of the wood. Turpentine consists of an average of 20% of the oleoresin separated by distillation. Turpentine has a wide range of uses, including as a solvent for waxes etc, for making varnishes.

**Table 3: Pharmacological activities of Pinus roxburghii.**

<table>
<thead>
<tr>
<th>Activity</th>
<th>Parts used</th>
<th>Dose</th>
<th>Methods</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hepatoprotective 50</td>
<td>Wood oil</td>
<td>(200, 300, 500) mg/kg</td>
<td>Carbon tetrachloride and ethanol induced hepatotoxicity</td>
</tr>
<tr>
<td>Analgesic 54</td>
<td>Bark</td>
<td>(100, 300, 500) mg/kg</td>
<td>Acetic acid induced writhing and tail immersion test in Swiss albino rats</td>
</tr>
<tr>
<td>Anti inflammatory 23</td>
<td>Bark</td>
<td>(100,300,500) mg/kg</td>
<td>Carrageenan induced paw oedema and cotton pellet granuloma in wistar albino rats</td>
</tr>
<tr>
<td>Anti convulsant activity 29</td>
<td>Bark</td>
<td>(300, 500) mg/kg</td>
<td>Maximal electroshock(MES) and Pentylenetetrazole(PTZ) induced seizures in wistar albino rats</td>
</tr>
<tr>
<td>Anti asthmatic activity 50</td>
<td>Whole plant</td>
<td>100mg/kg</td>
<td>Histamine induced broncospasm in guinea pig and catalepsy in mice</td>
</tr>
<tr>
<td>Antidysslipidemic 31</td>
<td>Needle</td>
<td>100mg/kg</td>
<td>High fat diet fed hyperlipidemic golden Syrian hamster</td>
</tr>
<tr>
<td>Anticancer 52,23</td>
<td>Bark</td>
<td>(100, 200, 400, 800) μg/ml</td>
<td>IMR-32 Human neuroblastoma cancer cell line</td>
</tr>
<tr>
<td>Antibacterial and antifungal 25, 81,34</td>
<td>Needle and female cones</td>
<td>5mg/ml</td>
<td><em>E. coli</em>, <em>Enterobacter aerogenes</em>, <em>Agrobacterium tumefaciens</em>, <em>Pseudomonas aurigiosa</em>, <em>E. coli</em>, <em>Staphylococcus aureus</em>, <em>Klebsiella pneumonia</em>, <em>Candida albicans</em></td>
</tr>
<tr>
<td>Antidiabetic 37</td>
<td>Bark</td>
<td>(500, 1000, 1500) μg/ml</td>
<td>Alloxan induced diabetic rats</td>
</tr>
</tbody>
</table>
Rosin is the substance left after turpentine is removed. This is used by violinists on their bows and also in making sealing wax, varnish etc. Pitch can also be obtained from the resin and is used for waterproofing, as a wood preservative etc.

Chilgoza is considered as one of the important dry fruits of the tribal area having carminative, stimulant and expectorant properties.

Commercial uses
The main economic use is its edible, oil-rich seeds (neoza in Hindi), which are harvested by knocking the cones from the trees in autumn and during early winter. The Chilgoza pine on tapping yield oleoresin of good quality, but owing to its limited availability and avoidance of destruction of trees for obtaining most valuable seeds the species has not been exploited commercially for timber. In traditional systems, sufficient cones are usually left on the tree to ensure that some seed is available for natural regeneration.

Pharmacological uses
Antioxidant assay
Hoon et. al. 2014, studied total antioxidant capacity and the presence of antioxidant compounds in Pinus gerardiana. Antioxidant compounds such as gallocatechin, catechin, lutein, lycopene, carotenoids and tocopherols are present in P. gerardiana. Galloocatechin had the highest presence out of all the compounds. Sharma et. al. 2016, revealed the presence of various biochemical compounds such as alkaloids, flavonoids, glycosides, triterpenoids and saponins in P. gerardiana. Quantitative phytochemical analysis of plant extracts showed the presence of phenolics, flavonoids, tannins, beta-carotene and lycopene. Bark extract showed significant antioxidant activity against DPPH, nitric oxide and H2O2 free radicals scavenging assays.

Cardiovascular disorders and thromboembolism
P. gerardiana nut oil caused blood clot lysis in-vitro, in vitro whole blood coagulation was also seen reduced. P. gerardiana nut oil has no effect on blood cell indices in-vivo. It was found effective in treatment of cardiovascular disorders and thromboembolism.
Antiinflammatory activity

Hydroalcoholic extract of *P. gerardiana* stem bark at 500, 1000, 1500, 2000, 2500 μg/ml showed in-vitro anti-inflammatory activity, carried out using albumin denaturation and HRBC membrane stabilization assays.\(^{31}\)

Antimicrobial and antifungal activity

Hydro-alcoholic extract of *P. gerardiana* at 500, 1000, 1500 μg/ml possessed potent antibacterial activity against Gram positive (S. aureus) and Gram negative (*E. coli*, *Bacillus subtilis*, *Staphylococcus aureus*, *Aspergillus*).\(^{31}\) Many species of *Pinus* yield valuable timber used for making furniture, door, window frames, paper pulp.\(^{53}\) The wood is moderately hard, durable and highly resinous. It is a good firewood but gives off a pungent resinous smoke. Pine timber is divided in hard pines of two or three needle species and soft pine of five needle species. In India *P. wallichiana* (Kail) and *Pinus roxburghii* yield commercial timber. It is a commercial source of turpentine which is superior quality than that of *P. roxburghii* but is not used so freely.\(^{42}\) It is of similar timber properties and quality to *P. strobus* and *P. monticola* in North America, with tall, straight trees producing wood of good strength.

**Phytoconstituents**

Sharma *et al.*, 2016, reported the presence of alkaloids, flavonoids, tannins, phenols, lycopene and carotenoids in hydroalcoholic extracts of *Pinus wallichiana* stem bark extract.\(^{51}\) Presence of other constituents are shown in Table 7. Structure of different bioactive compounds are given in Figure 5.

**Pharmacological Activities**

**Antimicrobial activity**

Sharma *et al.*, 2015 reported hydroalcoholic needle extract of *Pinus wallichiana* have significant antibacterial activity against *P. aeruginosa* and *E. coli*. Hydroalcoholic stem bark extract of *Pinus wallichiana* possess significant antibacterial activity against *Pseudomonas aeruginosa*, *S. aureus*, *K. pneumonia* and possesses potent antifungal activity against *Candida albicans*.\(^{31}\) In another study by Rahman *et al.*, 2016 *Pinus wallichiana* showed potent antibacterial and antifungal activity against *Escherichia coli*, Bacillus subtilis, *Shigella flexenari* (clinical isolate), *Staphylococcus aureus*, *Pseudomonas aeruginosa* and *Salmonella typhi*, the fungal strains were *Trichophyton longisus* (clinical Isolate), *Candida albicans*, *Aspergillus flavus*, *Microsporum canis* and *Candida glaberata*.\(^{62}\)

**Table 6: Taxonomy of Pinus wallichiana.**

<table>
<thead>
<tr>
<th>Taxonomic classification</th>
<th>Synonym</th>
<th>Common names</th>
</tr>
</thead>
<tbody>
<tr>
<td>Kingdom: Plantae</td>
<td><em>Pinus excels</em></td>
<td>Botanical name: <em>Pinus wallichiana</em></td>
</tr>
<tr>
<td>Division: Pinophyta</td>
<td><em>Pinus griffithii</em></td>
<td>English : Himalayan pine</td>
</tr>
<tr>
<td>Class: Pinopsida</td>
<td><em>Pinus chylla</em></td>
<td>Hindi: Kail</td>
</tr>
<tr>
<td>Order: Pinaceae</td>
<td>Kashmir Yiro, kail,kaiar</td>
<td></td>
</tr>
<tr>
<td>Family: Pinus</td>
<td>Blutan, Tongschilamshing</td>
<td></td>
</tr>
<tr>
<td>Genus: Pinus</td>
<td>German : Tranenkiefer</td>
<td></td>
</tr>
<tr>
<td>Subgenus: Strobus</td>
<td>Species: <em>Pinus wallichiana</em></td>
<td></td>
</tr>
</tbody>
</table>

**Table 5: Pharmacological activities of Pinus gerardiana.**

<table>
<thead>
<tr>
<th>Activity</th>
<th>Parts used</th>
<th>Dose</th>
<th>Methods</th>
</tr>
</thead>
<tbody>
<tr>
<td>Antioxidant assay</td>
<td>Chilgoza</td>
<td>(62.5, 125, 250, 500, 1000) mg/kg</td>
<td>DPPH, ABTS, radical cation scavenging assay.</td>
</tr>
<tr>
<td>Cardiovascular disorders and thromboembolism</td>
<td>Nuts oil</td>
<td>30μl/ml, 60μl/ml</td>
<td>Fibrolytic activity, Epinephrine and collagen activated platelet aggregation</td>
</tr>
<tr>
<td>Antiinflammatory</td>
<td>Bark</td>
<td>500, 1000, 1500, 2000, 2500 μg/ml</td>
<td>HRBC membrane stabilization assay, Albumin denaturation assay</td>
</tr>
<tr>
<td>Antimicrobial assay</td>
<td>Bark</td>
<td>500, 1000, 1500 μg/ml</td>
<td>S. aureus, <em>E. coli</em>, <em>P. aeruginosa</em> and <em>K. pneumonia</em>, <em>Candida albicans</em></td>
</tr>
</tbody>
</table>

**Table 7: Bioactive constituents in Pinus wallichiana.**

<table>
<thead>
<tr>
<th>Plant part extract</th>
<th>Bioactive constituents</th>
</tr>
</thead>
<tbody>
<tr>
<td>Needle extract</td>
<td>Quercetin (21.426 %), Isorhamnetin (2.857 %)</td>
</tr>
<tr>
<td></td>
<td>β-sitosterol, β-sitosterol-3-O-β-d-glucopyranoside, 5-hydroxy-7-methoxy-2-(4-methoxyphenyl)-4H-chromen-4-one, Oleanolic acid</td>
</tr>
<tr>
<td>Stem bark methanolic extract</td>
<td>Kampherol (2.300 %), Rhamnetin (2.08 %), Myrcetin (3.0 %), Isorhamnetin (2.005 %), Quercetin (5.009)</td>
</tr>
<tr>
<td>Turpentine</td>
<td>a-pinene (90 %), Abietic and isopimaric acid, lambertianic acid</td>
</tr>
</tbody>
</table>

**Traditional and commercial uses**

Many species of *Pinus* yield valuable timber used for making furniture, door, window frames, paper pulp.\(^{43}\) The wood is moderately hard, durable and highly resinous. It is a good firewood but gives off a pungent resinous smoke. Pine timber is divided in hard pines of two or three needle species and soft pine of five needle species. In India *P. wallichiana* (Kail) and *Pinus roxburghii* yield commercial timber. It is a commercial source of turpentine which is superior quality than that of *P. roxburghii* but is not used so freely.\(^{42}\) It is of similar timber properties and quality to *P. strobus* and *P. monticola* in North America, with tall, straight trees producing wood of good strength.

**Pharmacological Activities**

**Antimicrobial activity**

Sharma *et al.*, 2015 reported hydroalcoholic needle extract of *Pinus wallichiana* have significant antibacterial activity against *P. aeruginosa* and *E. coli*. Hydroalcoholic stem bark extract of *Pinus wallichiana* possess significant antibacterial activity against *Pseudomonas aeruginosa*, *S. aureus*, *K. pneumonia* and possesses potent antifungal activity against *Candida albicans*.\(^{31}\) In another study by Rahman *et al.*, 2016 *Pinus wallichiana* showed potent antibacterial and antifungal activity against *Escherichia coli*, Bacillus subtilis, *Shigella flexenari* (clinical isolate), *Staphylococcus aureus*, *Pseudomonas aeruginosa* and *Salmonella typhi*, the fungal strains were *Trichophyton longisus* (clinical Isolate), *Candida albicans*, *Aspergillus flavus*, *Microsporum canis* and *Candida glaberata*.\(^{62}\)
Sharma, et al.: A review on Himalayan Pine species

**Table 8: Pharmacological activities of Pinus wallichiana.**

<table>
<thead>
<tr>
<th>Activity</th>
<th>Parts used</th>
<th>Dose</th>
<th>Methods</th>
</tr>
</thead>
<tbody>
<tr>
<td>Antimicrobial activity</td>
<td>Needles</td>
<td>24mg/ml</td>
<td>Agar well diffusion method</td>
</tr>
<tr>
<td>Insecticidal activity</td>
<td>Needles</td>
<td>20mg/kg</td>
<td>Insects: <em>Rhyzopertha dominica</em>, <em>Tribolium castaneum</em> and <em>Callosobruchus analis</em>.</td>
</tr>
<tr>
<td>Antioxidant activity</td>
<td>Bark</td>
<td>(10, 20, 40, 80, 100) μg/ml</td>
<td>DPPH, Nitric oxide and Hydroxyl radical scavenging assay</td>
</tr>
<tr>
<td>Anti inflammatory activity</td>
<td>Bark</td>
<td>(500, 1000, 1500, 2000, 2500) μg/ml</td>
<td>Albumin denaturation, HRBC membrane stabilization</td>
</tr>
</tbody>
</table>

**Table 9: Marketed formulation of Pinus species.**

<table>
<thead>
<tr>
<th>Name of formulation</th>
<th>Plant part used</th>
<th>Pharmacological activity</th>
</tr>
</thead>
<tbody>
<tr>
<td>Polyherbal oil extract</td>
<td>Oleo resin of <em>Pinus roxburghii</em></td>
<td>Analgesic and anti-inflammatory</td>
</tr>
<tr>
<td>Rumalaya gel</td>
<td>Resin from <em>Pinus roxburghii</em></td>
<td>Joint and Bone pain associated with various orthopedic ailments</td>
</tr>
</tbody>
</table>

**Insecticidal assay**

Different fractions of *Pinus wallichiana* extract were tested against various insects *Rhyzopertha dominica*, *Tribolium castaneum* and *Callosobruchus analis*. The n-hexane fraction showed 20 % activity against *R. dominica*, while the ethyl acetate showed 20 % activities against all the strains. The chloroform revealed 20 % activity against *R. dominica*, while the aqueous showed 20 % and 40 % activity against *R. dominica* and *C. analis*.81

**Phototoxic activity**

The n-hexane, ethyl acetate, chloroform, aqueous fractions of *Pinus wallichiana* needles showed significant phytotoxicity activity at 500μg/ml, while at low concentration 50μg/ml and 5μg/ml showed moderate activity.69

**Antioxidant activity**

Hydroalcoholic extract of leaves and stem bark of *Pinus wallichiana* possess significant in-vitro antioxidant activity when tested in DPPH, nitric oxide radical scavenging, hydroxyl radical scavenging and hydrogen peroxide radical scavenging assays. Presence of phenolics, flavonoids, tannins, carotene were also reported in *Pinus wallichiana*.52,31

**Anti-inflammatory activity**

Hydroalcoholic stem bark extract of *Pinus wallichiana* possesses significant in-vitro anti-inflammatory activity when tested through albumin denaturation and RBC membrane stabilization assays.31

**Marketed formulations**

A summary of commercial formulations of Pine species is given in Table 9.

**CONCLUSION**

This review furnishes the presence of several phytochemical components and pharmacological properties of *Pinus roxburghii*, *Pinus wallichiana* and *Pinus gerardiana*. The pharmacological activities reported in the present review confirm that the therapeutic value of these plants is very high, having a leading capacity for the development of a new, safe, effective and cheaper drug in future. But there is need for more elaborative study, pharmacological investigations, clinical trials, more exploration and public awareness for the best utilization of medicinal properties of these pine species. Even the industrial entrepreneurs also should come forward with new concepts and steps towards the best use of these potential medicinal pine species. Let’s hope that in future herbal products will be competing modern medicines with added advantages of more safety and lower costs.

**CONFLICT OF INTEREST**

The authors have declared no competing interest.

**ABBREVIATIONS**

HDL: High Density Lipoprotein; DPPH: 2,2-diphenyl picrylhydrazyl; TEAC: Trolox equivalent antioxidant activity; ABTS: 2,2’-azino-bis(3-ethylbenzthiazoline-6sulphonic acid.

Figure 5: *Pinus gerardiana* (Chilgoza pine) a) Cone b) Tree c) Needles d) Trunk e) Kernels

Figure 6: *Pinus wallichiana* (Blue Pine) a) Cone b) Tree c) Needles d) Trunk.
REFERENCES


Sharma, et al.: A review on Himalayan Pine species


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**GRAPHICAL ABSTRACT**

*Pinus roxburghii*  *Pinus wallichiana*  *Pinus gerardiana*

- Alpha-pine
- Carophylle
- Limonene
- Phytol
- Quebracho
- Tannin

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**SUMMARY**

- A pine is any conifer in the genus Pinus of the family Pinaceae.
- Pinus is the largest genus of monoecious, resiniferous, evergreen trees commonly known as Pines.
- *Pinus roxburghii*, *Pinus wallichiana*, *Pinus gerardiana* are native species of Pine from Himalayas.
- The constituents present in these pine plant species are beneficial for the purpose of treatment of various ailments.
- The phytoconstituents and pharmacological activities of the pinus plant species confirm that the therapeutic value of these plants is very high, having a leading capacity for the development of a new, safe, effective and cheaper drug in future.

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