

A Critical Overview on *Casuarina equisetifolia*

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ABSTRACT

Casuarina equisetifolia is a fast-growing species and highly nutritive multipurpose, valued tree crop. It is a large, straight, attractive evergreen tree with hanging branches. The tree contains many bioactive compounds, nutritive compounds, phenolic compounds, flavonoids, Terpenes and also contain protein due to the presence of these compound the tree exhibit many biological/ Pharmacological activity and the all parts of tree such as Leaves, seed, flower, fruits and root also useful for the treatment of various diseases includes cancer treatment, GI disease and disorders, Liver diseases, etc. It is also useful for the treatment of Diabetes mellitus and possess various activity like anti-hypertensive activity, anti-arthritic activity, hypocholestraemic activity, etc. The indigenous population relied heavily on the Casuarinaceae family for the survival and the Casuarinaceae family was widely used as traditional bush medicine. Traditional medicine has long relied on plants as a safe and effective source of treatment. About 75% of people today still rely on conventional medical techniques for the treatment of a wide range of illnesses. Plants ability to serve as medicinal agents is dependent on their phytochemicals. There hasn't been enough research and study done on the pharmacological and therapeutic potential of tree species like *C. equisetifolia*. So, the main aim of this review was to promote or discover the knowledge about this multipurpose tree and its medicinal importance.

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INTRODUCTION

Casuarina equisetifolia is commonly known as Junglisaru, She-oak, Horse tail, Whistle pine, Ironwood, beef wood etc.;^[1] and the scientific name of the tree is *Casuarina equisetifolia*. *Casuarina equisetifolia* is a fast growing species and very valuable tree crop belonging to the family Casuarinaceae.^[2] It is a large, straight, attractive evergreen tree with hanging branches that can grow up to 10-50 m tall.^[3] India is a major producer of the plant. The tree *Casuarina equisetifolia* is grown in the sandy soil areas in the states of Gujarat, Orissa, West Bengal, and the Andaman. It is mostly cultivated in the districts of Cuddalore, Villupuram, Kancheepuram, Tiruvallur, Thanjavur, and Ramanathapuram in the Indian state of Tamil Nadu.^[1,3] The 17 species that comprise the genus *Casuarina* are found naturally in the regions of Australia, South-Eastern Asia, Malaysia, Southern Myanmar, the Kra Isthmus of Thailand, Melanesia, Polynesia, and the Islands of the Western Pacific Ocean, including New Guinea, Mascarene Island, New Caledonia. This attractive species are also grown in the tropical regions of Pakistan, Africa, and Sri Lanka, etc..^[1,3,4]

Numerous researchers studies shown that the tree *Casuarina equisetifolia* contain many active constituents in the category of

carbohydrates, alkaloids, proteins, glycosides, saponins, phenolics, flavonoids, tannins, steroids, amino acids, gum, reducing sugars, triterpenoids and phyto sterols such as kaempferol, quercetin, alicyclic acids, taraxerol, lupenone, lupeol, gallic acid, sitosterol, catechin, gallo catechol, campesterol, stigmasterol, cholesterol, cholest-5-en-3-b-ol derivatives, casuarine, citrulline, cupressulflavone, epicatechin, gallicin, gentisic acid, isoquercitrin, juglanin, proanthocyanidins, rutin, trifolin, etc..^[3-6]

Some Research study shown all Parts of Tree such as Leaves, Bark, Seed, Flowers (aerial parts) and Roots are useful to treat various disease and disorders and they exhibit various pharmacological/ medicinal properties such as anti-bacterial activity, anti-fungal activity, anti-cancer activity, anti-inflammatory activity, anti-oxidant activity and hepatoprotective activity, anti-diabetic activity, anti-hyperlipidaemic activity, anti-ulcer activity, etc and the bark of the tree are useful to treat stomachache, toothache, headache and also possess astringent property, anti-diarrhoeal property. The seeds of the tree exhibit anthelmintic property, antispasmodic property etc. leaves are used as a anti-spasmodic. The poly herbal gel of the tree contains anti-acne property.^[2,5,7] According to the study, Prior to European settlement in Australia, the indigenous population/aboriginal people relied heavily on the Casuarinaceae family for the survival and the Casuarinaceae family was widely used as traditional bush medicine.^[4]

In addition to this, *Casuarina equisetifolia* is one of the most lucrative tree crops in the world as a result of its many useful applications its market demand has remained consistent. it is also in high demand as an inexpensive housing material, banana



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stakes, and excellent fuelwood. It encourages the development of reclaimed land, stability of sand dunes, resistance to drought and the construction of buffer zones along coastal lands. This species is better for fixing nitrogen from the atmosphere. Recently Multiple major paper factories in India rely on this species as a raw source. More than 2 million tons of *Casuarina* wood is used annually by these mills at present.^[8,9] According to literature, In the second decade of the 19th century, *Casuarina equisetifolia* was brought into India from Australia. Its primary use was to provide fuel for steam engines.^[10]

Taxonomical Classification^[11-13]

Category	Botanical description
Kingdom	Plantae
Phylum	Spermatophyta (seed plant)
Subphylum	Angiospermae (flowering plant)
Class	Dicotyledon/magnoliopsida
Order	Casuarinales
Family	Casuarinaceae
Genus	Casuarina
Species	<i>Casuarina equisetifolia</i>
Binomial name	<i>Casuarina equisetifolia</i> L.

Geographical distribution

The tree *Casuarina equisetifolia* is widely distributed in seaside/ coastal area, mountain/ hill slopes, hot humid tropics, open forests (wet and dry both regions), rocky beach, etc. That they thrive in a range of temperatures/environment and humidity levels, therefore they're often planted in tropical and subtropical regions, as well as in Mediterranean nations.

It is believed that the first seeds were grown in Karwar between the years 1868 and 1869 as well as in the Nilgiri region of what was then the Madras Presidency and in the Chengalpet and South Arcot districts of the state of Tamil Nadu. Later on, the species found its way across the beaches to various sections of Tamil Nadu, Andhra Pradesh, Orissa, and West Bengal. Additionally, it was introduced into the coastal districts of Kerala, Maharashtra, and Karnataka. Because of its adaptability, allowing it to thrive in a variety of environment/temperature. It is cultivated in various regions of India and in almost all of the states that make up peninsular India. It is believed that over half a million hectares, mostly in the Peninsular area, are now devoted to its cultivation. India is the world's biggest producer, and it is grown widely by farmers in the eastern coastal states, as well as in the drier northern region of Karnataka.^[10]

Cultivation

The tree is best grown in locations that get between 250 and 2,500 millimetres of rain per year. The tree tolerates maximum

Vernacular Name^[12,14]

Languages	Vernacular Name
Hindi	Vilayati saru, Jungli jhao, Jangli saru, Savukku.
English	Australian beefwood, Australian oak, <i>Casuarina equisetifolia</i> , beach she-oak, beefwood, Casuarinas, Coast ironwood, Coast she-oak, Horsetail beefwood, Horsetail tree, Ironwood, She-oak, Swamp oak, Whistling pine, Whistling tree.
Bangladesh	Belaiti jhao, Jhau gachh, Hari
Italy	Casuarina
Fiji	Nakure, Nggaro, Nokonoko, Nokonoko ndamu, Qaro, Thau, Velau
Indonesian	Aru, Tjemara laut, Cemara laut, Ai samara, Eru.
Chinese	Duan zhi, pu tong mu ma huang, bo gu shu, ma wei shu.
Philippines	Agoho
German	Eisenholz, strandkasuarine
French	Bois de fer, Filao, Pin d'australie
Bahamas	Beef-wood
Brazil	Cavalinho, Choroa, Pinheiro
Malaysia	Ru, Ru laut
Myanmar	Tin yu
Netherlands	Kazuarisboom

temperature (48 degrees Celsius), and remain relatively unaffected by lows of zero degrees Celsius, while being at an altitude/height up to 1,200 or 1,500 metres.

The tree requires a lot of sunshine and can thrive/grow in practically any kind of soil. It is also very tolerant of saline in the soil. Its development is affected by heavy soil, clay soil and soils with inadequate drainage system. The best plantings are found in areas with laterite/ mineralised soils or well-drained sandy loams/ light soil.^[10]

Morphological characteristics of *Casuarina equisetifolia* and its parts^[1,12,14,15]

Casuarina equisetifolia is a large, evergreen plant. Which attain a height up to 50 meter with a solitary trunk with an open and irregularly shaped crown. It is a woodland tree has drooping branches and composed of wood. It belongs to the angiosperm family, the class of plants with vascular seeds and woody stems, such as conifers.

Tree parts

Leaves, Bark, Branches, Flower, Fruit, Seed.

Leaves

The tiny, shortened leaves are arranged in whorls of 7 to 8 per node. Drooping, needle like, wrinkled twigs are 23 to 38 centimetres in length and have a cross-section that is either angular or curved and is either glabrous or pubescent.

Bark

The outer part of the bark is a pale greyish brown in colour and the inner part is pale yellow to brown in colour and is smooth on younger tree s but becomes rough and deeply furrowed in older trees. Lenticels form notable encircling rings/lines on younger bark and the outer part of the older tree is greyish brown in colour and inner bark of the older tree is Reddish brown in colour.

Branches

There is a lot of branching in the crowns. Thin, drooping branches give the tree s as a delicate aspect. The needle-like branch let are between 10-20 centimetres (about 4-8 inches) in length with a greyish-green in colour.

Flower

The blooming season occurs twice a year, in the months of February to April and September to October. This tree may produce both male and female offspring. When male flowers bloom, it takes two years from planting to see a bloom, whereas female flowers bloom only a few days after they're planted.

Male blossoms are arranged in terminal spikes/whorls, while females blossom are clustered at the ends of branches (side branches of the tree). This tree is pollinated by the wind (anemophilous).

Fruit

Fruits that resemble pinecones in shape and are round, broad, rigid. The fruit consists of extremely tiny nutlets with wings. The fruits are wrapped in woody structures that resemble cones and are 0.75 inches (2 centimetres) in length. The months of June and December are ideal for the ripening of fruits. The strong constructed cones have an ovate form. The mature pinecones have a coloration that might be described as brownish red or grey. Seventy to ninety seeds may be found inside each cone. A single seed is enclosed inside a number of winged achenes that are arranged around the fruit. Each ripe fruit contains a single seed and has a pale brown in colour.

Traditional uses of the parts of *Casuarina equisetifolia*^[1,16-18]

According to various literature, All parts of tree such as leaves, root, seed, bark, etc.. are used traditionally in the treatment of

various ailments includes toothache, stomachache, diarrhea, throat infections, microbial/bacterial infection, diabetes mellitus, hyperlipoproteinemia, muscle spasms, cancer treatment, inflammation, etc. The methanolic, ethanolic, aqueous and hexane extract of tree parts possess numerous pharmacological activities such as anti-histaminic activity, anti-hyperlipidemic activity, antioxidant activity and anti-cancer activity, etc. Hence, the tree may be a promising source for the development of neutraceuticals. Various use of the parts of tree are briefly discussed in below:-

Leaves

Colic patients often utilise the leaf, which has anti-spasmodic properties. The leaves of the tree is used for the treatment of various diseases.

Bark

The anti-toothache properties of the bark may be attributed to the high tannin content that naturally occurs inside the bark. Decoctions made from the tree, whose bark contains tannins and is used to make astringent medicines, were traditionally used to treat dental pain and the bark decoction is also useful remedy for treating Abdominal pain, muscle strain, constipation. This decoction is used as gargle for treating pharyngitis.

Therefore, The bark of tree is useful in the treatment of various disease and disorders such as nervous system disorders, Peptic ulcer, diarrhea, throat infection, Vitamin/Thiamine deficiency, and its possess a high level of antioxidant activity, etc.

Branches

The Branches tree contains a variety of medicinal uses includes Ear infections may be treated by boiling crushed branchlets in oil. The mixture's extract is used to cure colic and as an ointment for swelling and rashes, and it also possess anti-cancerous property.

Seed

Numerous studies shown that the seed of the tree possess anti-helminthic activity, anti-spasmodic activity, anti-diabetic activity, etc.

The Pulverized/powdered seeds are rubbed on the head in the form of a plaster to alleviate headache or pain and the seeds pulp/ juice is used to treat persistent digestive problems.

Fruit

The fruit is indeed believed to have therapeutic powers since when the fruit is dried, crushed, and pulverized into a powder, then combined with nutmeg used as a remedy for toothache.



Australian pine tree with its parts.

Root

The therapeutic benefits of both the fresh and dried forms of the root have leading to its widespread usage. It is helpful to maintain oral hygiene by chewing on the roots on a regular basis.

Important pharmacological/Medicinal use of *Casuarina equisetifolia*

Casuarina equisetifolia is useful to treat some common disease and disorders includes high blood cholesterol, liver diseases, diabetes, arthritis and possess various pharmacological activity such as anti-inflammatory, anti-tumour, antispasmodic, anti-ulcer, Nephroprotective activity, etc. Details are discus below:-

Anti-inflammatory activity

The tree Bark extract shown anti-inflammatory efficacy at a range of concentrations (20, 40, 60, and 80 g/mL). When compared to ethanol and water extract, methanolic bark extract exhibit the greatest inhibition activity and the maximum/greatest inhibition activity (84.6 ± 0.26) and ($IC_{50} 33.6 \pm 0.23$ $\hat{I}^1/4g/mL$) were also seen at 80 $\hat{I}^1/4g/mL$ for the methanol root extract, indicating superior *in vitro* anti-inflammatory action.^[1]

Anti-bacterial activity

Crude extracts of *Casuarina equisetifolia* have been shown to contain a variety of phytoconstituents, including phenols, flavonoids, tannins, and terpenoids, which is responsible for the plant's therapeutic efficacy when extracted using a solvent and

the study revealed that the *Casuarina equisetifolia* methanol root extract combined with chemicals identified by GC-MS analysis shows promising as a medicinal agent due to its high anti-bacterial activity. Studies are also being examined to identify, purify, and characterise the pharmacologically active molecule implicated in these bioactivity. The chemical that was identified has the potential to be used as a basis for effective new antibacterial drugs with significantly less or no adverse effects.^[9] The root extract of the tree shown greatest zone of inhibition against *Proteus vulgaris*, *Shigella sonnei*, *Bacillus subtilis*, *Staphylococcus aureus*, etc.^[14]

Anti-histaminic activity-mice with clonidine-induced catalepsy were administered intravenously with the methanolic wood extract of tree to test its antihistamine activity. As a result, less histamine was released, perhaps because of the mast cell stabilising or anti-histamine qualities.^[1]

Anti-diabetic activity

Various researcher study shown that the tree is possible sources of biologically active chemicals for treating diabetes.^[5] The Diabetes alleviated using extract (aqueous, ethanol, methanol) of tree parts such as seed, leaves, etc. This suggests that it has potential as a new, natural medicine for treating diabetes and its consequences.

The extracts included compounds such as tannins, flavonoids, saponins, phenols, alkaloids, and reducing sugars. Blood glucose levels in diabetic rats treated with ethanol, water and methanol extracts dropped by 64 percent, 59 percent, and 58 percent, respectively and the leaf extracts also have been shown to reduce

blood sugar and cholesterol levels, making them a promising natural new lead for drug development in the treatment of diabetes and dyslipidemia.^[18]

Hepatoprotective activity

The methanolic extracts of *Casuarina equisetifolia* were evaluated for their hepatoprotective properties against carbon Tetrachloride-induced liver injury in Swiss albino rats. Serum levels of Alanine Aminotransferase (ALT), aspartate Aminotransferase (AST), and cholesterol were all observed to be significantly decreased after administration of a methanolic extract of the tree at a dosage of 500 mg/kg body weight, indicating a modest protective activity. The attenuation of the histological alterations involved with CCl₄ caused hepatotoxicity provided further evidence of the hepatoprotective action.^[19]

Anti-oxidant activity

Both ferric reducing/antioxidant power and 1,1-diphenyl-2-picrylhydrazyl (DPPH) radical scavenging activity were used to evaluate the antioxidant activities. The high levels of DPPH radical scavenging activity and ferric antioxidant capacity shown by tree extracts indicate that they might be used as a novel source of naturally occurring antioxidants in food and nutritional formulations;^[16] and the antioxidant effects of a methanolic extract of tree fruit are also confirmed by the presence of secondary metabolites like polyphenol.^[15,20]

Anti-spasmodic activity

Histamine, acetylcholine, barium chloride, and potassium chloride (spasmogens) caused decreased ileum contractions when combined with the methanol extract of the stem bark. Nifedipine effects were enhanced by the extract, showing that it has antihistaminic, antimuscarinic, and calcium channel blocking properties. Antispasmodic effects have been identified, which may be due to flavonoids and tannins present in the extract.^[1,21]

Anti-ulcer/Gastro-protective activity

In albino rats, the anti-ulcer activity of an ethanolic extract of tree was evaluated using models of stomach ulceration caused by ethanol, indomethacin, and cold-restraint stress. Reduced gastric lesion formation after ethanol administration was associated with increasing concentrations of ethanolic extract.^[1]

Anti-arthritic activity

The various literature discovered that methanolic extract of the fruit of *Casuarina equisetifolia* has shown powerful anti-arthritic and anti-inflammatory action due to its high polyphenol content. Rat paw oedema was reduced by the use of *Casuarina equisetifolia* fruit extract, and the fruit normalised haematological and biochemical deficiencies in adjuvant-induced arthritis in rats at both the early and later stages of CFA-induced arthritis. In this investigation have not been able to clarify the precise mechanism

through which extracts reduce the effects of adjuvant-induced/produce arthritis.^[15]

Cytotoxic activity

Various study shown that the *Casuarina equisetifolia* leaf methanol extracts exhibited considerable cytotoxic activity in a Brine Shrimp lethality bioassay analysis.^[19] In other hand research also showed that when comparing different fractions, the entire methanolic extract had the greatest amounts of biological and cytotoxic activity. This makes it a promising material from which to extract nanoparticles. When Au-NPs (gold nanoparticles) were added to the methanolic extract, the extract scavenging, and cytotoxic activities increased, and the extract inhibitory impact on α -amylase activity increased as well. The bark extract is also involved in the synthesis of eco-friendly Au-NPs with a beneficial impact as cytotoxic agents, methanolic *Casuarina equisetifolia* bark extract is a significant bioresource.^[22]

Nephroprotective activity

Researchers investigated the potential nephroprotective effects of a methanolic extract of *Casuarina equisetifolia* leaves on Wistar Rats with gentamicin-induced nephrotoxicity. Additional, It reduce lipid peroxidation and increase intracellular anti-oxidant defence against gentamicin-induced nephrotoxicity, an extract prepared from the leaves of the tree has been shown to be beneficial effect.^[2,23,24]

Other/ commercial Uses

This tree is mainly employed in agroforestry industry. The Wood of the tree is typically utilised for wooden boards, poles, rough buildings/barns, and other constructions. It is also employed as fuel by the local population. The parts of tree is rich in tannin so it is also useful in tanning process and few of the more significant applications are the production of soap from wood ash and the extraction of pigment from the bark of the tree. In other hand this tree is also play significant role in the field green chemistry for the synthesis of nanoparticles or chemical compounds. Various other and commercial uses of tree are briefly discussed in below:-

Useful for Production of Paper Pulp

The pulp of this tree is extensively used in paper industries. Using the neutral sulphite semi chemical method, the wood of *Casuarina equisetifolia* has been proven to create excellent paper pulp. However, the difficulties in breaking up this exceedingly hard wood hinders the pulping process.^[25]

Useful for controlling erosion

Casuarina species are reported for minimising soil erosion through decreasing wind erosion, as well as by developing a litter of interlinked needles that shields against rain and wind, and doing so with their networks of thin subterranean roots.^[10]

Some species of casuarina are useful for protecting riverbank, reducing soil erosion and stabilising sand, etc. Includes.

Both *C. equisetifolia* (Australian pine) and *C. cunninghamiana* (River oak) are particularly known for their ability to safeguard riverbanks. *C. equisetifolia* is often utilised for the purpose of stabilising sandy soils.

The abundant root suckering tree like *C. glauca* (swamp she-oak) might be effective for controlling erosion because of the tree ability to spread/expand and hold down the earth, particularly on steep, mountains slopes or in places that have been washed. In addition, the dropped leaves and branches from the tree s blow over the barren ground, covering it and preventing erosion while also creating an ideal environment for the traditional breeding of plants.

Useful for windbreak

The tree is Commonly used as a windbreak. *C. equisetifolia* may be found in regions as North Africa, West Africa, Middle East, India and South China, etc. The presence of wide range of highly branching branches absorbs wind energy very effectively.

In addition to their resistance to wind, the tree have other properties that make them an excellent choice for shelterbelts/ windbreak, including tolerate wide range of soils and climates, nitrogen self-sufficiency, quick early growth, appropriate height and durability, thick crown, and usable wood. It is quite rare for a single tree possess all of these characteristics; often, shelterbelts need two or more species to decrease wind properly.^[10,26-27]

Useful for Preserving the Stability of Sand Dunes

The tree is utilised to prevent erosion in coastal and estuarine areas because it can survive in salty, dry conditions and propagate easily in sand.^[10]

Useful for tanning process

The tree is a native to Madagascar that has been cultivated for centuries for its tannin-rich source.

Tannin, which is abundant in this plant, is used to treat alligator skins and maintain the integrity of fishing lines. Fast penetrating tannins provide a supple, durable, and light reddish-brown leather. Tannins might also be extracted from other species of casuarina.^[10,28]

Used as a firewood

In both China and India, it is mostly used for its firewood qualities. It has been referred to as "the finest firewood in the world" due to its high calorific content of 4,950 calories or 8,910 Btus.

When a Chinese farm's soil has been depleted from overplanting, the country's farmers often replace it with Casuarina. This allows the land to rest, restores fertility (the tree can fix nitrogen from the

atmosphere), and yields a valuable resource (maturing firewood) that may be sold for a profit.^[1,10] Because of their nitrogen-fixing capabilities, the tree make ideal biomass energy crops, pulp, and other industrial goods.

Used for the synthesis of silver nano particles or as a green synthesis

The term "nanotechnology" refers to one of the most recent developments in the field of contemporary science and technology it is also one of the most interesting fields of study. The wide variety of uses of nanoparticles in fields like medicine, biology, nano technology, physics, chemistry, and biological identificaton is remarkable. Silver nanoparticles were synthesised using a green method, using reducing agents obtained from the leaves of the medicinally valued tree *Casuarina equisetifolia*.^[11] The extract of bark used in the synthesis of Au-NPs as a green nanotechnology.

CONCLUSION

The present review/study conclude that the tree play a major role for improving the health of humans and also useful for treat and cure various diseases and disorder, possess different beneficial activity. This review mainly reveals that the tree possess many phyto-chemical constituents due to the presence of major bioactive constituent it is useful for the treatment of various diseases and possess many medicinal activity such as anti-arthritic activity, antioxidant activity, anti-cancer activity, hypoglycemic, hypo-cholesterolemic activity, anti-helminthic activity, spasmolytic activity and anti-bacterial, anti-fungal activity etc and the *Casuarina equisetifolia* is also one of the most lucrative tree crops in the world as a consequence of its numerous potential uses as a traditional and commercial.

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CONFLICT OF INTEREST

The authors declare that there are is no conflict of interest.

ABBREVIATIONS

C.: Casuarina; **M:** Meter; **GC-MS:** Gas chromatography-mass spectroscopy; **ALT:** Alanine aminotransferase; **AST:** Aspartate aminotransferase; **CCl₄:** Carbon tetrachloride; **CFA:** Complete freund's adjuvant; **Au-NPs:** Gold nanoparticles.

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