

**A REVIEW ON *PTEROCARPUS SANTALINUS* LINN.****Mohammad Azamthulla<sup>\*1</sup>, Rajkapoor Balasubramanian<sup>2</sup> and Kavimani S<sup>3</sup>**

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**ABSTRACT**

*Pterocarpus santalinus* Linn. commonly known as Red Sandalwood belongs to the family Fabaceae. It is used in India and other parts of the world, with illegal harvest being a key threat. The plant is renowned for its characteristic timber of exquisite color and beauty. The Red Sandalwood has natural dye i.e santalin, which is used as coloring agent in pharmaceutical preparations and foodstuffs. In the traditional system of medicine, the decoction from the heartwood is attributed various medicinal properties. It is used in ulcers, eye diseases, inducing vomiting and mental aberrations. The heartwood is known to have antihyperglycaemic activity, antipyretic, antiinflammatory, anthelmintic, tonic, hemorrhage, dysentery, aphrodisiac, diaphoretic activities and also used as a cooling agent. It has been reported that wood in combination with other drugs is prescribed for snake bites and scorpion

stings. Phytochemical studies of this plant indicate that it contains substances such as alkaloids, phenols, saponins, glycosides, flavonoides, triterpenoides, sterols and tannins. In addition, heart wood contains isoflavone, glucosides and two antitumour lignans, viz., savinin and calocedrin. This review explores the phytochemical and pharmacological effects of the *Pterocarpus santalinus* Linn and compiles vital information that may assist researchers on what is known about this plant for further investigation. However, the species has remained unexplored for many pharmacological activities claimed. Hence, the present paper reviewed about phytochemical, pharmacological and medicinal uses of *Pterocarpus santalinus* Linn.

**KEYWORDS:** Medicinal plants, Antifertility, Antiinflammatory, *Pterocarpus santalinus* Linn.

## INTRODUCTION

Healing with medicinal plants is as old as mankind itself. The connection between man and his search for drugs in nature dates from the far past, of which there is ample evidence from various sources: written documents, preserved monuments and even original plant medicines. Awareness of medicinal plants usage is a result of the many years of struggles against illnesses due to which man learned to pursue drugs in barks, seeds, fruit bodies and other parts of the plants.<sup>[1]</sup> The knowledge of the development of ideas related to the usage of medicinal plants as well as the evolution of awareness has increased the ability of pharmacists and physicians to respond to the challenges that have emerged with the spreading of professional services in facilitation of man's life. Therapeutic properties of medicinal plants are well recognized at global level.<sup>[2]</sup> World Health Organization has emphasized on the use of traditional medicines and reported about 80% of population from developing countries relies on medicinal plants for their primary health care.<sup>[3]</sup> In developing countries, all over the world, 80% of population continues to use traditional medicine in primary medical problems.<sup>[4]</sup> In the rural areas, people collect their requirements of medicinal plants from forests and communities practiced sustainable concepts with minimal damage to the habitats in which these precious plants are found. Medicinal plants are plants containing inherent active ingredients used to cure disease or relieve pain.<sup>[2]</sup> The use of traditional medicines and medicinal plants in most developing countries as therapeutic agents for the maintenance of good health has often been reported.<sup>[5]</sup>

### 1. History

*Pterocarpus* is a pantropical genus of trees in the family Fabaceae,<sup>[6]</sup> most of which yield valuable timber traded as padauk; other common names are mukwa or narra. The scientific name is Latinized Ancient Greek and means "wing fruit", referring to the unusual shape of the seed pods in this genus. Padauk wood is obtained from several species of *Pterocarpus*. All padauks are of African or Asian origin and are valued for their toughness, stability in use and decorativeness, most having a reddish wood. Most *Pterocarpus* woods contain either water or alcohol-soluble substances and can be used as dyes. It has been found that, there are 35 *Pterocarpus* species which are currently accepted and distributed through out the world.<sup>[7,8]</sup> They are *Pterocarpus acapulcensis*, *Pterocarpus albopubescens*, *Pterocarpus*

*amazonum* (Benth.), *Pterocarpus angolensis*, *Pterocarpus antunesii* (Taub.) Harms, *Pterocarpus brenanii*, *Pterocarpus claessensii*, *Pterocarpus dalbergioides*, *Pterocarpus echinatus* Pers., *Pterocarpus erinaceus*, *Pterocarpus gillettii*, *Pterocarpus hockii*, *Pterocarpus homblei*, *Pterocarpus indicus* Pashu Padauk, *Pterocarpus macrocarpus*, *Pterocarpus marsupium*, *Pterocarpus mildbraedii* Harms, *Pterocarpus mutondo*, *Pterocarpus officinalis* Jacq, *Pterocarpus orbiculatus* DC, *Pterocarpus osun* Craib, *Pterocarpus rohrii* Vahl, *Pterocarpus rotundifolius* (Sond.) Druce, *Pterocarpus santalinoides*, *Pterocarpus santalinus*, *Pterocarpus ternatus* Rizzini, *Pterocarpus tessmannii* Harms, *Pterocarpus tinctorius* Welw. *Pterocarpus velutinus*, *Pterocarpus villosus* Benth, *Pterocarpus violaceus* Vogel, *Pterocarpus zehntneri* Harms, *Pterocarpus zenkeri* Harms. About most of these species are found in Africa notably in Nigeria, Cameroon, Sierra Leone and equatorial guinea and some in Asian countries and the most important *Pterocarpus* species, which are commonly used is *Pterocarpus santalinus* Linn. and is over exploitation. Though the species has an increasing demand, reliable information has to be collected. Hence, The present paper reviews about medicinal, phytochemical and pharmacological & medicinal uses of *Pterocarpus santalinus* Linn.

## 2. Species

*Pterocarpus santalinus* Linn. belongs to the family Fabaceae. There are various *Pterocarpus* species which are widely distributed throughout the world i.e *Pterocarpus dalbergioides*, *Pterocarpus indicus*, *Pterocarpus marsupium* and *Pterocarpus santalinus*,<sup>[9]</sup> especially India and china.<sup>[10]</sup> The population in India is limited to several parts of which most can be found in Southern part of India.<sup>[11]</sup> It is a medium sized deciduous tree endemic to India with a very restricted range in the southern Eastern Ghats where it grows in dry, rocky ground at 150-900 m. Recent records in the wild are all from Andhra Pradesh state.

## 3. Synonyms

Red Sandal wood, Red Sanders.<sup>[12]</sup>

## 4. Vernacular/Common Names

The common names of *Pterocarpus santalinus* Linn are Red Sanderswood (English); satelipuu (Finnish); Raktachandan (Indian); Santal rouge (French); Sándalo rojo (Spanish)<sup>[13]</sup> and wide range of additional local names are Hindi-Lalchandan, Raktachandan, Kannada-Agaru, Honne, Malayalam-Patrangam, Tilaparnni, Marathi-Tambada chandana, Sankshit-Rakta chandana, Tamil-Ratha sandanam, Chenkunkumam, Sivappu chandanam,

Sandana vengai, Telugu-Agaru gandhami, Yerra chandanamu, Rakta chandanamu.<sup>[14]</sup>

## 5. Distribution

*Pterocarpus Santalinus* are found India: This species is endemic to the hills of Andhra Pradesh (Cuddapah, Chittoor, some parts of Nellore), some pockets of Karnataka and Tamil Nadu (North Arcot hills); cultivated in Maharashtra, Odisha and West Bengal. Introduced in Sri Lanka.<sup>[15]</sup>

## 6. Botanical Study

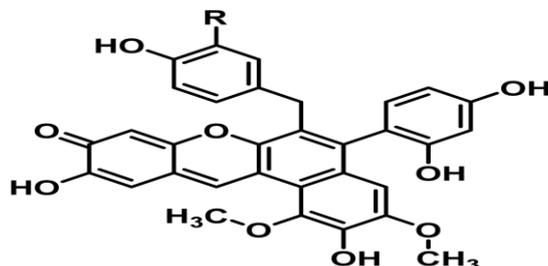
*Pterocarpus santalinus* Linn is a small to medium sized deciduous tree, with an extremely hard, dark purple heartwood with a bitter flavour.<sup>[16]</sup> Bark is blackish brown, 1-1.5cm thick and deeply cleft into rectangular plates by deep vertical and horizontal cracks, Blaze is pale yellow with numerous pink streaks exuding copious red sticky thick gum. Branchlets are drooping and hairless. Leaves are 3 foliated, 10-18cm long and rachis swollen at base. Generally, there are 3 leaflets, broadly egg-shaped or orbicular. Base is round or slightly heart-shaped. Apex is also rounded or deeply notched. Margin is entire, leathery, shiny, hairless and distinctly stalked. Flowers are bisexual, stalked in auxiliary simple or sparingly branched racemes, yellow, about 2cm long, fragrant. Pods are unequally orbicular, flat about 5×4.5 cm including the wing, and gradually narrow into a short tip about 1cm long. Seeds 1 or rarely 2, more or less kidney shaped, 1-1.5cm long, smooth, reddish brown and endemic to India, where it grows in dry, rocky ground at 150-900m. Though a mature plant produces thousands of flowers in a season, the natural fruit set of *Pterocarpus santalinus* Linn. is very low due to several reasons. The tree is able to fruit through both self and cross-pollination, thus initiates more fruit production, but gradually and selectively eliminates the growing weak offsprings, especially those resulting from self-pollination. The compatibility to self pollen seems to provide fertility assurance in the event of failure of outcrossing. Furthermore, the species is expected to maintain lower levels of variation due to its endemic status with restricted population size and consequently reduces opportunities for outcrossing. The species has been considered to be endangered due to constant human or other pressures, and any reduction in the population size is bound to enforce inbreeding and genetic bottlenecks. Thirdly, low maternal energy investment is available during the dry period for the rapidly growing off springs. These factors could be collectively responsible for the low natural fruit set rate.<sup>[17]</sup> The pollination ecology is vulnerable to dry and hot conditions. The flowers remain unvisited all day long due to the

absence of pollinator activity. The natural fruit set is a consequence of pollinator activity during moonlit night and early morning hours. The self-compatibility through geitonogamy is virtually inevitable for the species to produce fruits in situations when pollinators are scarce. Most of the endemic and endangered plant species have been reported to be self compatible through geitonogamy and this selfing ability is expected to be a 'fail-safe' strategy to produce fruits when pollinators are scarce.<sup>[18]</sup> However, the dominant cross-pollinating nature of the species exhibits facultative xenogamous breeding system. This breeding system is favorable for *Pterocarpus santalinus* Linn. as an endemic and endangered species to ensure continued survival.<sup>[17]</sup> It has been reported that conventional vegetative propagation techniques such as grafting and air-layering have limited scope in large-scale multiplication of this species and rooting of cuttings was also found to be poor.<sup>[19]</sup> However, the in-vitro propagation of the species was successful and no significant growth differences were found between seedlings and in-vitro propagated plants cultivation of *Pterocarpus santalinus* Linn. has been reported.<sup>[19]</sup> Commonly the species is planted as monoculture and as an ornament. Large quantities of extracts from artificially propagated sources have been exported. Reliable evidence of trade in wild-sourced wood is lacking; however illegal exports are suspected based on evidence of seizures.

*P. Santalinus*- Tree*P. Santalinus*- Stem*P. Santalinus*- Leaves*P. Santalinus*- Flowers*P. Santalinus*- Seeds

## 7. Phytochemistry

The phytochemical analysis of *Pterocarpus santalinus* Linn. Showed that it contains various components, such as carbohydrates, steroids, anthocyanins, saponins, tannins, phenols, triterpenoids, flavonoids, glycosides and glycerides.<sup>[20]</sup>



Chemical structure of santalin (R=OH, santalin A; R=OCH<sub>3</sub>, santalin B). *Pterocarpus* species also contains isoflavonoids, terpenoids and phenolic compounds,  $\beta$ -sitosterol, lupeol, (-)epicatechin.<sup>[21]</sup> In addition auron glycosides viz., 6-OH-1-methyl-3',4',5'-trimethoxyaurone-4-O-rhamnoside and 6,4'-dihydroxyaurone-4-O-neohesperidoside, and isoflavone glycoside 4',5-dihydroxy 7-methyl isoflavone 3'-O-beta-D-glucoside are present in *Pterocarpus santalinus*.<sup>[22]</sup> The heartwood also contains pterocarpol, santalins A and B, pterocarptriol, ispterocarpolone, pterocarpo-diolones with  $\beta$ -eudeslol and cryptomeridol<sup>[23]</sup>. Ether, alkalis and three other crystalline principles santal, pterocarpin, homopterocarpin, small quantity of tannin and kino-tannic acid are also found in the wood.<sup>[22,24]</sup> Triterpene has reported to be present in the callus of stem cuttings.<sup>[25]</sup> The leaves contain methanol<sup>[26]</sup> and ethanol can be extracted from stem bark.<sup>[27]</sup>

## 8. Common Uses of *Pterocarpus santalinus* Linn

The species has a wide range of uses. The timber is valued both domestically and internationally and is used for carvings, furniture, agricultural implements, poles and house posts. A rare wavy grain variant of the timber is particularly highly valued, especially in Japan, where it is used to make a traditional musical instrument. A red pigment, santalin, is extracted from the timber and is also widely used domestically and internationally. It is now mainly used as a colorant in foods. In India it has multiple uses in traditional medicine.

The heartwood is used to produce red pigments, specifically santalin as a dye for the furniture and crafts industry and as a colouring agent in cosmetics and food.<sup>[28,29]</sup> Its main use as a colorant in recent years has been in foods where it imparts orange-red shades and also a sweet-spicy flavour. In Europe it is classified as a "spice extract" rather than a food colorant.<sup>[28]</sup> It has therefore not been assigned an 'E number' and so its presence does not

have to be declared on packaging. The colorant is extracted only from the heartwood, which is first reduced to chips or powder and the colorant then extracted with alcohol. Specific formulations (as liquids, dispersed solids or water-soluble forms) are prepared prior to sale to particular users at strengths appropriate for the food product.<sup>[28]</sup> The species is used as an incense base both for its fragrance in Myanmar and also as Tibetan medicine.<sup>[30]</sup> Timber with a 'wavy' grain is in high demand in Japan for the manufacture of 'shamisen' a traditional musical instrument as the wood has very unusual acoustic properties.<sup>[31]</sup> The heartwood is also used to make 'hankos' (name seals), traditional dishes and carvings in Japan<sup>[32]</sup>. Santalins together with other related pigments are found in some other *Pterocarpus* and *Baphia* species.<sup>[28]</sup> Three of the four *Pterocarpus* species occurring in India are harvested for santalin. All four species are valued for their wood, but only *Pterocarpus santalinus* Linn. is highly valued for its "heavy, dark claret-red heartwood," especially that possessing a 'wavy' grain.<sup>[9]</sup> *Pterocarpus santalinus* Linn. is indigenous plant<sup>[33]</sup>, thus researches during the past two decades have shown a renewed interest.<sup>[34,35]</sup> The heartwood is rubbed with water, honey, ghee and oil applied as collyrium to alleviate defects of vision. It is also used for treating skin diseases, bone fracture, leprosy, spider poisoning, scorpionsting, hiccough, ulcers, general debility and metal aberrations.<sup>[36]</sup> Wood paste is applied on boils and other skin eruptions, infections, inflammation and on forehead to relieve headache. Decoction of fruits is used to cure chronic dysentery and to check dermatological conditions including psoriasis. Wood and bark brew taken orally relieves chronic dysentery, worms, blood vomiting, weak vision and hallucination. Wood powder is used to control hemorrhage, bleeding piles and inflammation. The antibacterial, anticancer, hepatoprotective and wound healing properties of this drug have been established recently.

### 9. Pharmacological activity

*Pterocarpus santalinus* Linn. is used for treatment of diabetes.<sup>[37,38]</sup> Cups made up with *Pterocarpus santalinus* woods have traditionally been used for drinking water as a treatment of diabetes.<sup>[39,40,41,42]</sup> *Pterocarpus santalinus* is useful in treating bilious affections, skin diseases such as antihelmintic, aphrodisiac and alexiteric as well as vomiting, thirst, eye diseases, ulcers and diseases of the blood.<sup>[42,43]</sup> Infusion of the decoction of the fruit is used as astringent tonic in chronic dysentery.<sup>[44]</sup> Stem bark powder with soft porridge has been used in treating diarrhea and the paste of the wood has been considered as a cooling agent for external application treating inflammations and headache, mental aberrations, and ulcers.<sup>[22]</sup> The ligand isolated from the heartwood is known to

inhibit tumor necrosis factor alpha production and T-cell proliferation.<sup>[45]</sup> The aurone glycosides isolated from heartwood have been reported to exhibit antiplasmodial activity<sup>[46]</sup> and has been used as a potential antileishmanial drug.<sup>[47]</sup> Methanol and aqueous extracts of heartwood have shown antihepatotoxicity in CCl<sub>4</sub>-induced hepatotoxicity.<sup>[48]</sup> Himoliv, a polyherbal ayurvedic formulation containing *Pterocarpus santalinus* as one of the ingredients has been reported to possess hepatoprotective activity.<sup>[49]</sup> The stem bark extract was shown to contain maximum activity against *Enterobacter aerogenes*, *Alcaligenes faecalis*, *Escherichia coli*, *Pseudomonas aeruginosa*, *Proteus vulgaris*, *Bacillus cereus*, *Bacillus subtilis*, and *Staphylococcus aureus*.<sup>[50]</sup> Ethanolic stem bark extract is known to possess antihyperglycemic activity.<sup>[27]</sup> The leaf extract also showed maximum activity against *E. coli*, *A. faecalis*, *E. aerogenes*, and *P. Aeruginosa*.<sup>[50]</sup>

## 6. CONCLUSION

*Pterocarpus santalinus* Linn. has been used as folklore remedy for various ailments afflicting people in various parts of the world for a long time. However, research interest to evaluate its therapeutic potential has developed recently perhaps on realization that this plant may contain novel chemicals that exhibit a wide range of pharmacological effects. Therefore, more studies are required on phytochemicals of this plant.

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