



Review Article

SANDALWOOD (*SANTALUM ALBUM*): ANCIENT TREE WITH SIGNIFICANT MEDICINAL BENEFITS

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ABSTRACT

Santalum album L. is commonly known as East Indian sandalwood, *Shrigandha*, sandalwood and *Chandana*. The plant is considered as the oldest, precious and commercially significant herbal plant which is also used as timber in India. The plant is well known for its unique and distinctive fragrance. Also, this plant is considered sacred and its importance and usage are also mentioned in Vedas, Puranas, Buddhism, epics and scriptures. It is used in various religions like Hindu, Buddhism and Jainism culture for auspicious work. The heartwood of the plant is very expensive and is associated with great commercial value in the national and international market as it is enriched with fragranced essential oil. The aromatic essential oil of the plant is used in various perfumes, food products, cosmetics, aromatherapy and pharmaceutical industries. Traditionally, the plant is used in various medicinal systems such as Ayurveda, Unani and Siddha to cure diseases like jaundice, dysentery, gastric irritability and is used as a tonic for liver, heart, fever, memory improvement, anti-poison and for blood purifier. In Ayurveda, the sandalwood plant is used as an expectorant, diuretic, astringent, stimulant, coolant and sedative agent. Besides this, the plant is associated with reported therapeutic and pharmacological properties such as antioxidant, anticancer, anti-inflammatory, antiviral, antibacterial, antifungal, hepatoprotective and cardio-protective properties. Due to the overexploitation of the plant it is enlisted in the IUCN Red List. In this review, the traditional medicinal usage of the sandalwood plant and its pharmacological properties along with its modern view is briefly described.

KEYWORDS: Indian sandalwood, Ayurveda, *Rasapanchak*, Pharmacological properties

INTRODUCTION

Santalum album L. is commonly known as East Indian sandalwood, Chandana, or sandal that belongs to the *Santalaceae* family^[1]. Sandalwood is a term of Sanskrit that means a large number of woods that are known for their cooling properties and aroma. It is a small evergreen hemiparasitic tree which is known for its valuable fragrant heartwood^[2]. The sandalwood plant is considered sacred and is associated with religious significance^[3]. The plant contains the highest oil content and is mainly used in perfumes, cosmetics, incense sticks (*Agarvati*) industries and medicines^[4]. The plant is a native species of India and is mainly found in the deciduous forests of the Deccan region of peninsular India.^[5] It is an economically important tree that is mainly harvested for heartwood oil. For more than 5000 years, India is the Chief exporter of sandalwood oil production for pharmaceuticals and perfumery industries^[6]. Globally, sandalwood is considered the second most expensive wood after African blackwood. The value of the sandalwood tree

depends on the volume of heartwood, quality and concentration of heartwood oil^[7,8]. The oil extracted from the heartwood of the plant is used in various medicinal systems such as Ayurveda, Siddha and Unani to treat variety of diseases and ailments^[9]. Traditionally, the sandalwood plant is used as a diuretic, expectorant, stimulant, disinfectant, coolant, astringent, bronchial tract and sedative agent. It is used to cure diseases like jaundice, dysentery, gastric irritability and is used as a tonic for liver, heart, fever, memory improvement, anti-poison and for blood purification^[10]. In Ayurveda, the plant is used to cure bleeding piles, vomiting, poisoning, hiccoughs, diarrhea with bleeding, intrinsic hemorrhage, urticarial, umbilicus inflammation and eye infection^[11,12]. The active constituents of the sandalwood plant include alpha and beta-santalols that are responsible for its pleasant characteristic aroma. Besides this, the plant is associated with various therapeutic and pharmacological properties such as antioxidant, anti-inflammatory, anticancer, hepatoprotective, anti-

ulcer, antibacterial, antifungal, antiviral, hemolytic, antipyretic and cardio protective. Moreover, the sandalwood plant is considered sacred and is used in various religious ceremonies in different religions such as in Hindu and Buddhist religions. Although, the wood of the plant is used in making different articles such as wooden boxes, jewel cases, pen holders, bookmarks, cabinet panels, hand fans and picture frames.^[13] The taxonomical classification of the plant is shown in table no. 1.

Table 1: Taxonomical Classification of Sandalwood

Taxonomical rank	Taxon
Kingdom	Plantae
Sub-kingdom	Tracheophytes
Superdivision	Spermatophyta
Division	Magnoliophyta
Class	Magnoliopsida
Subclass	Rosidae
Order	Santalales
Family	<i>Santalaceae</i>
Genus	<i>Santalum</i>
Species	<i>S. album</i>
Common name	Sandalwood, chandan

Botanical Description

S. album is a tall, evergreen, glabrous, root hemiparasitic, slow growing (15-20 years) tree with slender drooping branches that belongs to the *Santalaceae* family. The height of the plant reaches up to 12m with diameter of up to 2.5m. The flowers of the plant are small, purplish brown, green or violet, reddish, paniculate cymes, unscented in auxiliary or terminal with length 4-6mm containing numerous short stalks.^[14] The bark of the plant is smooth, dark brown or dark grey or nearly black and gray-brown. The heartwood of the plant is yellowish brown and strongly aromatic. The sapwood of the plant is odorless and white. The leaves of the plant are thin, opposite, ovate, elliptical subacute, shining green from upper side and slightly paler from beneath, glabrous, lanceolate with dimensions 3.8-6.3 by 1.6 to 3.2cm. Tip of the leaves are pointed or rounded with grooved stalk, 5-15cm long and reticulate venation. The fruits of the plant are purple to black when ripe, globose, hermaphrodite, axillary or terminal, fleshy drupe, smooth, single seeded, crowned with a scar, almost stalkless, about 1cm in diameter with hard ribbed endocarp.^[15] Flowering starts in the month of March to April in India and ripening of the fruits starts in winter.



Figure 1: *Santalum album* (Indian Sandalwood)
Geographical Distribution

S. album is indigenous to southern India mainly Mysore, Chennai and Coorg.^[16] The plant is distributed from Indonesia in the east to Juan Fernandez islands (Chile) in the west and 30°N to 40°S from Hawaiian Archipelago in the north to New Zealand in the south, Australia, Hawaii, China, Sri Lanka, Malaysia, Philippines and Northern Australia. *S. album* plant is spread in the area of about 9000 km² out of which 8200km² is in the states of Karnataka and Tamil Nadu. The plant occurs at an altitude of 2000-5000 m above the sea level. In India, the plant is mainly found in the dry deciduous forests of Deccan Plateau at the edge of the Western Ghats Range, Maharashtra, Andhra Pradesh, Karnataka, Kerala and Tamil Nadu. Karnataka and Tamil Nadu states of India produces about 90% of the natural population of *S. album*. It is grown best in highly rainfall conditions of 500-2000mm and at elevation of 650-1200 m.^[17]

Phytochemical Constituents of Sandalwood Plant

Santalum album plant is a rich source of volatile oil isolated from the roots and heartwood (central part of the trunk) of the plant. These volatile oils are extracted from the roots and heartwood after 30 years of its growth. The oil is yellowish, colorless, viscous, with a heavy sweet odor.^[18] The main active constituent present in the volatile oil is santalol which is a mixture of two primary sesquiterpene alcohol, beta-santalol (16.0%) and alpha-santalol (19.6%) where alpha form predominates.^[19,20] The minor constituent of the plant includes lanceol, bisabolol, nuciferol and sesquiterpene hydrocarbons like alpha and beta-santalenes (C₁₅H₂₄), beta-bisabolene, alpha, beta and gamma-curcumenes and bergamotenes phenylpropanoids.^[21] The reported major essential oil components of the plant include sesquiterpene alcohols like epi-cis-beta-santalol, alpha-trans-bergamotol, cis-beta-santalol and cis-alpha-santalol.^[22] The minor constituents are comprising of heterocyclics^[23], alpha-bisabolol, hydrocarbon santene, alpha-santalene, beta-santalene, epi-beta-santalene, alpha-bergamotene, alpha-curcumene, beta-curcumene, gamma-curcumene, beta-bisabolene, alpha-bisabolol^[24], trans-beta-santalol and cis-lanceol.^[25] The other

chemical constituents reported in Sandalwood plant oil include teresantalol, santenol, alcohol, aldehydes, alpha santalic acid, beta-santalol, ketones, nor-tricycloekasantalol, isovaleraldehyde, 1-santenone, santalone and other acids including teresantalol acids.^[26] The GC and GC/MS analysis results of the sandalwood oil extracted from the roots and heartwood of the plant showed the presence of 53 components which represents 99.9% of the total oil. The essential oil contains 30 sesquiterpenols (78.5%), 9 sesquiterpenes (7.8%), 5 sesquiterpenoid isomers (4.4%) and terpenoic acid (0.4%). It was also reported that santyl acetate and santalene are found in more quantity in the 10-year-old tree than in the 30-year-old tree.^[27] The essential oil contains 25.0% of bisanolol A, B, C, D and their isomers. The analysis of stem extracts was performed by GC-MS which showed the presence of 32 active phytochemical constituents.^[28] The analysis of the heartwood of the *S. album* plant showed the presence of 35 volatile metabolites in a 15 years old tree.^[29] Seven alpha-santalol derivatives were also isolated from the heartwood of the *Santalum album* when the spectroscopic analysis was performed. These derivatives include (10E)-12-hydroxy-alpha-santalol, (9E)-11, 13-dihydroxy-alpha-santalol, (9R,10E)-9-hydroxy-alpha-santalol and (10R,11R)-10,11-dihydroxy-alpha-santalol. The other metabolites found in the sesquiterpenoids of the sandalwood oil include alcohols, fatty acids, n-alkanes, sesquiterpene and hydrocarbons. The root part of the plant contains betulinic acid. The leaves of *S. album* contain various flavonoids constituents such as orientin, isovitexin, vitexin, vicenin-2, isorhamnetin, chrysin-6-C-Beta-D-glucopyranoside and chrysin-8-C-Beta-D-glucopyranoside.^[30]

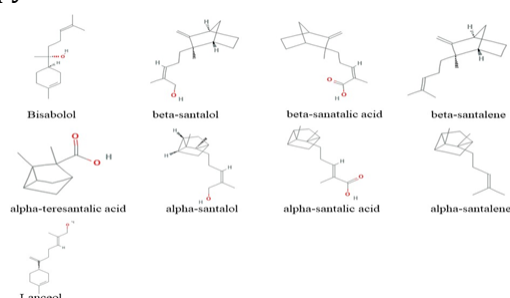


Figure 2 Chemical structures of major phytochemical constituents of *Santalum album* plant

Traditional and Modern View

a) Ayurvedic view: Ayurveda is based on the theory of *Tridosha* of the three biological forces i.e. *Vata*, *Pitta* and *Kapha*. The sandalwood plant is used in *Ayurvedic* medicinal system to cure various diseases. The plant has a long history of its use in the Ayurveda medicinal system and is used for 3000 years as per Sushruta and Charaka Samhita. Sandalwood oil is

defined as the lifeblood of the plant and is the reservoir of solar healing power. The oil extracted from the heartwood of the plant makes it a unique and valuable asset of the plant kingdom^[31]. It is known by the name of *Chandana* in India. It is a highly fragrant plant that is used in powder and oil form to balance the *Vata*, *Kapha* and *Pitta dosha* of the body. The sandalwood aroma helps in reducing gastric irritability, depression and nervous tension. It is used to cure cough, cold, skin disorders, bleeding piles, diarrhea, internal bleeding, vomiting, excessive sweating, urticarial, biliousness, fever, cardiovascular disorders, cleaning wound, respiratory disorders, anxiety, urinary disorders, hemorrhage, hiccoughs, inflammation of umbilicus poisoning and headache.^[32] Also, the plant is associated with antipyretic, diuretic, expectorant, antiseptic, anti-inflammatory, anti-wrinkling, anti-aging, anti-tanning and antimicrobial properties.^[33] The paste of the sandalwood plant is used to cleanse wounds, sunburn, acne and to treat inflammation. Besides this, the plant is used in various Ayurvedic cosmetics formulations like cream, soap, lotions and face wash because of the presence of their hydrating properties. In Ayurveda, the sandalwood plant is used as a mind stimulant, diuretic and demulcent^[34]. Due to the cooling property of the plant, it is used to pacify the aggravated nervous system, helps in balancing *Vyanavayu* (*Vyana* means circulating and *Vayu* means breath), calms *Sadhaka pitta* (caretaker of the heart) and is useful in treating depression and anxiety^[35]. The plant is externally applied in the paste form to treat burning sensation, skin eruptions, acne, sunburn, headache, fever, itching, pruritus, heat, inflammation and in pediatric formulations^[36]. The *Rasapanchak* (properties) of the plant is shown in table no. 3.

Table 2: Rasapanchak (properties) of Santalum album

Sanskrit / Hindi	Sanskrit / Hindi
Veerya / Potency	Sheet / Cold
Vipak/ Metabolic property	Katu / Bitter
Guna/ Physical property	Laghu / Light, Ruksha / Dry
Rasa/ Taste	Tikta / Astringent, Madhur/ Sweet

Actions and Properties

Kaphapittashamak: It alleviates the *Kapha* and *Pitta* components of the body.

Twagdosahara: It is useful in the treatment of skin disorders.

Durgandhhara: It helps in diminishing the foul smell of sweat, wounds and mouth etc.

Varnya: It helps in enhancing the color complexion of the skin.

Medhya: It is used as a brain tonic.

Trishnanigrahan: It helps in reducing excessive thirst.

Hridya: It helps in treating heart disorders.

Raktshodhak: It is used as a blood purifier.

Kaphanisarak: It helps in balancing the *Kapha dosha* in the body and reduces congestion.

Shleshamputihar: It helps in reducing the vitiated Kapha and helps in reducing halitosis (bad breath).

Mutrajanan: It is used as a diuretic agent.

Swedjanan: It helps in inducing sweating.

Jwaraghna: It cures vitiated fever and is used as an antipyretic agent.

Daahprashaman: It is used to reduce the burning sensation of the body.

Vishghna: It is used as an antivenom agent.

Angmardprashaman: It is used to cure body aches.

Kamla: It is used to treat jaundice.

Mutrakrij: It is used in the treatment of painful micturition or dysuria.

Pungyameh: It is used to cure urinary tract infections.

Vastishotha: It helps in reducing the swelling in urinary bladder.

b) Folk Uses: Sandalwood plant is considered as a sacred plant and is associated with various religious, ritual and ceremonies practices. The medicinal and cosmetic properties of the plant are well described in ancient literature. In India, people have a strong spiritual association with the sandalwood plant. The heartwood of the plant is burnt at funerals and weddings. The incense of Indian sandalwood is the oldest incense used for over 4000 years^[37]. In the Buddhist religion, sandalwood is burnt during prayers. The plant is used by Hinduism, Buddhism and Jain culture for religious purposes. It is believed that sandalwood essence helps to transform one's desires and maintain a person's alertness during meditation. In India, the plant is used in attar (a blend of sandalwood oil and flower oil, like rose petal, jasmine, kewda and others) production for centuries. These attar products are used in the manufacturing of incense sticks and scented tobacco like Zarada, Gutka and Pan Masala. The oil of the plant is used in various Ayurvedic, pharmaceutical, toiletries, soaps and perfumeries applications^[38]. In Chinese medicinal system, sandalwood extracts are used to treat gonorrhoea, stomach ache, skin disorders, anxiety and dysentery.^[39] In India, the sandalwood

plant is used to treat inflammatory and eruptive skin diseases from centuries in the paste, emulsion and essential oil form.^[40,41,42] In Unani medicinal system, sandalwood plant products are used to cure cardiac disorders, gastric ulcers, liver, stomach, skin and brain disorders.^[43,44] The oil of sandalwood is used in aromatherapy to reduce depression, anxiety and stress.^[45] Also, the plant possesses relaxing, bronchial dilating, neuroleptic and astringent effects.^[46] The oil obtained from the heartwood is sweet, fragrant, warm, woody, animalic, milky, persistent, spicy which is used in cosmetics, perfumery, aromatherapy and pharmaceutical industries. Also, sandalwood oil is used in food products like candy, pan masala, frozen dairy, desserts, puddings, baked food, alcoholic and non-alcoholic beverages to enhance the flavor.^[47] Traditionally, the wild berries of the sandalwood plant are consumed by the local tribes and birds.^[48] The ancient Egyptians used sandalwood plant in ritual burning to venerate the God, for embalming the dead and is used as medicine.^[49] In certain communities of Hindu culture, a piece of sandalwood plant is put in funeral pyre. Also, the devotees of Lord Krishna used to apply the paste of sandalwood on the forehead, the other body parts and is also used for ritual bathing of Hindu Gods^[50]. In Karnataka, Sandalwood is used as timber and has an intricately carved, imposing sandalwood door leading to the Cabinet Room. Sandalwood is used as an important ingredient in *Homa (Havana)* in Hindu culture. In a various medicinal system such as Tibetan, Chinese and Ayurveda, sandalwood oil is used to cure fever, dysentery, piles, scabies, common cold, bronchitis, urinary tract infection, mouth inflammation, liver disorders, gall bladder disorders and is used as an expectorant, digestive, carminative and muscle relaxant^[51]. The external application of the paste of sandalwood plant helps in toning up the skin and is also used to remove blackheads, acne and wrinkles.

c) Modern View: Sandalwood is considered for its commercial and economic value with an estimated market volume of more than \$1 billion.^[52] As per recent data, the production of sandalwood in India showed a declining trend despite its status as India's brand ambassador in international markets.^[53] The production rate decreases from 4000mg heartwood per year in the 1950s to a mere 500 mg in 2007. ^[54] The quality of sandalwood depends upon the volume of heartwood, its concentration and the quality of heartwood oil.^[55] The plant is well known for its oil and timber. Due to forest fires, grazing, overexploitation, unconventional monoculture eucalyptus plantations and other biotic interferences, it has lost its adaptive gene complexes which led to

the depletion of the species.^[56] For decades, India was known for its sandalwood oil production, but for the past few years, it is importing sandalwood oil from foreign countries.^[57] The acute shortage in supply and the imbalance in the demand resulted in the closure of various industries in India and other Asian countries. The non-availability of the *Santalum album* species has led to adulteration with other native species of the genus *Santalum*. As a result of this, the quality of the medicines and other products containing *Santalum album* extracts compromises. So, there is an immediate need to take some conservative plans and enhance its abundance so that our future generation can also enjoy the beneficial effects of this important medicinal plant.^[58]

Reported Pharmacological and Therapeutic Properties

The sandalwood plant and its extracts were evaluated for various pharmacological and therapeutic properties in various plant and animal models. Some of the major studies of the plant are briefly discussed below.

Hepatoprotective: The hepatoprotective activity of the leaves of the sandalwood plant was examined against experimentally induced liver injury by CCl₄ and paracetamol. The oral pretreatment with the hydroalcoholic extract of the leaves of the plant showed significant hepatoprotective activity against CCl₄ and paracetamol-induced hepatotoxicity by inhibiting the activities of serum marker enzymes, lipid peroxidation, bilirubin and rise in the levels of superoxide dismutase, glutathione, catalase and protein in a dose-dependent manner. This activity was confirmed by the reduction in the total liver weight and histopathological examinations^[59].

Antiulcer: The antiulcer activity of the sandalwood plant was examined against Wistar albino rats. The hydro-alcoholic extract of the stem at a dosage of 250 and 500mg/kg was administered by three *in vivo* models namely water-immersion restrain stress, indomethacin-induced gastric ulceration and ethanol models in Wistar albino rat. Results showed an increase in gastric protection and a significant decrease in the average number of ulcers, cumulative ulcer index and severity of ulcers.^[60]

Antibacterial: The essential oil extracted from the sandalwood plant showed significant antibacterial activity against axilla bacteria, methicillin-resistant *Staphylococcus aureus* and anti-mycotic resistant *Candida* species, *Herpes simplex* virus type 1.^[61,62,63] The alpha and beta-santalol as well as the crude extract of sandalwood oil showed antibacterial activity against a gram-negative bacterium *Helicobacter pylorus* which is strongly linked to the duodenal, stomach and gastric ulcers.^[64] The

methanolic extract of the plant was reported to show significant antibacterial effects against *Candida albicans*, *Salmonella typhi*, *Bacillus subtilis* and *Pseudomonas aeruginosa*.^[65] Beta-santalol showed anti-influenza activity against the H3N2 virus. The anti-dermatophytic activity of the sandalwood oil was reported against *Trichophyton rubrum*, *Microsporum canis* and *Trichophyton mentagrophytes*.^[66]

Antipyretic: The antipyretic activity of the sandalwood oil was reported against yeast-induced pyrexia in albino rats at the dosage of 200 mg/kg.^[11]

Insecticidal: The essential oil of the sandalwood plant showed insecticidal activity against *Varroa jacobsoni*.^[67] It was also reported that the sandalwood oil showed modest activity against *Lycoriella mali* (the mushroom fly). The santalol constituent of the essential oil was found to be active against spider mites *Tetranychus urticae*.^[68,69,70]

Anticancer: The alpha-santalol constituent of the plant showed chemo-preventive effects and molecular effects on skin cancer development in both skin cancer cell lines and animal models^[71]. The sandalwood oil of the plant showed anticancer effects against ultraviolet -B-induced skin carcinogenesis in SKH-1 mice, chemically-induced skin carcinogenesis in CD-1 and SENCAR mice, non-melanoma, *in vitro* models of melanoma, prostate and breast cancer. The ability to induce cell cycle arrest and apoptosis in cancer cells has also been found^[72]. Also, alpha-santalol constituent delayed the papilloma development in CD-1 and SENCAR mice by inhibiting 12-O-tetradecanoylphorbol-13-acetate (TPA)-induced ornithine decarboxylase (ODC) activity and DNA synthesis^[73]. In another study, the application of alpha santalol (5%) was found to delay the development of skin tumor in a dose-dependent manner, decrease tumor multiplicity and inhibit the liver microsomes and *in vitro* lipid peroxidation in the skin, hence act as an anti-peroxidant by preventing the development of UVB-induced skin tumor in mice^[74]. Another study was conducted against UV B induced skin development model in SKH-1 mice in which alpha-santalol was reported to increase the apoptosis-related proteins, tumor suppressor protein p53 and caspases 3 & 8 levels via an extrinsic pathway.^[75] Although, tumor selective cytotoxicity was reported by the derivatives of alpha-santalol in HL-60 human promyelocytic leukemia cells and TIG-3 normal human diploid fibroblasts.^[76]

Anti-inflammatory: The anti-inflammatory activity of the plant extracts was investigated in 25 Wistar rat models which are divided into 5 groups. Group 1 includes negative control, croton oil and 35% acetone, group 2 includes positive control, croton oil

and 2.5% hydrocortisone drug and group 3, 4 and 5 were treated with n-hexane extracts of the sandalwood plant along with croton oil in a dosage of 10, 20 and 40mg/ear. After 6 hours of observation, the thickness of rat ear inflammation was measured manually by using a micrometer. A significant reduction in the croton oil-induced rat ear edema was observed after the topical application of n-hexane extract of the leaf of *S. album* and hydrocortisone with percentage inhibition of 36, 52 and 73% respectively. Although, it did not show the inhibitory effect at a higher dosage of 40mg/ear as compared to negative control.^[77] Also, the methanolic extract of the plant showed anti-inflammatory activity against the mice model.^[78]

Cardioprotective: The aqueous extract of the sandalwood plant was demonstrated for its cardioprotective property. The extract was reported to reduce the lipid peroxidation, thus significantly inhibiting the cardiac tissue damage on doxorubicin-induced cardiotoxicity in the rat model.^[79] In another study, the protection action of the aqueous extract of the plant was observed against ISO-induced myocardial infarction in albino Wistar rats in a dose-dependent manner.

Anti-hyperglycemic and anti-hyperlipidemia effect: The petroleum ether extract of the sandalwood plant was demonstrated for the anti-hyperglycemic and anti-hyperlipidemic effect in streptozotocin-induced diabetic rats. The oral administration of the extract for a long time decreases the blood glucose level in the experimental model. Also, the reduction in the low-density lipoprotein, total cholesterol and triglycerides levels in the treated diabetic rats and increase in the high-density lipoprotein was observed.^[80]

Antiviral: The sandalwood oil was evaluated for the antiviral activity against Herpes simplex virus (HSV)-1 & 2 through inhibition of viral replication in a dose-dependent manner. It was found that the sandalwood oil showed *in vitro* hindering activity against herpes simplex virus type 2 (HSV-2) on RC-37 cells using a plaque reduction assay.^[81]

Hemolytic: The saponins component present in the leaf extract of the sandalwood plant was found to produce the lyses of RBC, thus show hemolytic activity against blood. Although, this activity only takes place with parenteral administration.^[21]

Antioxidant: The anthocyanin pigment cyanidin-3-glucoside of *S. album* was found to be nutritionally important and as an antioxidant.^[82] The sandalwood oil of the plant showed antioxidant activity against the liver of adult male Swiss albino mice by increasing glutathione S-transferase (GST) activity and acid-soluble sulfhydryl (SH) levels.^[83] The

methanolic extracts of the sandalwood plant showed DPPH, acetylcholinesterase inhibitory and superoxide free radical scavenging activities in albino mice. In an *in vivo* study, the antioxidant potential and anti-hyperglycemic activity of the sandalwood oil and its major constituent alpha-santalol showed antioxidant activity against D-galactose mediated oxidative stress-induced diabetic male Swiss albino mice model.^[84]

Toxicity: The sandalwood plant consists of several major and minor chemical constituents. The major phytochemical constituent of the sandalwood plant is alpha-santalol which was tested for its toxicity. It was found that the sandalwood oil and its derivatives show low acute oral and dermal toxicity in experimental models. As per the literature review, there are very few cases of irritation or sensitization reactions of sandalwood oil. However, the information on the toxicity of sandalwood oil is limited. Although the plant has a long history of its use without any reported adverse effects and is considered safe.^[85]

CONCLUSION

Sandalwood plant is known for its fragrant wood and the essential oil extracted from the heartwood of the plant. These essential oils are used in various therapies, perfumery, cosmetic, food and pharmacological industries. The active constituents of the plant are alpha-santalol and beta-santalol that are responsible for its fragrance. It is used in the various traditional medicinal systems to treat diseases like fever, dysentery, piles, scabies, common cold, bronchitis, urinary tract infection, mouth inflammation, liver disorders, gall bladder disorders and other diseases. Also, the plant is associated with significant religious and cultural value since ancient times. The essential oil obtained from the plant carries great commercial value and is used as an important ingredient in certain food items. Moreover, due to the overexploitation and illicit felling, sandalwood plant is enlisted under endangered species. So, there is an immediate need to formulate conservative strategies or plans to conserve this significant medicinal plant as the plant is considered economically important and holds great spiritual and commercial value.

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