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SANTALUM ALBUM LINN: A REVIEW ON MORPHOLOGY, PHYTOCHEMISTRY AND PHARMACOLOGICAL ASPECTS

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ABSTRACT: The sandal tree, also known as Chandana in India, is botanically *Santalum album* L belonging to family Santalaceae.The average yield of oil ranges from 4.5-2.5%. The sweet powerful and lasting odor makes Sandalwood oil useful in perfume industry. The fragrant parts of sandalwood oil constitutes of α- and β santalols . Sandalwood oil, the essential oil of santalum album L has been tested for invitro antiviral activity against Herpes simplex viruses-1 & 2. The sedative effect of sandalwood oil as well as HESP oil on albino mice of either sex in dose of 500/ 600 mg/kg. Skin cancer-and chemo preventive efficacy of α- Santalol. K.H Shankarnarayana et al investigated the anti-inflammatory effect of sandalwood oil as well as HESP oil against yeast induced pyrexia in albino rats. A significantly high antipyretic effect observed in case of sandalwood oil and HESP and astringent activity, making it useful as disinfectant in genitourinary and bronchial tracts, diuretic, expectorant and stimulant.
Key words; *Santalum album*, Sandalwood, Sandalwood oil, Santalol, Santalene.

INTRODUCTION

The plant, *Santalum album* is a native of the highlands of southern India mainly Coorg, Chennai and Mysore. It generally occurs at altitudes of 2000-3000 feet. The tree attains the height of 60-65 feet and is actually an obligate hemi parasite plant on various hosts—"*Cassia siamea, Pongamia glabra* and *Lantana acuminata*". Santlbum thrives well-drained loamy soil preferably on slopes of hills exposed to the sun. It requires a minimum of 20-25 inches rainfall per year. The finest wood grows in driest region particularly on red or stony ground while on rocky ground the tree often remains small but gives the highest yield of oil. Trees more than 30 years old may have circumference from 18 to 38 inches. The bark and sapwood are odorless and the roots and heartwood contains the essential oil .[1]

Sandal tree grows under different edaphic and eco climatic conditions. Considering large genetic distance between provenances, it is concluded that under diverse locality factors sandal adapts very well in terms of growth, heartwood and oil content (2) The plant has been mainly exploited for for sandalwood oil obtained by steam distillation of its root & heartwood. Sandalwood and its oil represent gold to Mysore, hence rules and regulation governing the production and handling of Sandalwood are strictly under Govt monitoring, the state of Mysore annually produces 2000 tonnes of Sandalwood. The distillation of sandalwood oil in India has been carried by water distillation method using coarse powder of chipped. Wood packed in copper stills the distillation requires 48 to 72 hours with low

pressure steam. The average yield of oil ranges from 4.5-2.5%.[1,3]

Description:

The plant was mainly exploited for fragrant sandalwood oil obtained by steam distillation.A small evergreen glabrous tree with slender drooping branches the sapwood white and odorless. The heartwood yellowish brown strongly scented. Leaves of dimension 3.8 – 6.3 by 1.6 to 3.2 cm; are elliptic lanceolate, subacute glabrous, and entire thin base acute; petioles 1 – 1.3 cm long slender flowers, brownish purple induorous, in terminal and auxiliary paniculate cymes shorter than leaves. Perianth campanulated limb of 4, valvate triangular segments stamens 4, exerted, alternating with 4 rounded obtuse scales. Drupe globose 1.3cm diameter. Purple black; endocarp hardribbed fruit conelaed about size of pea, spherical crowned by rim like remains of perianth tube, smooth, rather flesh, nearly black, seed solitary.[4]

Uses:

Sandalwood is mainly used as coolant, and also sedative effect and astringent activity, making it useful as disinfectant in genitourinary and bronchial tracts, diuretic, expectorant and stimulant. The sweet powerful and lasting odor makes Sandalwood oil useful in perfume industry. The same is also used as tonic for heart, stomach liver, anti-poison, fever, memory improvement and as a blood purifier.Various uses mentioned in Ayurveda system about sandalwood are in treatment of various other ailments like diarrhea with bleeding intrinsic hemorrhage bleeding piles, vomiting, poisoning, hiccoughs initial phase of pox, urticaria, eye infections and inflammation of umbilicus.[4,5]

Adulterants:

Castor oil is often added, and on the Continent oil of cedar, made by distilling the chips remaining from the manufacture of lead pencils.[5]

Other Species---*Pterocarpus santalinus* or *Santalum rubrum* (Red Sandalwood), *Santalum spicatum* , Santalum acuminatum solely used for colouring and dyeing. Other varieties come from the Sandwich Islands, Western Australia and New Caledonia.[4]

***General dimensions of sandal wood tree*:**

Mean tree dimensions (± standard error), from the stem at 30 cm and 100 cm above the ground, from 20 sandalwood trees.[6] Table 1.

PHYTOCHEMICAL INVESTIGATION

The volatile oil extracted from *Santalum album* L derived from the roots and heartwood is colorless to yellowish, viscous (ref. index-1.499-1.506, specific gravity 0.962-0.985 opt, rotation -19-20^0) liquid with peculiar heavy sweet odor, the chief constituents of the oil is santalol (90% or more) a mixture of two primary sesquiterpene alcohols, $C_{15}H_{24}O$ viz, α-santalol (bp-166-167^{0}C) and β-santalol(b.p-177-178^{0}C) in which the α–form predominates.(1,3). More than hundred constituents of sandalwood oil in categories of tannins, terpenes, resins and waxes have been reported which include such as hydrocarbons- santene(C_9H_{14}), nor-tricyclo-ekasantalene ($C_{11}H_{18}$), α- and β- santalenes ($C_{15}H_{24}$), alcohols-santenol ($C_9H_{16}O$), teresantalol ($C_{10}H_{16}O$), aldehydes- nor-tricyclo-kasantalal ($C_{11}H_{16}O$) [3,7,8] and the acids α-and β- santalic acids ($C_{15}H_{22}O_2$) and teresantalic acids ($C_{10}H_{14}O_2$).[9] The fragrant parts of sandalwood oil α- and β santalols were separated in pure form and a 0.5-0.8% higher yield in sandalwood oil was obtained by extracting wood powder with benzene.[10] Two minor components namely cyclosantalal (0.21-2.26%) and isocyclo-santalal(0.11-1.47%) new sesquiterpene aldehyde were reported . Also a new acid – ketosantalic(as methyl ester) & gamma – L – glutamyl-S-(trans-1-propenyl)-L-cysteine sulfoxide, an interesting natural sulfoxide diastereoisomers, have been isolatedfrom sandal. Some authors also report the presence of Tricyclosantalal, α-santalene, trans-β-bergamotene, β-santalene (S & E), α-curcumine, α-santalol, beta-santalol(S&E),nuciferol, α-santalal and β-santalal in Santalum album.[11,12] Sandalwood oil was also applied to Nardenisation- a technique to separate terpenic components by shaking with two immiscible solvents, the polar solvent dissolving oxygenated and non-polar holding the non-oxygenated one without santalenes.[13] The hydrolysis of non-steam volatile matter of the spent sandalwood powder with methanolic hydrochloric acid provides a new essential oil HESP[14,15] (acronym for Hydrolysed Exhausted Sandalwood Powder) which is demonstrated to have Anti-inflammatory, Anti-pyretic, Mildly Sedative Ganglionic blocker/hypotensive agent or Blood pressure depressant and insecticide in controlling forest pests.[8,16] Mean santalol contents (± standard error) within the oil of chips and cores, at 30 cm and 100 cm above the ground, from 20 sandalwood trees Table 2.

Wax of santalum album L: The wax from the leaves of sandal *Santalum album* Linn yields two interesting compounds which have not hitherto being found in

waxes i.e palmitone (44%) and d-10-hydroxypalmitone(6% ,M.P- 96.42-96.6^0 C) on saponification.[17] The elucidation of the structure of the d-10 hydroxypalmitone was greatly facilitated by X-ray analysis. The complete absence of paraffin is noteworthy During the course of work the following new compounds were prepared n-hentriacontan 10:16 dione (mpt.-87.9-88.) d-n hentriacontan-10-ol, (mpt.81-81.2 $^{0)}$ and n-tritriacontan-15-one ,(m.pt. 78.8-79.2^0 C).[18]

PHARMACOLOGICAL STUDIES

***Insect growth inhibitor from bark of S.album* :**

Triterpenoid- urs-12-en 3 β-yl palmitate (m.p 115-116^0, $(\alpha)_D$ 24 +200, $C_{46}H_{80}O_2$) has been isolated from sandalwood The tropical application of triterpenoiod on fresh pupae of forest insects viz: *Atteva fabriciella, Eligma narcissus, Eupterote geminate* etc produced morphologically defective adults indicating growth inhibition activity of the compound. Also observed the chemosterilant activity on freshly emerged moths of *Atteva fabricella*.[19]

***In-vitro Antifungal activities* :**

A detailed study was carried on seven essential oils and their constituents for their antifungal activities against eight strains known to be human pathogens. Sandalwood oil was found to be effective against *Microsporum canis, Trichophyton mentagrophytes* & *T. rubrum* but ineffective against *Candida albicans*, *Aspergillus niger, A.fumigatus* in comparison to Tolnaphtate and clotrimoxazole.[20]

***Antibacterial Activities of oil & bark*:**

Investigations reveal that antibacterial efficacy of some Indian essential oils including Sandalwood oil against *Bacillus anthracis* (+), *Bacillus mycoides*(+), *Bacillus pumilis*(+), *E.coli*(-), *Micrococcus glutamicus*(+), *Sarcina lutea* (+), *Salmonella paratyphi*(-), *Staphyllococcus albus* (+), *Xanthomonas campestris* (-) and *Xanthomonas malvacearum* (-),E.coli at different concentrations of- 100 %, 75%, 50%, 25%, 10%. Not only oil but also, the aqueous extract of air dried powdered bark in concentration of 25 to 1000 µg/ml in phosphate buffer showed good inhibition against virulent species, *Staphylococcus aureus*.[22,23]

Antiviral activity of sandalwood oil against Herpes Simplex Virus-1 & 2. (HSV-1 & 2):

It has been reported that the replication of Herpes simplex viruses is inhibited in the presence of the oil. Although it effect was a dose-dependent effect and more pronounced against HSV-1. A slight diminution of the effect was observed at higher multiplicity of infections. The oil was not virucidal and showed no cytotoxicity. [24]

Skin cancer- and chemo preventive efficacy of α-Santalol:

α-santalol, an active component of sandalwood oil, has been studied for its skin cancer preventive efficacy in murine models of skin carcinogenesis; employing human epidermoid carcinoma A-431 cells It was assessed whether α-santalol at concentrations of 25-75 µml resulted in a concentrations and a time dependant decrease in a cell number, which was largely due to cell death. Mechanistic studies showed an involvement of caspase-3 activation and poly (ADP-ribose) polymerase cleavage & disruption of the mitochondrial membrane potential and cytochrome-C release into the cytoso l, thereby suggesting involvement of both caspase – dependant and independent pathways. [23]

Antioxidant activity:

Santalum album, along with other medicinal plants used in Ayurvedic Rasayana like *Embellica officinalis* L, *Curcuma longa* L, *Mangiferra indica* L, *Momordica charantia* L, *Swertia chirata* Buch-ham, *Withania somniferra* L when viewed for their historical, etymological, morphological, phytochemical and pharmacological have proven to contain antioxidant principles which justify their use in traditional medicine in the past as well as the present. [24]

I*n treatment of anginal attacks as herbal Kuan- Xiong aerosol:*

Kuan- Xiong aerosol contains sandalwood oil along with oils of *Piper longum, Dryobalanops aromatica*, *Asarum seiboldi*, *Alpinea officinarum.* An immediate and quick relief in anginal pain was proved in 69 cases of angina pectoris in comparision with nitroglycerine. Studies on the mechanism of action revealed to be different from nitroglycerine. [25]

The evaluation of nitric oxide scavenging activity of certain Indian plants in vitro: a preliminary study:

The extracts of Indian medicinal plants including *S.album* were examined for their possible regulatory effect on nitric oxide (NO) levels using sodium nitroprusside as an NO donor in vitro. Most of the plant extracts demonstrated direct dose dependant scavenging on NO and exhibited significant activity. [26]

Clinical evaluation in treatment of various eye infections as herbal eye-drop preparation:

Herbal eye drops containing Sandalwood Nimba, Bhringaraj, Nirgundi, Sobhanjana, Punarnava, Satapatri, Madhu etc were studied in cases of refractive error and cataract cases with herbal eye drop for six months. Some improvements were noted in the associated symptoms but subjective improvements of vision were reported by some patients. No side effects of the drug have been reported in any patients. [14,27]

Anti-ulcerogenic activity:

Anti-ulcerogenic activity of a herbal preparation: UL-409 containing six medicinal plants namely *Santalum album* L, *Glycirrhiza glabra* L, *Saussurea lappa* C.B Clarke, *Aegle marmelos* corr, *Foeniculum vulgare* mill, *Rosa damascena* mill in a dose of 600mg/kg significantly prevented the occurrence of ulcerations induced by stress, aspirin and alcohol in albino Wister rats. [28]

Effect on central nervous system :

The sedative effect of sandalwood oil as well as HESP oil was studied on albino mice of either sex in dose of 500/ 600 mg/kg as well as 600/800 mg/kg respectively using 0.2% tween 80 as control. Severe depression occurs with death at LD_{50} 558.and 747.6 mg/kg respectively. [29]

Anti-inflammatory effect:

Investigations reveal the anti-inflammatory effect of sandalwood oil as well as HESP oil against formalin induced paw edema in albino rat in dose of 200mg/kg Using 0.2% tween 80 as control and 150 mg/kg of phenyl butazone as standard. A significant reduction in edema observed in case of HESP. [29,30]

Antipyretic effect:

The anti-inflammatory effect of sandalwood oil as well as HESP oil was investigated against yeast induced pyrexia in albino rat in dose of 200mg/kg using 0.2% of tween 80 as control and 100 mg/kg paracetamol as standard. A significantly high antipyretic effect observed in case of sandalwood oil and HESP. [30]

Effect on blood pressure/ respiration:

A prolonged fall in carotid BP, increase in heart rate and respiration has been observed while investigating effect of sandalwood oil (8mg/kg) and HESP (10mg/kg) in adult, healthy mongrel dogs (10-12 kg anaesthesised with 35 mg/kg pentobarbitone). [17]

CONCLUSION

From the large number of papers published so far it is clear that Sandal wood oils possess interesting Pharmacological potential and practical purposes. In future studies one should pay more attention to the possible use of essential oils for specific purposes and various type diseases.

Table 1: Mean tree dimensions (± standard error), from the stem at 30 cm and 100 cm above the ground, from 20 sandalwood trees.

Stem height		
Measurement	30 cm	100 cm
Diameter(cm)		
over-bark	20.3 ± 0.8	17.6 ± 0.7
under-bark	19.3 ± 0.8	16.6± 0.7
heartwood	10.0 ± 1.4	7.8 ± 1.2
Area (cm^2)		
under-bark	301 ± 22	224 ± 20
heartwood	109 ± 26	69 ± 14
Heartwood (%)	33.8 ± 5.6	28.9 ± 4.6

Table 2: Mean santalol contents (± standard error) within the oil of chips and cores, at 30 cm and 100 cm above the ground, from 20 sandalwood trees

	Compounds (%)		
Samples	α-santalol	β -santalol	Total santalol
Heartwood chips			
30 cm	46.7 ± 1.0	22.2± 0.5	68.9±1.4
100 cm	44.7 ± 1.0	20.8 ± 0.6	65.5±1.5
Cores			
30 cm	42.5 ± 1.7	19.4 ± 1.3	62.0±2.9
100 cm	42.9 ± 1.9	19.6 ± 1.2	62.5±3.1

REFERENCES

1. Kirtikar KR and Basu; *Santalum album* Indian MedicinalPlants, Vol.3, II ed., (L M Basu, 49, Leader Rd.Allahabad), 1933, 2184-88;.
2. Jain SH, Angadi VG & Shankaranarayana KH, Edaphic, Environmental and Genetic Factors associated with Growth and adaptability of Sandal (*Santalum album* L) In provenances. *Sandalwood Research Newsletter* 2003, 17, 6-7.
3. 0022X Sandalwood Research Newsletter ISSN 1321-0022X Issue 21 March 2006
4. Benencia F, Courreges MC;Antiviral Activity of Sandalwood oil against Herpes Simplex Viruses 1 & 2, Phytomedicine, 1999, 6(2),119-123.
5. Desai VB et al; PharmacologicalScreening of HESP and Sandalwood oil, Indian Perfumer, 1991, 35(2), 69-70.
6. Sastry SG.; J.Sci.Industry Research, 1994, 3(2).
7. Shankaranaryana KH; Chromatographic Separation of ∝ andβ Santalenes, Indian Perfumer.1980, XXIV(1),40-43.
8. Brunke EJ et al; Cyclosantal and Epicyclosantalal- a new sesquiterpene aldehyde from east Indian sandalwood oil, Flavour & Fragrance Journal, 1995, 10, 211-219.
9. Kaur M et al; Skin cancer Chemopreventive agent, α-santalol induces apoptotic death of Human Epidermoid carcinomaA431 cells via caspase activation with Dissipation of mitochondrial membrane and cytochrome-C release Carcinogenesis; 2005, 26(2), 369-80.
10. Ranibai P et al; Ketosantalic Acid A New Sesquiterpenic Acid From Indian Sandalwood Oil Indian Journal of Chemistry, 1986, 25, 1006-1013.
11. Christopher GJ, Emilio L. Ghisalberti JA. and Elizabeth L. Barbour. Quantitative co-occurrence of sesquiterpenes; a tool for elucidating their biosynthesis in Indian sandalwood, *Santalum album*. Phytochemistry, 2006, 67(22), 2463-2468.
12. Braun NA, Meier M and Pickenhagen W. "Isolation & chiral GC analysis of beta-bisabolols- trace constituents from the essential oil of *Santalum album* L. (Santalaceae). *J. Essent. Oil Res.*2003, 15(1), 63-65.
13. Kuttan R et al; The isolation and characterization of γ-L glutamyl S-(trans –1-propenyl)-L-cysteine sulfoxide from sandal(*Santalum album L)*: an interesting occurrence of sulfoxide diastereoisomers in nature. Biochemistry, 1974, 13(21), 4394-400.
14. Mrinal K et al; Clinical Evaluation an Indigenous Herbal Eyedrop Preparation (a preliminary report) The Indian Practitioner, 1985,38(11), 149-53.
15. Natural Preservatives Anthony C. Dweck, www.scientific papers.com\papers by acd\natural preservatives.doc
16. Shankaranaryana KH & Venkatesan KR; Rectification of Benzene Extract: a Simple Method for Extracting Sandal Oil in Higher Yield, Indian Perfumer, XXV (3&4), 31-34;(1981).
17. Albert C. Chibnall et al, Biochem J, 1981-1986, oct 1937.
18. Shankaranaryana KH et al; insect growth inhibitor from the bark of *Santalum album* Phytochemistry, 1986, 19,1239-1240.
19. Chaumont JP , Bardey I;Activities Antifongques *In- Vitro* de Sept Huiles Essentielles, Fitoterapia, 1989, LX(3),263-266.
20. Chourasia OP and Rao J. Tirumala; Anti bacterial Efficacy of Some Indian Essential Oils, Perfumery and Cosmetic, 1987, 68(Jahrgang, Nr.9/87), 564 -566.
21. Shankaranaryana KH et al; Antibacterial Activity of Sandal bark Tannins against *Staphllococcus aureus*,Van Vigyan, 1986, 24(3&4),120-121.
22. Kaur M et al; Skin cancer Chemopreventive agent, α-santalol induces apoptotic death of Human Epidermoid carcinomaA431 cells via caspase activation with Dissipation of mitochondrial membrane and cytochrome-C release Carcinogenesis; 2005, 26(2), 369-80.
23. Scartezzini P, Speroni E; review on some plants of Indian traditional medicine with antioxidant activity., J,Ethnopharmacol; 2000, 71(1-2),23-43.
24. Guo Shi-Kui et al; Immediate Effect of Kuan-Xiong Aerosols in the Treament of Anginal attack, Journal of Medicinal Plant Research, 1983, 47,116.
25. Jagetia GC, Baliga MS; Evaluation of Nitric Oxide Scavenging Activity of Certain Indian Medicinal Plants *In-Vitro*: a preliminary study.Journal of Med. Food, 2004, 7(3),343-8.
26. Paul AK et al, Clinical Evaluation of an Indigenous herbal Eye Drops Preparations, Indian Journal of Clinical Practice. 1992, 2 (11), 58-60.
27. Venkataranganna MV et al;J.Ethnopharma cology, 1998, 63,187-192.

28. Shankaranaryana KH & Kamala BS; Six new essential oils from waste plant material, Indian Perfumer, 1989, 33(1), 40-43.
29. Sivaramakrishnan VR & Shankaranarayana KH; Investigation on the insecticidal properties of plant extractives-I testing of new medicinal oils, HESP from spent sandalwood powder on insects, Science & culture, 1990. 56(03), 124-127.
30. Shankaranaryana KH & Parathasarthi K; KESP: a new essential oil from the acid hydrolysis of spent sandalwood,Perfumer & Flavorist, 1985, 10,60.

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