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THE FIRST TRULY INDEPENDENT WATCHDOG FOR THOSE
WORKING WITH NATURAL AROMATIC MATERIALS

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Cropwatch's Sandalwood Bibliography.

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Note: in this bibliography, articles on sandalwood are arranged by relevance to geographical origin rather than being arranged species-by-species. More information on the ecological status of individual *Santalum* species & general notes are available on Cropwatch's *Updated List of Threatened Aromatic Plants Used in the Aroma & Cosmetic Industries*. Please note also that where chemical formulae for certain sandalwood constituents are illustrated, some are added from the Cropwatch natural chemicals structure library.

***Contents*:**

Thai Sandalwood
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Unclassified Articles on Sandalwood

Australian Sandalwoods.

***Cropwatch comments**: Australia has two commercially important Sandalwood spp.* (Santalum album & S. spicatum)*, and a number of other Sandalwood spp. of more minor economic importance* (*such as* S. acuminatum, S. lanceolatum*, and* S. murrayanum)*.*

Biocidal Properties of Australian Sandalwoods

Ritchie S.A., Williams C.R. & Montgomery B.L. (2006) "Field evaluation of New Mountain Sandalwood Mosquito Sticks and New Mountain Sandalwood Botanical Repellent against mosquitoes in North Queensland, Australia." *J Am Mosq Control Assoc*. **22**(1), 158-60. Abstract. The mosquito repellent efficacy of New Mountain Sandalwood Mosquito Sticks (containing 0.5% w/w essential oils) and New Mountain Sandalwood Botanical Repellent (containing soybean and geranium oils) was assessed. Tests were conducted in the field with 4 volunteers in a wooded area near Cairns, North Queensland, Australia. Predominant biting species were *Verrallina funerea* and *Ve. lineata*. A pair of burning Mosquito Sticks immediately upwind of the subject (acting as an area repellent) provided a 73.1% mean reduction in mosquito landing and probing over the 3-h test period. The Botanical Repellent and a DEET-based control were both 100% effective in preventing mosquito probing for 3 h. These data are consistent with other studies of area repellents in that such products provide significant protection from mosquito bites, albeit inferior to the protection provided by topically applied repellents.

Spafford H., Jardine A., Carver S., Tarala K., Van Wees M. & Weinstein P. (2007) "Laboratory determination of efficacy of a *Santalum spicatum* extract for mosquito control." *J Am Mosq Control Assoc.* **23**(3), 304-11. Abstract. The activity of QN50, a sequiterpene alcohol derived from Australian sandalwood (*Santalum spicatum*), was tested for its effectiveness against larvae of 2 mosquito species (*Culex molestus* and *Aedes camptorhynchus* [Diptera: Culicidael), nymphs of 2 species of water boatmen (*Micronecta robusta* and *Agraptocorixa* [Hemiptera: Corixidae]), immature *Daphnia* sp. (Crustacea), and mosquito eggs (*Cx. molestus*). In a series of laboratory bioassays, field-collected mosquito larvae, eggs, and immature corixids and daphnids were placed in beakers with either QN50, methoprene or source water only (control). The mosquito larvae exposed to QN50 had reduced survivorship and average longevity relative to the control and to methoprene at most concentrations used in this study. The hatching rate of mosquito eggs was unaffected by methoprene or QN50. Corixid nymphs and daphnids experienced high mortality in both methoprene and QN50 relative to the control, but there was no difference in the effect between the compounds. The results of this preliminary study suggest that further research into the mode of action and efficacy of QN50 as a potential alternative to methoprene for mosquito abatement is warranted.

Chemistry of Australian Sandalwoods

Adams D.R., Bhatnagar S.P. & Cookson R.C. (1975) "Sesquiterpenes of *Santalum spicatum*" *Phytochemistry* **14**(5-6), 1459-1460.

Birch A.J., Moslyn K.M.C. & Penfold A.R. (1953) "The sesquiterpene alcohols of *Eucarya spicata* Sprague & Summ." *Aust. J. Chem* **6**, 391-394. ***Cropwatch comments***: *Eucarya spicata* Sprague & Summ. Is the outdated botanical name for *Santalum spicata* R.Br.

Birch A.J., Chamberlain K.B., Moore B.P. & Powell V.H. *Australian Journal of Chemistry* **23**(11), 2337-2341. Abstract. The oil of *Santalum spicatum* (R.Br.) A.DC. has been fractionated to yield 10-cis- (1) and 10-trans-2,6,10-trimethyldodeca-2,6,10-triene (2). These compounds have been synthesized by reduction of a mixture of cis- and trans-farnesyl acetate. Although not identical

with the trail pheromone of Nasutitermes they have similar specific trail activities, the former being the more active.

Brand J., Kimber P. & Streatfield J. (2006). "Preliminary analysis of Indian sandalwood (*Santalum album* L.) oil from a 14-year-old plantation at Kununurra," Western Australia *Sandalwood Research Newsletter* **21.**

Braun N.A., Meier M. & Pickenhagen W. (2003) "Isolation & chiral GC analysis of beta-bisabolols - trace constituents from the essential oil of *Santalum album* L. (Santalaceae). *J. Essent. Oil Res*. **15**(1), 63-65.

Braun N.A., Mieir M., Schmaus G., Holsher B. & Pickenhagen W (2003) "Enantioselectivity in odor perception: synthesis and olfactory properties of iso-beta-bisabolol, a new natural product." *Helv Chim Acta* **86**(7), 2698-2708. Abstract. The odorous trace constituent iso--bisabolol (4) was isolated from East Indian and Western Australian sandalwood oil and synthesized by using the (E/Z)-triene 12 (iso--bisabolene) as a key intermediate. Only one of four stereoisomeric forms of 4, (6R,7R)-4a, is odor active, having a strong floral, muguet-like, very pleasant scent.

Braun N.A., Meier M., Kohlenberg B., Valder C. & Neugebauer M. (2003) "*Santalum spicatum* (R.Br.) A. DC. (Santalaceae) – nor-helifolenal and acorenol isomers: isolation & biogenic considerations." *J. Essen. Oil. Res*. **15**, 381-386.

Braun N.A. & Spitzner D. (2007) "Synthesis and natural occurrence of (Z/E)-β-and γ-curcumen-12-ol." ARKIVOC (vii) 273-279. Abstract: (Z/E)-β-Curcumen-12-ol (Z/E)-(1) was synthesized via Birch reduction of acid 6 starting from α-curcumene (5). An olefin isomerization of 1 is the key step in the synthesis of (Z/E)-γ-curcumen-12-ol (Z/E)-(2). Sesquiterpene alcohol (E)-1 was found for the first time in nature as a minor constituent of different *Santalum* species by using the synthetic sample as reference.

Bristow M., Taylor D. & Robson K. (2002) "Queensland Sandalwood (*Santalum lanceolatum*):regeneration following harvesting." *Sandalwood Research Newsletter* 2002. Abstract. In 1994, a trial, funded by Queensland Department of Primary Industries Forestry, was established near Hughenden investigating regeneration of natural stands of Queensland sandalwood from two harvestingmethods, vis, stump cutting vs. stump pulling. Merchantable size trees in five, one hectare plots wereharvested by the respective methods and vegetative regeneration was recorded over the successive fiveyear period. Overall indications are that retaining sandalwood stumps is unlikely to result in a greateramount or more successful coppice regeneration following harvesting than stump pulling, and that it may well result in less successful cpppice regeneration.. Data from the trial suggests that the propor-tion of pulled stumps that produce coppice is higher than the coppice produced through the cut stumpmethod, and these are more likely to survive. Concerns about the impact of stump pulling on soil prop-erties and erosion are unwarranted as the number of sandalwood removed from any area is relatively few and the area of soil disturbed during the operation is very small.

Bristow M. (2004) "Review of Agroforestry in Tropical Savanna Regions of Northern Australia." A Report for the RIRDC/Land & Water Australia/FWPRDC/MDBC Joint Venture Agroforestry Program Mar 2004. "# 2.4 Ord River early sandalwood plantation projects."

Brophy J.J., Fookes C.J.R. & Lassak E.V. (1991) "Constituents of *Santalum spicatum* (R. Br.) A. DC. Wood oil." *J. Essen. Record Res* **3**, 381.

Jones G.P., Rao K.S., Tucker D.J., Richardson B.J., Barnes A. & Rivett D.E. (1995) "Antimicrobial activity of *Santalum acuminatum* (quandong) kernels." *International Journal Pharmacognosy* **33**, 120-123.

Liu Y.D., Longmore R.B. & Kailis S.G. (1995) “A comparison of kernel compositions of sandalwood (*Santalum spicatum*) seeds from different Western Australian locations. *Mulga Research Centre Journal* **12**, 15-21.

Liu Y.D., Longmore R.B., Fox J.E.D. (1996) “Separation & identification of ximenynic acid isomers in the seed oil of *Santalum spicatum* R. Br. as their 4,4-dimethyloxazoline derivatives.” *Journal of the Americ. Oil Chemists Soc*. **73**(12), 1729-1731.

Liu Y.D., Longmore R.B. & Kailis S.G. (1997) "Proximate and fatty acid composition changes in developing sandalwood (*Santalum spicatum*) seeds." *Journal of the Science of Food and Agriculture* **75**(1), 27-30,

Liu Y.D., Longmore R.B., Boddy M.R. & Fox J.E.D. (1997) “Separation & identification of triximenynin from *Santalum spicatum* R. Br.” *Journal of the Americ. Oil Chemists Soc*. **74**(10), 1269-1272.

Loveys B.R., Sedgley M. & Simpson R.F. (1984) “Identification and quantitative analysis of methyl benzoate in quandong (*Santalum acuminatum*) kernels. *Food Technology Australia*. **36**, 280-289

Moretta P., Ghisalbert E.L., Piggott M.J & Trengove R.D. (1998) “Extraction of oil from *Santalum spicatum* by supercritical fluid extraction.” *ACIAR Proceedings Series* **84**, 83-85. Abstract. Steam distillation, solvent extraction, supercritical fluid extraction (SCCO2) and liquid CO2 extraction were used to obtain the volatile oil from Western Australian Sandalwood (*Santalum spicatum* (R. Br.) A. DC.). Supercritical fluid extraction afforded the highest yields of extractable material and total volatiles. The percentages of five sesquiterpene alcohols, epi--bisabolol (1), (Z)--santalol (2), 2(E), 6(E)-farnesol (3), (Z)--santalol (4) and (Z)-nuciferol (5), were highest in the steam distillate. The variations in the relative amounts of these sesquiterpenes in the essential oil recovered by SCCO2 extraction of different sections of a single tree have been investigated. ***Cropwatch comments***: According to ISO 9235, the supercritical fluid extraction of aromatic material produces an extract; it cannot be termed an essential oil.

Moretta P. *et al*. (2001). "Longitudinal variation in the yield and composition of sandalwood oil from *Santalum spicatum*." *Sandalwood Research Newsletter* **14**, 5-7.

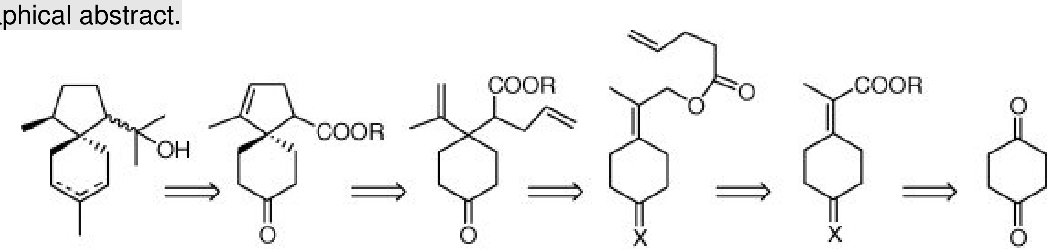
Marongiu B., Piras A., Porcedda S. & Tuveri E. (2006) "Extraction of Santalum album and Boswellia carterii Birdw. volatile oil by supercritical carbon dioxide: influence of some process parameters." *Flavour and Fragrance Journal* **21**(4), 718 - 724 Abstract. Wood of *Santalum album* and resin of *Boswellia carterii* Birdw. were used to obtain their volatile oils by means of supercritical fluid extraction with carbon dioxide. Different extraction conditions were tested: 90 bar, 45 ℃; 120 bar, 60 ℃; and 120 bar, 45 ℃. On both matrices, a good process performance was obtained working at 120 bar and 45 ℃ (density of CO2 = 0.658 g cm-3) in the extraction vessel, at 20 bar and 15 ℃ in the separator and at CO2 flow of 1.5 kg/h. At these conditions the higher yields were obtained: 1.9% for *S. album* and 6.5% for *B. carterii.* The main compounds contained in the sandalwood volatile oil were: -santalol (46.1%), -santalol (20.4%), epi--santalol (6.8%) and trans--bergamotol (5.4%). In the corresponding HD essential oil the -santalol and -santalol contents were lower: 35.0% and 14.0%, respectively. The volatile oil of B. carterii were made up of incensole acetate (32.0%), octanol acetate (25.1%), incensole (17.8%) and phyllocladene (7.7%). The percentage of the main constituents in the oil obtained by HD was quite different. It contained larger amounts of octanol acetate (45.2%) and phyllocladene (13.2%) and lower amounts of incesole (6.1%) and incensole acetate (13.0%).

Piggott M.J., Ghisalberti E.L. & Trengove R.D. (1997) “West Australian sandalwood oil: extraction by different techniques and variations of the major components in different sections of the same tree.” *Fl. & Frag. J.* **12**, 43-46.

Shellie R., Marriott P. & Morrison P. (2004) " Comprehensive two-dimensional gas chromatography with flame-ionization and time-of-flight mass spectrometry detection: qualitative

& quantitative analysis of West Australian sandalwood oil" *J Chromatog Sci*. **42**(8), 417-422. Abstract: The use of gas chromatography (GC)-mass spectrometry (MS), GC-time-of-flight MS (TOFMS), comprehensive two-dimensional GC (GCxGC)-flame ionization detection (FID), and GCxGC-TOFMS is discussed for the characterization of the eight important representative components, including *Z*-alpha-santalol, *epi*-alpha-bisabolol, *Z*-alpha-*trans*-bergamotol, *epi*-beta-santalol, *Z*-beta-santalol, *E,E*-farnesol, *Z*-nuciferol, and *Z*-lanceol, in the oil of West Australian sandalwood (*Santalum spicatum*). Single-column GC-MS lacks the resolving power to separate all of the listed components as pure peaks and allow precise analytical measurement of individual component abundances. With enhanced peak resolution capabilities in GCxGC, these components are sufficiently well resolved to be quantitated using flame ionization detection, following initial characterization of components by using GCxGC-TOFMS.

Srikrishna A. & Babu R.R. (2007) "Total syntheses of (±)--acorenol, β-acorenol, -epi-acorenol and β-epi-acorenol via an Ireland ester Claisen rearrangement and RCM reaction sequence." *Tetrahedron Letters* **48**(39), 6916-6919. Abstract. Total syntheses of (±)-- and β-acorenols and (±)-- and β-epi-acorenols, spiro[4.5]decane sesquiterpenes, isolated from the western Australian sandalwood oil, have been accomplished employing a combination of Ireland ester Claisen rearrangement and RCM reactions for an efficient construction of the spiro[4.5]decane present in acoranes.
Graphical abstract.



Valder C., Neugebauer M., Meier M., Kohlenberg B., Hammerschmidt F.-J., Braun NA (2003) "Western Australian sandalwood oil – new constituents of *Santalum spicatum* (R.Br) A DC. (Santalaceae)" *J. Essent. Oil Res.* **15**(3), 178-186. Abstract. Commercial Australian sandalwood oil produced from *Santalum spicatum* (R. Br.) A. DC. roots was analyzed using GC and GC/MS. Seventy constituents were identified: four monoterpenes, 64 sesquiterpenes and two others. Four compounds (Z)-beta-curcumen-12-ol, (Z)-12-hydroxysesquicineole, 6,10-epoxybisabol-2-en-12-ol andnor-helifolen12-al were found to our knowledge for the first time in nature and were characterized using^sup 1^H-,^sup 13^C-NM MR, GC/FTIR and GC/MS analyses. ***Cropwatch comments***: The authors show lower concentration of *cis*- alpha santalol & *cis*-beta santalol, higher conc of (*Z*) *trans*-alpha bergamotol & epi-beta-santalol in the oils of *S. spicatum* compared with *S. album.* Regarding the bisabolols, the main isomer in *S. spicatum* is 6R, 7S-epi-beta-bisabolol whereas in *S album* it is 6R, 7S-beta-bisabolol. The oils should therefore be regarded as different

Valder C., Neugebauer M., Meier M., Kohlenberg B., Hammerschmidt F.-J., Braun N.A. (2003a) "*Santalum spicatum* (R.Br.) A DC. (Santalaceae) – nor-helifolenal & acorenol Isomers: Isolation and biogenic considerations" *J. Essent. Oil Res.* **15**, 381-386.

Australian Sandalwoods - General

Anon (2000) "Qld: Five fined for sandalwood harvesting" *AAP General News Perth (Australia)* Dec 12th WA: sandalwood claims would be dealt with if true: Abstract Court story alleging that West Australian government officials were exporting sandalwood to dealers in Taiwan who had offered state officials bribes or prostitutes.

Anon (2002) *AAP General News (Australia) Nov 18 (2002).* Abstract: Five people fined in the Cairns Magistrate Court for illegal harvesting of the protected sandalwood plant, the Queensland EPA reportedly said.

Anon (2002) "A Crop in Crisis" – a part of "A calming influence" *Soap, Perfumery & Cosmetics* (Oct 2002) p42-3.

Anon (2006) "Big expansion for sandalwood plantation." *ABC Newsonline* Abstract 19th June 2006. An Indian sandalwood plantation in the Ord Valley is undergoing its biggest expansion in seven years. Tropical Forestry Services is planting a further 235 hectares of the exotic hardwood, increasing its total plantation to more than 800 hectares. The company plans to harvest its first crop in 2012, banking on continuing strong demand from Asia, Europe and the United States. Chief executive Tom Cullity says the company is planning processing facilities at Kununurra to produce sandalwood oil which is used for perfumes and cosmetics. "Oil is from the hardwood. Over $100,000 Australian for a tonne of hardwood. The sandalwood oil that is distilled from the hardwood is very valuable and it's used in a lot of perfumes and cosmetics," he said. The other major grower of indian sandalwood in the Ord, ITC Limited, has now planted 750 hectares, owned by investors.Its first harvest is planned for 2014.

Anon (2007) "W.A. Sandalwood set to dominate world trade." *ABC News* 11/12/2007. Abstract. The head of one of the world's leading fragrance companies believes the Ord Valley in Western Australia will overtake India, as the major producer of Indian sandalwood. The Ord has the only commerical crop of Indian sandalwood trees in the world. With a global shortage, oil from the processed timber is currently worth around $US1800 per kilogram. Georges Ferrando, from Albert Vieille, says with a processing plant due to be built in Kununurra next year, the region will become a world leader within five years. "India is number one in supplying sandalwood oil, but I think very, very quickly, Kununurra will become the supplier number one in the world," he says.

Anon (2007) "Sandalwood oil – Smells like success." *RIRDC Press release* 27.01.08 - see http://www.rirdc.gov.au/pub/media_releases/23jan07.html

Anon (2008) "Event Notes: Sustainable Indian Sandalwood in Australia." *P&F Now* June 25th 2008. ***Cropwatch comments:*** Sad to see P & F staff act as advertising agents for TFS via their obedient reproduction of TFS promo material & sympathetic coverage of the recent Sandalwood conference at the Kimberly Grande Hotel in Kununurra Western Australia. Cropwatch has received opinions from conference attendees which give a more independent account, and that's what we should expect in *Perfumer & Flavourist* features. Or have they no-one on the payroll now with an experienced eye to what really goes on in this trade?

Anon (2008) "Givaudan enters ethical sustainability partnership for sandalwood oil." The Givaudanian 05 Feb 2008 – see http://www.givaudan.com/vgn-ext-templating/v/index.jsp?vgnextoid=17889631fd5e7110VgnVCM1000004a53410aRCRD&cpsextcurrchannel=1 ***Cropwatch comments:*** We believe that linking to Mount Romance, with its history of involvement in animal-products, is a major mistake by the Givaudin management. We are also told Givaudin are actively sourcing "more than 190 pure & natural raw materials for fragrances. "

Applegate G.B, Davis A. & Annable P.A (1990) "Managing sandalwood for conservation in N. Queensland, Australia" in *Proc of the symposium on sandalwood in the Pacific*: April 9-11, 1990, Honolulu, Hawai/technical co-ordinators: Lawrence Hamilton, C. Eugene Conrad. pub: *Symposium on Sandalwood Conservation* (1st: 1991: Honolulu, Hawaii). Abstract.: *Santalum lanceolatum,* the commercial species of sandalwood harvested in Queensland, was worth $4.2 million in export earnings in 1988. The ecology of the species in natural forests is summarized, and information on seedling regeneration and coppice and root suckering strategies is provided. Stand characteristics and size class distribution in two different environments in northwest Queensland are provided. It is important to manage the resource for conservation. The harvesting guidelines, pricing criteria, and procedures are discussed along with information on heartwood recovery and moisture content of harvested sandalwood. Future research should be undertaken to monitor stand dynamics, growth rates, and the effects of land use practices on the distribution, growth, and dynamics of sandalwood in natural stands.

Applegate G.B. & McKinnell F.H. (1993) “The Management & Conservation Status of *Santalum* species occurring in Australia.” In McKinnell F.H. ed. *Sandalwood in the Pacific Region. Symposium 2nd June 1991 at XVII Pacific Science Congress, Honolulu*, ACIAR Proceedings No. **49**, 5-12.

Barrats D.R., Wijesuriya S.R. & Fox J.E.D. (1985) “Observations on foliar nutrient content of sandalwood (*Santalum spicatum* R. Br. DC.) *Mulga Research Centre Journal* **8**, 81-91.

Barrats D.R. (1987) “Initial observations on flowering and fruiting in *Santalum spicatum* (R. Br.) A. DC the Western Australian sandalwood.” *Mulga Research Centre Journal*, Australia **4**, 61-65.

Barrats D.R. (1987) “Germination & planting out techniques for the Western Australian sandalwood *Santalum spicatum*.” *Mulga Research Centre Journal,* Australia **9**, 31-32.

Barrett D R (1987) Initial observations on flowering and fruiting in *Santalum spicatum* (R. Br.) A. DC. – the Western Australian sandalwood. *Mulga Research Centre Journal* **9**:33–37.

Bentley D. (1997) “Field grafting of Quandong. Acuminatum” Summer 1997 pp2-3. (*Newsletter of the Australian Quandong Industry Association*).

Bird K. (2008) "Lush secures supply of sustainable sandalwood." *CosmeticsDesign-Europe* 21.02.2008. ***Cropwatch comments.*** Further move illustrating rising tendency of natural aromatic ingredient users to by-pass essential oil traders and sign contracts directly with producers. In this case the report notes the deal is to buy Indian sandalwood from the Australian TFS Corporation, which expects sandalwood oil to be available from its'plantations by 2011. For full story - see http://www.cosmeticsdesign-europe.com/news/ng.asp?id=83433-lush-tfs-sandlewood

Bird K. (2008) "Fragrance house sources sustainable ingredients." *CosmeticsDesign-Europe* 07.02.2008. ***Cropwatch comments***. Givaudin have announced a partnership with Mount Romance, according to the article, and we are also informed that Givaudin claim to be the first fragrance house using an aboriginal source of wood, since we are told that the sandalwood is harvested by aboriginal communities in SW Australia, and inspected by the independent indigenous certification body, the Songman Circle of Wisdom. Full details can be seen at http://www.cosmeticsdesign-europe.com/news/ng.asp?n=83107-givaudan-fragrance-natural-ehtical. Mount Romance’s involvement with emu oil is quite well known (5,000 litres claimed to have been produced in 1997), as is Stephen Birkbeck’s (MD at Mount Romance) previous track-record in crocodile & turtle farming. Given this animal-product-exploitation scenario, the “ethical sustainability relationship” between Givaudin & Mount Romance will probably ring hollow with many ecology-concious consumers & vegetarians, at least. Interestingly, the farm gate value of the emu-farming industry was put at $6-8 million/y (CoAS 2003), compared with a valuation of (only) $12m for the whole of the Australian tea tree oil industry. Opposition to emu farming in Australia by the Australian Royal Society for the Prevention of Cruelty to Animals, can be viewed at http://www.rspca.org.au/pdf/B_policystatements.pdf
Further comments. Aveda also have an agreement with Mount Romance for supply steam-distilled Sandalwood oil (instead of the solvent extract initially marketed by Mount Romance as ‘oil’ More details, as well as their involvement with the Ingenous Communities of Mardu Peoples of Kuktabubba for harvested sandalwood can be seen at http://aveda.aveda.com/protect/we/sandalwood.asp.

Bolt C. (2001) “Tax scheme controversy fells plantation timber company” *The Financial Review* 31 July 2001 p12.

Bradfield A.E., Francis E.M., Penfold A.R. & Simonsen J.L. (1936) "Lanceol, a sesquiterpene–alcohol from the oil of *Santalum lanceolatum.* Part I." *J. Chem. Soc*., 1936, 1619 - 1625,

Brand J.E. & Jones P.J. (year?) “The influence of landforms on sandalwood (*Santalum spicatum* (R.Br) A.DC.) size structure & density in the North East Goldfields, Western Australia.” *Rangeland Journal* **24**(2), 219-226.

Brand J.E. (1993) “Preliminary observations on ecotypic variations in *Santalum spicatum*. 2. Genotypic variation.” *Mulga Research Centre Journal* **11**, 13-19.

Brand, J.E. (1994). “Genotypic variation in *Santalum album*.” *Sandalwood Research Newsletter* **2**, 2–4.

Brand J.E. (1999) “Ecology of sandalwood (*Santalum spicatum*) near Paynes Find & Menzies, Western Australia: size structure & dry-sided stems” *Rangeland Journal* **21**(2), 220-228. Abstract. Population size structure of sandalwood (*Santalum spicatum*) was studied on four pastoral leases near Paynes Find and Menzies, in semi-arid Western Australia. Stem diameter, height, height to crown and the orientation of dry-sided stems were recorded for 1017 individual sandalwood. Populations of *S. spicatum* at Paynes Find contained only mature trees, indicating no successful recruitment for at least 30 years. In contrast, populations of *S. spicatum* at Menzies had a high proportion of seedlings and saplings. Crown measurements of mature *S. spicatum* trees indicated high grazing intensity at Paynes Find: mean height to crown at Paynes Find (147-148 cm) was significantly higher than Menzies (92-94 cm). Dry-side percentage differed significantly between directional faces, consistent with sun damage. Highest mean dry-side percentages were on stem sides facing the sun between midday and late afternoon: west, north-west, south-west and north. This directional pattern was the same between pastoral leases, and there was no interaction between pastoral lease and dry-side direction. Mean percentage of mature trees with a dry-sided stem was also significantly higher at Paynes Find (76-82%) than at Menzies (42-46%). Significantly less foliage low to the ground on mature trees at Paynes Find may have exposed the stems to more sun damage. Land systems did not significantly influence dry-side direction on Burnerbinmah or Goongarrie. No *S. spicatum* seedlings or saplings had a dry-sided stem.

Brand J.E., Ryan P.C. & Williams M.R. (1999) “Establishment and growth of sandalwood (*Santalum spicatum*) in South-Western Australia: the Northampton pilot trial.” *Australian Forestry* **62**(1), 33-37.

Brand J. & Jones P. (1999). "Grow-ing sandalwood (*Santalum spicatum*) on farmland in Western Australia." *Sandalwood Information Sheet No1. Conservation and Land Management* (Perth WA)

Brand J.E., Crombie D.S. & Mitchell M.D. (2000) “Establishment and growth of sandalwood (*Santalum spicatum*) in South-Western Australia: the influence of host species.” *Australian Forestry* **63**(1), 60-65.

Brand J.E., Fox J.E.D. & Moretta P. (2001). “Review of research into sandalwood (*Santalum spicatum*) tree farm systems in south-western Australia.” In *Conference Proceedings: Forests in a Chang-ing Landscape: 16th Common-wealth Forestry Conferencejointly with the 19th Biennial Con-ference of the Institute of Foresters of Australia, Fremantle, Western Australia, 18-25 April, 2001* Promaco Conventions, Perth, pp 527-535

Brand J.E. (2002) “Review of the Influence *of Acacia* species on establishment of sandalwood (*Santalum spicatum*) in Western Australia “ *Conservation Science Western Australia* **4**(3), 125-129. *Rangeland Journal* **21**(2), 220-228.

Brand J.E., Robinson N & Archibald R.D. (2003) “Establishment & growth of sandalwood (*Santalum spicatum*) in South-Western Australia: *Acacia* host trials.” *Australian Forestry* **66**(4), 294-299. Abstract. The influence of four different *Acacia* species (*Acacia acuminata*, *A. saligna*, *A. microbotrya* and *A. hemiteles*) on the establishment and growth of sandalwood (*Santalum spicatum*) was examined at two sites in the wheatbelt, Western Australia, Australia. The host seedlings were planted in June 1998, and four *S. spicatum* seeds were planted adjacent to each host at age 1 year (May 1999). Direct sowing *S. spicatum* near 1-year-old host seedlings again proved to be a successful establishment technique, with 81-91% germination per spot, at both sites. At age 3 years, the survival of *S. spicatum* near *A. saligna* (94%) and *A. acuminata* (81%) was significantly greater than near *A. hemiteles* (45%). At the same age, the mean stem diameter of *S. spicatum* growing near *A. saligna* was 53 mm, significantly greater than near *A. acuminata* (33 mm), *A. microbotrya* (20 mm) and *A. hemiteles* (11 mm). Growth was superior at the Dandaragan site, with *S. spicatum* near *A. saligna* having a mean stem diameter of 59 mm and a mean height of 2.3 m. At the host age of 4 years, the mean height of *A. microbotrya* (4.3 m) was significantly greater than *A. saligna* (3.3 m), *A. acuminata* (3.2 m) and *A. hemiteles* (1.1 m). Between host ages of 1 and 4 years, the mean survival of *A. saligna* dropped by 27%, significantly more than the other host species (2.5-10%). Mean potassium and phosphorus concentrations in the foliage of S. spicatum were significantly higher near *A. saligna* than near *A.* hemiteles. The mean potassium:calcium ratio was highest near *A. microbotrya* (2.2-3.7) at both sites. Stem water potentials in *S. spicatum* were significantly lower near A. microbotrya (-2.9 MPa) than near *A. hemiteles* (-2.2 MPa) at Dandaragan. There were no significant differences between *S. spicatum* stem water potentials at Narrogin.

Brand J., Jones P & Donovan O. (2004). "Current growth rates and predicted yields of Sandalwood (*Santalum spictum*) grown in plantations in south-western Australia." *Sandalwood Research Newsletter* **19**, 4-7 Abstract. Aromatic timber from *S. spicatum* is a valuable commodity, and this species hasthe potential to provide an income to farmers in the medium annual rainfall (400-600 mm) regions of the wheatbelt. Since 1987, *S. spicatum* plantations have beensuccessfully established in the wheatbelt, by direct seeding near 1-2 year old host seedlings, especially *Acacia acuminata*. This establishment technique has been very effective, with over 80 % survival per spot, and mean stem diameters (at 150 mm above the ground) increasing at 10-12 mm yr-1near *A. acuminata*. Allowing two years to establish both *A. acuminata* and *S. spicatum*, and then a mean stem diameter growth of only 7 mm yr-1for 18 years, the *S. spicatum* are expected to reach commercial size (127 mm) at plantation age 20 years. At this age, the expected yields are approximately 4.4 tonnes ha-1, with a net return ofover AU $14,000 ha-1. The sandalwood trees are also producing 60-170 kg ha- 1of seeds at age only 4-6 years. The value of the seeds may also provide a supple-mentary income to the sandalwood growers, while they are waiting for the trees to reach commercial size. ***Cropwatch comments***: The authors state that core samples taken from 10-year old trees produced oil containing 16.7 to 21.1% α- & β-santalols, "which are the compounds that produce the distinct sandalwood fragrance" referencing Adams *et al.* (1975), The authors take no account of the effect on the odour profile of other major components found in the oil, such as the presence of 17.8% to 20.5% farnesol, a sesquiterpene alcohol recently identified as a sensitiser by IFRA and currently the subject of a (yet unpublished) SCCP Opinion.

Braun N.A. & Meier M. (2004) "Western Australian & East Indian sandalwood oil – a comparison" *Euro Cosmetics* **12**(1), 22-29.

Bristow, M. et al. 2000. "Queensland sandalwood (*Santalum lanceolatum*): regeneration following harvesting." *Sandalwood Research Newsletter* **11**, 4-8.

Burfield T. & Wildwood C. (2004) "Cropwatch 2: Australian Sandalwood Oil: a tale of Spin & Hype" at http://www.cropwatch.org/cropwatch2.htm & www.users.globalnet.co.uk/~nodice/

Byrne M., McDonald B. & Brand J. (2003) "Phylogeography & divergence in the chloroplast genome of Western Australian sandalwood (*Santalum spicatum*) *Heredity* **91**(4), 389-395. Abstract. Western Australian sandalwood (*Santalum spicatum*) is widespread throughout Western Australia across the semiarid and arid regions. The diversity and phylogeographic patterns within the chloroplast genome of *S. spicatum* were investigated using restriction fragment length polymorphism analysis of 23 populations. The chloroplast diversity was structured into two main clades that were geographically separated, one centred in the southern (semiarid region) and the other in the northern (arid) region. Fragmentation due to climatic instability was identified as the most likely influence on the differentiation of the lineages. The lineage in the arid region showed a greater level of differentiation than that in the southern region, suggesting a higher level of gene flow or a more recent range expansion of sandalwood in the southern region. The phylogeographic pattern in the chloroplast genome is congruent with that detected in the nuclear genome, which identified different genetic influences between the regions and also suggested a more recent expansion of sandalwood in the southern region.

Byrne M., McDonald B., Broadhurst L. & Brand J. (2003) "Regional genetic differentiation in Western Australian sandalwood (*Santalum spicatum*) as revealed by nuclear RFLP analysis." *Theoretical & Applied Genetics* **107**(7), 1208-1214. Abstract. Western Australian sandalwood, *Santalum spicatum*, is widespread in the semi-arid and arid regions of Western Australia, and there is some morphological variation suggestive of two ecotypes. The level and structuring of genetic diversity within the species was investigated using anonymous nuclear RFLP loci. *Santalum spicatum* showed moderate levels of genetic diversity compared to other Australian tree species. The northern populations in the arid region showed greater levels of diversity and less population differentiation than the southern populations in the semi-arid region due to differences in the distribution of rare alleles. Equilibrium between drift and gene flow in the northern populations indicated that they have been established for a long period of time with stable conditions conducive to gene flow. In contrast, the southern populations showed a relationship between drift and gene flow indicative of a pattern of fragmentation and isolation where drift has greater effect than gene flow. The different patterns of diversity suggest that the ecotypes in the two regions have been subject to differences in the relative influences of drift and gene flow during their evolutionary history.

CALM (2001) (Dept of Conservation & Land Management 2001) "New sandalwood contracts for station owners" Media Release 17th July *Perth: Dept of Conservation & Land Management*.

Choupechoux R. (1931) *Contribution a l'etude de l'essence de santal Australie*. pub. Lyon, Boso & Riou 1931.

Clarke M. (2006) "Australia's Sandalwood Industry: an overview & analysis of research needs". Publicn no 06/131- For RIRDC – see http://www.rirdc.gov.au/reports/EOI/06-131.pdf

Crossland T. (1982). "Germination of sandalwood seed." *Mulga Research Centre Report*, Curtin University, Perth. 5:13-16.

Crossland T. (1982) "Response to fertiliser treatment by seedlings of sandalwood, *Santalum spicatum* (R.Br) DC." *Annual Report, Mulga Research Centre* Australia **5**, 13-16.

Crossland T. (date?) "Preliminary investigations into germination and establishment of sandalwood, *Santalum spicatum* (R. Br.) DC. *Annual Report, Mulga Research Centre* Australia **4**, 61-65.

Donovan R.J. (undated) *A history of the sandalwood industry of Western Australia* Battye Library, Perth, Australia

Duus J. E. (1987).. "Harvesting of Sandal-wood from Crown Lands in Queen-sland." (Unpublished).

Fergeus J. (undated pamphlet) "Australian sandalwood aromatic review" *Australian Botanical Products Pty Ltd.*

Flanagan F. & Barrett D.R. (1993) "Sandalwood nuts as food." *Mulga Research Centre Journal* **11**, 21-26.

Forest Products Commission WA Media Release (27 March 2006) "Preliminary oil results from a 14-year-old Indian sandalwood plantation at Kununurra, WA."

Forest Products Commission WA Media Release (16th May 2006) "First Indian sandalwood plantations established in Carnavon."

Fox J.E.D. & Brand J.E. (1993) "Preliminary observations on ecotypic variations in *Santalum spicatum.* 1. Phenotypic variation." *Mulga Research Centre Journal* **11**, 1-12.

Fox J.E.D. & Wijesunya S.R. (1985) “Sandalwood planting with property owners” *Mulga Research Centre Journal* **8**, 3340.

Fox J E D & Brand J E (1993). “Preliminary observations on ecotypic variation in *Santalum spicatum.* 1. Phenotypic variation.” *Mulga Research Centre Journal* **11**:1–12.

Fox J.E.D. (1997) "Why is *Santalum spicatum* common near granite rocks?" *J. Royal Soc. of Western Australia* **80**, 209-220. Abstract. Sandford Rocks Nature Reserve is dominated by a large granite outcrop. This reserve is notably well-endowed with trees of the root parasite sandalwood (*Santalum spicatum*). These are comparatively common in and among granite exposures. Trees attain 4 m in height and 20 cm basal diameter on favourable sites but are small gnarled shrubs in rock fissures. Fruiting ability differs considerably between trees. Despite apparently high densities of rabbits, continuous regeneration appears to have occurred, but only in the vicinity of parent trees. The reserve contains a number of distinct vegetation associations that are soil determined. Although sandalwood is common near exposed granite it is rarely found in association with *Eucalyptus* stands. It is suggested that the water-shedding properties of the granite exposures are less important to sustaining sandalwood than the presence of preferentially parasitised host species.

George, A. S. (1984). “*Santalum*.” in *Flora of Australia*, vol. **22**. Bureau of Flora and Fauna. Australian Government Publishing Service. Canberra, Australia.

George, A.S. (1996) “Sandalwoods and quandongs of Australia.” *Australian Plants* **13**, 318-319

Gearon V. (2000) at http://www.essentiallyoils.com/Newsletters/October_2000_Newsletter/october_2000_newsletter.html

Gearon V. (2002) *Aromatherapy Today* **24**, Dec 2002 p21

Grant, W.J.R. & Buttrose, M.S. (1978) "Domestication of the quandong, *Santalum acuminatum.*" *Australian Plants* **9**, 316-318

Harbaugh D. (2007) "A taxonomic revision of Australian northern sandalwood (*Santalum lanceolatum*, Santalaceae)." *Australian Systematic Botany* **20**(5) 409–416. Abstract. A previously published molecular phylogenetic analysis of the sandalwood genus, *Santalum* L. (Santalaceae), identified that the Australian endemic northern sandalwood, *S. lanceolatum* R.Br., is not monophyletic and contains a distinct, yet cryptic, lineage within it as currently circumscribed. This study examines nuclear ribosomal gene sequences of additional specimens from across its geographic range, and 30 morphological characters, in order to revise the taxonomy of *S. lanceolatum* sensu lat. (s.l.) and the segregate species that should bear the name *S. leptocladum* Gand. *Santalum lanceolatum* sensu stricto (s.s.) is distributed in the humid to subhumid regions of northern Australia north of 20°S latitude, whereas *S. leptocladum* occurs in the arid and temperate regions of central and southern Australia. Putative interspecific hybrids were discovered in two localities, and may represent either natural or human-mediated hybridisation. The results of this study have major economic and conservation implications because *S. lanceolatum* s.s., which is known to have higher levels of fragrance compounds than *S. leptocladum*, has a much more restricted range than previously thought.

Harbaugh D.T. (2008) "Polyploid and Hybrid Origins of Pacific Island Sandalwoods (*Santalum*, Santalaceae) Inferred from Low-Copy Nuclear and Flow Cytometry Data." *Int. J Plant Sci.* 169(5), 677–685. Abstract. It has been argued that polyploids are better adapted than diploids for long-distance dispersal to and establishment on oceanic islands. To address this issue in a molecular phylogenetic framework, the extensive history of auto- and allopolyploidization in *Santalum* (Santalaceae), the sandalwood genus, was studied by sequencing the low-copy nuclear gene waxy and investigating the ploidy level of all 16 species. Ploidy level was estimated by measuring the C value (total amount of DNA per nucleus) using flow cytometry and calibrating it by known chromosome numbers and new root-tip chromosome counts of several taxa. Results indicate four ploidy levels in *Santalum*: diploid (n=10), tetraploid (n=20), hexaploid (n=30), and octoploid (n=40). The waxy phylogeny suggests that at least six independent polyploid events occurred in the history of *Santalum*: two allopolyploid events between distantly related species and four putatively autopolyploid events. An additional hybrid event between two tetraploid Hawaiian clades evidently produced the tetraploid species *S. boninense*, endemic to the Bonin Islands. By finding more than twice as many long-distance island colonizations from polyploid as from diploid ancestors, this study provides novel evidence for the role of polyploidy in plant colonization throughout the Pacific Islands.

Henschke I. (2000) "Sandalwood brings sweet smell of success." Landline. Australian Broadcasting Corp at http://www.abc.net.au/landline/stories/s206172.html

Herbert D A (1925) "The root parasitism of Western Australian Santalaceae." *Journal and Proceedings of the Royal Society of Western Australia* **11**, 127–149.

Heuberger E., Gearon V., Birbeck S., Buchbauer G. (2002) "The essential oil of Australian sandalwood (*Santalum spicatum*) – effects of different samples on human physiology & subjective evaluation," *33rd ISEO*, Sept 2002, Lisbon, Portugal.

Hobman, F.R. (1991) "The SA Dept of Agriculture evaluation programme for quandongs.." In *Quandongs, a viable opportunity*. Minnipa Research Centre, Oct. 18, 1991. Dept of Agriculture, South Australia

Hood J.R., Cavanagh H.M. & Wilkinson J.M. (2004) "Effect of essential oil concentration on the pH of nutrient and Iso-sensitest broth." *Phytother Res.* **18**(11), 947-9. Abstract. The role of pH on the antimicrobial activity of essential oils has not been well studied. The effect of four essential oils: *Backhousia citriodora*, *Melaleuca alternifolia, Lavandula angustifolia* and *Santalum spicatum* (0.1% to 10%) on the pH of two commonly used media, nutrient broth and Iso-sensitest broth, was therefore undertaken. Small (less than 0.5 pH units) but statistically significant differences between the pH of the two media followed the addition of *M. alternifolia*, *L. angustifolia* and *S. spicatum* essential oil. In general the effect on pH was greatest at higher concentrations and the fall in pH was greatest in the nutrient broth. The addition of *B. citriodora* essential oil to nutrient broth resulted in a fall in pH from 7.29 +/- 0.02 (no oil) to 5.2 +/- 0.03 (10% oil). This effect was not observed in the Iso-sensitest broth.

Hudson (2008) "Kununurra could become world's biggest producer of Indian Sandalwood". http://www.abc.net.au/rural/wa/content/2006/s2244847.htm ***Cropwatch comments:*** Hopefully the 75 or so delegates (presumably manily shareholders) were impressed by reports of 3,000 + ha of sandalwood under cultivation, and nobody mentioned that the hard-pressed perfumery trade has mainly switched to cheap sandalwood synthetics on cost grounds. But maybe TFS could still sell sandalwood logs to China ?

Ilah A. *et al*. (2002). "Somatic embryo irregularities in in vitro cloning of sandal (*Santalum album* L.)." *Sandalwood Research Newsletter* **15**, 2-3.

Jain S.H., Angandi V.G. & Shankaranarayana, K.H. (2003) "Edaphic, environmental and genetic factors associatedwith growth and adaptability of Sandal (*Santalum album* L.) in provenances." *Sandalwood Research Newsletter* **17**, 4-5. Abstract. Sandal tree grows under different edaphic and eco climatic conditions. Consid-ering large genetic distance between provenances, it is concluded that under di-verse locality factors sandal adapts very well in terms of growth, heartwood and oil content.

Jones G.P., Tucker D.J., Rivett D.E. & Sedgley M." (1985). "The nutritional potential of the quandong (*Santalum acuminatum*) kernel." *Journal Plant Foods* **6,** 239-246.

Jones G.P., Birkett A., Sanigorski A., Sinclair A.J., Hooper P.T., Watson T.& Rieger V. (1994) "The effect of feeding quandong (*Santalum acuminatum*) oil to rats on tissue lipids, hepatic ctochrome P450 and tissue histology." *Food and Chemical Toxicology* **32,** 521-525

Jones P. (1999) “'Growing Sandalwood (*Santalum spicatum*) on farmland in Western Australia.' *Forest Products Commission Information Sheet* Issue **1**, May 1999.

Jones P. (2002) “Estimating Returns on Plantation Grown Sandalwood (*Santalum spicatum*)” *Forest Products Commission Sandalwood Information Sheet* Issue **3,** July 2002

Jyothi P.V., Atluri J.B. & Subba R.C.(1991). "Pollination ecology of *Santalum album* (Santalaceae)." *Tropical Ecology* **32**, 98-104

Kauber K. “Australian sandalwood oil – acute oral toxicity and acute dermal toxicity”, Scantox, Denmark 2000 (unpublished). ***Cropwatch comments***: Cropwatch previously asked Scantox to release details of this study, allegedly funded by Mount Romance, which is said to include animal testing experiments. Later all references to this research were removed from Mount Romance’s internet presence, perhaps because many perfumery companies will not accept perfumery materials manufactured by companies who have tested their products on animals. .

Kealley I.G. (1991) “The management of Sandalwood” Dept of Conservation & Land Management, *W. Australian Wildlife Management Program* No **8**, 3-9..

Keenan R (1996) “*Santalum lanceolatum in* Queensland.” *Sandalwood Research Newsletter* - Issue **1**.Department of Conservation and LandManagement, Kununurra, Western Australia.

Kerr J. (2000) “Essential Oil Profile – Australian Sandalwood Oil” *Aromatherapy Today* **15**, 8-12.

Kerr J. (2002) “Editorial Comment” *Aromatherapy Today* **24** Dec 2002 p32-33.

Lethbridge B. (1998) “Germinating bitter quandong.” *Acuminatum* Autumn 1998, p 4

Lethbridge B. (1998) "Root rot, rootstock and phosphorous acid." *Acuminatum*, Winter 1998, p 4"

Lethbridge, B. (1999) “Host plants I - Melaleucas. "*Acuminatum*, Autumn 1999, p 4.

Lethbridge, B. (2001). “Grafting compatibility of quandong, *Santalum acuminatum.*”. *Sandalwood Research Newsletter* **12**, 2.

Lethbridge B. & Randell B. (2003) "Genetic and agronomic improve-ment of Quandong." RIRDC Pub-lication No. 03/110.

Lethbridge B. (2004) "Do Our Own Research (DOOR) quandong production." RIRDC publication No. W04 / 111

Lethbridge B.(2004) "Native Foods : Quandong." In The New Crop Industries Handbook. Edited by Salvin S., Bourke M. Byrne A. Rural Industries Research and Development Corporation.

Lethbridgw B. (2005) "Field grafting of Quandong (*Santalum acuminatum*)." *Sandalwood Research Newsletter* **20**. April 2005.

Luong T.M. (2002) "Competitive effects within and between Santalum albumand pot host *Alternanthera dentata*." *Sandalwood Research Newsletter* **16**. Abstract. The growth of *Santalum album* seedlings and the preferred pot host Alternanthera dentata under nursery conditions is the first important step in establishing this species in planta-tions. A 19 week pot trial was conducted in a glasshouse at Curtin University of Technol-ogy, Perth, Western Australia. The aim was to test whether an increase in host density im-proved growth of sandalwood seedlings. *S. album* seedlings had a tendency to grow betterat lower densities of *A. dentata* (one or two hosts per pot), compared with higher densities (three or four hosts per pot). Seedlings with two hosts had greater heights, dry root andshoot weights and leaf area, while seedlings with one pot host had more leaves. There wereno clear trends between number of haustorial connections made as host density increased.As host density increased, the leaf area, root and shoot weights of *A. dentata* declined. Bothparasite and host were more affected by competition, however the host was more affected byintraspecific competition, indicated by large competitive responses to each other. *S. album* seedlings had less effect or response to density of *A. dentata* after 19 weeks, perhaps due tonot being limited by the same resources as the host at this early establishment phase

Loveys B.R. & Jusaitis M. (1994) "Stimulation of germination of quandong (*Santalum acuminatum*) and other native plant seeds. *Australian Journal of Botany*. **42**, 563-574.

Liu Y.D. & Longmore R.B. (1997) "Dietary sandalwood seed oil modifies fatty acid composition of mouse adipose tissue, brain & liver." *Lipids* **32**(9), 965-969. Abstract. Sandalwood (*Santalum spicatum*) seed oil, which occurs to about 50% of the weight of the seed kernels, contains 30-35% of total fatty acids (FA) as ximenynic acid (XMYA). This study was designed to obtain basic information on changes in tissue FA composition and on the metabolic fate of XMYA in mice fed a sandalwood seed oil (SWSO)-enriched diet. Female mice were randomly divided into three groups, each receiving different semisynthetic diets containing 5.2% (w/w) fat (standard laboratory diet), 15% canola oil, or 15% SWSO for 8 wk. The effects of SWSO as a dietary fat on the FA composition of adipose tissue, brain, and liver lipids were determined by analyses of FA methyl ester derivatives of extracted total lipid. The FA compositions of the liver and adipose tissue were markedly altered by the dietary fats, and mice fed on a SWSO-enriched diet were found to contain XMYA but only in low concentration (0.3-3%) in these tissues; XMYA was not detected in brain. Oleic acid was suggested to be a principal XMYA biotransformation product. The results were interpreted to suggest that the metabolism of XMYA may involve both biohydrogenation and oxidation reactions.

Liu Y.D., Longmore R.B. & Kailis S.G. (1997) "Proximate & fatty acid composition changes in developing sandalwood (*Santalum spicatum*) seeds." *J. Science of Food & Agriculture* **75**(1), 27-30. Abstract. Changes in the proximate composition of developing seeds of sandalwood (*Santalum spicatum* R Br) were quantified. The developing fruits were collected regularly over a period of 5 months commencing 14 days after flower opening. Rapid deposition of seed lipid began at about 91 days after flowering (DAF) at a level of 4 g kg-1 and continued to about 396 g kg-1 at 147 DAF. Protein and ash contents displayed similar trends to that of lipid with a corresponding decrease in moisture content. Fatty acid analysis of the seed oil demonstrated marked changes in composition during seed development. In particular, major increases in oleic and ximenynic acids were noted with corresponding decreases in the other fatty acids.

Lonergan O.W. (1990) "Historical review of sandalwood (*Santalum spicatum*). Research in Australia". *Perth: Research Bulletin* No 4 Dept of Conservation & Land Management Dec 1990 p28.

McKinnell F.H. (1990) "Status of management & silvicultural research on sandalwood in W. Australia & Indonesia" In Hamilton L. & Conrad C.E. ed. *Proceedings of the Symposium on Sandalwood in the Pacific*; April 9-11 1990 Tech. Rep PSW-122, Pacific Research Station, Forest Service, UJS Dept of Agric, Honolulu, 19-25. Abstract. The current status of the conservation and management of *Santalum spicatum* in Western Australia and *S. album* in East Indonesia is outlined. Natural and artificial regeneration techniques for both species in selected areas are discussed. The present Australian Centre for International Agricultural Research program on S. album in Nasa Tenggara Timur is described in relation to the management needs of the species in that province. In *S. spicatum*, research on silviculture is essentially complete, and interest is now focused on the marketability of the kernels for human consumption.

Maslin B.R., Byrne M., Coates D., Broadhurst L. et al. (1999) "The Acacia acuminata (Jam) group: an analysis of variation to aid Sandalwood (*Santalum spicatum*) " Report to the Sandalwood Business Unit, Department of Environment & Conservation, Australia (1999).

Mullholland J. (1994) “An investigation of the harvesting processing and export of Western Australia sandalwood (*Santalum spicatum*).” - Abstract of Masters Thesis University of Australia; summary available at the website of Institute of Foresters of Australia http://www.ifa.unimelb.edu.au/abstracts/master/1994/mulholland1994.htm

Murphy M.T., Garkakalis M.J. & Hardy G.E.S.J. (2005) “Seed catching by woylies *Bettongia penicillata* can increase sandalwood *Santalum spicatum* regeneration in Western Australia” *Austral. Ecology* **30**(7), 747-755.

Murphy M. & Mark Garkaklis M. (2003) "Hopping Into A Bright Future- The Woylie Sandalwood Story." *Sandalwood Research Newsletter* **18**.

Murthy S.G. (1985) “Sandalwood: case study of a resource in decline.” *Garden* 16-19.

Oates A. (1989) *The Story of Sandalwood* The Museum of the Golfields Kalgoorlie

Owen L.N. (1949) "Lanceol, a sesquiterpene alcohol from the oil of *Santalum lanceolatum*. Part II. Some observations on the degradation product." *J. Chem. Soc.*, 1949, 1582 - 1586,

Possingham J. (1986) "Selection for abetter Quandong." *Australian Horticulture* February 1986 pp55-59

Radomiljac A. (2000) see: http://users.bigpond.net.au/sellwood/kimsoc/pasttalk00.htm

Radomiljac A.M. (1998). “The influence of pot host species, seedling age and supplementary nursery nutrition on *Santalum album* (Linn.) plantation establishment within the Ord River Irrigation Area, Western Australia.” *Forest Ecology and Management* **102**(2–3), 193–201.

Raychaudhuri S.P. & Varma A. (1980) “Sandal spike” *Review of Plant Pathology* **59**(3), 99-107.

Razikari H. (1996) “An assessment of the commercial potential of quandong (*Santalum acuminatum*) varieties in Broken Hill. *Thesis, University of Western Sydney, Hawkesbury*.

RIRDC (undated) see: http://www.rirdc.gov.au/champions/MtRomanceAustralia.html

Robson K. (2003). “Sandalwood species x host interaction trial in North Queensland.” *Pacific Islands Forest and Trees*, 3/2003, pp. 14-16.

Robson K. (2004) “Experiences with Sandalwood in plantations in the South Pacific & N. Queensland.” In: *Prospects for high value hardwood in the “dry” tropics of N. Australia*. Proceedings of a workshop held in Mareeba, N. Queensland, Australia 19-21st Oct 2004. pub. Private Forestry North Queensland Association Inc. N. Queensland. Abstract. Sandalwood is an important commercial industry in the south western Pacific. A number of sandalwood species occur across the south western Pacific, *Santalum austrocaledonicum* in New Caledonia and Vanuatu, and *Santalum yasi* in the Fiji Islands and Tonga. Communities do the majority of sandalwood plantings, manage and harvest existing stands. There is a growing interest among villagers, other smallscale growers and Governments to expand the scale of planting in both countries. The most common type of planting is garden plantings of sandalwood by villagers. However, large investors and Governments now starting to invest in plantations across the south western Pacific.

Rugkhla A. & Jones M.G.K. (1998) “Somatic embryogenesis & platelet formation in *Santalum album* & *S. spicatum*.” *J of Exptl. Botany* **49**(320), 563-571.

Rugkhla A., McComb J.A. & Jones M.G.K. (1997) “Intra- & inter-specific pollination of *Santalum spicatum* & *S. album*.” *Australian J of Botany* **45**(6), 1083-1095. Abstract. The flower morphology, receptivity and sexual compatibility between genotypes and species were determined in Western Australian sandalwood (*Santalum spicatum*) and Indian sandalwood (*S. album*). The results showed that the stigma of both species became receptive at anthesis and reached a peak at 3 or 4 days after anthesis. Pollen tubes took 2 days to grow to the ovary when pollinated at anthesis, and 1 day when pollinated 2 or 3 days after anthesis. The egg apparatus matured at least 2 days after pollination and varied between genotypes. Fertilisation occurred 2 or 3 days following cross pollination. Although 10–40% of ovules were fertilised following intra-specific crosses of both species, the average initial fruit set was much lower: 4% in *S. spicatum* and 19% in *S. album*. Most immature fruit (75–80%) abscised following intra-specific pollination. The number of pollen tubes that grew in styles after self-and inter-specific pollination was lower than that for intra-specific pollination. Following self and inter-specific pollination, growth of pollen tubes was arrested in the style, ovary and around the embryo sac; a few penetrated the embryo sac. Initial fruit set was low and developing fruit abscised prematurely. The results indicated that pre- and post-fertilisation mechanisms control self-incompatibility and inter-specific incompatibility between the sandalwood species.

Ryan, P.C. & Brand, J.E. 2002. Techniques to improve sandalwood (*Santalum spicatum*) regeneration at Shark Bay, Western Australia: stem coppice and direct seeding. Sandalwood *Research Newsletter* 15, 4-7.

Samson, Basil (1980): *The camp at Wallaby Cross*. Canberra: *Australian Institute of Aboriginal Studies*; 199-202.

Sawyer (1892) through Applegate Graham B, Davis Allan G.W. & Annable. Peter A. (1990) “Managing Sandalwood for Conservation in N. Queensland, Australia” in *Proc of the Symposium on Sandalwood in the Pacific*: April 9-11, 1990, Honolulu, Hawai/technical co-ordinators: Lawrence Hamilton, C. Eugene Conrad. pub: Symposium on Sandalwood Conservation (1st: 1991: Honolulu, Hawaii).

Sedgley M. (1982). “Preliminary assessment of an orchard of quandong seedling trees.” *J. Aust. Inst. Agr. Sci.* **48**(l):52-56.

Sedgley M (1982) "Floral anatomy andpollen-tube growth in the Quan-dong (*Santalum acuminatum* (R Br) a Dc)." *Australian Journal of Botany* **30**, 601-609

Sen-Sarma P.K. (1982) “Insect vectors of sandal spike disease” *European J of Forest Pathology* **12**(4/5), 297-299.

Shea S.R., Radmomiljac A.M., Brand & Jones P. (1998) “An overview of sandalwood and the development of sandal in Farm Forestry in W. Australia”. *ACIAR Proceedings* **84**, 9-18.

Sidheswaran P. & Ganguli S. (1997) “Sandalwood oil substitutes – a review” *Supplement to Cultivation & Utilisation of Aromatic Plants* 123-139.

Statham P. (1988). “The Australian sandalwood trade, small but significant.” *Working Paper No. 100.* Canberra, Australia. Department of Economic History, The Australian National University. 36 p.

Statham P. (1990) “The sandalwood Industry in Australia: A history” in *Proc of the Symposium on Sandalwood in the Pacific*: April 9-11, 1990, Honolulu, Hawai/technical co-ordinators: Lawrence Hamilton, C. Eugene Conrad. Pub: Symposium on Sandalwood Conservation (1st: 1991: Honolulu, Hawaii). p26. Abstract. From its inception in 1805, when it contributed to Sydney merchant incomes from whaling ventures, until today, when it earns several million dollars in export revenue, the sandalwood industry has played a small but significant part in Australia's economic development. The history of the industry falls into three major stages: first is the off-shore exploitation of the wood from Sydney, from 1805 to the 1840's and beyond; second is the free exploitation of Australian grown sandalwood from 1844 to 1929; and finally the period of government controlled exploitation from 1929 to the present.

Struthers R., Lamont B.B., Fox J.E.D., Wijesuriya S. & Crossland T. “Mineral nutrition of sandalwood (*Santalum spicatum*).” *J. of Exptl. Botany* **37**(182), 1274-1284.

Surate I.K. (1994) “The effect of hostplants on the growth of sandalwood seedlings (*Santalum album* Linn).” In: *Sandalwood Research Newsletter* Issue **3**. Department of Conservationand Land Management, Kununurra, Western Australia.

Talbot L. (1983) "Wooden gold. Early days of the sandalwood industry." *Forest Focus* **30**, 21-31. pub W. Austr. Forest Dept, Perth.

Taylor D., Swift S. & Collins S. (2000) “Testing growth & survival of four sandalwood species in Queensland” *Sandalwood Research Letter* **10**, 6-8. Abstract. Sandalwood production in Queensland has been based on harvesting from naturally occurring *Santalum lanceolatum*, principally from relatively remote areas in northern Queensland between Hughenden and Normanton. *Santalum lanceolatum* has a relatively low oil yield in comparison to other sandalwood species and a consequent lower market value. With declining amounts of natural sandalwood available for harvest and an increasing market the potential exists for sandalwood production from plantations. To date, little work has been done in Queensland on production of Sandalwood in plantations. This report details anexperiment established in late 1999 to investigate the growth and survival of four sandalwood species, viz; *Santalum album*, S. *austrocaledonicum*, *S. yasi* and *S. macgregorii* on two sites in Queensland

Tennakoon K.U. & Pate J.S. (1997) “Biological and physiological aspects of the *Santalum acuminatum* (quandong) and its hosts in Western Australia.” *Sandalwood Research Newsletter* **6**: 1-2

Tennakoon K.U., Pate J.S. & Arthur D. (1997) “Ecophysiological aspects of the woody root hemiparasite *Santalum acuminatum* and its common hosts in south Western Australia.” *Annals of Botany*. **80**: 254-256

Tennakoon K.U., Pate J.S. & Stewart, G.R. (1997) “Haustorium-related uptake and metabolism of host xylem solutes by the root hemiparasitic shrub *Santalum acuminatum*. *Annals of Botany*. **80**: 257-264

Tonts M. (2001) *Sandalwood Market Study* (Draft Report) Perth: Dept of Agriculture.

Tonts M. & Selwood J. (2002) “Niche Markets, Regional Diversification and the Reinvention of Western Australia’s Sandalwood Industry” *Tijdschrift voor Economische en Sociale Geografie* **94**(5), 564-575. Abstract. Diversification and niche marketing have become very important economic strategies for many rural small businesses, farmers and communities. As part of these strategies, new opportunities often emerge for traditional products and industries. In the case of Western Australia, this has contributed to the revitalisation of the sandalwood industry. While sandalwood has been exported from Western Australia for more than 150 years, for much of the second half of the twentieth century it was of little economic significance. In recent years, however, the industry has become increasingly entrepreneurial, successfully marketing its products into niche markets in the global economy. For farmers and communities in rural areas, the revitalisation of the sandalwood industry has also provided opportunities for economic diversification and a profitable way of tackling land degradation.

Trueman S., Warburton C., James E., Fripp Y. &. Wallace H. (2001) “Clonality in remnant populations of *Santalum lanceolatum*.” *Sandalwood Research Newsletter* **14**, 1–4.

Vernes T. & Robson K. (2002). “Indian sandalwood industry in Australia.” *Sandalwood Research Newsletter* **16**, 1-4.

Warburton C.L. James E.A., Fripp Y.J., Trueman S.J. & Wallace H.M. (2000) "Clonality and sexual reproductive failure in remnant populations of *Santalum lanceolatum* (Santalaceae)." *Biological Conservation* **96**(1), 45-54 Abstract. Habitat fragmentation can have important conservation consequences for clonal plant species that possess self-incompatibility mechanisms, as lack of genetic variability within remnant populations may result in sexual reproductive failure. Allozymes and RAPDs were used in this study to determine the extent of clonality in remnant Victorian populations of the northern sandalwood, *Santalum lanceolatum* (Santalaceae), a species that has been heavily wild-harvested. S. lanceolatum can reproduce asexually by root suckers, and each population was identified as a unique single clone composed of numerous ramets of a single genet. Examination of pollination and fruit set indicated that little or no sexual reproduction was occurring in the remnants, due to pollen sterility in one population and self-incompatibility or pistil dysfunction in others. Clonality, genetic isolation and sexual reproductive failure indicate that preservation of each population, and possibly the establishment of new ones, should be objectives of the conservation strategy for the *S. lanceolatum* remnants.

Warburton C.L. (2001) "Clonality in remnant populations of *Santalum lanceolatum*" *Sandalwood Research Newsletter:* **14**, 1-4. Abstract. *Santalum lanceolatum*, the northern sandalwood or plumbush, was very heavily harvested in Victoria and New South Wales in the late 1800s. Clearing, fire and grazing have also contributed to the species' decline. Only seven populations remain in Victoria, where we studied the five southernmost populations of the species. Since exclusion of grazing animals, the remnant populations have been reproducing asexually by root suckers. However, we observed little or no fruit production in the populations, and allozyme and RAPD analyses suggested that sexual reproduction had not been contributing to recruitment. Each population appeared to exist as a unique single clone composed of numerous ramets of a single genet. Therefore, conservation of the species in Victoria may require protection of all remnant populations, and possibly the establishment of new populations.

Wharton, G. (1985). "Antiquarians and sandalwood-getters: the establishment of the Cape York Collection at Weipa." In: *Proceedings of the North Australian Mine Rehabilitation Workshop, No 9* Weipa, 1985.

Wijesuriya S.R. & Fox J.E.D. (1985) "Growth and nutrient concentration of sandalwood seedlings grown in different potting mixtures." *Mulga Research Centre Journal* **8**, 33-40.

Woodall G.S. & Robinson C.J. (2002) "Same day plantation establishment of the root hemiparasite sandalwood (*Santalum spicatum* (R Br) A DC: Santalaceae) and hosts." *J Royal Soc of Western Australia* **85**, 37-42. Abstract. Interest and investment in a plantation sandalwood (*Santalum spicatum* (R Br) A DC) industry in southern Western Australia has been steadily growing over the last few years. Current plantation establishment involves planting host seedlings in year one and then direct sowing of untreated seeds of the parasitic sandalwood in year two or three. An innovative establishment technique in which host seedlings of *Acacia acuminata* Benth and partially germinated sandalwood seeds are planted on the same day was compared to the current establishment methods. The study showed that sandalwood and host establishment in one season is achievable and that it was three times more successful than the most widely used and promoted technique at present. Results also indicated that water availability influenced the germination, summer survival and growth of sandalwood. The use of small seedling hosts on well-watered, cleared land results in a higher rate of sandalwood establishment and growth.

Woodall G.S. & Robinson C.J. (2002) "Direct seeding Acacias of different form & function as hosts for Sandalwood (*Santalum spicatum*)." *Conservation Science Western Australia* **4**(3), 130-134.

Woodall G.S. & Robinson C.J. (2003) "Natural diversity of *Santalum spicatum* host species in south-coast river systems and their incorporation into profitable and biodiverse revegetation" *Australian Journal of Botany* **51**(6), 741 –753.

Woodall G.S. (2004) "Cracking the woody endocarp of *Santalum spicatum* nuts by wetting and rapid drying improves germination" *Australian J. of Botany* **52**(2), 163-169.

Chinese Sandalwood (*Santalum album*).

Chen F. (1999) "Cuttage of *Santalum album*." *Zhong Yao Cai* **22**(3), 109-111. Abstract: The effects of cuttage times, miaternal plant ages, hormones and mediums on the taking root of a cutting were studied in 1991-1996. The results showed that the sprouts of germinating and growing 20-30 days from the cut back of maternal plant as cuttings, the rate of the taking root get to about 70%; the suitable cuttage time was in June to August; the proper medium was river sands, but the effects of hormones were not obvious.

Gao Z., Wu Y., Dong Z. & Wu W. (2004) "Habit & control of pests in *Santalum album*." *Zhong Yao Cai* **27**(8), 549-51. Abstract: The habit of 5 species pests from South China Botanical Garden was reported in this paper, they are *Delias aglaia* Linni, *Zenzera coffeae* Nietner, *Parlatoria pergandii* Comstock, Scarab (grub), *Agrotis ypsilon* Rottemberg. Their control methods were presented.

Ma G.H.., Bunn E., Zhang J.-F., Wu G.-J. (2006) "[Evidence of Dichogamy in *Santalum album* L.]" *J Integrative Plant Biology* **48**(3),300-306. Abstract. Flowering, fruit set, embryological development, and pollination trials were investigated in *Santalum album* L. Each ovary may have three to four ovules. Microsporogenesis and megasporogenesis in the same flower were synchronized at the earlier stages of flower development. However, at anthesis, when pollen was mature, the magaspore had developed only to the stage of a one- to two-nucleus embryo sac. As the eight-nucleus embryo sac developed, some mamelon cells began to undergo programmed cell death, forming holes into which the eight-nucleus embryo sacs extended, becoming "N" or "S" shaped. The development from a two-nucleus embryo sac to a matured eight-nucleus embryo sac lasted up to 10 d. Fruit-set from open pollination was less than 2%. The endosperm develops prior to division of the zygotic embryo and one to three embryos and endosperms were formed in the same fruit. A mature seed usually germinates to produce one seedling; however, two and three seedlings from one seed were also observed, albeit at a low frequency. Pollination trials showed that no seed sets when inflorescences were covered with a bag; however, artificial pollination could improve fruit set. Our pollination trials and embryological studies proved that the flower of *S. album* is dichogamous and fruit set has high heterozygosity.

Ma G.-H., YueMin H., JingFeng Z., FuLian C (2005) "Study on semi-parasitism of sandalwood seedlings." *Journal of Tropical and Subtropical Botany* **13**(3),233-238. Abstract. Semi-parasitism of sandalwood (*Santalum album*) seedlings was studied on the basis of the propagation of the different host plant species. Sandalwood plants can grow normally without host plant during its seed germination and early seedling stage. However, the subsequent growth needs roots of the host plant. Results indicated that the host plant species had a significant impact on the growth of sandalwood seedlings and their root haustoria as exhibited by the differences in haustorium's number, size and adhesiveness. Host plant species such as *Hibiscus rosa-sinensis* and *Phyllanthus reticulatus* were found as good host plants for the growth of sandalwood seedlings. Sandalwood roots lack root hairs, but its vessels were well developed, which are suitable for absorption of water and nutrients from the host's roots. The semi-parasitism of sandalwood on Hibiscus roots was also investigated.

Ma G-H. & Bunn E. (2007) "Embryology and pollination trials support dichogamy in *Santalum album* L." *Sandalwood Research Newsletter* **23** (Oct 2007) Abstract. Embryo development and pollination trials were studied in *Santalum album* L. The formation of the male (microspore) and female (megaspore) tissues in the same flower were synchronized during the early stages of flower-bud development. How-ever, at anthesis when pollen was mature, the megaspore had developed only to the stage of a 1-2 nucleate embryo sac. The development from 2-nucleate embryo sac to matured 8-nucleate embryo sac lasted up to 10 days. These results indicate thatthe flower of *S. album* is dichogamous where the pollen matures before the embryo sac. Following fertilisation of the ovule the endosperm developed prior to division of the zygotic embryo, and 1-3 embryos and endosperms were formed in the samefruit. Seed-set resulting from open pollination was less than 3%. No seed set was observed when inflorescences were coveredwith a bag; however artificial pollination increased fruit set to14%. Mature seed usually

germinated to produce one seed-ling, but two- and three-seedlings from one seed were also observed at low frequency

Li Y. (1997) "Preliminary studies on grafting of *Santalum album*." *Zhong Yao Cai* **20**(11), 543-545. Abstract: With the purpose of propagating high production Clone of *Santalum album*, the best season and practical method of grafting, and the selection of shoots for scion are studied. The preliminary results show: The best season for grafting in Guangzhou District occurs from June to October, when the daily mean temperature is over 25 degrees C, the side graft is recommedable; the scion from 1-5-year old young trees is much in favor for grafting than that from adult trees. In the right condition, side grafting of *Santalum album* has had up to 80 percent success rate.

Lin L, Wei M, Xiao S, Xu X, Hu Z, Qiu J, Cai Y, Lu A, &Yuan L. (2000) "[The influence of external stimulation on content and quality of volatile oil in Lignun Santali albi]" *Zhong Yao Cai*. **23**(3), 152-4. Abstract. The authors analyzed the quality of Ligmum Santali Albi formed by the external stimulation of hormone and windburn by GC-MS-DS. The results showed that the content of volatile oil is 2.34% in the heart wood formed in 10 years tree age of *Santalum album* (SA) after 2 years stimulation continuously with a definite concentration of hormone, which is near to the 25 years tree age of SA in the same place. The GC-MS analysis showed that the content of santalol and other chemical components in volatile oil are similar to the 25 years tree age of SA. It is indicated that a definite concentration of hormone stimulated the SA may shorten the formation of the heart wood. The heart wood can be also formed by the broken branches after 2 years windburn, but its content of volatile oil is only 1/2 of the heart wood formed by hormone stimulation.

Yu J.G., Cong P.Z., Lin J.T., Fang H.J. (1988) "Studies on the chemical constituents of Chinese sandalwood oil & preliminary structures of five novel compounds". *Yao Xue Xue Bao* **23**(11), 868-872.

Yu, J. G., Cong P.Z., *et al*. (1993). “Studies on the structure of alpha-trans-bergamotenol from Chinese sandalwood oil.” *Acta Pharmaceutica Sinica* **28**(11), 840-844.

Wei M, Lin L, Qiu JY, Chai YW, Lu AN, Yuan L, Liao HF, Xiao SE. (2000) "[Wind-damage effects on quality of heartwood of Lignum Santali Albi]" *Zhongguo Zhong Yao Za Zhi* **25**(12), 710-3. Abstract. OBJECTIVE: To evaluate the wind-damage effects on quality of heartwood of Lignum Santali Albi. METHOD: GC-MS, TLC and pharmacodynamic test. RESULTS: The content of volatile oil from heartwood of Wind-damaged Lignum Santali Albi is 1.42%; the content of various components in the oil and the chromatography of different extracts are similar to those of reference drug and 25 years old trees. CONCLUSION: Wind-damage should accelerate the formation of heartwood of Lignum Santali Albi without influence on its quality.

East African Sandalwood.

Cropwatch comments: ‘*East African sandalwood’ includes* Osyris *spp. such as* O. lanceolata *&* O. tenuifolia).

Koross K. (2008) "Kenya: Sandalwood Ban Proves Hard to Enforce." *The Nation (Niaobi)* 27th June 2008. ***Cropwatch comments***: Story about 7 tons of sandalwood being impounded on Wednesday at Salawa Division in the Baringo Disatrict. Villagers from Baringo & East Pokot districts sell sandalwood to dealers in spite of the trade ban in 2007. The wood finds a ready market in China. The article goes on to speculate about corrupt officials & security officers being involved in the illegal trade as well as prominent individuals and politicians.

Kreipl A. Th. & König W.A. (2004) “Sesquiterpenes from the East African sandalwood *Osyris tenuifolia*” *Phytochem* **65**(14), 2045-2049. Abstract: The essential oil of the east African sandalwood Osyris tenuifolia was investigated by chromatographic and spectroscopic methods. Beside several already known sesquiterpenes four new compounds could be isolated by preparative gas chromatography and their structures investigated by mass spectroscopy and NMR techniques. Two of the new compounds – tenuifolene (17) and ar-tenuifolene (15) – show a new sesquiterpene backbone. 2,(7Z,10Z)-Bisabolatrien-13-ol (23) and the cyclic ether lanceoloxide (21) belong to the bisabolanes. Graphical Abstract: The essential oil of East African sandalwood *Osyris tenuifolia* was investigated by NMR, Mass spectrometry and chemical correlations. Four new sesquiterpenes including 15 and 17 with a new skeleton were identified.

Mwang'ingo, P.L & Mwihomeke S.T. (1997) "Some highlight on a research program into cultivation of *Osyris lanceolata* (African sandalwood)." In: Mbwambo, L.R., Mwang'ingo, P.L., Masayanyika S.W and Isango, J.A (eds.). *Proceedings of the Second Workshop on Setting Forestry Research Needs and Priorities.* 18-22 August 1997 Moshi Tanzania. TAFORI, Morogoro, Tanzania. pp 82-84.

Mwang'ingo P.L.., Teklehaimanot Z., Hall J.B. & Lulanda L.L. (2003) "African Sandalwood (*Osyris lanceolata*): resource assessment & quality variation among poulations in Tanzania: research note." *Southern Hemisphere Forestry Journal* **199**, 77-88. Abstract. African sandalwood (*Osyris lanceolata*) populations occurring in Tanzania were assessed to determine the current resource status and ascertain variation in quality existing among them. This will provide a guide in the selection of populations where conservation efforts and improvement programmes can be concentrated. The resource status was assessed through estimation of the species' density per unit area and measurements of tree dimensions. Quality variation was assessed by determining the amount of oil extracted from a given amount of wood and the proportion composition of santalol, a prime determinant of sandalwood oil quality. The study revealed that populations supporting *O. lanceolata* in Tanzania occur mostly in arid to semiarid areas with the majority being on stony and rocky soils. However, big sized trees are supported in humid climates, being favoured by relatively low soil pH and reasonable amounts of soil nitrogen. Tree density ranged from 38 individuals to 76 per hectare. The mean tree height was 3, 8 m (2, 1 to 6, 5 m) while the mean diameter was 5, 7 cm (3, 6 cm to 8, 6 cm). The best quality and quantity of oil came from populations of relatively arid climates compared to those of humid climates. Populations differed significantly in both yield and quality. The highest yield obtained was 8, 45 ± 0, 54% from Gubali population while the highest santalol content (32, 2 ± 1, 2%) was from Bereko populations. Within trees, quantity and quality of oil was higher in wood portions close to the ground in both the root and shoot system. The amount decreased toward the root and shoot tip. The root and the shoot system were similar in quality and quantity of oil. The observed harvesting selectivity is thus primarily influenced by quality differences among populations while the large dimension and density differences among populations seem to be secondary. Inclusion of the root systems during harvesting is also a matter of maximizing the raw material to be collected rather than differences between the two portions. The exact factors controlling wood quality in the species have however remained uncertain. Probably, genetic factors alone or in combination with the environmental factors play a significant role.

Mwang'ingo P.L., Teklehaimanot Z., Hall J.B, Zilihona J.E. (2007) "Sex distribution, reproductive biology and regeneration In the dioecious species *Osyris lanceolata* (African Sandalwood) In Tanzania." *Tanzania Journal of Forestry and Nature Conservation* 76, 118-133. Abstract. Sex distribution, reproductive biology and regeneration of African Sandalwood (*Osyris lanceolata*) were assessed in six natural populations of Tanzania between January 1999 and February 2001. The aim was to acquire basic information required for efficient management, conservation and sustainable utilization of the species. The study had four objectives: to assess the spatial distribution of male and female trees in O. lanceolata supporting stands and whether this has any significance in influencing the reproductive success; to document the phenological events occurring between flower initiation and fruit ripening; to examine the reproductive success of various stages through pollination experiment; and to assess the regeneration mode and potential of the species. The study revealed that, the distribution of male and female trees in most populations was random with no evidence of sex clustering. It takes 104 days from flowering until when 25% of fruit initiated become ripe. About 75% of the initiated fruits become ripe in 163 days. This study has also demonstrated absence of agamospermy behaviour in *O. lanceolata*. A limited reproductive success was noted however, due to either low level of pollen production or limited

pollinators' movement. Assisted pollination significantly increased the reproductive success of the species. The tree regenerates through seeds, rootstocks and coppice. Of the total regenerating plants assessed at sapling stage, 61% had originated from rootstock or coppice while 39% came from seed source. It is concluded that, recruitment of the species relies mainly on rootstock or coppice source although the importance of seeds cannot be ignored. Thus uprooting of the species as a mode of harvesting has to be discouraged since the practice is likely to severely limit the recruitment rate.

Mwang'ingo P.L, Teklehaimanot Z., Maliondo S.M. & Msanga H.P. (2004). "Storage and pre-sowing treatment of recalcitrant seeds of Africa Sandalwood (*Osyris lanceolata*)." *Seed Science and Technology*, **32**, 547-560. Abstract. The best seed conditions and environment in which seeds of *Osyris lanceolata* could be stored to prolong their life span were investigated at Iringa Tree Seed Centre, Tanzania, by varying the storage moisture content of seeds and storage temperatures. The study also investigated the effectiveness of various seed pre-sowing treatments in enhancing germination and early seedling growth. Seeds stored at 3-5°C, after being dried to moisture content of 20% retained viability longer than those stored at other conditions. By the end of the 36th week, the viability was 60% with 0.5% being as an estimated rate of viability loss per week. Temperatures below 3°C and over 13°C decreased rapidly the life span of seeds. Moisture content below 15% and over 25% were also noted to be lethal. Thus seeds of *O. lanceolata* could be stored at least for short-term supply, although their life span generally remains short, suggesting the need for further research to find out other better storage conditions. The seed coat covering the embryo plays a significant role in limiting germination by restricting gas and water entry. It also acts as a mechanical barrier to embryo growth. Complete removal of the seed coat and soaking in hot water enhanced seed germination (66.5% and 57.5%, respectively), shortened the time of seed to commence germination and promoted early seedling growth and are thus recommended for adoption. Nevertheless, the highest germination (66.5%) attained in this study is still unsatisfactory, suggesting the existence of other types of dormancies. This calls for further investigation to identify the dormancies and the means of resolving them. The possible existence of chemical dormancies, which was not dealt with in the present study, be given a priority in future research.

Mwang'ingo P. L. Teklehaimanot Z., Lulandala L. L. & Maliondo S. M. (2006) "Propagating *Osyris lanceolata* (African sandalwood) through air layering: Its potential and limitation in Tanzania." *Southern African Forestry Journal* **207**, 7-14. Synopsis. Propagation of African sandalwood (*Osyris lanceolata*) by air layering (marcotting) was investigated at Sao Hill, Tanzania, aiming at providing an alternative propagation technique to the use of seeds or cuttings that germinate or root poorly. Air layers were initiated on the young shoots (1 – 2 years old) of mature *O. lanceolata* trees growing at Sao Hill catchment Forest. After root initiation, which took 8 weeks, they were detached from the parents, potted in polyethylene tubes and reared at the nursery for a further three months. The factors assessed in this experiment were the effect of time at which air layers were initiated (i.e. February, June, September and December); and the influence of IBA as rooting promoter at three concentrations (50, 100 and 150 ppm). From the data collected it was observed that rooting success of up to 80% can be achieved from air layers, making this propagation technique a viable alternative to seedlings or cutting propagation. Rooting success was influenced by both the season and application of rooting hormone with optimal rooting being achieved during June and September with the addition of IBA at a rate of 50 ppm. The significance increase in rootability of air layers during June and September may be linked to the advantage of the dry season in Tanzania where reduction of plant development activities such as budding, leafing and flowering in the dormant dry season might have reduced resource competition and thus promoting the observed rooting.

Srikrishnaa A. & Beeraiah B. (2005) "First synthesis of (′)-tenuifolene and ar-tenuifolene." *Indian J of Chemistry* Sect B. **44**(8), 1641-1643. Abstract. First total synthesis of the sesquiterpenes (′)-tenuifolene and (′)-ar-tenuifolene, isolated from the essential oil of the East African sandalwood tree *Osyris tenuifolia*, has been accomplished.

Teklehaimanot Z., Mwang ingo P. L., Mugasha A. G. & Ruffo, C. K. (2004) "Influence of the origin of stem cutting, season of collection and auxin application on the vegetative propagation of African Sandalwood (*Osyris lanceolata*) in Tanzania." *Southern African Forestry Journal* **201**, 13-24.

Wells R. (2006) "On the scent: Rhona Wells investigates sandalwood poaching, the ugly downside of the luxurious natural perfumery raw material trade" *Soap, Perfumery & Cosmetics* Feb 2006 **79**(2), 31. ***Cropwatch comments***: Informative one-page article on the Tanzanian situation where sandalwood logs are smuggled to India for distillation to produce sandalwood oil.

East Indian Sandalwood (*Santalum album*).

Biocidal properties – E.I. Sandalwood oil.

Amer A. & Mehlhorn H. (2006) "Larvicidal effects of various essential oils against *Aedes*, *Anopheles*, and *Culex* larvae (Diptera, Culicidae)." *Parasitol Res*. **99**(4), 466-72. Abstract. Mosquitoes in the larval stage are attractive targets for pesticides because mosquitoes breed in water, and thus, it is easy to deal with them in this habitat. The use of conventional pesticides in the water sources, however, introduces many risks to people and/or the environment. Natural pesticides, especially those derived from plants, are more promising in this aspect. Aromatic plants and their essential oils are very important sources of many compounds that are used in different respects. In this study, the oils of 41 plants were evaluated for their effects against third-instar larvae of *Aedes aegypti*, *Anopheles stephensi* and *Culex quinquefasciatus*. At first, the oils were surveyed against *A. aegypti* using a 50-ppm solution. Thirteen oils from 41 plants (camphor, thyme, amyris, lemon, cedarwood, frankincense, dill, myrtle, juniper, black pepper, verbena, helichrysum and sandalwood) induced 100% mortality after 24 h, or even after shorter periods. The best oils were tested against third-instar larvae of the three mosquito species in concentrations of 1, 10, 50, 100 and 500 ppm. The lethal concentration 50 values of these oils ranged between 1 and 101.3 ppm against *A. aegypti*, between 9.7 and 101.4 ppm for *A. stephensi* and between 1 and 50.2 ppm for *C. quinquefasciatus*.

Courreges B.F. (1999). "Antiviral activity of sandalwood oil against *Herpes simplex* viruses- 1 and 2." *Phytomedicine* **6**, 119-123.

Jirovetz L., Buchbauer G., Dednkova Z., Stoyanova A., Murgov I., Gearon V., Birkbeck S., Schmidt E., Gelssler M. (2006) "Comparative study on the antimicrobial activities of different sandalwood essential oils of various origin." *Flavour and Fragrance Journal* **21**(3), 465 - 468. Abstract. In total, eight samples of different sandalwoods [*Amyris balsamifera* L., *Santalum album* L. and *Santalum spicatum* (R.Br.) A.DC.] and a mixture of - and -santalols, as well as eugenol as reference compound, were tested by an agar dilution and agar diffusion method for their antimicrobial activities against the yeast *Candida albicans*, the Gram-positive bacterium *Staphylococcus aureus* and the Gram-negative bacteria *Escherichia coli*, *Pseudomonas aeruginosa* and *Klebsiella pneumoniae*. The main compounds of each essential oil were investigated by gas chromatographic-spectroscopic (GC-FID and GC-MS) and -olfactory methods to obtain information about the inßuence of these volatiles on the observed antimicrobial effects. For the santalol mixture, as well as for one *S. album* and one *S. spicatum* sample with moderate concentrations of santalols, antimicrobial activity was found against all the strains used. The *A. balsamifera* sample, containing only a small quantity of -santalol and nearly no -santalol, showed high effects only against *Klebsiella pneumoniae*, while against the other strains weak or no activity was observed. Therefore, santalols in medium and/or high concentrations in sandalwood oils show a significant influence on antimicrobial potential in such natural products.

Schnitzler P, Koch C, Reichling J. (2007) "Susceptibility of drug-resistant clinical herpes simplex virus type 1 strains to essential oils of ginger, thyme, hyssop, and sandalwood." *Antimicrob Agents Chemother*. **51**(5):1859-62. Abstract. Acyclovir-resistant clinical isolates of herpes simplex virus type 1 (HSV-1) were analyzed in vitro for their susceptibilities to essential oils of ginger, thyme, hyssop, and sandalwood. All essential oils exhibited high levels of virucidal activity against acyclovir-sensitive strain KOS and acyclovir-resistant HSV-1 clinical isolates and reduced plaque formation significantly.

Zhu J., Zeng X., O'Neal M., Schultz G., Tucker B., Coats J., Bartholomay L. & Xue RD. (2008) "Mosquito larvicidal activity of botanical-based mosquito repellents." *J Am Mosq Control Assoc*. **24**(1),161-8. Abstract. The larvicidal activity of 4 plant essential oils--innamon oil, lemon eucalyptus oil, sandalwood oil, and turmeric oil--previously reported as insect repellents was evaluated in the laboratory against 4th instars of *Aedes albopictus*, *Ae. aegypti*, and *Culex pipiens*. Sandalwood oil appeared to be the most effective of the larvicides, killing larvae of all 3 mosquito species in relatively short times. The values of LT50 and LT90 at the application dosage (0.2 mg/ml) were 1.06 +/- 0.11 and 3.24 +/- 0.14 h for *Ae. aegypti,* 1.82 +/- 0.06 and 3.33 +/- 0.48 h for *Ae. albopictus*, and 1.55 +/- 0.07 and 3.91 +/- 0.44 h for *Cx. pipiens*, respectively. Chemical compositions of these essential oils were also studied, and the lavicidal activity of their major ingredient compounds was compared with that of each of the essential oils. The acute toxicity of the 4 essential oils to fathead minnows was also evaluated. The safe use of these natural plant essential oils in future applications of mosquito control was discussed.

Contact Dermatitis – E.I. Sandalwood oil.

An S., Lee A.Y., Lee C.S., Kim D.W., Hahm J.H., Kim K.J., Moon K.C., Won Y.H., Ro Y.S., Eun H.C. (2005) "Fragrance contact dermatitis in Korea: a joint study." *Contact Dermatitis* **53**(6) , 320-323. Abstract: The purpose of this study is to determine the frequency of responses to selected fragrances in patients with suspected fragrance allergy and to evaluate the risk factors. 9 dermatology departments of university hospitals have participated in this study for the past 1 year. To determine allergic response to fragrances, 18 additional fragrances in addition to the Korean standard and a commercial fragrance series were patch-tested in patients with suspecting cosmetic contact dermatitis. Over 80% of the patients were women, and the most common site was the face. Cinnamic alcohol and sandalwood oil (*Santalum album* L.) showed high frequencies of positive responses. Of the specific fragrances, ebanol, alpha-isomethyl-ionone (methyl ionone-gamma) and Lyral (hydroxyisohexyl 3-cyclohexane carboxdaldehyde) showed high positive responses. We compared the results obtained during this study with those of other studies and concluded that including additional fragrance allergens may be useful for the detection of fragrance allergy.

Sharma R., Bajaj A.K. & Singh K.G. (1987) “Sandalwood dermatitis” *Int. J. Dermatol* **26**(9), 597. ***Cropwatch comments***: A short report of a man who had been appying *Santalum album* paste to his forehead daily for eight years. He presented with a well defined, hyperpigmented, erythematous plaque, with a mild surrounding zone of erythma. Patch tests proved positive to sandalwood, and the lesion disappeared after the application of a corticosteroid cream.

Tewary M, Ahmed I. (2006) "Bindi dermatitis to 'chandan' bindi." *Contact Dermatitis*. **55**(6), 372-4. Abstract. Bindi (meaning dot in Sanskrit) is a mark worn by most Indian women on their forehead for religious and social purposes. Traditionally it was worn by only Hindu women to signify their marital status. Nowadays, it is a huge fashion accessory, being worn in different sizes, shapes, designs and colours. The variety includes sequined designs, motifs dusted with gold and silver powder, studded with beads, or even surrounded by glittering gems. Stick-on and liquid ranges are both equally in demand. We report a case of bindi dermatitis with 'chandan' (sandalwood) bindi. To our knowledge this is the first report of contact allergic dermatitis to 'chandan' (sandalwood) bindi.

Cancer Chemoprevention – E.I. Sandalwood oil..

Arasada B.L., Bommareddy A., Zhang X., Bremmon K. & Dwivedi C. (2008) "Effects of alpha-santalol on proapoptotic caspases and p53 expression in UVB irradiated mouse skin." *Anticancer Res.* **28**(1A), 129-32. Abstract. BACKGROUND: Cancer chemoprevention by naturally occurring agents, especially phytochemicals, minerals and vitamins has shown promising results against various malignancies in a number of studies both under in vitro and in vivo conditions. One such phytochemical, alpha-santalol, a major component of sandalwood oil, is effective in preventing skin cancer in both chemically and UVB-induced skin cancer development in CD-1, SENCAR and SKH-1 mice; however, the mechanism of its efficacy is not fully understood. The objective of the present investigation was to study the effects of alpha-santalol on apoptosis proteins and p53 in UVB-induced skin tumor development in SKH-1 mice to elucidate the mechanism of action. MATERIALS AND METHODS: Female SKH-1 mice were divided into two groups: Group 1, which served as control received topical application of acetone (0.1 ml) one hour before UVB treatment; Group 2 received alpha-santalol (0.1 ml, 5% w/v in acetone, topical) one hour prior to UVB treatment. UVB-induced promotion was continued for 30 weeks. RESULTS: Pre-treatment with alpha-santalol one hour prior to UVB exposure significantly ($p < 0.05$) reduced tumor incidence and multiplicity, and resulted in a significant ($p < 0.05$) increase in apoptosis proteins, caspase-3 and -8 levels and tumor suppressor protein, p53. CONCLUSION: These results suggest that alpha-santalol prevents skin cancer development by inducing proapoptotic proteins via an extrinsic pathway and increasing p53.

Banerjee S., Ecavade A. & Rao A.R. (1993) “Modulatory influence of sandalwood oil on mouse hepatic glutathione S-transferase activity and acid soluble sulpydryl level” *Cancer Lett* **68**(2), 105-9. Abstract: The effect of the oil from the wood of *Santalum album* on glutathione S-transferase (GST) activity and acid soluble sulphydryl (SH) levels in the liver of adult male Swiss albino mice was investigated. Oral feeding by gavage to mice each day with 5 and 15 microliters sandalwood oil for 10 and 20 days exhibited an increase in GST activity in time- and dose-responsive manners. Feeding a dose of 5 microliters sandalwood oil for 10 and 20 days caused, respectively, a 1.80-fold ($P < 0.001$) and 1.93-fold ($P < 0.001$) increase in GST enzyme activity, while feeding a dose of 15 microliters of the oil per day for 10 and 20 days induced, respectively, 4.73-fold ($P < 0.001$) and 6.10-fold ($P < 0.001$) increases in the enzyme's activity. In addition, there were 1.59-fold ($P < 0.001$) and 1.57 ($P < 0.001$) increases in acid-soluble SH levels in the hepatic tissue of the mice following feeding of the oil at the dose levels of 5 and 15 microliters for 10 days. Furthermore, mice fed on a diet containing 1% 2(3)-butyl-4-hydroxyanisole (positive control) also showed an increase in hepatic GST activity and SH levels. Enhancement of GST activity and acid-soluble SH levels are suggestive of a possible chemopreventive action of sandalwood oil on carcinogenesis through a blocking mechanism.

Dwivedi C. & Abu-Ghazaleh A. (1997) "Chemopreventive effects of sandalwood oil on skin papillomas in mice." *Eur J Cancer Prev.* **6**(4), 399-401. Abstract. The essential oil, emulsion or paste of sandalwood (*Santalum album* L) has been used in India as an ayurvedic medicinal agent for the treatment of inflammatory and eruptive skin diseases. In this investigation, the chemopreventive effects of sandalwood oil (5% in acetone, w/v) on 7,12-dimethylbenz(a)anthracene-(DMBA)-initiated and 12-O-tetradecanoyl phorbol-13-acetate(TPA)-promoted skin papillomas, and TPA-induced ornithine decarboxylase (ODC) activity in CD1 mice were studied. Sandalwood oil treatment significantly decreased papilloma incidence by 67%, multiplicity by 96%, and TPA-induced ODC activity by 70%. This oil could be an effective chemopreventive agent against skin cancer.

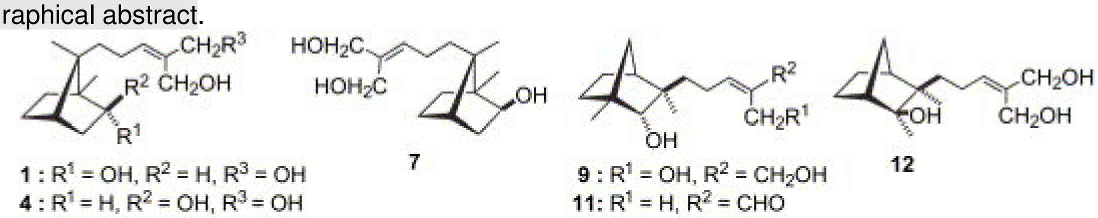
Dwivedi C., Guan X., Harmsen W.L., Voss A.L., Goetz-Parten D.E., Koopman E.M., Johnson K.M., Valluri H.B. & Matthees D.P. (2003) " Chemopreventive effects of alpha-santalol on skin tumor development in CD-1 and SENCAR mice." *Cancer Epidemiol Biomarkers Prev.* **12**(2), 151-6. Abstract. Studies from our laboratory have indicated skin cancer chemopreventive effectsof sandalwood oil in CD-1 mice. The purpose of this investigation was to study the skin cancer chemopreventive effects of alpha-santalol, a principal component of sandalwood oil in CD-1 and SENCAR mice. alpha-Santalol was isolated from sandalwood oil by distillation under vacuum and characterized by nuclear magnetic resonance and gas chromatography-mass spectrometry. Chemopreventive effects of alpha-santalol were determined during initiation and promotion phase in female CD-1 and SENCAR mice. Carcinogenesis was initiated with 7,12-dimethylbenz(a)anthracene and promoted with 12-O-tetradecanoylphorbol-13-acetate (TPA). The effects of alpha-santalol treatment on TPA-induced epidermal ornithine decarboxylase (ODC) activity and (3)H-thymidine incorporation in epidermal DNA of CD-1 and SENCAR mice were also investigated. alpha-Santalol treatment during promotion phase delayed the papilloma development by 2 weeks in both CD-1 and SENCAR strains of mice. alpha-Santalol treatment during promotion phase significantly (P < 0.05) decreased the papilloma incidence and multiplicity when compared with control and treatment during initiation phase during 20 weeks of promotion in both CD-1 and SENCAR strains of mice. alpha-Santalol treatment resulted in a significant (P < 0.05) inhibition in TPA-induced ODC activity and incorporation of (3)H-thymidine in DNA in the epidermis of both strains of mice. alpha-Santalol significantly prevents papilloma development during promotion phase of 7,12-dimethylbenz(a)anthracene-TPA carcinogenesis protocol in both CD-1 and SENCAR mice, possibly by inhibiting TPA-induced ODC activity and DNA synthesis. alpha-Santalol could be an effective chemopreventive agent for skin cancer. Additional experimental and clinical studies are needed to investigate the chemopreventive effect of alpha-santalol in skin cancer.

Dwivedi C., Maydew E.R., Hora J.J., Ramaeker D.M. & Guan X. (2005) "Chemopreventive effects of various concentrations of alpha-santalol on skin cancer development in CD-1 mice." *Eur J Cancer Prev.* **14**(5), 473-6. Abstract. Previous studies from this laboratory have indicated that alpha-santalol (5%) provides chemopreventive effects in 7,12-dimethylbenz[a]anthracene (DMBA)-initiated and 12-O-tetradecanoylphorbol-13-acetate (TPA)-promoted skin cancer in CD-1 and SENCAR mice. Skin cancer development is associated with increased ornithine decarboxylase (ODC) activity, DNA synthesis and rapid proliferation of epidermal cells. The purpose of this investigation was to determine the effects of various concentrations (1.25% and 2.5%) of alpha-santalol on DMBA-initiated and TPA-promoted skin cancer development, TPA-induced ODC activity, and DNA synthesis in CD-1 mice. alpha-Santalol treatment at both concentrations (1.25% and 2.5%) prevented the skin cancer development. alpha-Santalol treatment (1.25% and 2.5%) resulted in a significant decrease in the TPA-induced ODC activity and incorporation of [3H]thymidine in DNA in the epidermis of CD-1 mice. There was no significant difference in the effects of 1.25% and 2.5% alpha-santalol on tumour incidence, multiplicity, epidermal TPA-induced ODC activity, or DNA synthesis in CD-1 mice.

Dwivedi C., Valluri H.B., Guan X. & Agarwal R. (2006) "Chemopreventive effects of alpha-santalol on ultraviolet B radiation-induced skin tumor development in SKH-1 hairless mice." *Carcinogenesis*. **27**(9),1917-22. Abstract. Recent studies from our laboratory have shown the chemopreventive effects of alpha-santalol against 7,12-dimethylbenzanthracene (DMBA) initiated and 12-O-tetradecanoylphorbol-13-acetate (TPA) promoted skin tumor development in mice. The objective of the present investigation was to study the effects of alpha-santalol on ultraviolet B (UVB) radiation-induced skin tumor development and UVB-caused increase in epidermal ornithine decarboxylase (ODC) activity in female hairless SKH-1 mice. For the tumor studies, 180 mice were divided into three groups of 60 mice each, and each group was divided into two subgroups of 30 mice. The first subgroup served as control and was treated topically on the dorsal skin with acetone. The second subgroup served as experimental and was treated topically on the dorsal skin with alpha-santalol (5%, w/v in acetone). The tumorigenesis in the first group was initiated with UVB radiation and promoted with TPA; in the second group it was initiated with DMBA and promoted with UVB radiation; and in the third group it was both initiated and promoted with UVB radiation. In each case, the study was terminated at 30 weeks. Topical application of alpha-santalol significantly (P<0.05) decreased tumor incidence and multiplicity in all the three protocols, suggesting its chemopreventive efficacy against UVB radiation-caused tumor initiation, tumor promotion and complete carcinogenesis. In a short-term biochemical study, topical application of alpha-santalol also significantly (P<0.05) inhibited UVB-induced epidermal ODC activity. Together, for the first time, our findings suggest that alpha-santalol could be a potential chemopreventive agent against UVB-induced skin tumor development and, therefore, warrants further investigations.

Kaur M., Agarwal C., Singh R.P., Guan X., Dwivedi C. & Agarwal R. (2005) "Skin cancer chemopreventive agent, {alpha}-santalol, induces apoptotic death of human epidermoid carcinoma A431 cells via caspase activation together with dissipation of mitochondrial membrane potential and cytochrome c release." *Carcinogenesis* **26**(2), 369-80. Abstract. alpha-Santalol, an active component of sandalwood oil, has been studied in detail in recent years for its skin cancer preventive efficacy in murine models of skin carcinogenesis; however, the mechanism of its efficacy is not defined. Two major biological events responsible for the clonal expansion of transformed/initiated cells into tumors are uncontrolled growth and loss of apoptotic death. Accordingly, in the present study, employing human epidermoid carcinoma A431 cells, we assessed whether alpha-santalol causes cell growth inhibition and/or cell death by apoptosis. Treatment of cells with alpha-santalol at concentrations of 25-75 microM resulted in a concentration- and a time-dependent decrease in cell number, which was largely due to cell death. Fluorescence-activated cell sorting analysis of Annexin V/propidium iodide (PI) stained cells revealed that alpha-santalol induces a strong apoptosis as early as 3 h post-treatment, which increases further in a concentration- and a time-dependent manner up to 12 h. Mechanistic studies showed an involvement of caspase-3 activation and poly(ADP-ribose) polymerase cleavage through activation of upstream caspase-8 and -9. Further, the treatment of cells with alpha-santalol also led to disruption of the mitochondrial membrane potential and cytochrome c release into the cytosol, thereby implicating the involvement of the mitochondrial pathway. Pre-treatment of cells with caspase-8 or -9 inhibitor, pan caspase inhibitor or cycloheximide totally blocked alpha-santalol-caused caspase-3 activity and cleavage, but only partially reversed apoptotic cell death. This suggests involvement of both caspase-dependent and -independent pathways, at least under caspase inhibiting conditions, in alpha-santalol-caused apoptosis. Together, this study for the first time identifies the apoptotic effect of alpha-santalol, and defines the mechanism of apoptotic cascade activated by this agent in A431 cells, which might be contributing to its overall cancer preventive efficacy in mouse skin cancer models.

Kim T.H., Ho H., Takayasu T., Tokuda H., Machiguchi M. & T. (2006) "New antitumor sesquiterpenoids from *Santalum album* of Indian origin." *Tetrahedron* **62** (29), 6981-6989. Abstract. Three new campherenane-type (1, 4, 7) and three new santalane-type (9, 11, 12) sesquiterpenoids, and two aromatic glycosides (21, 22) together with 12 known metabolites including β-santalols (14, 18), (E)-,β-santalals (15, 19), β-santaldiols (16, 20), -santalenoic acid (17), and vanillic acid 4-O-neohesperidoside were isolated from *Santalum album* chips of Indian origin. The structures of the new compounds, including absolute configurations, were elucidated by 1D- and 2D-NMR spectroscopic and chemical methods. The antitumor promoting activity of these isolates along with several neolignans previously isolated from the same source was evaluated for both in vitro Epstein–Barr virus early antigen (EBV-EA) activation and in vivo two-stage carcinogenesis assays. Among them, compound 1 exhibited a potent inhibitory effect on EBV-EA activation, and also strongly suppressed two-stage carcinogenesis on mouse skin.
Graphical abstract.



Palep S. & Lebwohl M. (2007) "Inhibitory effects of alpha and beta santalol on UVB-induced mouse skin carcinogenesis." *Journal of the American Academy of Dermatology* **56**(2) Suppl. 2, pAB36.

Chemistry of E.I. Sandalwood

Anonis D.P. (1998) "Sandalwood & sandalwood compounds" *Perf. & Flav.* **23**(5), 19-24.

Bajgrowicz J.A. & Frater G. (2000) "Chiral recognition of sandalwood odourants." *Enantiomer* 5(3-4), 225-234. Abstract: Looking for more efficient sandalwood oil smelling compounds, new campholenic aldehyde derivatives with rigidifying cyclopropane rings were prepared. For some of them, having the lowest odor threshold ever measured for this type of odorants and a very appreciated scent, close to that of the scarce natural sandalwood oils, pure stereoisomers were obtained and their olfactory properties were evaluated. Thus acquired structure-odor relationship data, together with consolidated and completed previous knowledge on structurally different

sandalwood-smelling compounds, allowed to propose new models of the sandalwood olfactophore.

Beyer A., Wolschann P., Becker A., Pranka E. & Buchbauer G. (1988) "Conformational calculations in odiferous molecules of sandalwood." *Montash. Chem*. **119**, 711.

Beyer A., Wolschann P., Becker A., Pranka E. & Buchbauer G. (1988) "Conformational calculations in sandalwood odour molecules" *Flav. Frag. J.* **3**, 173.

Bhati A. (1962) "Studies in the Sandalwood oil Series. 111. Chain Effect on Terpene Transformations." *J of Organic Chemistry* Dec 1962 p4485. Abstract. Thc carboxyl chain of some moleciiles has been found to be responsible for causing rearrangements and controlling their course, This chain effect, which opcrates during reactions involving carbonium ions, is illustrated with examples from Sandalwood oil chemistry.

Bohlmann F. & Zedro C. (1968) "Isolierung von (-)-a-santalal aus Piqueria Trinerva" *Tetrahedr. Lett.* 1533.

Braun N.A., Meier M., Schmaus G., Hölscher B. & Pickenhagen (date?) "Enantioselectivity in odour perception: synthesis & olfactory properties of iso-b-bisabolol, a new natural product" *Helv. Chim. Acta* **86**, 2698-2708.

Briggs C.H. (1915). "Some notes on Sandalwood, its assay, yield of oil, and changes in the oil during distillation." *J of Industrial. & Engineering. Chemistry* **8**(5), 428.

Brunke E.-J. & Hammerschmidt F.-J. (1980) "New Constituents of East Indian Sandalwood oil". *Proceedings of VIII Congress Intl. Des Huiles Essentielles* Oct 1980 Pub. 1982 Fedarom.

Brunke E-J. & Rojahn W. (1980) "Sandalwood Oil" *Dragoco Report* **5**/1980, 127-135.

Brunke E-J (1983) "Woody Aroma Chemicals" *Dragoco Report* **6**/1983 p146

Brunke E-J. & Hammerschmidt F.-J. (1988) "Constituents of East Indian sandalwood oil – an eighty year old stabilty test" *Dragoco Report* **4**/1988 pp107-113.

Brunke E.J. & Schmaus (1995) "New active odour constituents in Sandalwood Oil: part 2: Isolation, structural elucidation and synthesis of nor-a-trans-bergamotenone" *Dragoco Report* **6**/1995 p245-257.

Brunke, E. J., Vollhardt J., et al. (1995). "Cyclosantalal and epicyclosantalal-new sesquiterpene aldehydes from East Indian sandalwood oil." *Flavour and Fragrance Journal* **10**(3), 211-219

Brunke E-J, Fahlbusch K-G, Schmaus G & Volhart (1997) "The chemistry of sandalwood odour – a review of the last 10 years". In *Rivista Ital. EPOS* (Actes des 15emes Journeés Internationales Huilles Essentielles; Digne-les-Baines, France 5-7th Sept 1996 special issue 01/97) pp49-83.

Brunke E.J. & Tumbrink L. (1986) "First total synthesis of spirosantalol." *Progress in Essential Oil Research* pp321-327.

Brunke E.-J. Hammerschmidt F.-J. & Struwe H. (1980) "(+)-epi-Santalol isolierung aus sandelholzol und partialsynthese aus (+) -alpha-santalol. *Tetrahedron Lett.* (1980) 2405.

Brunke E.-J. & Klein E. (1982) "Chemistry of sandalwood fragrance" In *Fragrance Chemistry. The Science of Smell*, Academic Press NY p397.

Buchbauer G., Stappen I., Pretterklieber C & Wolschann P. (2004) "Structure–activity relationships of sandalwood odorants: synthesis and odor of tricyclo β-santalol" *Eur J Med Chem* **39**(12), 1039-1046. Abstract: In a series of structure–odor relationship investigations the synthesis of a new tricyclic β-santalol derivative is described. The product of a multi-step synthesis appears in an olfactive evaluation more or less odorless may be slightly creamy but definitely with no sandalwood odor. This modification with a bulky aliphatic bridge in the neighbourhood of the quaternary C3-atom demonstrated the sensitivity of sandalwood odor on the structure of β-santalol analogues.

Buchbauer G., Winiwarter S. & Wolschann P. (1992) "Surface comparisons of some odour molecules: conformational calculations on sandalwood odour V." *J. Comput. Aided Mol. Des*. 6(6), 583-592. Abstract: Molecular surface comparison seems to be a very suitable tool for the investigation of small differences between biologically active and inactive compounds of the same structural type. A fast method for such comparisons, based on volume matching followed by the estimation of comparable surface dots, is presented and applied on a few selected sandalwood odour molecules.

Demole E., Demole C. & Enggist P. (1976) "A chemical investigation of volatile constituents of volatile constituents of East Indian sandalwood oil (*Santalum album* L.)" *Helv. Chim. Acta* **59**, 737.

Dimoglo A.S., Beda A.A., Shvets N.M., Gorbachov M.Yu., Kheifits L.A. & Aulchenko S. (1995) "Investigation of the relationship between sandalwood odour & chemical structure: electron topological approach." *New J of Chemistry* **19**(2), 149-154.

Kovatcheva A., Buchbauer G., Golbraikh A. & Wolschann P. (2003) "QSAR modeling of alpha-campholenic derivatives with sandalwood odor." *J Chem Inf Comput Sci.* **43**(1), 259-66. Abstract. Three-dimensional quantitative structure-activity relationship (3D-QSAR) models were developed for a series of 44 synthetic alpha-campholenic derivatives with sandalwood odor. These compounds have complex stereochemistry as they contain up to five chiral atoms. To address stereospecificity of odor intensity, a 3D-QSAR method was developed, which does not require spatial alignment of molecules. In this method, compounds are represented as derivatives of several common structural templates with several substituents, which are numbered according to their relative spatial positions in the molecule. Both wholistic and substituent descriptors calculated with the TSAR software were used as independent variables. Based on published experimental data of sandalwood odor intensities, two discrete scales of the odor intensity with equal or unequal intervals between the threshold values were developed. The data set was divided into a training set of 38 compounds and a test set of six compounds. To build QSAR models, a stepwise multiple linear regression method was used. The best model was obtained using the unequal scale of odor intensity: for the training set, the leave one out cross-validated R(2) (q(2)) was 0.80, the correlation coefficient R between actual and predicted odor intensities was 0.93, and the correlation coefficient for the test set was 0.95. The QSAR models developed in this study contribute to the better understanding of structural, electronic, and lipophilic properties responsible for sandalwood odor. Furthermore, the QSAR approach reported herein can be applied to other data sets that include compounds with complex stereochemistry.

Hatt H.H. & Schoenfeld R. (1956) "Some seed fats of the Santalaceae family." *J. Sci Food Agric* **7**(2), 130-133. ***Cropwatch comments***. The drying oil from the hard-shelled seeds (50-60% fixed oil) contains 30-35% santalbic acid and 1% stearolic acid. Tthese acetylenic compounds inhibit lipoenzymes in experimental animals.

$$CH_3(CH_2)_5CH{=}CH{-}C{\equiv}C{-}(CH_2)_7COOH$$

santalbic acid

Hayashi K., Haseegawa T., Machiguchi T. & Yoshida T. (2005) ""Isolation and structure of a new aroma constituent from Indian Sandalwood, *Santalum album* L." *Nippon Kagakkai Koen Yokoshu* **85**(2), 863. Abstract. This work presents the isolation and structural elucidation of a new aroma compound in the major component from Indian sandalwood tree, *Santalum album* L., not from sandalwood oil obtained through steam distillation. We have found that the compound has a novel hemiacetal structure and has sandalwood odor stronger than those of.alpha.- and.beta.-santalols (the major components of sandalwood oil). (author abst.)

Heissler D. & Riehl J.-J. (1980) “Synthesis with benzenesulfenyl chloride. On the structure of a $C_{12}H_{18}$ hydrocarbon from East Indian sandalwood oil” *Tetrahedron Letters* **21**(49), 4711-4714. Abstract: The tetracyclic hydrocarbon was synthesized by means of the electrophilic addition of benzenesulfenyl chloride to an appropriately substituted methylenenorbornene. The synthetic methodology used to prepare this letter compound includes a mild enol ether hydrolysis with acidic silica gel.

Hopkins C.Y. & Chisholm M.J. (1969) "Fatty acid composition of some Santalaceae seed oils." *Phytochem*. **8**, 161-165.

Howes M.-J. R., Simmonds M.S.J. & Kite G.C. (2003) “Evaluation of the quality of sandalwood essential oils by gas chromatography–mass spectrometry” *Journal of Chromatography A*, **1028**(2), 307-312. Abstract: Trade and historic oils from ‘sandalwoods’, labelled as *Amyris balsamifera*, *Eremophila mitchelli*, *Fusanus acuminatus* (= *Santalum acuminatum*), *Santalum album*, *S. austrocaledonicum*, *S. latifolium*, *S. spicatum* and *S. yasi*, were assessed using gas chromatography–mass spectrometry (GC–MS). Using GC–MS, none of the oils assessed complied with the internationally recognised standard of a 90% santalol content, and only about half of the trade sandalwood oils met with recent International Organisation for Standardisation standards. The majority of trade oils, reportedly from *S. album*, contained approximately 50–70% santalols (*Z*-α and *Z*-β). Thus, the internationally recognised specification (90% santalols) for S. album requires re-evaluation by more efficient analysis methods. In view of the issues associated with the quality of sandalwood oils being traded, specifications of ≥43% *Z*-α-santalol and ≥18% *Z*-β-santalol for *S. album* oil estimated by GC–MS are suggested. GC–MS are recommended as it assists with authentication and quality control issues associated with sandalwood oils. ***Cropwatch comments***: The authors seem confused. The ‘90% santalols figure’ is largely a relict of the past from when santalols in sandalwood oil were estimated by wet chemical methods – either by the acetylation method e.g. by EOA Determination 1B as set out in EOA Spec. No 103, or by wide-bore GC. This result is inaccurate and non-comparable to the superior information revealed by modern high performance capillary GC/MS determinations. The latter can break down the identity of a number of santalol isomers within sandalwood oil, and can help identify other sesquiterpene alcohols which might have previously have been included with the total santatols figure by the wet chemical procedure. Thus, by high performance capillary gas chromatography, a different story unfolds, and some 16 years previously, Verghese *et al*. (1990a) established that in Sandalwood oil E.I. the normal range is as follows: α-santalol 40-45% and β-santalol 17-27% [Lawrence (1991) q.v.]. The ISO standard ISO 3518 (2002) for sandalwood oil is surely taken by most workers as the current standard for the commodity and sets the limits on the *Z*-α-santalol content to 41-55% and the *Z*-β-santalol content to 16-24%. Cropwatch does not accept therefore that the situation for steam distilled sandalwood oils is quite as Howes *et al*. present it. Sandalwood extracts – via the benzene (etc.) extraction of sandalwood powder to produce sandalwood concrete, followed by methanolic extraction to produce a so-called ‘oil’ – can however produce high santalol containing sandalwood commodities in higher yield than steam distillation, which are sometimes traded as ‘oils’ or mixed in with the normal oil. Co-distillation technology with high boiling solvents (which are subsequently removed) can also produce high santalol containing sandalwood ‘oils’. East African sandalwood oil and certain fractions of Australian sandalwood oil have also frequently been added as adulterants to traded East Indian sandalwood oils. The analyst should be aware therefore that not everything offered as sandalwood oil is as necessarily ‘100% derived from the named botanical source’ – but this is hardly news to any experienced essential oil analyst!

Jie M. S. F. L. K., Pasha M.K. *et al*. (1996). “Ultrasound-assisted synthesis of santalbic acid and a study of triacylglycerol species in *Santalum album* (Linn.) seed oil.” *Lipids* **31**(10), 1083-1089.

Jirovetz L. *et al*. (1988). “Differentiation of double bond isomers of sesquiterpene alcohols in East Indian sandalwood oil by means of GC-MS and GC-FTIR: Dihydrosantalols.” *Spectroscopy* **6**(5-6), 283-294.

John M.D, Paul T.M. & Jaiswal P.K. (1991) “Detection of adulteration of polyethylene glycol in oil of sandalwood” *Indian Perfumer* **35**, 186-187.

Kim T.H., Ito H., Hayashi K., Hasegawa T., Machguchi T., & Yoshida T. (2005) "Aromatic constituents from the heartwood of *Santalum album*." *Chem Bull Pharm* (Tokyo) **53**(6), 641-646. Abstract: A phytochemical investigation of the polar constituents in the heartwood of Indian *Santalum album* L. resulted in the isolation of three new neolignans (1-3) and a new aromatic ester (4), along with 14 known components. The structures of the new compounds (1-4) were established using spectroscopic methods.

Kim T.H., Ito H., Hatano T., Haswegawa T., Akiba A., Machiguchi T., Yoshida T. (2005) "Bisabolane & santalane-type sequiterpemoids from *Santalum album* of East Indian origin" *J. Nat Products* **68**(12), 1805-1808. Abstract: Six new bisabolane-type (1-3) and santalane-type (4-6) sesquiterpenoids, together with (+)-alpha-nuciferol, (+)-citronellol, and geraniol, were isolated from the heartwood of *Santalum album* of Indian origin. Their structures, including two bisabolol diastereomers (1, 2), were established on the basis of spectroscopic data interpretation.

Kovatechva A., Buchbauer G., Golbraikh A. & Wolschann P. (2003) "QSAR modelling of alpha-campholenic derivatives with sandalwood odour" *J. Chem. Inf. Comp. Sci* **43**, 259-266.

Kretschmar H.C., Barneis Z.J. & Erman W.F. (1970) “The isolation & synthesis of a novel tetracyclic ether from East Indian sandalwood oil. A facile intramolecular Prins reaction.” *Tetrahedron Letters* **11**(1), 37-40.

Lawrence B. M. (1991) “Progress in Essential Oils: Sandalwood Oil” *Perf & Flav*. **6**, 50-52.

Manjarrez A., Rios T. & Guzman A. (1954) “The stereochemistry of l-lanceol and the synthesis of its racemate” *Tetrahedron* **20**, 333-339.

Mörgenthaler J.M. & Spitzner (2004) “Ring-closing olefin metathesis reactions: synthesis of iso-b-bisabolol” *Tetrahedron Letters* **45**, 1171-1172.

Ohloff G. (1994) *Scent & Fragrances* Springer-Verlag p175-178.

Pasha, M. K. & Ahmad F. (1993). “Synthesis of oxygenated fatty acid esters from santalbic acid ester.” *Lipids* **28**(11), 1027-1031.

Ruzicka L. & Thomann G. (1935) "Polyterpene und polyterpenoide XCIII. Uber die konstitution des beta-santalols und des beta-santalenes. *Helv. Chim. Acta* **18**, 355.

Sato K., Miyamoto O., Inoue S. & Honda K. (1980) "Stereospecific synthesis of beta-santalol" Paper presented at *Proceedings the VIII Congress International des Huiles Essentielles*, Cannes, Grasse, Oct. 1980 pub Fedarom 1982

Schmaus G., Meier M., Braun N.A., Hölscher B. & Pickenhagen (2001) “Iso-β-bisabolol as a fragrance & aroma substance” WO 03/011802.Schmincke K.-H. (1985) “Sandalwood Oil” in *Flavour & Fragrances of Plant Origin: (Non-Wood Forest Products 1*) Food & Agricultural Organisation of the United Nation (FAO) Rome.

Semmler F.W. (1908) "Zur Kenntnis der Bestandtelle atherische Ole. (Weitere Mitteilungen uber die Santole C15H24O und ihre Derivative). *Ber. Dtsche. Chem. Ges.* **41**, 1488.

Semmler F.W. (1910) Zur Kenntnis der Bestandtelle atherische Ole. (Konstitution der alpha-Santalol und alpha-Santalen-Reihe: Die Konstitution der Seasquiterpenalkohole und Seaquiterpene). *Ber. Dtsche. Chem. Ges*. **43**, 1893.

Shankaranarayana K.H., Angadi V.G., Rajeevalochan A.N.,. Theagarajan K.S., Sarma C.R. & Rangas-wamy C.R. (1997). “A rapid method ofestimating essential oil content inheartwood of *Santalum album* Linn.” *Current Science* **72**(4), 241-242.

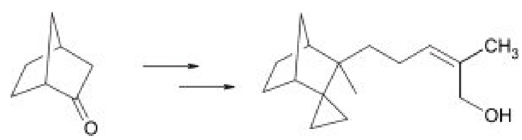
Shankaranarayana K.H., Rajeevalochan G., Rajeevalochan A.N. & Angadi V.G. (2005) "Fragrant oils from exhausted sandalwood powder and sandal sapwood." *J. Sci.Ind. Res.* **64**, 965-966.

Shukla B.V., Ravindra M., Shukla S.V., Lahire L. & Singh D.P. (1999) “Qualitative assessment of sandalwood oil using gas chromatography” *PAFAI J.* **13**, 41-43.

Sidheswaran P. & Ganguli S. (1997) "Sandalwood oil substitutes - A review" *Supplement to Cultivation & Utilisation of Aromatic Plants* CIMAP (1997).

Spreitzer, H., Roesslhuber I, *et al*. (1990). “Structure/odor relationships of beta-santalol analogues: *E*-homo-beta-santalol and *E*-dehydrohomo-beta-santalol.” *Monatshefte Fuer Chemie* **121**(2-3), 195-202.

Stappena I., Höfinghoff J., Friedl S., Pammer C., Wolschann P. & Buchbauer G. (2008) "Structure–activity relationships of sandalwood odorants: Total synthesis and fragrance properties of cyclopropano-β-santalol." *European Journal of Medicinal Chemistry* **43**(7),1525-1529. Abstract. The synthesis and odor properties of cyclopropano-β-santalol, a new santalol analogue, are described. The exocyclic double bond of the original molecule, β-santalol, is replaced by a cyclopropane ring. Despite the analogies in the binding properties between the double bond and cyclopropane this change in the bulky hydrophobic part of the molecule leads to the complete loss of the characteristic sandalwood odor: in an olfactory evaluation the (*Z*)-product appears spicy and sweet, the (*E*)-isomer woody, but neither of them exhibits the typical sandalwood character.
Graphical abstract:



Verghese J., Sunny T.P. & Balkrishnan K.V. (1990) “-(-)-α-santalol & (-)-β-santalol concentration, a new quality determinant of East Indian sandalwood oil.” *Flavours & Fragrances J*. **5**, 223-226

Walker G.T. (1968) "The chemistry of the oil of sandalwood." *Perf & Essen Oil Record* **59**(11), 778-781.

Wang Z. & Hong X. (1991) "Comparitive GC analysis of essential oil in imported sandalwood" *Zongguo Zong Yuo Za Zhi* **16**(1), 40-43, 64. Abstract: The GC-fingerprint spectra of essential oils in imported sandalwood are established by the new technique of GC-relative retention value fingerprint spectrum (GC-FPS). According to the GC-FPS of samples, their chromatographic peaks, overlap ratio of peaks and eight strong peaks are studied comparatively.

Witteveen J.G. & van der Weerdt A.J.A. (1987) "Structure-odour relationships of some new synthetic sandalwood aroma chemicals - Synthesis and olefactive properties in a series of bicyclo [4.4.0] decan-3-ols. *Rec Trauvase Chim., Pays-Bas* **106**, 29

General Articles – E.I. Sandalwood.

Adkoli N.S. & Kushalappa K.A. (eds)(1977) *Proceedings of All India Sandal Seminar*, Bangalore, 7-8 February, 1977. *Myforest*, Special Issue. pub Karnataka Forest Dept, Bangalore.

Ananthapadmanabha H.S., Rangaswamy C.R.; Sarma C.R.., Nagaveni H.C., Jain S.H.., Venkatesan K.R. & Krishanappa H.P. (1984). “Host requirements of sandal (*Santalum album* L.).”. *Indian Forester* **110** (3).

Ananthapadmanabha H.S., Nagaveni H.C. & Rai S.N. (1988). “Dormancy principles in sandalwood seeds (*Santalum album*) Linn. *Myforest* **24(l**):22-24.

Ananthapadmanabha H.S. (2000) “The present status of sandalwood in India & Australia” *PAFAI Journal* **2**, 33-36.

Angadi V.G. & Anathapadmanabha H.S. (1988). “Variations in isoenzyme pattern associated with spike disease in sandal.” *Indian Journal of Forestry* **11**(1), 37-38.

Angadi V.G., Ramalakshmi S., Jain S.H., Rangaswamy C.R. & Theagarajan K.S. (1999). "Allozymicvariation in the seed tissue of Sandal (*Santalum album* L.) population of different provenances." (unpublished).

Angadi V.G., Jain S.H., Rajeevalochan A.N., Ravikumar G. & Shankaran-yana K.H. (2002) "A note on Peroxidase reagents to distinguish between highand low yielders of Sandal (*Santalum album*) in the field." *Sandalwood Research Newsletter* 2002.

Anil V.S., Harmon A.C.& Rao K.S. (2000) "Spatio-temporal accumulation and activity of calcium-dependent protein kinases during embryogenesis, seed development, and germination in sandalwood." *Plant Physiol*. **122**(4), 1035-43. Abstract. Western-blot analysis and protein kinase assays identified two Ca(2+)-dependent protein kinases (CDPKs) of 55 to 60 kD in soluble protein extracts of embryogenic cultures of sandalwood (*Santalum album* L.). However, these sandalwood CDPKs (swCDPKs) were absent in plantlets regenerated from somatic embryos. swCDPKs exhibited differential expression (monitored at the level of the protein) and activity in different developmental stages. Zygotic embryos, seedlings, and endosperm showed high accumulation of swCDPK, but the enzyme was not detected in the soluble proteins of shoots and flowers. swCDPK exhibited a temporal pattern of expression in endosperm, showing high accumulation and activity in mature fruit and germinating stages; the enzyme was localized strongly in the storage bodies of the endosperm cells. The study also reports for the first time to our knowledge a post-translational inhibition/inactivation of swCDPK in zygotic embryos during seed dormancy and early stages of germination. The temporal expression of swCDPK during somatic/zygotic embryogenesis, seed maturation, and germination suggests involvement of the enzyme in these developmental processes.

Anil, V. S. &. Rao K..S. (2000). “Calcium-mediated signaling during sandalwood somatic embryogenesis. Role for exogenous calcium as second messenger.” *Plant Physiology* August 2000 **123**(4), 1301-1311. Abstract. Calcium-dependent protein kinase (CDPK) is expressed in sandalwood (*Santalum album* L.) seeds under developmental regulation, and it is localized with spherical storage organelles in the endosperm [Anil *et al*. (2000) *Plant Physiol.* **122**: 1035]. This study identifies these storage organelles as oil bodies. A 55 kDa protein associated with isolated oil bodies, showed Ca(2+)-dependent autophosphorylation and also cross-reacted with anti-soybean CDPK. The CDPK activity detected in the oil body-protein fraction was calmodulin-independent and sensitive to W7 (N-(6-aminohexyl)-5-chloro-1-naphthalene sulfonamide) inhibition. Differences in Michaelis Menton kinetics, rate of histone phosphorylation and sensitivity to W7 inhibition between a soluble CDPK from embryos and the oil body-associated CDPK of endosperm suggest that these are tissue-specific isozymes. The association of CDPK with oil bodies of endosperm was found to show a temporal pattern during seed development. CDPK protein and activity, and the in vivo phosphorylation of Ser and Thr residues were detected strongly in the oil bodies of endosperm from maturing seed. Since oil body formation occurs during seed maturation, the observations indicate that CDPK and Ca(2+) may have a regulatory role during oil accumulation/oil body biogenesis. The detection of CDPK-protein and activity in oil bodies of groundnut, sesame, cotton, sunflower, soybean and safflower suggests the ubiquity of the association of CDPKs with oil bodies.

Anil V.S. & Rao K.S. (2001) "Purification and characterization of a Ca(2+)-dependent protein kinase from sandalwood (*Santalum album* L.): evidence for Ca(2+)-induced conformational changes." *Phytochemistry* **58**(2), 203-12. Abstract. An early development-specific soluble 55 kDa Ca(2+)-dependent protein kinase has been purified to homogeneity from sandalwood somatic embryos and biochemically characterized. The purified enzyme, swCDPK, resolved into a single band on 10% polyacrylamide gels, both under denaturing and non-denaturing conditions.

swCDPK activity was strictly dependent on Ca(2+), K(0.5) (apparent binding constant) for Ca(2+)-activation of substrate phosphorylation activity being 0.7 microM and for autophosphorylation activity approximately 50 nM. Ca(2+)-dependence for activation, CaM-independence, inhibition by CaM-antagonist (IC(50) for W7=6 microM, for W5=46 microM) and cross-reaction with polyclonal antibodies directed against the CaM-like domain of soybean CDPK, confirmed the presence of an endogenous CaM-like domain in the purified enzyme. Kinetic studies revealed a K(m) value of 1.3 mg/ml for histone III-S and a V(max) value of 0.1 nmol min(-1) mg(-1). The enzyme exhibited high specificity for ATP with a K(m) value of 10 nM. Titration with calcium resulted in the enhancement of intrinsic emission fluorescence of swCDPK and a shift in the lambda(max) emission from tryptophan residues. A reduction in the efficiency of non-radiative energy transfer from tyrosine to tryptophan residues was also observed. These are taken as evidence for the occurrence of Ca(2+)-induced conformational change in swCDPK. The emission spectral properties of swCDPK in conjunction with Ca(2+) levels required for autophosphorylation and substrate phosphorylation help understand mode of Ca(2+) activation of this enzyme.

Anil V.S., Harmon A.C. & Rao K.S. (2003) "Temporal association of Ca(2+)-dependent protein kinase with oil bodies during seed development in *Santalum album* L.: its biochemical characterization and significance." *Plant Cell Physiol.* **44**(4),367-76. Abstract. Calcium-dependent protein kinase (CDPK) is expressed in sandalwood (*Santalum album* L.) seeds under developmental regulation, and it is localized with spherical storage organelles in the endosperm [Anil *et al.* (2000) *Plant Physiol.* 122: 1035]. This study identifies these storage organelles as oil bodies. A 55 kDa protein associated with isolated oil bodies, showed Ca(2+)-dependent autophosphorylation and also cross-reacted with anti-soybean CDPK. The CDPK activity detected in the oil body-protein fraction was calmodulin-independent and sensitive to W7 (N-(6-aminohexyl)-5-chloro-1-naphthalene sulfonamide) inhibition. Differences in Michaelis Menton kinetics, rate of histone phosphorylation and sensitivity to W7 inhibition between a soluble CDPK from embryos and the oil body-associated CDPK of endosperm suggest that these are tissue-specific isozymes. The association of CDPK with oil bodies of endosperm was found to show a temporal pattern during seed development. CDPK protein and activity, and the in vivo phosphorylation of Ser and Thr residues were detected strongly in the oil bodies of endosperm from maturing seed. Since oil body formation occurs during seed maturation, the observations indicate that CDPK and Ca(2+) may have a regulatory role during oil accumulation/oil body biogenesis. The detection of CDPK-protein and activity in oil bodies of groundnut, sesame, cotton, sunflower, soybean and safflower suggests the ubiquity of the association of CDPKs with oil bodies.

Anon (1999) "Tree farming: More on sandalwood cultivation: Economics of sandalwood plantations." *Agric. & Industry Survey*, Mar/April pp30-32.

Anon (1997) "Sandalwood oil crop suffers burn." *HerbalGram* **41**, 54.

Anon (2004) "Squads to check Sandalwood smuggling" *The Hindu* 14.05.04 at: www.hinduonnet.com/thehindu/2002/05/ 14/stories/2002051403200400.htm

Anon (2007) "Company News: Karnataka Soaps launches turmeric soap in Andhra." *Focus on Surfacants* **12** (Dec 2007), p7. Quote: "Karnataka Soaps also plans to increase its production of sandalwood soaps from 7200 tonnes in 2005-2006 to 8000 tonnes in 2007-2008." ***Cropwatch comments***: Let's hope they are not using authentic sandalwood oil to do this!

Bagchi S. K. & Veerendra H.C.S. "Variation and relationship in developmental growth phases of *Santalum album* after pruning." *Indian Forester* **117**(12), 1053-1058.

Bagchi S.K. & Kulkarni H.D. (1987). "A note on seedling abnormality frequency in the half-sib progenies of *Santalum album*." *Indian Forest* **113**, 650-651.

Balachandran N. & Kichenamourthy S. (2007) "Profile of natural stands of *Santalum album* L. in the Pondicherry region, India." *Sandalwood Research Newsletter* **22**. Abstract. The enumeration of sandal and its habitats, soil type, girth, height, status of re-production and associated plants were studied within the Pondicherry region inIndia. A total of 463 mature sandal trees (girth at breast height (gbh) ≥ 10 cm) and 360 sapling trees (<10 cm gbh) were recorded from 10 different locations, 5habitats and 4 soil types. The analyses of growth (girth and height), reproduction and associates were compared with different soil types. Generally clay with lime-stone and sandy soils had substantially greater numbers of sandal trees than clayand red earth soils. *Azadirachta*, *Glycosmis*, *Morinda* and *Phoenix* were the most predominant associated species across all soil types.

Barber C.A. (1906). "Studies of rootparasitism – The haustorium of *Santalum album* L. 1.Early stages up to penetration." *Mem. Dept.Agri., Ind, Bot,* Ser.1. Pt.,1:1-30.

Barber C.A. (1907). "Studies ofroot parasitism – The haustoriumof *Santalum album* L.2.The mature haustorium." *Mem.Dept. Agri., Ind, Bot*, Ser.1 Pt.,11 : 1-58.

Barret D.R. (1988) "*Santalum abum* (Indian Sandalwood) literature review" *Mulga Research Centre Report* No 3. Perth. Curtin University of Technology.

Barrett, D. R. & Fox J.E.D. (1994). "Early growth of *Santalum album* in relation to shade." *Australian Journal of Botany* **42**(1), 83-93.

Barrett D R & Fox J E D (1995) "Geographical distribution of Santalaceae and botanical characteristics of species in the genus *Santalum*." In: *Sandalwood Seed Nursery and Plantation Technology* (eds L Gjerum, J E D Fox & L Ehrhart). FAO, Suva, Fiji. RAS/92/361. Field Document **8**, 3–23.

Barrett D.R. & Fox J.E.D. (1997). "*Santalum album*: Kernel composition, morphological and nutrient characteristics of pre-parasitic seedlings under various nutrient regimes." *Annals of Botany* **79**(1), 59-66.

Bapat V.A. & Rao P.S. (1984). "Regulatory factors for in vitro multiplication of sandalwood tree (*Santalum album*): 1. Shoot bud regeneration and somatic embryogenesis in hypocotyl cultures." *Proceedings Of The Indian Academy Of Sciences Plant Sciences* **93**(1), 19-28.

Bapat V.A. & Rao P.S. (1988). "Sandalwood plantlets from synthetic seeds." *Plant Cell Reports* **7**(6), 434-436.

Bapat V.A., Fulzele D.P., *et al.* (1990). "Production of sandalwood somatic embryos in bioreactors." *Current Science* **59**(15), 746-748.

Bapat V.A. & Rao P.S. (1992). "Biotechnological approaches for sandalwood (*Santalum album* L.) micropropagation." *Indian Forester* **118**(1), 48-54.

Bapat V. A., Iyer R.K., *et al.* (1996). "Effect of cyanobacterial extract on somatic embryogenesis in tissue cultures of sandalwood (*Santalum album*)." *Journal of Medicinal & Aromatic Plant Sciences* **18**(1), 10-14.

Baruah A. D. (1999)." The economics of sandal-oil." *The Indian Forester* **125** (6), 640-643.

Benencia F. & Courreges M.C. (1999) "Antiviral activity of sandalwood oil against herpes simplex viruses-1 and -2." *Phytomed*. **6**(2), 119-23. Abstract: Sandalwood oil, the essential oil of *Santalum album* L., was tested for in vitro antiviral activity against Herpes simplex viruses-1 and -2. It was found that the replication of these viruses was inhibited in the presence of the oil. This effect was dose-dependent 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 at the concentrations tested.

Bhaskar, V. (1992). “”Pollination biology and fertilization in *Santalum album* L. (Santalaceae).” *Flora Jena* **187**(1-2), 73-78.

Bhaskar V. & Swami Rao N. (1999) “Vegetative and physico-anatomical traits and their relation heartwood content in small leaved and large leaved forms of sandal tree (*Santalum album* L.).” *PAFAI Journal* **1**, 33-38.

Bhatnagar SP (1959). “Some observa-tions on the post-fertilization devel-opment of the embryo sac of Santalum.” *Phytomorphology* **9**, 87-91.

Bhattacharya A. & Lakshmi S.G. (1999). “Isolation and characterization of PR1 homolog from the genomic DNA of sandalwood (*Santalum album* L.).” *Current Science* **77**(7), 958-961. Abstract. Genomic library was constructed using nuclear DNA prepared from tender leaves of sandalwood. Subsequently, screening with heterologous probes we could isolate the PR1 genomic hemolog, Restriction mapping and hybridization experiments were carried out to obtain the coding region for PR1 gene. A 750 bp EcoRI fragment thus obtained was subcloned to yield pSaPR1, which was compared with the related sequences. Southern hybridization with genomic DNA digests was carried out to check its genomic organization. The induction of this gene was observed in the somatic embryos treated with salicylic acid, thereby implying its possible involvement during systemic acquired resistance.

Bhattacharya, A. & Sita G.L. (1998). “cDNA cloning and characterization of a proline (or hydroxyproline)-rich protein from *Santalum album* L.” *Current Science* **75**(7), 697-701.

Bieri S., Monastyrskaia K. & Schilling B. (2004) "Olfactory receptor neuron profiling using sandalwood odourants" *Chem Senses* 29(6), 483-487. Abstract: The mammalian olfactory system can discriminate between volatile molecules with subtle differences in their molecular structures. Efforts in synthetic chemistry have delivered a myriad of smelling compounds of different qualities as well as many molecules with very similar olfactive properties. One important class of molecules in the fragrance industry are sandalwood odorants. Sandalwood oil and four synthetic sandalwood molecules were selected to study the activation profile of endogenous olfactory receptors when exposed to compounds from the same odorant family. Dissociated rat olfactory receptor neurons were exposed to the sandalwood molecules and the receptor activation studied by monitoring fluxes in the internal calcium concentration. Olfactory receptor neurons were identified that were specifically stimulated by sandalwood compounds. These neurons expressed olfactory receptors that can discriminate between sandalwood odorants with slight differences in their molecular structures. This is the first study in which an important class of perfume compounds was analyzed for its ability to activate endogenous olfactory receptors in olfactory receptor neurons.

Bock J. (2003) “Sandalwood oil’s effect on the autonomic nervous system” *Original Internist* 3/1/2003. Abstract: The hypothesis is sandalwood oil causes a decrease in sympathetic tone as accessed by patients with Heart Rate Variation (HRV), blood pressure (systolic, diastolic, and pulse pressure) and pulse rate.

Brand, J.E. 1994. “Genotypic variation in *Santalum album*.” *Sandalwood Research Newsletter* **2**, 2-4.

Brummitt, R.K. (1992). “Santalaceae.” pp 659–660. In: Brummitt, R.K. *Vascular plant Families and genera*. Royal Botanic Gardens, Kew, UK.

Burdock GA & Carabin IG (2008) "Safety assessment of sandalwood oil (*Santalum album* L.)." *Food Chem Toxicol*. **46(**2), 421-32. Abstract. Sandalwood (*Santalum album* L.) is a fragrant wood from which oil is derived for use in food and cosmetics. Sandalwood oil is used in the food industry as a flavor ingredient with a daily consumption of 0.0074 mg/kg. Over 100 constituents have been identified in sandalwood oil with the major constituent being alpha-santalol. Sandalwood oil and its major constituent have low acute oral and dermal toxicity in laboratory animals. Sandalwood oil was not mutagenic in spore Rec assay and was found to have anticarcinogenic, antiviral and bactericidal activity. Occasional cases of irritation or sensitization reactions to sandalwood oil in humans are reported in the literature. Although the available information on toxicity of sandalwood oil is limited, it has a long history of oral use without any reported adverse effects and is considered safe at present use levels.

Castro J.M., Linares-Palomino P.J., Salido S., Altarejos J., Nogueras & Sanchez A. (2005) "Enantiospecific synthesis, separation & olfactory evaluation of all diastereomers of a homologuee of the sandalwood odournt Polysantol." *Tetrahedron* **61**(47), 11192-11203. Abstract. The four stereoisomers of (5E)-4,4-dimethyl-6-(2′,2′,3′-trimethylcyclopent-3′-en-1′-yl)-hex-5-en-3-ol, a homologue of the valuable sandalwood-type odorant Polysantol®, were enantiospecifically synthesized from (+)- and (−)-α-pinene, through (−)- and (+)-campholenic aldehyde, by aldol condensation with 3-pentanone, deconjugative α-methylation and reduction. The mixtures of epimeric alcohols obtained after reduction were separated by means of derivatization with (−)-(1S)-camphanic chloride. The enantiomerically pure final products were evaluated organoleptically.

Chabra S. K. & Rao A.R. (1993). “Postnatal modulation of xenobiotic metabolizing enzymes in liver of mouse pups following translactational exposure to sandalwood oil.” *Nutrition Research* **13**(10), 1191-1202.

Chapuis C. (2004) "In the quest for a virtual pseudo receptor for sandalwood-like odorants. Part I: The empirical approach." *Chem Biodivers*.**1**(7):980-1021. Abstract. Based on similarities between naturally occurring (-)-(*Z*)-β-- or (+)-(*Z*)-α-santalol ((-)- 1 or (+)-2, resp.) and the reversed (E)-configured synthetic derivatives from campholenal (7a), a simple model A was developed. Besides reconciliation of this stereochemical aspect, this initial model also tentatively explained the enantiodiscriminations as well as the large spectra of distances separating the OH function from the lipophilic quaternary center(s) reported for different classes of substrates. Evolution, modifications, and refinement of this imperfect model allied with the research for alternative possibilities are illustrated, along with a historical guideline, in the light of olfactively challenging synthetic seco-substructures as well as literature reports. Despite evolution of the inadequate model A and a plausible interpretation of the lipophilic part, the topological positions of the OH function and its vicinal alkyl substituent could nevertheless not be fully ascertained by this approach. This apparently inconclusive empirical concept prompted us to turn our attention towards a computerized methodology, which will constitute the second and third part of this study.

Christenson P.A., Secord N. & Willis B.J. (1981) *Phytochemistry* **20**(5), 1139-1141. Abstract: An analysis of East Indian sandalwood oil (*Santalum album*) has resulted in the isolation and identification of trans-β-santalol and epi-cis-β- santalol.

Choudhuri J.C.B. (1963) "Sandalwood tree & its diseases." *Indian Forester* **89**(7), 456-462.

Das S., Das S., Pal S., Mujib A., Sahoo S. S., Dey S., Ponde N. R. & Dasgupta S.(1999). “A novel process for rapidmass propagation of *Santalum album* L. in liquid media and bioreactors.” In: Giberti, G. (Ed) Proc. WOCMAP-2. *Acta Hort*. 502(ISHS), 281-288.

Das S., Ray S., Dey S. & Dasgupta S. (2001). "Optimisation of sucrose, inorganic nitrogen and abscisic acid levels for *Santalum album* L. somatic embryoproduc tion in suspension culture.” *Process Biochemistry* (details?)

Desai V. B., Hiremath R.D., *et al.* (1991). “On the pharmacological screening of HESP and sandalwood oils.” *Indian Perfumer* **35**(2), 69-70.

Dey S. (2002) “Mass cloning of *Santalum album* L. through somatic embryogenesis: scale up in bioreactor.” *Sandalwood Research Newsletter* (Australia), **13**, 1-3. Abstract. *Santalum album* L., the East Indian Sandalwood, enjoys acceptance worldwide because of the uniquefragrance in it’s oil and wood. The natural propagation of this important plant faces twin threats –spike disease and poaching. Regeneration by silvicultural methods being insufficient to meet the demand, several biotechnological routes of propagation has been tried. Somatic embryogenesis offers highest clonal propagation efficiency. Scale up in air-lift bioreactor improves embryo quality, saves laboratory space and minimizes incubation time as well as production cost.

Dijkstra J. & Hiruki C. (1974) "A histochemical study on sandal (*Santalum album*) affected with spike disease and its diagnostic value." *Netherlands J. of Plant Pathology* **80**(2), 37-47.

Dijkstra J. & Lee P.E. (1972) "Transmission by dodder of sandal spike disease and the accompanying mycoplasma-like organisms via *Vinca rosea*." *Netherlands J. of Plant Pathology* **78**(5), 218-224.

Doran J.C., Thomson L.A.C. &. Brophy J.J.(2002). "Sandalwood." *Paper to Regional Workshop on Sandalwood Research, Development and Extension in the Pacific Islands and Asia.* Noumea, New Caledonia, 7–11 October 2002.

Erligmann A. (2001) "Sandalwood oils" *Int. J. of Aromatherapy* **11**(4), 186-192.

European Patent EP1059086 "Use of sandal wood oil or constituents of sandal wood oil for the prevention and treatment of warts, skin blemishes and other viral-induced tumors." Abstract The present invention provides a method for the prevention and treatment of viral-induced tumors, more specifically, human warts. The method uses sandalwood oil and/or derivatives from the sandalwood oil to prepare medicaments for the prevention and treatment of viral-induced tumors (i.e., warts caused by the human papillomavirus (HPV)) in humans. The method of the invention comprises the topical administration of the sandalwood oil or a composition derived therefrom to the human epidermis and/or to the genital tract as needed. The present invention is also concerned with a unique antiviral composition useful for topical application. The antiviral composition according to this invention is also effective against other DNA viruses such as the DNA pox virus that causes *Molluscum contagiosum* and may be effective against other DNA viruses such as AIDS virus and RNA viruses. The sandalwood oil compositions are also effective against genital warts and HPV of the genital tract and will prevent cancer of the skin and cervix. Sandalwood oil or a constituent of sandalwood oil, is also effective in preventing dryness of the skin, rashes and flakiness associated with seborrheic dermatitis, psoriasis and allergic or eczematous rashes of the skin. This oil or constituent is also effective in the treatment of acne lesions of the face and the body and in the eradication of pustular acne lesions caused by Staphylococcal *acne* and Streptococcal bacterial infections.

Fernandes P. C., Bapat V.A. *et al*. (1992). "In vivo germination of encapsulated somatic embryos of *Santalum album* L. (Sandalwood)." *Indian Journal of Experimental Biology* **30**(9), 839-841.

Fernandes, P., Bapat V.A., *et al*. (1994). "Effect of crushed seed homogenate on germination of synthetic seeds of *Santalum album* L." *Indian Journal of Experimental Biology* **32**(11), 840-841.

Fernandes P. C., Bapat V.A., *et al.* (1994). "Investigations on the development of somatic seeds of *Santalum album* L. (Sandalwood)." *Proceedings of the National Academy of Sciences India Section B Biological Sciences* 64(1), 1-8.

Florento A. (1997) "Sandalwood oil faces trouble as crop is destroyed by fire" *Chemical Marketing Reporter* March 31, 1997.

Fox J.E.D.. (2000) "Sandalwood: the royal tree" *Biologist* London **47**(1), 31-34. Abstract. Sandalwood is the most valuable tree in the world. As with gold, platinum and diamonds, it owes its value to a demand based on ritual, fashion and scarcity. It is the stuff of mystery and intrigue, and fortunes can still be made from it.

Fragrance raw materials monographs (1974): "Sandalwood oil, East Indian." *Food & Cosmetics Toxicology* **12**(7-8), 989-990.

Gjerum L., Fox, J.E.D. & Ehrhart L., (eds) (1995) *Sandalwood Seed Nursery and Plantation Technology* FAO, Suva. RAS/92/2361. Field Document No.8.

Griffith W (1836). "On the ovulum of *Santalum album*." *Transactions ofthe Linnean Society of London* (Botany) **18**, 59-70.

Haffner D. (1993). “Determining heartwood formation within *Santalum album* and *Santalum spicatum*.” *Sandalwood Research Newsletter* **1**, 4–5.

Haque M.H. & Haque A.U. (date?) United States Patent 6406706; EP Patent 1,059,086, 2000 "Use of α- and β-santalols major constituents of sandal wood oil, in the treatment of warts, skin blemishes and other viral-induced tumors." Abstract. The present invention provides a method for the treatment of viral-induced tumors in mammals, more specifically, human warts. The method uses α- and β-santalols, or mixtures or derivatives thereof, to prepare medicaments for the treatment of viral-induced tumors i.e., warts caused by the human papillomavirus (HPV) in humans. The method of the invention comprises the topical administration of α- and β-santalols, or mixtures or derivatives thereof, in a composition derived therefrom, to the human epidermis, as needed. The present invention is also concerned with a unique antiviral composition useful for topical application. The antiviral composition according to this invention is also effective against other DNA viruses such as the DNA pox virus that causes Molluscum contagiosum and may be effective against other DNA viruses such as AIDS virus and RNA viruses. The α- and β-santalols composition, or mixtures or derivatives thereof, may also be effective in the treatment of genital warts and HPV of the genital tract and in the treatment of cancer of the skin and cervix. The α- and β-santalols, or mixtures or derivatives thereof, may also be effective in the prevention of dryness of the skin, rashes and flakiness associated with seborrheic dermatitis, psoriasis and allergic or eczematous rashes of the skin. The α- and β-santalols, or mixtures or derivatives thereof, may also be effective in the treatment of acne lesions of the face and the body and in the eradication of pustular acne lesions caused by staphylococcal acne and streptococcal bacterial infections.

Henfrey A (1856). "On the develop-ment of *Santalum album*." *Transac-tions of the Linnean Society of Lon-don (Botany)* **22**, 69-79.

Heuberger E., Hongratanaworakit T. & Buchbauer G. (2001) “Biological properties of the essential oil of East Indian sandalwood (*Santalum album* L.) and its main compounds alpha- and beta-santalol.” Oral presentation *4éme Symposium Internat. D’Aromatherapie Scientifique*, March 2001, Grasse, France.

Heuberger E., Hongratanaworakit T., Buchbauer G. (2001) “Die Wirkung von Sandelholzöl auf das autonome Nervensystem und die subjective Befindlichkeit.” *Vortrag 3, Internat. Primavera Life-Kongress* Oct 2001.

Heuberger E, Hongratanaworakit T, Buchbauer G. (2006) "East Indian Sandalwood and alpha-santalol odor increase physiological and self-rated arousal in humans. *Planta Med.* **72**(9), 792-800. Abstract. In Ayurvedic medicine, East Indian Sandalwood is an important remedy for the treatment of both somatic and mental disorders. In this investigation, the effects of inhalation of East Indian Sandalwood essential oil and its main compound, alpha-santalol, on human physiological parameters (blood oxygen saturation, respiration rate, eye-blink rate, pulse rate, skin conductance, skin temperature, surface electromyogram, and blood pressure) and self-ratings of arousal (alertness, attentiveness, calmness, mood, relaxation and vigor) were studied in healthy volunteers. Compared to either an odorless placebo or alpha-santalol, Sandalwood oil elevated pulse rate, skin conductance level, and systolic blood pressure. alpha-Santalol, however, elicited higher ratings of attentiveness and mood than did Sandalwood oil or the placebo. Correlation analyses revealed that these effects are mainly due to perceived odor quality. The results suggest a relation between differences in perceived odor quality and differences in arousal level.

Hill R., Harne R.W. & Nayar R.M. (1969) “Mycoplasma-like bodies associated with sandal spike” *Nature* **224**, 1121-1122.

Hongratanaworakit T. Dissertation, "Effects of fractions of sandalwood oil on human physiological parameters by inhalation and massage." Vienna, Austria. June 2001. (through Bock J. (2003).

Hongratanaworakit T., Heuberger E., Buchbauer G. (2000). “Effects of sandalwood oil & alpha-santalol on humans I: Inhalation.” Poster presentation, *31st ISEO*, Sept 2000, Hamburg, Germany.

Hongratanaworakit T, Heuberger E. & Buchbauer G. (2004) “Evaluation of the effects of East Indian sandalwood oil and alpha-santalol on humans after transdermal absorption.” *Planta Med.* **70**(1),3-7. Abstract. The aim of the study was to investigate the effects of East Indian sandalwood oil (*Santalum album*, Santalaceae) and alpha-santalol on physiological parameters as well as on mental and emotional conditions in healthy human subjects after transdermal absorption. In order to exclude any olfactory stimulation, the inhalation of the fragrances was prevented by breathing masks. Eight physiological parameters, i. e., blood oxygen saturation, blood pressure, breathing rate, eye-blink rate, pulse rate, skin conductance, skin temperature, and surface electromyogram were recorded. Subjective mental and emotional condition was assessed by means of rating scales. While alpha-santalol caused significant physiological changes which are interpreted in terms of a relaxing/sedative effect, sandalwood oil provoked physiological deactivation but behavioral activation. These findings are likely to represent an uncoupling of physiological and behavioral arousal processes by sandalwood oil.

Husain M., Ponnuswamy A.M. & Ponnuswamy P.K. (1982) “An innovation in the vegetative propagation of sandal (*Santalum album* L.).” *Indian J. Forest.* **5**, 1-7.

ISO 3518 Oil of Sandalwood (*Santalum album* L.) 2nd edn 2002. pub. ISO. Geneva 2002.

Iyengar G.S. (1937). "Life-history of *Santalum album* L." *Journal of Indian Botanical Society* **16**, 175-195

Iyengar A.V.V. (1968). "The East Indian sandalwood oil." *Indian Forester* 57, 57-68

Iyengar A.V.V. (1972) “Control of sandal spike” *Current Science* **41**(9), 318-319.

Iyenger A.V.V. (1972) "Some aspects of sandal spike disease" *J. Scient. Ind. Res.* **31**, 331-342.

Jain S.H., Angadi V.G., Rajeevalochan A.N., Shankaranarayana K.H., Theagarajan K.S. & Rangaswamy C.R. (1998) "Identification of provenances of Sandal in India for genetic conservation" *ACIAR Proceedings*, No.**84**, 1998, 117-120.

Jain S.H. & Rangaswamy C.R. (1998). "Soil properties and their relationship to the growth of Sandal (*Santalum album* L) in three study areas in Karnataka." *Myforest* **24**, 141-146.

Jain S.H., Angadi V.G., Ravikumar G., Thegrajan K.S. & Shankaranarayana (1999) “Studies on cultivation & chemical utilisation of sandal (*Santalum album* L.).” *PAFAI Journal* **1**, 49-53.

Jain S.H. Angadi V.G., Shankaranarayana K.H. & Ravikumar G. (2003) "Relationship between Girth and percentage of oil in treesof sandal (*Santalum album* L.) provenances." *Sandalwood Research Newsletter* 18. Abstract. In three provenance areas of sandal viz. Bangalore, Thangli (Karnataka) and Maryoor (Kerala), studies have been made in respect of GBH and oil. It was observed that percentage of oil remains nearly constant at 4 % after 80 cm girth and that rise in oil percentage beyond 80 cm girth was found to be just marginal.

Jirovetz L, Buchbauer G, & Jager W. (1992) “Analysis of fragrance compounds in blood samples of mice by gas chromatography, mass spectrometry, GC/FTIR and GC/AES after inhalation of sandalwood oil.” *Biomed. Chromatography* **6**, 133-134. Abstract. After inhalation experiments with sandalwood oil and the pure fragrance compounds coumarin and alpha-terpineol, substances were detected and measured in the blood samples of test animals (mice) using gas chromatography/mass spectrometry (GC/MS) (MID) in connection with GC/FTIR (SWC), GC/AES (carbon and oxygen trace) and flame ionization detection/gas chromatography. Using tiglinic acid benzyl ester as the internal standard the following concentrations in serum could be found: alpha-santalol 6.1 ng/mL, beta-santalol 5.3 ng/mL and alpha-santalene 0.5 ng/mL. In separate inhalation experiments with coumarin and with alpha-terpineol the corresponding concentrations were 7.7 ng/mL and 6.9 ng/mL, respectively.

Jones C.G., Ghisalberti E.L., Plummer J.A. & Barbour E.L. (2006) "Quantitative co-occurrence of sesquiterpenes; a tool for elucidating their biosynthesis in Indian sandalwood, *Santalum album*." *Phytochemistry*. **67(**22), 2463-8. Abstract. A chemotaxonomic approach was used to investigate biosynthetic relationships between heartwood sesquiterpenes in Indian sandalwood, *Santalum album* L. Strong, linear relationships exist between four structural classes of sesquiterpenes; alpha- and beta-santalenes and bergamotene; gamma- and beta-curcumene; beta-bisabolene and alpha-bisabolol and four unidentified sesquiterpenes. All samples within the heartwood yielded the same co-occurrence patterns, however wood from young trees tended to be more variable. It is proposed that the biosynthesis of each structural class of sesquiterpene in sandalwood oil is linked through common carbocation intermediates. Lack of co-occurrence between each structural class suggests that four separate cyclase enzymes may be operative. The biosynthesis of sandalwood oil sesquiterpenes is discussed with respect to these co-occurrence patterns. Extractable oil yield was correlated to heartwood content of each wood core and the oil composition did not vary significantly throughout the tree.

Jones C.G., Keeling C.I., Ghisalberti E.L., Barbour E.L., Plummer J.A., Bohlmann J.(2008) "Isolation of cDNAs and functional characterisation of two multi-product terpene synthase enzymes from sandalwood, *Santalum album* L." *Arch Biochem Biophys.* 2008 May 27. Abstract. Sandalwood, *Santalum album* (Santalaceae) is a small hemi-parasitic tropical tree of great economic value. Sandalwood timber contains resins and essential oils, particularly the santalols, santalenes and dozens of other minor sesquiterpenoids. These sesquiterpenoids provide the unique sandalwood fragrance. The research described in this paper set out to identify genes involved in essential oil biosynthesis, particularly terpene synthases (TPS) in *S. album*, with the long-term aim of better understanding heartwood oil production. Degenerate TPS primers amplified two genomic TPS fragments from *S. album*, one of which enabled the isolation of two TPS cDNAs, SamonoTPS1 (1731bp) and SasesquiTPS1 (1680bp). Both translated protein sequences shared highest similarity with known TPS from grapevine (*Vitis vinifera*). Heterologous expression in Escherichia coli produced catalytically active proteins. SamonoTPS1 was identified as a monoterpene synthase which produced a mixture of (+)-alpha-terpineol and (-)-limonene, along with small quantities of linalool, myrcene, (-)-alpha-pinene, (+)-sabinene and geraniol when assayed with geranyl diphosphate. Sesquiterpene synthase SasesquiTPS1 produced the monocyclic sesquiterpene alcohol germacrene D-4-ol and helminthogermacrene, when incubated with farnesyl diphosphate. Also present were alpha-bulnesene, gamma-muurolene, alpha- and beta-selinenes, as well as several other minor bicyclic compounds. Although these sesquiterpenes are present in only minute quantities in the distilled sandalwood oil, the genes and their encoded enzymes described here represent the first TPS isolated and characterised from a member of the Santalaceae plant family and they may enable the future discovery of additional TPS genes in sandalwood.

Jones C. (date?) "Indian Sandalwood: Genetic and oil diversity and bio-chemistry of the Australian germplasm collection." *Sandalwood Research Letter* ?

Jyothi, P. V., J. B. Atluri, *et al*. (1991). “Pollination ecology of *Santalum album* (Santalaceae).” *Tropical Ecology* **32**(1), 98-104.

Kapoor M.L. (1981) “A technique for chromosome count from developing leaf buds of induced tetraploids & diploid *Santalum album* L.” *Indian Forester* **107**, 290-300.

Kababick, J. P. (1996). “Evaluation on incense purity using simultaneous steam distillation-extraction and HRGC analysis.” *Journal of High Resolution Chromatography* **19**(4), 241-242.

Kawanishi Y., Nin K. & Toyoda K. (2004) “The influence on the autonomic nervous system of a preference for the smell of sandalwood” *Aroma Research* **5**(4), 382-385.

Khan M.M.., Faroqui A.A., Vasundhara M. & Srinisappa K.N. (1999) “Clonal propagation of sandalwood (*Santalum album* Linn.) *PAFAI Journal* **1**, 20-24.

Kulkami H.D. & Srithmathi R.A. (1981) “Polyembryony in the genus *Santalum* L.” *Indian Forester* **107**(11), 704-706.

Madhi A. (1986) "The biology of *S. album* seed." *Biotrop. Tech. Bull.* **1**(1), 1-9.

Mathur, N.K. 1979. An annotated bibliography of spike disease of sandal (*Santalum album* Linn.) *Forestry Research Institute*. Dehra Dun. 74 p.

Mayar R. (1988) “Cultivation Information, Exploitation & Protection of *Santalum album*.” *Advances in Forestry research in India* Vol II p117-152.

Merlin M. & Van Ravenswaay D. “The history of human impact on the genus *Santalum* in Hawai’i.” Paper presented at the *Symposium on Sandalwood in the Pacific,* 1990. Abstract. Adaptive radiation of *Santalum* in the Hawaiian archipelago has provided these remote islands with a number of endemic species and varieties. The prehistoric Polynesian inhabitants of Hawai‘i utilized the sandalwood trees for many of the same traditional purposes as their South Pacific ancestors who had developed ethnobotanical relationships with *Santalum*. The ancient Hawaiians probably reduced the number and geographical distribution of sandal-wood trees significantly through their extensive cutting and burning, especially in the dry forest regions. Nevertheless, vast numbers of the fragrant trees still existed in Hawai‘i at the time of Western contact in 1778. Within a century after this contact, the extensive trade in sandalwood produced a massive decline in the Hawaiian species of *Santalum*. Although cultivation attempts during this cen-tury with both introduced and native sandalwood species have had limited success in Hawai‘i, there is renewed interest in developing a sustainable forest industry based on the production of sandalwood for export trade. Biologists in general, however, have cautioned against large-scale harvesting of the remain-ing *Santalum* trees, suggesting that more research be undertaken first to deter-mine the distribution and vigor of the remaining species.

Mookherjee B., Kamath V., Patel R. & Shuster E. (of International Flavours & Fragrances Ltd.) (1976) US Patent 4,000.050.

Mookherjee B., Kamath V. & Shuster E. (of International Flavours & Fragrances Ltd.) (1977) US Patent 4,014,823.

Morris E.T. (1983) “The Fascinating History of Sandalwood” *Dragoco Report* 44-51.

Nagaveni H.C. & Srimathi R.A. (1980) "Use of giberellic acid to assist germination of sandal seeds." *Indian Forester* **106**(11), 792-799.

Nagaveni H.C. & Srimathi R.H. (1981) “Studies on germination of sandal seeds *Santalum album* L. Linn. II” *Indian Forester* **106**, 792-799.

Nagaveni. H.C. & Vijayalakshmi G. (2003) Sandalwood Research Newsletter 18. "Growth performance of sandal (*Santalum album* L.) with different host species." Abstract. *Santalum album* L (Sandal plant) is a partial root parasite on several host plants.It shows a preference to certain host species and grows well. In the presentstudy, *Pongamia pinnata* and *Casuarina equisetifolia* supported the sandal plants, yielding robust growth, where as some hosts like *Artocarpus integrifolia*, *Acacia auriculiformis* and *Swietenia mahogany* hindered the growth of sandal. Understanding the dynamics of parasitism may help in raising successful multi species plantations of sandal along with other valuable timber species.

Narayana K.H.S. & Parthasarathi K. (1986) "HESP - a new essential oil from the acid hydrolysis of spent sandal heartwood." *Perf. Flav*. **10**(6), 60-1.

Naqvi A.A., Singh A.K. & Mandal S. (1999) “Quality evaluation of sandalwood (*Santalum album*) oil grown in northern parts of India. *Indian Perfumer* **43**, 67-69.

Nasi, R., and Y. Ehrhart. (1996). “Le Santal, un parfum de prospérité. 1ère partie–une longue histoire.” *Bois et Forêts des Tropiques* **247**, 5–19.

Nasi R. & Ehrhart Y. (1996) “Sandalwood, a perfume of prosperity” Part 2 Plantations.” *Bois-et-Forets-des-Tropiques* **248**, 5-20.

Nayar R. (1981) “Interrelations between mycoplasma-like organisms in spiked sandal (Santalum *album* L.) & infected collateral hosts” *Eur. J. For. Pathol*. **2**, 29-32.

Nayar, R. (1984). “Investigations with sandalwood (*Santalum album*) Mycoplasma and toxins.” *European Journal Of Forest Pathology* **14**(1), 59-64.Nikiforov, A.,

Nayar R. (1988) "Cultivation, improvement, exploitation & protection of *Santalum album* Linn." *Advances in Forestry Research in India* **2**, 117-151.

Ngo K-S. & Brown G. D. (2000) "Autoxidation of alpha-santalene." *Journal of Chemical Research* **2000** (2). 68-70(3) Abstract. Fifteen compounds (2 - 11) have been isolated from the spontaneous slow autoxidation of the tri-substituted double bond in the side-chain of the tricyclic sesquiterpene -santalene; most of these compounds have also been reported as natural products.

Ochi T., Shibata H., Higuti T., Kodama K.H., Kusumi T., Takaishi Y "Anti-*Heliobacter pylori* compounds from *Santalum album*."*J. Nat Products* **68**(6), 819-824. Abstract: Six new sesquiterpenes, (Z)-2-beta-hydroxy-14-hydro-beta-santalol (1), (Z)-2alpha-hydroxy-albumol (2), 2R-(Z)-campherene-2,13-diol (3), (Z)-campherene-2beta,13-diol (4), (Z)-7-hydroxynuciferol (5), and (Z)-1beta-hydroxy-2-hydrolanceol (6), together with five known compounds, (Z)-alpha-santalol (7), (Z)-beta-santalol (8), (Z)-lanceol (9), alpha-santaldiol (10), and beta-santaldiol (11), were isolated from *Santalum album*, by using bioassay-guided fractionation for *Helicobacter pylori*. The structures were determined by extensive NMR studies. The absolute configuration of compound 3 was determined by a modified Mosher method. The crude extracts as well as the isolated compounds showed antibacterial activity against *H. pylori*. Especially, compounds 7 and 8 have strong anti-*H. pylori* activities against a clarithromycin-resistant strain (TS281) as well as other strains.

Ohmori A., Shinomiya K., Utsu Y., Tokunaga S., Hasegawa Y. & Kamei C. (2007) "[Effect of santalol on the sleep-wake cycle in sleep-disturbed rats]" *Nihon Shinkei Seishin Yakurigaku Zasshi.* **27**(4),167-71. Abstract. Sandalwood oil is widely used in aromatherapy for alleviating various symptoms. Santalol, a major component of sandalwood oil, has been reported to have central nervous system depressant effects such as sedation. In the present study, we investigated the effect of santalol on the sleep-wake cycle in sleep-disturbed rats. When inhaled at a concentration of 5 X 10(-2) ppm, santalol caused a significant decrease in total waking time and an increase in total non-rapid eye movement (NREM) sleep time. In order to clarify the mechanism of action, olfactory hypofunction was caused in rats by intranasal application of 5% zinc sulfate solution, and thereafter the effects of inhalation of fragrances were evaluated. In this study, it was found that the impairment of the olfactory system showed no significant effect on the changes in sleep parameters induced by santalol. This result suggests that santalol may act via the circulatory system rather than the olfactory system. That is, santalol is thought to be absorbed into the blood through the respiratory mucosa, and then exert its action. From these results, it is concluded that santalol may be useful in patients having difficulty maintaining sleep without being affected by individual differences in perfume-related preference.

Okugawa H., Ueda R., Matsumoto K., Kawanishi K. & Kato A. (1995). "Effect of a-santalol and b-santalol from sandalwood on the central nervous system in mice." *Phytomed* **2** (2), 119-126.

Parry E.J. *Sandalwood Oil* Pub. Govt. of Mysore (date unknown).

Parthasarathi K., Rangaswamy C.R. & Anguah V.C. (1985) "Leaf peroxidase, malate dehydrogenase & ertrase isoenzyme pattern in ten sandalwood (*Santalum album*) types showing variation in leasf pattern." *Indian Forester* **111**, 441-449.

Parthasarathi K., Rangaswamy C.R., Jayaraman K & Rao P.S (1973) "Studies on sandal spike. Part X. Deoxyribonuclease & ribonuclease activities and nucleic acid levels in sandal (*Santalum album* Linn.) affected by spike mycoplasma." *Proceedings of the Indian Academy of Sciences* **77**(3), 131-136.

Parthasarathi K. *et al.* (1973) "Hosts of sandalwood." *Current Science* **43**(1), 20.

Parthasarathi K., Gupta S.K. & Rao P.S. (1974). "Differential response in the cationexchange capacity of the hostplants on parasitization on sandal (*Santalum album*)." *Curr.Sci*. **43**, 20

Parthasarathi K. & Venkatesan K.R. (1982) "Sandal spike disease" *Current Science* **51**(5), 225-230.

Parthasarathi K., Angadi V.G.,Shankaranarayana K.H. & Ra-jeevalochan, A.N. (1986). "Peroxi-dase isoenzyme activity in the livingbask tissue as a marker for the oil-bearing capacity in Sandal." *Current Science* **55**, 831-34.

Parthasarathi, K; Rai, S.N. (1989). "Physiology, chemistry and utilization of sandal (*Santalum album* Linn.)." *My Forest* **25**(2): 181-219.

Prakash NA, Farooqi AA & Vasundhara M. (1999) "Studies on root parasitism and nutrition of sandalwood (*Santalum album* L.) *PAFAI Journal* **1**, 25-29.

Preen C. (2005) "Update on Sandalwood Essential Oil" *Aromatherapy Regulation News* Summer 2005 Newsletter **2**(2), 4. Aug 2005. ***Cropwatch comments***: Further proof, if it were needed, that some Aromatherapy (AT) organisation officials have been 'in denial' about the role of aromatherapy as a consumer market affecting the serious demise of sandalwood species - here Preen attempted to shift the blame to the perfumery trade. Further, Preen argued that *Santalum album* is not actually endangered (the IUCN Red List http://www.iucnredlist.org/search/details.php/31852/all classifies it as vulnerable), wrings her hands a little about sandalwood smuggling, and pledges faith in the much-criticised sandalwood replanting schemes to eventually solve the problem 30-40 years hence. Cropwatch currently observes that little, if any, Sandalwood oil East Indian is currently available on the spot market, and what there is, is practically always adulterated - it is of note that the AT professional organisations have no formal analytical standards for sandalwood oil used in aromatherapy to determine whether or not this is the case. Further, the carbon footprint of sandalwood oil is particularly unacceptable wrt climate change concerns, with excessive energy consumption occurring as a result of long distillation times. Therefore by continuing to defend the use of E.I. sandalwood oil in AT, one can only conclude that any ecological interests have been inappropriately sold out to the commercial interests of AT essential oil traders, who anyway have an unhealthy & unseen influence on the policy of many AT professional organisations. Further, aromatherapists are likely to be indirectly supporting gangland by consuming sandalwood oil, most of which is either smuggled with or without the help of corrupt officials, or otherwise illegally produced. This was a completely wrong-headed & misleadfing article (in Cropwatch's humble opinion, of course)..

Radomiljac, A. M., J. A. McComb, *et al.* (1998). "Xylem transfer of organic solutes in *Santalum album* L. (Indian sandalwood) in association with legume and non-legume hosts." *Annals of Botany* **82**(5), 675-682.

Radomiljac, A.M., McComb J.A., Shea S.R. (1998) "Field establishment of *Santalum album* – the effect of the time of the introduction of a pot host (*Alternanthia nana* R.Br.)" *Forest Ecology & Management* **111** (2-3), 107-118. Abstract: Field establishment of the root hemi-parasite *Santalum album* L. under large-scale plantation conditions, until recently, has been largely unsuccessful. In this experiment, the growth of *S. album* seedlings grown with the herbaceous pot host *Alternanthera nana* R. Br. for 134, 109, 84, 60 and 35 days in a nursery container prior to field establishment was examined after 11, 16 and 23 weeks in the field. *S. album* survival and growth was greater, and root:shoot ratio was lower for the 23 weeks for *S. album* seedlings grown with *A. nana* compared with seedlings grown without a host. Seedlings grown with *A. nana* for 134 days in the nursery prior to field establishment had greater stem diameter, height and root, shoot and total plant dry weight (DW) over the 23 weeks in the field than all other treatments. Seedlings grown with A. nana for 109 days in the nursery prior to field establishment had greater field survival than all other treatments. *A. nana* survival in the field remained high when grown with *S. album* for 134 and 109 days in the nursery prior to field establishment whereas survival within remaining treatments declined significantly and *A. nana* growth was significantly less. *S. album* grown with *A. nana* for 134 days in the nursery prior to field establishment had a lower root:shoot ratio than all other treatments at all assessments. A strong negative linear relationship exists between *S. album* root:shoot ratio and *A. nana* DW, whereas a positive linear relationship exists between *S. album* DW and *A. nana* DW. Foliar phosphorus and sodium concentrations for *S. album* were lower and foliar potassium concentration higher when seedlings were grown with *A. nana* for 134 days in the nursery prior to field establishment compared with the remaining treatments at the 16-week assessment. The period of the *S. album*:-*A. nana* association in the nursery significantly influenced S. album survival and growth following field planting.

Radomiljac A. M. & McComb J.A. *et al.* (1999). "Intermediate host influences on the root hemi-parasite *Santalum album* L. biomass partitioning." *Forest Ecology and Management* **113**(2-3), 143-153.

Radomiljac A. M. & McComb J.A. *et al.* (1999). "Gas exchange and water relations of the root hemi-parasite *Santalum album* L. in association with legume and non-legume hosts." *Annals of Botany* **83**(3), 215-224.

Radomiljac A.M., Ananthapadmanabho H.S., Welbourne R.M & Satyanarayan Rao, K.(eds), (1999). "*Sandal and its Products". Proceedings of an International Seminar held on 18-19 December 1997* organised by the Institute of Wood Science and Technology (ICFRE) and Karnataka State Forest Department, Bangalore India. Canberra: ACIAR Proceedings No 84.

Radomiljac, A.M., McComb, J.A. and Pate, J.S. (1999). "Organic solute transport and assimilation in *Santalum album* L. (Indian sandalwood): intermediate host partnerships involving beneficial and non-beneficial hosts." *Annals of Botany* **83**, 215-224.

Rai S N (1990) "Status and cultivation of sandalwood in India." In: *Proceedings of the Symposium on Sandalwood in the Pacific* (eds L Hamilton. & C E Conrad). General Technical Report PSW – 122. USDA Forest Service, Berkeley, 66–71. Abstract: Sandalwood (*Santalum album*) has been part of Indian culture and heritage for thousands of years, and was one of the first items traded with other countries. The heartwood yields fragrant oil, which is used mainly in the perfume industry but also has medicinal properties. The wood is used for carving and manufacturing incense. Generally *S. album* is found in the dry deciduous forests of Deccan Plateau, mostly in the states of Karnataka and Tamil Nadu, The evergreen tree regenerates naturally when conditions are favorable and has been spreading in its distribution. Lack of understanding of the dynamics of hemiparasitism by sandalwood has caused failure of pure plantations in the past; haustorial connections with its hosts supply sandalwood with nitrogen, phos-phorus, and potassium. Plantable seedlings can now be raised in the nursery in 6-8 months with the protection of a nematicide and fungicide. Several tech-niques for planting seeds directly in the field have also been developed. A tree that is growing well can put on an annual increment of 1 kg per year. The sandalwood resource in India is currently threatened by four factors: fire, browsing by livestock, spike (little leaf) disease, and smuggling.

Rai S.N. & Sarma C.R. (1990) "Depleting sandalwood production and rising prices. *Indian Forester* **116**, 348-355.

Ramanathan C. (1997). “Indian Sandalwood Trade.” In: *TED Case Studies: Sandalwood Case.* www.american.edu/projects/mandala/TED/sandalwood.htm

Rangaswamy N. S. & Rao P.S.(1963). "Experimental studies on *Santalum album* L.: Establishment of tissue culture of endosperm." *Phytomorphology* **13**, 450-454.

Rangaswamy, C.R., Jain S.H. & Parthasarathy K. (1986). "Soil proper-*ties* of some Sandal bearing areas." *Van Vigyan* **24** (3&4), 61-68.

Rangaswamy K.T. & Jayarajan R. (1998) “The distribution of spike disease in the forests of Tamil Nadu.” *Current Research University of Agricultural Sciences Bangalore* **27**(4), 76-77.

Rao P. S., Bapat V.A., *et al.* (1984). “Regulatory factors for in vitro multiplication of sandalwood tree (*Santalum album*): 2. Plant regeneration in nodal and internodal stem explants and occurrence of somaclonal variations in tissue culture raised plants.” *Proceedings of the Indian National Science Academy Part B: Biological Sciences* **50**(2), 196-202.

Rao P.S. & Ozias-Atkins P. (1985) "Plant regeneration through somatic embryogenesis in protoplast cultures of sandalwood.” *Protoplasma* **124**(1-2), 80-86.

Rao P.S. (1987) Clonal multiplication of plants of economic value: sandalwood, mulberry and oil palm. pp. 225-229. In *Proceedings of Workshop on Increasing Crop Productivity*, Bombay, 20-21 June, 1986. New Delhi: Oxford and IBH.

Rao P.S., Chrungoo N.K., *et al.* (1996). “Characterization of somatic embryogenesis in sandalwood (*Santalum album* L.). *In vitro* cellular and developmental biology” *Plant* **32**(3),123-128.

Remadevi, O. K., Muthukrishnan R., *et al*. (1997). “Epidemic outbreak of lac insect, *Kerria lacca* (Kerr.), on *Santalum album* (Sandal) and its control.” *Indian Forester* **123**(2), 143-147.

Ross M.S. (1983). *Bibliography on Sandalwood, Santalum album*. Unpublished - copy held at University of Oxford, UK (although see Ross (1985). ***Cropwatch comments***: A unique bibliography of nearly 800 references & papers, many of them reviewed (& much of the subject matter concerning splike disease) drawn from references within the former Commonwealth Forestry Institute at Oxford, and from other sources

Ross M.S. (1985). *Annotated bibliography on sandalwood, Santalum album, and its uses*. Bos-Document 2. Dutch Forestry Development Cooperation, Wageningen, The Netherlands. 135pp

Roychoudhuri S.P. & Verma A. (1980) “Sandalwood spike.” *PAFAI Journal* **1**, 25-29.

Sahai A.. & Shivanna K.R. (1984). “Seed germination, seedling growth and haustorial induction in *Santalum album*, a semi-root parasite.” *Proceedings ff the Indian Academy of Sciences: Plant Sciences* **93**(5), 571-580.

Sekhar A. R. C & Vinaya Rai R. S. (2000) “Production and export of selected non-wood forest products in India in 2005.” *Journal of Tropical Forest Products* **6** (1) 1-11

Sanjaya B.M., Thrilok S.R. & Vittal R.R. (2006) "Micropropagation of an endangered Indian sandalwood (*Santalum album* L.). J. of Forest Research* **11**(3), 203-209. Abstract *Santalum album* is known as East Indian sandalwood. It is the most economically important tree harvested for heartwood oil, and India is among the chief exporters of sandalwood and its products. Multiple shoots were induced from nodal shoot segments derived from a 50- to 60-year-old candidate plus tree (CPT) on Murashige and Skoog (MS) medium supplemented with 0.53 µM α-naphthaleneacetic acid (NAA) and 11.09 µM 6-benzylaminopurine (BA). In vitro differentiated shoots were multiplied on MS medium with 0.53 µM NAA, 4.44 µM BA, and additives: 283.93 µM ascorbic acid, 118.10 µM citric acid, 104.04 µM cystine, 342.24 µM glutamine, and 10% (v/v) coconut milk. New shoots were harvested repeatedly for up to three subculture passages on fresh medium at 4-week intervals. Microshoots treated with 98.4 µM indole-3-butyric acid (IBA) for 48 h produced roots on growth-regulator-free, quarter-strength MS basal salts medium with vitamin B5 and 2% sucrose. In vitro root induction was achieved from microshoots pulsed with 1230 µM IBA for 30 min in soilrite rooting medium. The percentage of rooting in soilrite was higher than that for agar medium, and in vitro raised plants were established in the field and showed normal growth.

Scartezzini P. & Speroni E. (2000). "Review on some plants of Indian traditional medicine with antioxidant activity." *J. of Ethnopharm.* **71**(1-2), 23-43.

Scheffel M. (1990) "Sandalwood: Current Interest and Activity by the Hawaii Division of Forestry and Wildlife." *Proceedings of the Symposium in the Pacific* 1990 Abstract: The State of Hawaii Department of Land & Natural Resources (DLNR) protects native species growing on State land, but has no official program funding for growing sandalwood. Part of the DLNR, the Division of Forestry and Wildlife forest and nursery managers maintain exuberant activity in attempting to establish their nursery stock of sandalwood in the field out of personal interest. Nursery and planting techniques are described.

Scott J. (1871) "Root parasitism by sandalwood." J. *Agric. Hort. Soc. India* **2**,287.

Sen Sarma P.K. (1982) "Sandalwood – its Cultivation & Utilisation." In *Cultivation and Utilisation of Medicinal & Aromatic Plants* (eds C.K. Atal & B.M. Kapur). Regional Research Laboratory, Jammi–Tawi pp 395-405.

Shankaranarayana K.H. & Parthasarathi K. (1984). "Compositional differences in sandal (*Santalum album*) oils from young and mature trees and in the sandal oils undergoing color change on standing." *Indian Perfumer* **28**(3-4), 138-141.

Shankaranarayana, K. H., Angadi V.G., *et al.* (1997). "A rapid method of estimating essential oil content in heartwood of *Santalum album* Linn." *Current Science* **72**(4), 241-242.

Shankaranarayana, K.H., Ravikumar G., Rajeevalochan A.N., Theagarajan K.S. & Rangaswamy C.R. (1998). "Content and composition of oil from the central and transition zones of sandalwood discs. *ACIAR Proceedings* **84**, 86–88.

Sheen J. & Stevens J. (2001) "Self-perceived effects of Sandalwood" *Intl J. of Aromatherapy* **11**(4), 213-219. Abstract: Eight female participants used the essential oil of *Santalum album*, East Indian Sandalwood, as a perfume daily for a week. Their self-perceived effects were analyzed for common experiences, using the grounded theory method. Four categories of the experience were developed into an initial theory of the effects of sandalwood. It was found that sandalwood did have self-perceived effects, which varied with initial psychological state and emporal factors. The observed self-perceived effects of calming, ability to manage and well being have limited co-relation with claimed therapeutic effects. A further self-perceived effect, uplifting, was observed such that further investigation is required. This study is a demonstration of the initial steps of a holistic research model that would allow for aromatherapy, essential oils, their therapeutic effects and the experience of their use to be researched. Thus a sound scientific knowledge base for the profession of aromatherapy, relevant to its practice can be developed.***Cropwatch comments***: Recommended reading on self-perceived therapeutic effects of sandalwood!

Shieh J. C., Lin T.S. *et al*. (1990). “Essential oil yield and component variation from S*antalum album* wood of different age in Taiwan.” *Bulletin Of Taiwan Forestry Research Institute: New Series* **5**(1), 45-52.

Shineberg D. (1967) *They came for Sandalwood: A study of Sandalwood Trade in The SW Pacific 1830-1865*.”Melborn University Press 1967.

Shiri, V. & K. S. Rao K.S. (1998). “Introduction and expression of marker genes in sandalwood (*Santalum album* L.) following *Agrobacterium*-mediated transformation. *Plant Science* **131**(1), 53-63.

Shankaranarayana K.H. & Parthasarathi K. (1984) "Compositional differences in sandal oils from young and mature trees and in the sandal oils undergoing colour change on standing." *Indian Perfumer* **28**(3/4), 138-141.

Shankaranarayana, K. H. & K. Parthasarathi K.(1984) "Synthetic sandalwood aroma chemicals." *Perf. & Flav*. **9**(1), 17-20.

Shankaranarayana, K. H. & Kamala B.S. (1989) "Fragrant products from less obvious sandalwood oil" *Perf. & Flav.* **14**(1), 19-21.

Sindhuveerendra, H. C., S. Ramalakshmi, et al. (1999). Variation in seed characteristics in provenances of sandal (*Santalum album* L.). *Indian Forester* **125**(3), 308-312.

Sita G.L. (1991) "Tissue cultured sandalwood." *Current Science* **61**(12), 794-795.

Sindhuveerendra HC & Sujatha M. (1989). "Pollination studies in *Santalum album* L." *Current Science* **58**, 629-630.

Srinivasa I.G. (1937). "Life history of *Santalum album*." *Journal of Indian Botanical Sciences* **16**,175-196

Srivinivisan V.V. Sivaramakrishnan V.R., Rangaswamy C.R., Ananathpodmanabha MS & Shankaranarayana (1995) “Sandal (*Santalum album*)”. *Indian Council of Forestry Research & Education, Dehradun.*

Starke J.C. (1967) "Photoallergy to sandalwood oil" *Arch Dermatol* **96**(1), 62-63.

Struthers R.; Lamong B.B.; Fox J.E.D.; Wejesuriya S.R. & Crossland T. (1986). “Mineral nutrition of sandalwood (*Santalum spicatum*). *Journal of Experimental Biology* **37**(182), 1274-1284.

Subbarao, N. S., Yadav D., *et al*. (1990). “Nodule haustoria and microbial features of Cajanus and Pongamia parasitized by sandal (sandal wood).” *Plant And Soil* **128**(2), 249-256.

Suma T.B. & Balasundaran M. (2003). "Isozyme variation in fiveprovenances of *Santalum album* in India." *Australian Journal of Botany* **51**, 243-249.

Sunil T. & Balasundaran, M (2001) "Purification of sandal spike phytoplasma for the production of polyclonal antibody." *Current Science Online* **80**(12), 1489-1494. Abstract. Sandal (*Santalum album.* L), a semiroot parasitic tree is the source of the East Indian sandalwood and oil. Spike disease caused by phytoplasma is the major disease of sandal. The disease is noticed in all major sandal-growing states of India.

Suriamidhardja S. (1978) "Problems on Sandalwood (*Santalum album* Linn.) silviculture & improving its production." In: *Proc of 3rd Seminar on Volatile Oils*, Bogor, Indonesia, July 1978. Bogor: Balai Penelitian Kimia

Surendran, C., Partiban, K.T., Bhuvenaswaran, C. and Murugesh, M. (1998) . “Silvicultural strategies for augmentation of sandal regeneration.” In: Radomiljac A.M., Ananthapathmanabha H.S., Welbourn R.M., Stayanarayan K. (eds.) *Sandal and its products.* ACIAR Proceedings Volume **84**. Arawang Communications, Canberra. pp. 69-73.

Swami R.N. & Srinivasa R.V. (1980) “Accelerated germination of sandal seeds (*Santalum album* L.) *Lal Bagh J.* **25**, 68-69.

Thomas, S. & Balasundaran M. (1999). “Detection of sandal spike phytoplasma by polymerase chain reaction.” *Current Science* **76**(12), 1574-1576.

Uniyal, D. P., Thapliyal R.C. *et al.* (1985). “Vegetative propagation of sandal (*Santalum album*) by root cuttings.” *Indian Forester* **111**(3), 145-148.

Valluri, J. V., Treat W.J. *et al*. (1991). “Bioreactor culture of heterotrophic sandalwood (*Santalum album* L.) cell suspensions utilizing a cell-lift impeller.” *Plant Cell Reports* **10**(6-7), 366-370.

Valluri J.V., and D.B. Chambers (1992). "Protein synthesis in sandalwood callus cultures exposed to drought and salt stress." *Plant Physiology and Biochemistry* **99**(5), 51 – 52. .

Vaze Suresh (1999) “Sandal – introductory Note” *PAFAI Journal* **1**, 17-19.

Veerendra, H. C. S. & Sarma C.R. (1990). “Variation studies in sandal (*Santalum album* L.): I. Time of emergence and seedling vigor.” *Indian Forester* **116**(7), 568-571.

Veerendra, H. C. S. & Padmanabha H.S.A. (1996). “The breeding system in sandal (*Santalum album* L.).” *Silvae Genetica* **45**(4), 188-190.

Venkata Rao, M.G. (1938). “The influ-ence of host plants on sandal andspike disease.” *Ind. For.* **64**(11) : 656-669.

Venkatesha, M. G. & Gopinath K. (1994). “Description of immature stages of a species of gt lyptapanteles (Hymenoptera: Braconidae), a gregarious endoparasitoid of *Amata passalis* (Fabricius) (Lepidoptera: Arctiidae), a defoliator of sandalwood, *Santalum album* L. *Insect Science and its Application* **15**(2), 161-165.

Walker H. (1966). "The market for sandalwood oil." *Tropical Product Institute, Ministry of Overseas Development. London.*

Yusuf, R. (1999). “*Santalum album* L.” pp 161–167 In: Oyen, L.P.A., and Nguyen Xuan Dund (eds.). *Plant Resources of South-East Asia Vol 19. Essential-oil Plants*. Prosea, Bogor, Indonesia.

Indonesian Sandalwood (*Santalum album).*

Anon (2003) “Police seize 13.6 tons of sandalwood” *Jakarta Post* 9.30.2003 KUPANG, East Nusa Tenggara: Abstract. 13,645 kilograms of sandalwood allegedly smuggled from neighboring East Timor was seized, supposedly being sent to sandalwood distilling firm PT Tropicana Oil.

Husain A.M.M. (1983) “Report on the Rehabilitation of Sandalwood & the trade in Nasa Tenggara Timur Indonesia. *World Bank PPIPD Project Report, West Timor.*

Omon, R. M. (1994). “The effects of N, P, K and NPK fertilizer on the growth of Cendana (*Santalum album* Linn.) in nursery of Latosol soil.” *Buletin Penelitian Hutan* (565), 55-64. Forest Research and Development Centre, Bogor 16001, Indonesia.

Risseeuw P. (1950)."Sandelhout (Sandalwood)." In C.J.J. van Hall and C.van deKoppel, *De Landbouw in de Indische Archipel (Agriculture in the Indonesian Archipelago).* The Hague Vol 3 pp686-705.

Suriamihardia S. (1978) "[Problems on sandalwood (*Santalum album* Linn.) silviculture and improving its production]". pp. 115-125. In *Proceedings of Third Seminar on Volatile Oils*, Bogor, Indonesia, July, 1978. Bogor: Balai Penelitian Kimia.

Walker H (1966) "The Market for Sandalwood Oil" *TPI Rep. Trop. Prod. Inst. London* (G22): 13.

Widiadana, Rita A. (13.03.2002) "Illegal trade in endangered species on the rise in RI" *Jakarta Post* 13.03.2002. Abstract. Widiadana comments on the increasing trade in endangered species including trade in orchids and sandalwood.

Yadav V.G. (1993) "Sandalwood: its origin, synthetic substitutes & structure-odour relationship." *PAFAI Journal* **15**(4), 21-54.

Yemris Fointuna (2004) "Myth about sandalwood broken" *Jakarta Post* 9.8.2004. Abstract. Sandalwood now only found on Timor and Sumba islands. According to the East Nusa Tenggara Statistics Office, the number of sandalwood trees is estimated to be only some 100,000 due to illegal logging.

Ogasawara Island Sandalwood (*Santalum boninensis*).

Maina S. L., Pray L. A. & Defilipps R. A. 1988. "A historical note on the endangered *Santalum boninensis* (Santalacaea) of the Ogasawara Islands: Early reports by Jahrasi Tuyoma." *Atoll Research Bulletin* **319**, 19-24.

Tuyama, T. (1939). "On *Santalum boninense*, and the distribution of the species of *Santalum*." *Jap. J. Bot.* **15**, 697-712.

Pacific Sandalwoods.

Cropwatch comments: *Several Sandalwood spp are distributed throughout the Pacific including* Santalum austrocaledonicum *(Vanuatu & New Caledonia* & Santalum yasi *(Fiji).* The Lush company of the UK publically own up to using 1 ton per annum of New Caledonian sandalwood oil at http://www.lush.co.uk/Shop/FeatureDetail.aspx?fdShopFeatureId=6888

Cook Islands

Sykes W.R. (1980)." Sandalwood in the Cook Islands." *Pacific Science* **34**(l), 77-82.

Fiji (*Santalum yasi*, *Santalum album*).

Bulai P.B. (1995). "Sandalwood in Fiji." In L Gerum, JED Fox and Y Ehrhart (eds.) *Sandalwood seed, nursery and plantation technology. Proceedings of a regional workshop for Pacific Island Countries; August 1-11, 1994; Noumea, New Caledonia.* RAS/92/361. Field Document No. 8. UNDP/FAO South Pacific Forestry Development Programme, Suva, Fiji. Pp 167-172.

Bulai P. & Nataniela V. (2002). "Research, development and extension of Sandalwood in Fiji: A new Beginning." In *Proceedings of SPC Regional Workshop On Sandalwood Research, Development And Extension In The Pacific Islands And Asia. 7-11 October 2002, Noumea, New Caledonia.*

Jiko L.R. (2000) “Status & current interest in Sandalwood in Fiji” *Sandalwood Research Newsletter* **10**, 1-3. Abstract. *Santalum yasi*, the only sandalwood species in Fiji, earned 4.74 million Fijian dollars in foreign exchange over the period 1987-90. This recent resurgence in the utilisation of sandalwood has created an interest among landowners in planting and restocking new areas with the species. Information is presented on early history, traditional uses, growing conditions, silviculture and marketing of *yasi*, together with some notes on current research directions.

Silaitoga S. (2008) “Sandalwood rip-off.” *Fiji Times* 17th Feb 2008. ***Cropwatch comments***: Article describes how traders in the North are being offered 50c per kilo (down from $1) by local buyers for *Sandalwood yasi*. The traders are members of mataqali Nakorovatu of Nabavatu Village in Dreketi, and they want the Ministry of Forestry to intervene.

Smith R.M. & Morris P.R. (1979). Composition of Fijian sandalwood oil (*Santalum yasi*). *International Flavour and Food Additives* **10**(2), 57.

Tabunakawai, K. & A. Chang, (1984) "Sandalwood resource of the Ono-i-LauIslands. Suva, Fiji." unpublished reportof the Forestry Department.

Usumaki, J.T. (1981). *Sandalwood Survey Report—Bua Province*. Unpublished report of Forestry Department. Suva, Fiji.

Hawaii (*Santalum haleakalae - Maui only, Santalum freycinetianum, Santalum. paniculatum & Santalum ellipticum*).

Le Barron, Russell K. (1970).”Hawaii's sandalwood. Aloha Aina.” *Department of Land and Natural Resources*, State of Hawaii; 6-7.

Cartwright B. (1935). “Extinction of trees soon followed the Sandalwood Rush—Hawaii’s unhappy first export trade.” *Paradise of the Pacific*, Honolulu.

Harada-Stone, D. (1988). “Sandalwood logging defended, ripped at special Kona hearing.” *Hawaii Tribune-Herald*, September 30, 1, 10.

Judd C.S. (1933). "The parasite habit of the sandalwood tree." Thrum, Hawaiian Annual, Honolulu: The Printshop Co. Ltd. 59th Issue; 81-88.

Judd C.S. (1935). "Reviving the sandalwood industry." *Paradise of the Pacific*. April 1935 p 19.

Judd C.S. (1936) “Growing Sandalwood in the territory of Hawaii.” *Journal of Forestry* Vol XXXIV (1) 1936.

Kepler A.K. (1985). “Sandalwood: Hawaii’s precious ‘iliahi.” *Mauian* **2**(6), 6–11.

Lydgate J.M. (1916). “Sandalwood days.” *Thrum's Hawaiian Annual*.

Merlin M. & VanRavenswaay D. (1990) "The History of Human Impact on the Genus *Santalum* in Hawaii." *Proceedings of the Symposium on Sandalwood in the Pacific* April 9-11, 1990, Honolulu, Hawaii. Abstract: Adaptive radiation of *Santalum* in the Hawaiian archipelago has provided these remote islands with a number of endemic species and varieties. The prehistoric Polynesian inhabitants of Hawai‘i utilized the sandalwood trees for many of the same traditional purposes as their South Pacific ancestors who had developed ethnobotanical relationships with *Santalum*. The ancient Ha-waiians probably reduced the number and geographical distribution of sandal-wood trees significantly through their extensive cutting and burning, especially in the dry forest regions. Nevertheless, vast numbers of the fragrant trees still existed in Hawai‘i at the time of Western contact in 1778. Within a century after this contact, the extensive trade in sandalwood produced a massive decline in the Hawaiian species of *Santalum*. Although cultivation attempts during this cen-tury with both introduced and native sandalwood species have had limited success in Hawai‘i, there is renewed interest in developing a sustainable forest industry based on the production of sandalwood for export trade. Biologists in general, however, have cautioned against large-scale harvesting of the remain-ing *Santalum* trees, suggesting that more research be undertaken first to determine the distribution & vigor of the remaining species.

Rock J.F. (1916) "The sandalwoods of Hawaii. “A revision of the Hawaiian species of the genus *Santalum*." Hawaii Board Agric. *Forest. Bot. Bull.* **3**, 1–43.

St. John, H. (1947). “The History, Present Distribution, and Abundance of Sandalwood on O‘ahu, Hawaiian Islands.” *Hawaiian Plant Studies* **14**, 1(1): 5–20.

Scheffel M. (1990) "Sandalwood: Current Interest and Activity by the Hawaii Division of Forestry and Wildlife." *Proceedings of the Symposium on Sandalwood in the Pacific April* 9-11, 1990, Honolulu, Hawaii. Abstract: The State of Hawaii Department of Land & Natural Resources (DLNR) protects native species growing on State land, but has no official program funding for growing sandalwood. Part of the DLNR, the Division of Forestry and Wildlife forest and nursery managers maintain exuberant activity in attempting to establish their nursery stock of sandalwood in the field out of personal interest. Nursery and planting techniques are described.

Stemmermann L. (1980). “Vegetative anatomy of the Hawaiian species of *Santalum* (Santalaceae).” *Pacific Science* **34**(l):55-75

Stemmermann R.L. (1980). “Observations of the Genus *Santalum* (Santalaceae)” in *Hawaii Pacific Science* **34**(1), 41-54.

Stemmermann L. (1990) "Distribution and Status of Sandalwood in Hawaii." *Proceedings of the Symposium on Sandalwood in the Pacific* April 9-11, 1990, Honolulu, Hawaii. Abstract. This paper attempts to summarize what is known of the distribution and status of sandalwoods in Hawai‘i. Four species of sandalwood are recog-nized as being endemic to the Hawaiian Islands, and one has been introduced. Ecological factors affecting the present and former distribution of Hawaiian sandalwoods are considered.

TenBruggencate J. (1988). “Private sandalwood logging has state upset”. *Hono-lulu Star-Bulletin/Advertiser,* September 27, A3.

U.S. Fish & Wildlife Service (1985). Endangered and threatened wildlife and plants: proposed endangered status for *Santalum freycinetianum* Guad. var. l*anaiense* Rock (Lanai sandalwood or ‘iliahi). Fed. Reg. 50(44): 9086-9089.

Wagner J.P. (1986). “The rape of the fragrant trees.” *Honolulu Magazine*, November, 97 ff.

Wilkinson K.M. (2007) "Propagation Protocol for 'iliahi (*Santalum freycinetianum*).” *Native Plants Journal* **8**(3),248-251. Abstract. 'Iliahi or Hawaiian sandalwood (*Santalum freycinetianum* Gaudich. [Santalaceae]) is a hemiparasitic plant that can be readily grown in the nursery, provided some general guidelines are followed. Seeds germinate best if scarified and sown fresh. Plants can be grown to outplanting size (20 cm [8.0 in] tall with stems 8 mm [0.3 in] in diameter) in just 8 to 12 mo using controlled release fertilizer. The best survival and growth occurs when sandalwood is grown with a companion plant. Keywords sandalwood, nursery host plant, Santalaceae, Hawai'i Nomenclature USDA NRCS (2007) Click for larger view Jack Jeffrey inspects *Santalum paniculatum* tree on Mauna Kea. Photo by Craig Elevitch [Begin Page 250] Iiahi or Hawaiian sandalwood (*Santalum freycinetianum* Gaudich. [Santalaceae]) is endemic to the Hawaiian islands of O'ahu, Kaua'i, Lana'i, Maui, and Moloka'i. It is found in dry, mesic, and wet forest, with rainfall of 50 to 380 cm (20 to 150 in) and at elevations of 250 to 950 m (820 to 3120 ft). It is a hemiparasitic plant, meaning its roots attach to the root systems of other plants to.

Marquesas Islands (*Santalum insulare*, *Santalum marchionense*).

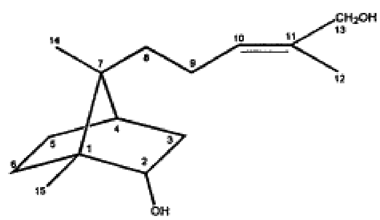
Butaud J-F, Raharivelomanana P, Bianchini J-P & Baron V. (2003) "A new chemotype of Sandalwood (*Santalum insulare* Bertero ex A DC.) from Marquesas Islands" *J. Essen. Oil Res*. **15**, 323-6. Abstract. Volatile constituents of sandalwood (S. insulare) concrete from the island of Nuku-Hiva in Marquesas Islands were studied using GC, GC-MS, HPLC and NMR. The investigation of nine main compounds showed important variations among sandalwood samples (from 3.5 to 53.2% for α-santalol and from trace to 29.3% for (Z)-nuciferol). Statistical analysis put in relief a geographical segregation between sandalwoods growing in dry area in Terre-Déserte (14.6% of α- and β-santalol, 17.1% of (Z)-nuciferol and 11.7% of 6,13-dihydroxybisabola-2,10-diene) and sandalwoods growing in wetter area of the other parts of the island (60.9% of α- and β-santalol, 1.2% of (Z)-nuciferol and 0.7% of 6,13-dihydroxybisabola-2,10-diene). The chemotype rich in (Z)-nuciferol of Terre-Déserte constitutes a rare and new chemotype, which is described for the first time.

Verhaegen D. (2000) "AMI in the Marquesas Islands: Sandal Preservation." *L'Ami Ingrediénts Naturels* No **26**, 1-2.

New Caledonia (*Santalum austrocaledonicum*).

Alpha T., Raharivelomanana P., Blanchini J.-P., Faure R. & Cambon A. & Joncheray L. (1996) "Santalenes from *Santalum austrocaledonicum.*" *Phytochemistry* **41**, 829-832.

Alpha T., Raharivelomanana P., Blanchini J.-P., Faure R. & Cambon A. (1997) "A sequiterpenoid from *Santalum austrocaledonicum* var. *austrocaledonicum*." *Phytochemistry* **46**, 1237-1239. Abstract. A new sesquiterpenoid, campherene-2,13-diol, has been isolated and characterized from the heartwood of *Santalum austrocaledonicum* var *austrocaledonicum*. Its structure has been established by the use of 1D and 2D NMR spectral techniques and shown to contain the campherenane skeleton.



Alpha T., Raharivelomanana P., Blanchini J.-P., Faure R. & Cambon A. (1997) "Bisabolane sesquiterpenoids from *Santalum austrocaledonicum*". *Phytochemistry* **44**, 1519-1552. Abstract. Two new sesquiterpenoids, 6,13-dihydroxybisabola-2,10-diene and 7,13-dihydroxybisabola-2,10-diene, were isolated, together with (E)-anceol, from the heartwood of *Santalum austrocaledonicum* var. *austrocaledonicum*. The compounds were characterized by one- and two-dimensional NMR.

Alpha T., Raharivelomanana P., Blanchini J.-P., Faure R. & Cambon A. (1997) "Identification de deux nouveaux dihydroxyles du bisabolene a partir de santal oceanien." In *Rivista Ital. EPPOS* (*Actes des 15emes Journeés Internationales Huiles Essentielles:* Digne-les-Bains, France., 5,6& 7 Sept 1996 Special Issue 01/97 pp 84-91.

Azais, T. (1995). "Sandalwood management in the Southern Province of New Caledonia.". pp. 217–227. In: Gerum, Fox, and Ehrhart Gerum, L., J.E.D. Fox, and Y. Ehrhart (eds.). 1995. *Sandalwood Seed, Nursery and Plantation Technology*. *Proceedings of a regional workshop for Pacific Island Countries*, August 1–11, 1994, Noumea, New Caledonia. RAS/92/361. Field Document 8. UNDP/FAO South Pacific Forestry Development Programme, Suva, Fiji.

Bottin L, Vaillant A, Sire P, Cardi C, Bouvet J M (2005) “Isolation and characterization of microsatellite loci in *Santalum austrocaledonicum*, Santalaceae”, *Molecular Ecology Notes*, **5**(4), 800-802.

Bottin L., Isnard C., Godefroy C., Lagrange A., Butaud. & Raharivelomanana, Bianchini & Bouvet J.M. (2005). “Chemical variability of sandalwood in New-Caledonia.” Technical note CIRAD 20p + annexes.

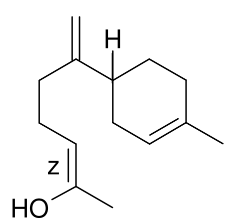
Bottin L., Verhaegen D., Tassin J., Olivieri I., Vallant A. & Bouvet J.M. (2005) “Genetic Diversity & Population Structure of an Insular tree, *Santalum austrocaledonicum* in New Caledonian archipelago.” *Molecular Ecology* **14**(7), 1979-89. Abstract: We present a study of the genetic diversity and structure of a tropical tree in an insular system. *Santalum austrocaledonicum* is endemic to the archipelago of New Caledonia and is exploited for oil extraction from heartwood. A total of 431 individuals over 17 populations were analysed for eight polymorphic microsatellite loci. The number of alleles per locus ranged from 3 to 33 and the observed heterozygosity per population ranged from 0.01 in Mare to 0.74 in Ile des Pins. The genetic diversity was lowest in the most recent islands, the Loyautes, and highest in the oldest island, Grande Terre, as well as the nearby small Ile des Pins. Significant departures from panmixia were observed for some loci-population combinations (per population FIS = 0-0.03 on Grande-Terre and Ile des Pins, and 0-0.67 on Loyautes). A strong genetic differentiation among all islands was observed (FST = 0.22), and the amount of differentiation increased with geographic distance in Iles Loyaute and in Grande Terre. At both population and island levels, island age and isolation seem to be the main factors influencing the amount of genetic diversity. In particular, populations from recent islands had large average FIS that could not be entirely explained by null alleles or a Wahlund effect. This result suggests that, at least in some populations, selfing occurred extensively. Conclusively, our results indicate a strong influence of insularity on the genetic diversity and structure of *Santalum austrocaledonicum*.

Bottin L. (2006) *Thesis: Ecole Nationale Superieure d’Agrnomie de Montpellier. Agro Montpellier*: *Déterminants de la variation moléculaire et phénotypique d'une espèce forestière en milieu insulaire: cas de Santalum austrocaledonicum en Nouvelle Calédonie*. – see http://tel.archives-ouvertes.fr/tel-00097974/en/ Abstract. Les îles océaniques constituent de véritables « laboratoires naturels » pour comprendre l'impact des forces évolutives sur la biodiversité. Les effets de dérive génétique et l'impact de la sélection naturelle apparaissent d'autant plus exacerbés que les îles sont isolées et soumises à de forts gradients environnementaux. Notre étude associe des marqueurs moléculaires neutres et des caractères liés à l'adaptation afin d'évaluer l'influence de ces différentes forces dans le contexte insulaire de Nouvelle-Calédonie sur l'espèce forestière *Santalum austrocaledonicum*. L'étude des microsatellites nucléaires et chloroplastiques montre une différenciation nette des populations des petites îles Loyauté et un isolement par la distance au sein de l'île la plus vaste, Grande Terre. En outre elle met en évidence un déficit en hérérozygotes au sein de certaines populations pouvant être attribué à une sous-structuration spatiale ou un régime de reproduction autogame. La variation de la taille des feuilles et des graines, caractères liés à l'adaptation, résulte des effets de dérive mais aussi de la sélection naturelle provoquée par des contrastes environnementaux notamment par des différences de pluviométrie. De même la composition chimique du bois de coeur, analysée par chromatographie, subirait, en plus de la dérive, une pression sélective exercée par le cortège d'insectes et de champignons phytophages. Cette étude exploratoire permet de dégager de nombreuses perspectives de recherche relevant des questions évolutives en milieu insulaire. Sur un plan opérationnel, elle permet de définir des unités de gestion de l'espèce associant caractères adaptatifs et variables moléculaires.

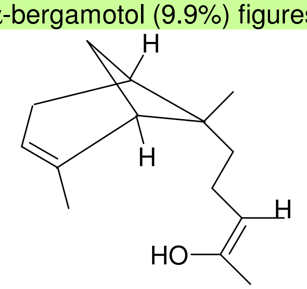
Bottin L., Isnard C., Lagrange A. & Bouvet J.M. (2007) "Comparative molecular and phytochemical study of the tree species *Santalum austrocaledonicum* (Santalaceae) distributed in the New-Caledonian archipelago." *Chem Biodivers*. **4**(7):1541-56. Abstract. We have tried to elucidate the origin of phytochemical variation in trees by studying concomitantly the chemical and microsatellite variations in *Santalum austrocaledonicum*. Eight natural populations were sampled in the New-Caledonian archipelago, a total of 157 individuals being analyzed. The main

components, as revealed by gas chromatography (GC), were alpha- and beta-santalol (as in other sandalwood species), although the level of (Z)-lanceol was particularly high. Most of the chemical variation was observed within populations (83.7%). With microsatellites, the variation between populations was more pronounced (32% of the total variation). Although the chemical variation between populations was small, we investigated the effects of genetic drift and migration by comparing the chemical- and molecular-differentiation patterns. The poor congruence between neighbor-joining trees, confirmed by the non-significant Mantel test between the molecular and chemical distance matrices (R=0.26, P=0.12), showed that genetic drift and migration are not the main evolutionary forces acting on chemical differentiation between populations. We could not find any effect of soil and rainfall conditions neither. Although the impact of drift and migration cannot be discounted in rationalizing between-population differentiation, the low variation among populations could result from a stabilizing selection caused by the same phytopathogen charge across the natural range.

Braun N.A., Meier M. & Hammweschmidt F.-J. (2005) "New Caledonian sandalwood – a substitute for East Indian sandalwood oil?" *J. Essen Oil Res* **17**, 477-480. Abstract: Three qualities of New Caledonian sandalwood oil were analysed using GC and GC/MS. Eighty-four constituents were identified: 10 monoterpenes, 72 sesquiterpenes and two others. In addition b-bisabolol/epi-b-bisabolol isomers were isolated and characterised via chiral GC chromatography. Our results indicate that New Caledonian sandalwood oil is much closer related to East Indian sandalwood oil than its West Australian counterpart. ***Cropwatch comments***: Arguably in 2005, the world production of sandalwood oil was approx. 50 tons/annum, and the demand 200 tons/annum. How then can the authors maintain, bearing in mind New Caledonia's very limited production capability (1-2 tons at most), that this oil can be a substitute for the ever-scarcer East Indian Sandalwood oil? Furthermore, the authors assume that the GC analytical trace similarity (i.e. between E.I. sandalwood oil against New Caledon sandalwood oil) will make it an automatic pertfumery substitution choice, without performing detailed odour profiling trials, or by comparing perforemance in product In fact the authors own figures show considerable differences in compositiomn exist between New Caledonoium & E.I. sandalwood oils, especially in respect to the high (Z)-lanceol (9.1%) and high (Z)-trans-α-bergamotol (9.9%) figures.



Z-lanceol



(Z)-trans-alpha-bergamotol

Brennan P. & Merlin M (1993). "Biogeography and traditional use of *Santalum* in the Pacific Region". pp. 30–38. In: McKinnell, F.H. (ed.). 1993. *Sandalwood in the Pacific Region*. Proceedings of a symposium held on 2 June 1991 at the XVII Pacific Science Congress, Honolulu, Hawaii. ACIAR Proceedings 49. ACIAR, Canberra, Australia. Abstract. *Santalum* has a disjunct? known distribution among the islands of the Pacific Ocean. During the prehistoric period, Melanesian and Polynesian Islanders, who had access to native sandalwood trees and shrubs, utilised the aromatic heartwood for a variety of medicinal and other purposes. Some uses had significant social import, motivating trade of Santalum from Fiji to Tonga for status and aesthetic reasons. Pre-contact trade of sandalwood may also have occurred between other South Pacific Islands in Eastern Polynesia. The biogeography of *Santalum* spp. is described, and some aspects of the ancient and more recent history of the use of, and human environmental impact on, sandalwood species in the Pacific are reviewed.

Bulai P. & Nataniela V. (2002).. "Research, development and extension of Sandalwood in Fiji - A new beginning." Paper to *Regional Workshop on Sandalwood Research, Development and Extension in the Pacific Islands and Asia*. Noumea, New Caledonia, 7–11 October 2002.

Chauvin J.P. & Ehrhart Y. (1998). "Germination of two provenances of *Santalum austrocaledonicum* var. *austrocaledonicum*." *ACIAR Proceedings* **84**: 113–116.

Chauvin, J.P. (1990). "La production de plants de santal en Nouvelle Caledonie." *Bois et Forests des Tropiques* N°**218**, 1-10.

Cherrier, J-F (1993). "Sandalwood in New Caledonia". In F.H. McKinnell (ed) *Sandalwood in the Pacific Region*. Proceedings of a symposium held on 2 June 1991 at the *XVII Pacific Science Congress*, Honolulu, Hawaii. Canberra: *ACIAR Proceedings* No.49. pp19-23. Abstract. Results of research on wood formation in *Santalum austrocaledonicum* in New Caledonia are discussed. There is high variability of heartwood content at any tree size. Trees also reach maturity at different heights and diameters, making predictive models of limited value. The best correlation of yield of heartwood is with sapwood width. The latter is positively correlated with recent growth rate. Sapwood is at a minimum and the proportion of heartwood is highest when the tree matures and growth rate is reduced. It is concluded that the management of sandalwood to maximise heartwood production is complex.

Douheret J. (1981). "Le santal en Nouvelle Calédonie." *Nature calédonienne* 11/1981.

Ehrhart Y. (1996). "The status of the genus *Santalum* and *Agathis* in New Caledonia." Paper at *SPRIG (South Pacific Regional Initiative on Forest Genetic Resources) Meeting,* Nadi, Fiji 2–4 December 1996. Unpublished.

Lawrence B.M. (2008) "Progress in Essential oils. New Caledonian Sandalwood oil." *Perf. & Flav.* **33** (Juy 2008) p 44.

Veillon J.M. & Jaffré T. (1995) "Sandalwood (*Santautm azrstrocaledonicum* Vieillard) in New Caledonia: taxonomy, distribution, ecology." In L Gerum, JED Fox and Y Ehrhart (eds.) Sandalwood seed, nursery and plantation technology. Proceedings of a regional workshop for Pacific Island Countries; August 1-11, 1994; Noumea, New Caledonia. RAS/92/361. Field Document No. 8. UNDP/FAO South Pacific Forestry Development Programme, Suva, Fiji. Pp. 25-36.Abstract. Sandalwood is represented in New Caledonia by a single species, *S.austrocaledonicum*, which is divided into three varieties showing different geographic distributions: the Nouméa area for the pifosulicm variety, the foot of ultramafic rock formations for the minutzim variety and the Loyalty Islands, the Isle of Pines and a few locations in New Caledonia for the *austrocaledonicum* variety. It is mainly limited to secondary vegetation stands with diverse flora, but can also be found in sclerophyll forest and in low altitude scrub, which could well be its original environment. It grows in extremely varied soils, with a pH of 4 to 8 or more, containing a variety of exchangeable bases (Ca, K, Na); these soils may be rich in magnesium, nickel and chrome. Its foliar mineral composition features relatively high concentrations of nitrogen and potassium, low to medium-level concentrations of phosphorus and highly variable levels of calcium. As in other Pacific islands, sandalwood, which is highly sought after for its wood and essential oils, has undergone intensive harvesting in New Caledonia. This overexploitation, along with the destruction of its original biotopes (sclerophyll forest and low-altítude scrub) by both agricultural and grazing activities and fire, has contributed to the growing scarcity of this species through the disappearance of numerous stands.At the present time, the minufum variety, which may well be an edaphic scrubland variety, can only be found in a single location and must be considered as an endangered species. Urgent action is therefore necessary for its survival.

Tonga (*Santalum yasi*).

Erhart Y. (1997) “Technical Report on Sandalwood Workshop, Tonga 17–21 November 1997. CIRAD–Forêt/New-Caledonia

Kaufusi S. (1995) “Status of the Sandalwood tree in Tonga.” In:: Gerum, L., J.E.D. Fox, and Y. Ehrhart (eds.). 1995. *Sandalwood Seed, Nursery and Plantation Technology. Proceedings of a regional workshop for Pacific Island Countries, August 1–11, 1994*, Noumea, New Caledonia. RAS/92/361. Field Document 8. UNDP/FAO South Pacific Forestry Development Programme, Suva, Fiji.Gerum, Fox, and Ehrhart (eds) ,

Kaufusi S, Harmani S, and Thomson L. (1999). “Sandalwood work on ‘Eua, Kingdom of Tonga.”. *Sandalwood Research Newsletter*. CALM, Kununnura, Western Australia.

Siwatibau S., Bani C, & Kaloptap J. (1998). “SPRIG Rapid Rural Appraisal Survey of selected tree species in Vanuatu.” *Report by Island Consulting to CSIRO Division of Forestry/SPRIG Project.*

Yuncker T, 1959. Plants of Tonga. B.P. Bishop Museum Bulletin, 220pp.

Vanuatu (*Santalum austrocaledonicum*).

Barrance A.J. (1989). “Controlled development of sandalwood in Vanuatu - a mid-term review of the five year moratorium on sandalwood cutting.” *Vanuata Forest Service*, June 1989.

Barrance, A. 1989 (November). Research Trials: Results of trials up to 1989. Research report on file, Forestry Department, Port Vila, Vanuatu.

Berry A. (2002). Vanuatu country report. In proceedings of SPC Regional Workshop On Sandalwood Research, Development And Extension In The Pacific Islands And Asia. 7-11 October 2002, Noumea, New Caledonia. (2002).

Bule L. & Daruhi G. (1990) “Status of sandalwood resources in Vanuatu.” *Proceedings of the Symposium on Sandalwood in the Pacific April 9-11, 1990, Honolulu, Hawaii* Abstract. On eight islands of Vanuatu archipelago, sandalwood stands have been heavily exploited since the late 1800's. Because of the over-exploitation, which worried the Vanuatu Government, a moratorium was imposed in early 1987. The status of the valuable wood and the beginnings of research into one of the country's potential commodities are reviewed.

Channel S. & Thompson L. (1999) “Development of a Sandalwood conservation strategy for Vanuatu. In *Forest Genetic Resources* No **27**, 68-72.

Daruhi, G. (1991). “Sandelwud blong Vanuatu. A bright future?” Sandalwood paper for the XVII[e] P.S.A. Congress. Honolulu, Hawaii. Forestry Department, Vila.

Ehrhart Y. 1998. “Oil composition of the sandalwood (*Santalum austrocaledonicum*) from Erromango and Aniwa Islands, Vanuatu.” Report for CIRAD–Foret, Nouvelle–Calédonie, 10 June 1998. Unpublished.

Neil P.E. (1986) “Sandalwood of Vanuatu” *Forest Research Report 5/86, Vanuatu Forest Service* (**5**/86): ii + 7.

Page T., Tate H., Tungon J., Sam C., Dickinson C., Robson K., Southwell I., Russell M., Waycott M., Leakey R. (2004). "Evaluation of heartwood and oil characteristics in nine populations of *Santalum austrocaledonicum* from Vanuatu." *Sandalwood Research Newsletter* ? Abstract. Heartwood cores were collected from 222 trees across nine populations on six different islands from Vanuatu. Oil was ethanol extracted and oil concentration and the main constituents were determined for each of the cores sampled andanalysed on a tree-to-tree and site-by-site basis.

Heartwood oil concentration and all major oil constituents exhibited significanttree-to-tree variation, within and between all populations. Each population had a range of trees with high and low concentrations of α- and β-santalol. The popula-tions from the two northern islands had a greater proportion of trees with high santalol content than the populations sampled from the southern islands

Tacconi L. & Mele. L. (1995). *Economic Aspects of Sandalwood Cultivation in Relation to the Erromango Kauri Protected Area. Vanuatu Forest Conservation Research Report 7*. Department of Economics and Management, University College, University of New South Wales, Campbell, Canberra, Australia.

Tacconi L. & Mele I. (1997). "Sandalwood Cultivation and the Establishment of the Erromango Kauri Protected Area, 71-85." In: Tacconi, L. and Bennett, J. (Eds) *Protected Area Assessment and Establishment in Vanuatu: a Socioeconomic Approach* ACIAR Monograph 38, ACIAR, Canberra, 180p.

Tate H., Sethy M. & Tungon J. (2004) "Grafting Sandalwood in Vanuatu." *Sandalwood Research Newsletter* ?. Abstract. Historically sandalwood plantings in Vanuatu have been established mainly by seed propagation and transplanted wildings. This method continues to be very important for village communities to grow sandalwood collected from their natu-ral sources. With increasing interest across the country in planting sandalwoodthe Department of Forests (DoF) is actively encouraging improved clonal seed orchards to keep up with demand. Clonal propagation of mature trees by cuttings has been difficult to achieve byconventional methods, but grafting has proven a viable alternative method. Thesuperior individuals identified within the current ACIAR sandalwood project are now being grafted using the methods developed in conjunction with SPRIG

General Pacific Region

Allen J.A. (2002)." *Santalum freycinetianum* Gaudich." In Vozzo, J.A. (ed.). *Tropical Tree Seed Manual. Agriculture Handbook* 721. U.S. Forest Service, Washington, DC.

Alpha T., Raharivelomanana P., Bianchini J.-P., Faure R., Cambon A., & Joncheray L. (1995) "alpha-Santaldiol & beta-santaldiol, two santalane sesquiterpenes from *Santalum insulare*." *Phytochem.* **41**(3), 829-831. Abstract. Two new sesquiterpene alcohols, beta-santaldiol and alpha-santaldiol, have been isolated from the heartwood of *Santalum insulare* var. *marchionese* and, by means of two-dimensional NMR experiments, shown to have the beta- and alpha-santalane skeleton respectively.

Alpha, T. (1997). *Etude des concrètes et des essences de santal d'origine océanienne. Elucidation de nouveaux sesquiterpenoïdes par la RMN multi-impulsionnelle et bidimensionnelle*. Ph.D. Thesis. Université Française du Pacifique, Papeete, French Polynesia.

Alpha, T., P. Raharivelomanana, J.-P. Bianchini, Y. Ehrhart & A. Cambon. (1997). "Etude de la composition chimique d'essences de santal d'origine du Pacific Sud." pp 499–465 In: *Revista Italiana EPPOS (Actes des 15èmes Journées Internationales Huiles Essentielles*; Digne-les-Bains, France, 5, 6 & 7 Septembre 1996, Special issue 01/97.

Applegate G.B. (1990). "Sandalwood in the Pacific: A state of knowledge. Synthesis and summary from the April 1990 symposium." pp 1–11. In: Hamilton, L., and C.E. Conrad (eds.). 1990. *Proceedings of the Symposium on Sandalwood in the Pacific, April 9–11, 1990, Honolulu, Hawai'i.* General Technical Report PSW–122. Pacific Southwest Research

Barrau, J. (1960). "Plantes utiles des îles du Pacifique–Le Santal." *Bulletin des études Pacifiques,* July 1960.

Brennan, P., and M. Merlin. (1993). "Biogeography and traditional use of *Santalum* in the Pacific Region". In: F. McKinnell (ed.). Proceedings of a symposium held on June 2, 1991 at the XVII Pacific Science Congress, Honolulu, Hawai'i. *ACIAR Proceedings* **49**. ACIAR, Canberra, Australia.

Butaud J.F. & Tetuanui W. (2002). "Le Santal en Polynésie Française." *Proceedings of the Regional Workshop on Sandalwood Re-search, Development and Extension in the Pacific Islands andAsia, 7-11 October, 2002,Noumea, New Caledonia*

Butaud J.-F. (2004) "*Santalum insulare* (Bertero ex A. DC.): Distribution and ecology." *Sandalwood Research Newsletter* **19**. July 2004. Abstract. The Eastern Polynesian sandalwood is one of the sixteen *Santalum* species of Asia and the Pacific. It is known under the name puahi in Marquesas Islands, ai in Cook Islands and ahi elsewhere in its geographical area. Overexploited during the beginning of the 19th century, Polynesian sandalwood is still used for carvingor in powder mixed with coconut oil (monoi ahi or pani puahi) for cosmetic or medicinal purposes.

Butaud J.F. (2003). "Autécologie et phytosociologie des Santals de Polynésie française." *Proceedingsof the Regional Workshop on San-dalwood Research, Developmentand Extension in the Pacific Is-lands and Asia*, 7-11 October, 2002, Noumea, New Caledonia.

Butaud J.-F., Rives F., Verhaegen D. * Bouvet J.-M. (2005) "Phylogeography of Eastern Polynesian sandalwood (*Santalum insulare*), an endangered tree species from the Pacific: a study based on chloroplast microsatellites." *Journal of Biogeograohy* **32** (10) , 1763–1774.

Butaud J.-F., Raharivelomanana P., Bianchini J.-P. Faurec R. & Gaydou E.M. (2006) "Leaf C-glycosylflavones from *Santalum insulare* (Santalaceae)" *Biochemical Systematics and Ecology* **34**(5), 433-435

Butaud J.-F., Raharivelomanana P., Bianchini J.-P. & Gaydou E.M. (2008) "*Santalum insulare* Acetylenic Fatty Acid Seed Oils: Comparison within the *Santalum* Genus." *J of American Oil Chemists Society* **85**(4), 353-356.. Abstract. The sandalwood kernels of *Santalum insulare* (Santalaceae) collected in French Polynesia give seed oils containing significant amounts of ximenynic acid, E-11-octadecen-9-oic acid (64–86%). Fatty acid (FA) identifications were performed by gas chromatography/mass spectrometry (GC/MS) of FA methyl esters. Among the other main eight identified fatty acids, oleic acid was found at a 7–28% level. The content in stearolic acid, octadec-9-ynoic acid, was low (0.7–3.0%). An inverse relationship was demonstrated between ximenynic acid and oleic acid using 20 seed oils. Results obtained have been compared to other previously published data on species belonging to the *Santalum* genus, using multivariate statistical analysis. The relative FA *S. insulare* composition, rich in ximenynic acid is in the same order of those given for *S. album* or *S. obtusifolium*. The other compared species (*S. acuminatum*, *S. lanceolatum*, *S. spicatum* and *S. murrayanum*) are richer in oleic acid (40–59%) with some little differences in linolenic content.

Chauvin J.-P. & Erhart J. "Germination of two provenances of *Santalum austrocaledonicum* var. *austrocaledonicum." ACIAR-Proceedings Series* **84**, 113-116.

Doran J., Thomson L., Brophy J., Goldsack B., Bulai P., Faka'osi & Mokosa T. (date?) "Variation in heartwood oil composition of young sandalwood trees in the South Pacific (*Santalum yasi*, *S. album* and F1 hybrids in Fiji, and *S. yasi* in Tonga and Niue)." Abstract. This study was undertaken during 2003 as part of AusAID's SPRIG (South Pacific Regional Initiative in Forest Genetic Re-sources) project. It had the primary aim of extending the knowledge base on the production of heartwood and heartwood oils in young Pacific Island sandalwoods, *Santalum yasi*, the introduced *S. album*, and the spontaneous F1 hybrid, *S. album* ×*yasi*. A solvent (pentane) extraction technique was used to determine heartwood oil chemistry, following verification againststeam distillation. The heartwood was obtained from trees by non-destructive coring. Ages of the trees sampled ranged between 5 years and more than 25 years. Many of them had not yet started to lay downheartwood at their base. For those that had, heartwood was restricted to the lower most cores i.e. 0.1m or 0.2m above groundor very occasionally extending to 0.3m in older trees. Tree-to-tree variation in oil quality in *S. yasi*, as determined by allow-able α-santalol and β-santalol levels in the International Standard (2002) for *S. album*, was substantial indicating a potentialof improvement through selection and breeding if genetic parameters are favourable. Trees in Fiji of the spontaneous F1 hy-brid, *S. album* × *yas*i, were very vigorous and the heartwood oil of two (out of three) of the 7-year-old trees with heartwoodwas of excellent quality. The results suggest that rotation lengths of 25 to 30 years for the Pacific sandalwoods may be more realistic than the 15 to 20 year rotation lengths suggested by some workers.

Ehrhart Y. (1997). *Technical Report on Sandalwood Workshop, Tonga* 17–21 November 1997. CIRAD–Forêt/ New Caledonia, Pouembout. Unpublished.

Ehrhart Y. (1998) "Descriptions of some sandal tree populations in the South West Pacific : consequences for the silviculture of these species and provenances." In : Radomiljac A.M. (ed.), Ananthapadmanabho H.S. (ed.), Welbourn R.M. (ed.), Satyanarayana Rao K. (ed.). *Sandal and its products : proceedings of an international seminar. Canberra* : ACIAR, p.105-112. Sandal and its Products, 1997-12-18/1997-12-19, (Bangalore, Inde). Abstract. Many of the islands of the South West Pacific that bear sandal have been visited and the stands described. Mostly the population is depleted, but some stands still exist. Depending on the status of the existing population, several possible management strategies are feasible. The aim is to rebuild stands which are as diverse as possible which will be able to be managed sustainably in a few decades. Some are presently managed with the objective of regular annual heartwood production with an increase of the stock. The observations reported here, especially those regarding shade intensity, can be used to improve the silviculture of the various provenances which differ markedly. Even aspects of seed storage differ, and this demande further investigation. New techniques, which differ significantly from those previously identified for the Ile des Pins provenance, are proposed. (Résumé d'auteur)

Elevitch C.R. & K.M. Wilkinson K.M..(2003). “Propagation protocol for production of container *Santalum freycinetianum* Gaudich.” In: Native Plant Network.University of Idaho, College of Natural Resources, Forest Research Nursery, Moscow, Idaho.–see http://www.nativeplantnetwork.org

Emeline L., Alexandre V, Jean-Francois B. *et al*. (2006) "Isolation & characterisation of microsatellite loci in *Santalum insulare*, Santalaceae." *Molecular Ecology Notes*, 2006.

Felgelson J. (1990) "Sandalwood - the myth & the reality." Paper presented at the *Symposium on Sandalwood in the Pacific*, April 9-11, 1990, Honolulu, Hawai‘i. Abstract: *Santalum paniculatum* trade after more than a century was revived by the author in 1988. Revival of the trade has called attention to this resource, and the focus is now on management of this resource. A discussion about recent sandalwood logging and marketing activities in Hawai‘i is presented. The author also points out various anomalies that may be related to habitat and land use variations. The obligatory parasitic nature of this species is questioned and the coppicing tendency is confirmed. Criteria are suggested concerning the harvesting and sales that minimize fragmentation of forest areas. The concept of establishing a sandalwood research center and the cultivation of sandalwood in Hawaii is presented.

Fosberg F.R. & Sachet M.H. “*Santalum* in Eastern Polynesia” *Candollea* **40**, 459-470.

Harbaugh D.T. & Bruce G. Baldwin B.G. (2007) *American Journal of Botany* **94**, 1028-1040. "Phylogeny and biogeography of the sandalwoods (*Santalum*, Santalaceae): repeated dispersals throughout the Pacific." Abstract. Results of the first genus-wide phylogenetic analysis for *Santalum* (Santalaceae), using a combination of 18S–26S nuclear ribosomal (ITS, ETS) and chloroplast (3' trnK intron) DNA sequences, provide new perspectives on relationships and biogeographic patterns among the widespread and economically important sandalwoods. Congruent trees based on maximum parsimony, maximum likelihood, and Bayesian methods support an origin of *Santalum* in Australia and at least five putatively bird-mediated, long-distance dispersal events out of Australia, with two colonizations of Melanesia, two of the Hawaiian Islands, and one of the Juan Fernandez Islands. The phylogenetic data also provide the best available evidence for plant dispersal out of the Hawaiian Islands to the Bonin Islands and eastern Polynesia. Inability to reject rate constancy of *Santalum* ITS evolution and use of fossil-based calibrations yielded estimates for timing of speciation and colonization events in the Pacific, with dates of 1.0–1.5 million yr ago (Ma) and 0.4–0.6 Ma for onset of diversification of the two Hawaiian lineages. The results indicate that the previously recognized sections *Polynesica*, *Santalum*, and *Solenantha*, the widespread Australian species *S. lanceolatum*, and the Hawaiian species *S. freycinetianum* are not monophyletic and need taxonomic revision, which is currently being pursued

Hirano R.T. (1990) "Propagation of Santalum, Sandalwood tree." *Proceedings of the Symposium on Sandalwood in the Pacific April 9-11, 1990, Honolulu, Hawaii* Abstract. The history of the genus *Santalum* (sandalwood) in Hawaii is re-viewed, along with all the early reference regarding its botany and horticulture. This paper gives some seed germination and viability information on *Santalum haleakalae* Hbd. and *S. paniculatum* H. & A. both native to Hawaii and *Santalum album* L. native to Indonesia. Germination was shown to be highly variable: as early as 26 days after sowing for *S. album*, 75 days for *S. paniculatum*, and 155 days for *S. haleakalae*. Seed viability varied from 324 days in S. album, 387 days in S. *haleakalae* and 824 days in *S. paniculatum*. Germination percentages ranged from 38 percent to 77 percent. This study also showed that supplemental chelated iron is essential in the propagation of all the species tested.

Lhuillier E., Butaud J.F. & Bouvet J.M. (2006) "Extensive clonality and strong differentiation in the insular pacific tree *Santalum insulare*: implications for its conservation." *Ann Bot (Lond).* **98**(5), 1061-72. Abstract. BACKGROUND AND AIMS: The impact of evolutionary forces on insular systems is particularly exacerbated by the remoteness of islands, strong founder effects, small population size and the influence of biotic and abiotic factors. Patterns of molecular diversity were analysed in an island system with *Santalum insulare*, a sandalwood species endemic to eastern Polynesia. The aims were to evaluate clonality and to study the genetic diversity and structure of this species, in order to understand the evolutionary process and to define a conservation strategy. METHODS: Eight nuclear microsatellites were used to investigate clonality, genetic variation and structure of the French Polynesian sandalwood populations found on ten islands distributed over three archipelagos. KEY RESULTS: It was found that 58 % of the 384 trees analysed were clones. The real size of the populations is thus dramatically reduced, with sometimes only one genet producing ramets by root suckering. The diversity parameters were low for islands (n(A) = 1.5-5.0; H(E) = 0.28-0.49). No departure from Hardy-Weinberg proportion was observed except within Tahiti island, where a significant excess of homozygotes was noted in the highland population. Genetic structure was characterized by high levels of differentiation between archipelagos (27 % of the total variation) and islands (F(ST) = 0.50). The neighbour-joining tree did not discriminate the three archipelagos but separated the Society archipelago from the other two. CONCLUSIONS: This study shows that clonality is a frequent phenomenon in *S. insulare*. The genetic diversity within populations is lower than the values assessed in species distributed on the mainland, as a consequence of insularity. But this can also be explained by the overexploitation of sandalwood. The differentiation between archipelagos and islands within archipelagos is very high because of the limited gene flow due to oceanic barriers. Delineation of evolutionary significant units and principles for population management are proposed based on this molecular analysis.

McKinnell, F.H. (ed.). (1993). "Sandalwood in the Pacific Region". *ACIAR Proceedings* **49**. ACIAR, Canberra, Australia.

Merlin M.D., Thomson L.A.J. & Elevitch C.R. (2005). "*Santalum ellipticum*, *S. freycinetianum*, *S. haleakalae*, and *S. paniculatum* (Hawaiian sandalwood), ver. 3.1." In: C.R. Elevitch (ed.). *Species Profiles for Pacific Island Agroforestry*. Permanent Agriculture Resources (PAR), Holualoa, Hawai'i. http://www.traditionaltree.org. ***Cropwatch comments***: Recommended article & excellent biblio!

Raharivelomanana P., Bianchini J.-P., Faure R., Cambon A. & Azzaro M. (1994) *Phytochem*. **35**,1059.

Raharivelomanana P., Faure R., Cambon A. & Azzaro M. (1993) *Phytochem*. **33**,235.

Skottsberg C. (1930) "Further notes on Pacific sandalwoods." *Acta Horti Gothob*. **5**, 135–145.

Skottsberg C. (1930) "The geographical distribution of the sandalwoods and its significance." *Proc. 4th Pacific Sci. Congr*., Java **3**, 435–442.

Thomson, L.A.J. (2005). "*Santalum austrocaledonicum* and *S. yasi* (sandalwood)." ver. 1.1. In: Elevitch, C.R. (ed.). *Species Profiles for Pacific Island Agroforestry. Permanent Agriculture Resources (PAR),* Hōlualoa, Hawai'i. <http://www.traditionaltree.org ***Cropwatch comments:*** Recommended article & excellent biblio!

Tuisese, S., P. Bulai, T. Evo, K. Singh, L. Jiko, T. Faka'osi, S. Napa'a, M. Havea, and L.A.J. Thomson (2000). "A strategy for conserving, managing and better utilising the genetic resources of *Santalum yasi* (sandalwood) in the Kingdom on Tonga and Republic of Fiji." *Department of Forestry, Fiji, Forestry and Conservation Division, Tonga and SPRIG, Canberra, Australia*.

Wilson, C. A. (1985). "Endangered and threatened wildlife and plants; proposed endangered status for *Santalum freycinetianum* Gaud. var. l*anaiense* Rock (Lanai sandalwood or`iliahi). *Fed. Reg*. **50**, 9086–9089.

Papua New Guinea Sandalwood (*Santalum macgregorii*)

Bosimbi, D. (1997) "Sandalwood develop-ment in Papua New Guinea." A progressive report on recent activities. Unpublished report of National Tree Seed Centre, Divi-sion of Reforestation and Extension, PapuaNew Guinea Forest Authority, Bulolo, PNG.

Gunn B., Bewang I.F. & Bun Y. (2002). A strategy for conserving and managing the genetic resources of *Santalum macgregorii* (PNG Sandalwood) in Papua New Guinea. A report presented to the Papua New Guinea Forest Authority as part of the Domestication of Papua New Guinea's Indigenous Forest Species Project (ACIAR FST/1998/115). CSIRO Forestry and Forest Products, Canberra (unpublished).

Paul J.H. (1990) "The status of Sandalwood (*S. macgregorii*) in Papua New Guinea." *Proceedings of the Symposium on Sandalwood in the Pacific* April 9-11, 1990, Honolulu, Hawaii. Abstract**:** *Santalum macgregorii* grows between 100 and 1500 m and is not evenly distributed throughout the country. It grows only around the central province where savannahs are found. Most of this original *S. macgregorii* stand was harvested during 1890-1910 and again in 1933. The government of Papua New Guinea does not have a stand of sandalwood. Any remains of *S. macgregorii* are owned and harvested by the landowners. Landowners then sell the graded logs to agents in Port Moresby, who in turn sell them to buyers in Hong Kong, Singapore, Taiwan, and Japan. Studies including phenology, silviculture, and growth of *S. macgregorii* are yet to be established.

Radomiljac, A. M. (1997) Sandalwood nursery and plantation workshop, Port Mo-resby, Papua New Guinea, November 8-141996. Unpublished report, Department ofConservation & Land Management, Kununurra, Western Australia.

Radomiljac, A. M. & Bosimbi, D. (1999) "*Santalum macgregorii* F. v. Mueller in Papua New Guinea." *Sandalwood Research Newsletter* **8**, 5. Department ofConservation & Land Management, West-ern Australia

Thomson, L. & Bosimbi, D. (2000) "*Santalum macgregorii* – PNG sandalwood." Un-published paper prepared for CSIRO/PNGForest Research Institute/ACIAR project entitled Domestication of papua NewGuinea's Indigenous Forest Species. Aus-tralian Tree Seed Centre, CSIRO Forestryand Forest Products, Yarralumla, ACT.

Vernes T. (2001?) "Preliminary results from *Santalum macgregorii* ex situ conservation planting." *Sandalwood Research Newsletter* **10**, 6-8.

Sri Lankan Sandalwood (*Santalum album*)

Anon (2000) "*Santalum album* in Sri Lanka." *Parasitic Plants Newsletter* No **38** (2000).

Kathriarachchi H. S. & Tennakoon K. U. (1999). "A preliminary investigationon the biology of *Santalum album* (Sandalwood) in Sri Lanka." *Proceedings of the Sri lanka Association forthe Advancement of Science, Annual Sessions* **55**, 147-148

Tennakoon K.U., Ekanayake S.P. & Etampawala L. (2000). "An overview of *Santalum album* research in Sri Lanka." *International Sandalwood Research News Letter* **11,** (1-4). Abstract. This paper outlines the background and present status of *Santalum album* research in Sri Lanka. The cur-rent project is a detailed study undertaken to investigate the biology, ecology, siviculture and physiology of sandalwood in Sri Lanka. Assessments made during the pilot study and the experimental data collectedfrom the two established model nurseries of sandalwood will be used to provide training and know how tothe farmers and interested governmental and non-governmental organisations to establish their own San-dal nurseries and subsequent sandalwood plantations. This project is funded by the Community Environ-ment Initiative Facility implemented by the Environment Action 1 project of the Ministry of Forestry and Environment. Sri Lanka under a World Bank fund

Thai Sandalwood (*Santalum album*).

Anon (2004). "Police hunt for Thai sandalwood collectors" *New Straits Times*, Johor Baru. 28.6.2004

Timorese Sandalwood (*Santalum album*).

Alongi D.M. & de Carvalho N.A. (date?) "The effect of small-scale logging on stand charfacteristics & soil biogeochemistry in mangrove forests of Timor Leste." *Forest Ecology and Management*, **255** (3),1359-1366. Abstract. The impact of small-scale cutting of mangroves by family groups was examined in three high-salinity forests on the dry tropical, north coast of Timor Leste. Before logging, these forests were characterized by moderately dense stands (3633–9610 stems ha−1) of Ceriops tagal, Rhizophora apiculata, Bruguiera gymnorrhiza, and Avicennia marina, with average basal areas of 13–34 m2 ha−1, total above-ground biomass of 51–221.5 t ha−1, canopy cover of 61–73%, and leaf area index (LAI) of 4.9–5.4 m2 leaf area m−2 ground area. Approximately 1 year after the start of harvesting, these forests experienced a 30–50% decline in live stems and a 46–86% loss of above-ground biomass with more canopy gaps between less dense, smaller trees. There was some evidence of selectivity of trees 5–15 cm dbh in size, interpreted as a trade-off between cutting trees small enough for women and children to carry but large enough to warrant cost/benefit of selling for firewood. Concentrations of most particulate nutrients increased in surface soils in the harvested stands, reflecting bark, leaves, twigs, and small branches discarded on the forest floor. Interstitial concentrations of dissolved sulfide, metals, and ammonium also increased due to enhanced soil desiccation (evidenced by increased salinity) and decline in solute uptake and O2 translocation to live roots. Rates of anaerobic soil metabolism (sulfate reduction) declined after the onset of cutting, attributed to the

decline in live roots and their metabolic activities. These cutting operations, although small-scale, are unsustainable as these forests are likely to be slow-growing in such highly saline soils. A community-based approach to conservation and sustainable management of the remaining mangrove forests of Timor Leste is recommended. ***Cropwatch comments:*** Article mentions decline of sandalwood forests, once plentiful with white sandalwood up to 1915, through export of wood to China, Indonesia & Europe

Badan PengembanganEkspor Nasional (BPEN). 1993. "Informasi perkembangan harga minyak Cendana (Sandalwood) tahun 1993." *Pusat Informasi dan Analisa Pasar*. Jakarta.

Brand. J.E. (1993) *Phenotype and genotype variation within Santalum album in West Timor*. Thesis for degree of master of Science in Biology, Curtin University of Technology (unpublished).

DepartmentKehutanan (1991). “Cendana (*Santalum album* L.).” Kupang. Bagian Proyek Perencanaan Pimbinaan dan Pengendalian Pembangunan Kehutanan Kantor Wilayah, Department Kehutanan.

Effendi M. & Susila, I.W.W. (1994) "Genetics improvement of sandalwood (*Santalum album* L.) in Nusa Tenggara Timur" *International Symposium on Asian Tropical Forest Management*: proceedings, Samarinda, 13-15 Sep 1994

Effendi M. I. & Rachmawati dan U.R.Fauzi (1995). “Identifikasi sumber benih cendana (*Santalum album*) di Nusa Tenggara Timur dan Yogyakarta.” *Santalum* **17**. 20-27

Fox, J.E.D. (1990). “Silviculture of *Santalam album* (sic) in Timor NTT. (Report for the period 1988-1990). *ACIAR /Australia-Indonesia Sandalwood Project*. Curtin University Western Australia.

Fox J.E.D., Brand J.E., Barrett D.R., Markhum E. (1995). “Genetic variation in *Santalum album* in Timor.” In *Sandalwood Seed Nursery and Plantation Technology*, (Eds. LGjerum, JED Fox, L Erhart) pp 93–110. (FAO: Suva, Fiji).

Fox J E D, Doronila A I, Barrett D R & Surata I K (1996) “*Desmanthus virgatus* (L.) Willd. an efficient intermediate host for the parasitic species *Santalum album* L. in Timor, Indonesia.” *Journal of Sustainable Forestry* **3**(4):13–23.

Harisetijono & Sutarjo Suriamihardja (1993). “Sandalwood in Nusa Tenggara Timur.” In McKinnell, F.H. (ed) *Sandalwood in the Pacific Region*. Proceedings of a symposium held on 2 June 1991 at the XVII Pacific Science Congress, Honolulu, Hawaii. Canberra ACIAR Proceedings No.49 pp39-43.

Hamzah (1976). “Sifat Silvika dan Silivikultur Cendana (*Santalum album L.*) di Pulau Timor.” *Laporan Lembaga Penelitian Hutan*. Bogor 227.

Husain A.M.M. (1983). *Report on the Rehabilitation of Sandalwood and the Trade in Nusa Tenggara Timur Indonesia. PPIPD West Timor*

Kharisma & Sutarjo, S. (1988). “Effects of host plants on seedling growth of Cendana (*Santalum album* L.). *Santalum* **2**,1-8

Kushalapa K.A. (1998). “Trade liberalisation in Sandalwood.” In Radomiljac, A.M, Ananthapadmanabho, H.S, Welbourne, R.M, and Satyanarayan Rao, K. (eds), *Sandal and its Products.* Proceedings of an international seminar held on 18-19 December 1997 organised by the Institute of Wood Science and Technology (ICFRE) and Karnataka State Forest Department, Bangalore India. Canberra: ACIAR Proceedings No 84 24-26.

McWilliam A. (2001) “Haumeni, not many: renewed plunder and mismanagement in the Timorese Sandalwood Industry” *Resource Management in Asia Pacific Working Paper No 29* pub.

Resource Management in Asia-Pacific Program, Division of Pacific and Asian History, Research School for Pacific and Asian Studies, The Australian National University, Canberra 2001.

Marks S.V. (2002) "NTT sandalwood: roots of disaster." *Bulletin of Indonesian Economic Studies* **38**(2), 223-240. Abstract. For decades the government of Nusa Tenggara Timur (NTT) province has exploited the sandalwood sector, to the detriment of the growers of the trees. Severe depletion of the stock of sandalwood in the province has been the result. This paper documents NTT policies toward the sector, which it argues have been both inefficient and inequitable, and offers a detailed approach for reform. It also examines the political economy of these policies, and argues that the case of sandalwood provides an example of the dangers of decentralisation of economic authority in the absence of local democracy.

Messakh, M & Dewa A. (1999). "Dalam Hutanku ada cendana, tapi bukan milikku. [In my forest there is sandalwood but it does not belong to me]." *Udik: Advokasi Newsletter (***5**) Kupang. August

Messakh M.V. (1999). "Orang Timor Mencuri Cendana di Tanah Sendiri. Suatu tinjauan terhadap kebijakan Pemerintah Daerah NTT tentang komoditas cendana dan implikasi bagi kesejahteraan masyarakat lokal. [Timorese Steal Sandalwood from their Own Land: A study of NTT Government policy towards sandalwood and the implications for local community welfare]." *Lokakarya Penulisan Pegelolaan Sumber Daya Alam untuk Rakyat.* Lembaga Alam Tropika Indonesia (LATIN) [unpublished].

Nuningsih R., Mudita I .W., & Mella W. (1994). "Kajian Permudaan Cendana (*Santalum album* L) Secara vegetatif pada Habitat Alamiah di Timor Tengah Selatan NTT. [Study of vegetative root propagation of Sandalwood in natural habitats of South Central Timor]." Kupang. Universitas Nusa Cendana.

Nuningsih R. (1996). "Kajian Perkembangan Sistem Perakaran Anakan Vegetatif Alami Cendana (*Santalum album L*.) pada Habitat Alaminya di Kabuapaten Timor Tengah Selatan. [Study of development of vegetative root sprouting of Sandalwood in natural habitats of South Central Timor]". Kupang: Universitas Nusa Cendana.

Ormeling F.J. (1955) "The Timor problem. A geographical interpretation of an undeveloped island." PhD thesis, University of Indonesia. J.B. Walters, Djakarta & Groningen (through Rohadi *et al.* (undated).

Rahm Th. (1925)."Sandelhout op Timor." *Tectona* Buitenzorg **18**, 499-545.

Rohadi D., Maryani R., Widyana M. & Azhar I. (undated) "Ch 12. A case study of the production-to-consumption system of sandalwood (*Santalum album*) in South Central Timor, Indonesia. See http://www.cifor.cgiar.org/publications/pdf_files/Books/NTFPAsia/Chapter12-Chapter16.PDF.
Cropwatch comments: Recommended study of the Timorese sandalwood situation.

Rohadi D., MAryani R., Belcher B., Perez M., & Widnyana M. (2000). "Can sandalwood in East Nusa Tenggara survive? Lessons from the policy impact on resource sustainability." *Sandalwood Research Newsletter* Issue **10,** 3-6. Abstract. This paper discusses the policy aspects of sandalwood in East Nusa Tenggara province, focusing primar-ily on the impacts of regional government regulations on the resource sustainability. The paper is basedon a field survey that was conducted during July-August 1999, as well as from various publications and official reports from the region

Setiadi D & Komar T.E. (2001) "Current Sandalwood seed source in Timor Island." *Sandalwood Research Newsletter* 1**3**. Abstract. Sandalwood (*Santalum album* Linn) is one of the native species to East Nusa Tenggara which hashigh economic value. Effort has been put to increase its productivity, especially through artificialplantation since its natural regeneration success is very low. Artificial regeneration is the onlyalternative to overcome the shortage of raw material for various wood-base industries as well as for the production of santalol.

Steenis C.G.G.J van (1939). “The native country of sandalwood and teak: a plant geographical study.” *Hendelingen 8e Nederland Indische. Natuurwetenschappelijke Congres,* Sorabaja, pp408-418.

Susila I. W. W. (1994). “Estimate of hard-wood yield and natural regeneration ofsandalwood (Santalumalbum) inAmanuban Selatan, Timor Tengah Selatan.” *Santalum* **15**.

Surata K. (1992). “Effect of host plants on growth of sandalwood (*Santalum album*) seedlings.” *Santalum* **9**,1-10.

Surata I. K., Sutrisno E. & Sinaga M. (1995) "Utilisation and conservation ofSandalwood in Nusa Tenggara Timur,Indonesia." In Cjerum L., Fox J. E. D. & Ehrhart Y. (Editors). *Sandalwood seed nursery and plantation technology (Proceedings)*. RAS/92/361 Field Document No. **8**. CIRAD, ACIAR and UNDP.

Surata, K., Harisetijono & Sinaga, M., (1993). “Effect of intercropping system on sandalwood growth (*Santalum album*) “ *Santalum* **20**, 17-24.

Suriamihardja S & Susila I.W.W. (1993). “Strategi dan Upaya Pelestarian Potensi Cendana di Nusa Tenggara Timur [Strategies and Efforts for the Preservation of Sandalwood in NTT]” Savanna. Kupang: Balai Penelitian Kehutanan. 1-8. Suripto, 1992. Pemulihan Potensi Cendana di NTT. Makalah

Susila I.W.W. & Ormeling, F.J. (1955) “The Timor Problem.”. J.B. Walters, Djakarta, Gröningen. 994). "Estimate of hardwood yield & natural regeneration of sandalwood (*Santalum album*) in Amanuban Seletan, Timor Tengah Seltan. *Santalum* **15**

Susila I.W.W. (1994) “Estimation of heartwood yield & natural regeneration of sandalwood in Amanuban Selatan, Timor Tenga Selatan.” *Santalum* **15.**

Wright, A. (2001). “East Timor (Timor Timur) sandalwood plantation development: a feasibility study.” *Sandalwood Research Newsletter* **12**, 5-6.

Unclassified.

Denham R (1998) “Southern Sandalwood: an introduction” http://agspsrv38.agric.wa.gov.au/pls/portal30/docs/folder/ikmp/lwe/vegt/trees/f02798.pdf.

McKinnell F.H. (1990) “Status of Management & Silviculture research on Sandalwood in W Australia and Indonesia” in *Proc of the symposium on sandalwood in the Pacific* : April 9-11, 1990, Honolulu, Hawai/technical co-ordinators: Lawrence Hamilton, C. Eugene Conrad. Pub: Symposium on Sandalwood Conservation (1st: 1991: Honolulu, Hawaii). Abstract. The current status of the conservation and management of *Santalum spicatum* in Western Australia and *S. album* in East Indonesia is outlined. Natural and artificial regeneration techniques for both species in selected areas are discussed. The present Australian Centre for International Agricultural Research program on *S. album* in Nasa Tenggara Timur is described in relation to the management needs of the species in that province. In *S. spicatum*, research on silviculture is essentially complete, and interest is now focused on the marketability of the kernels for human consumption.

Metcalf C.R. (1935) “The structure of some Sandalwoods and their substitutes and of some Other little known scented woods.” *Bulletin of Miscellaneous Information* (Royal Gardens, Kew), 1935 – JSTOR.

Nagaraja Rao (1939) *J Ind Chem Soc Ind Division* (1939) **2**, 1.

Naipawer R.E. (1988) "Synthetic sandalwood chemistry - a decade in review." *Dev. Food Sci.* **18**, 805-818.

Neil, P. E. (1989). “Possible techniques for raising and planting sandalwood in Nepal.” *Banko Janakari* **2**(3):1-6; 1989.

Neil P.E. (1990) “Growing sandalwood in Nepal - Potential Silvicultural Methods and Research Priorities.” *Proceedings of the Symposium on Sandalwood in the Pacific April 9-11, 1990, Honolulu, Hawaii* Abstract. Interest in sandalwood has increased recently in Nepal as a result of a royal directive to plant it in the Eastern Development Region. The most suitable seed sources, seed acquisition, nursery techniques, direct sowing and plantation establishment methods are discussed here on the basis of results from elsewhere. Suggestions are made as to what research is most needed to assist with successful establishment of sandalwood in Nepal. The silvicultural methods discussed could well be of use to other countries that are interested in introducing and establishing sandalwood plantations.

Surendran, C., Partiban, K.T., Bhuvenaswaran, C. & Murugesh, M. (1998). “Silvicultural strategies for augmentation of sandal regeneration.” In: Radomiljac AM, Ananthapathmanabha HS, Welbourn RM, Stayanarayan K. (eds.) *Sandal and its products*. *ACIAR Proceedings* Volume **84**. Arawang Communications, Canberra. pp. 69-73.

Wang Z, Hong X. (1991) "]Comparative GC analysis of essential oil in imported sandalwood] *Zhongguo Zhong Yao Za Zhi*. **16**(1), 40-3 Abstract. The GC-fingerprint spectra of essential oils in imported sandalwood are established by the new technique of GC-relative retention value fingerprint spectrum (GC-FPS). According to the GC-FPS of samples, their chromatographic peaks, overlap ratio of peaks and eight strong peaks are studied comparatively.

Widiarti, A. (1991). “Site and heartwood formation of sandalwood.” *Buletin Penelitian Hutan* (**534**), 1-14.

Zhang D-Q., Ma Q-Z, Peng W-x & Liu Q-M. (2008) "Pyrolysis- GC/MS analysis of biomedical components of the pyrolyzate of *Santalum album* leaf treated by benzene/ethanol extraction." *Bioinformatics and Biomedical Engineering 2nd Intl. Conference 16-18 May 2008*, 1213-1218,