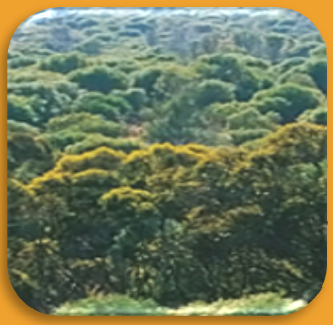


Relevance of the chemical constituency of East Indian Sandalwood essential oil to therapeutic and traditional uses

Kate Fallick

Australasian College of Natural Therapies (ACNT)
Aromatherapy Chemistry and Pharmacology Assignment

"The aim of this assignment is to investigate essential oil chemistry and it's relevance to the therapeutic use of an essential oil. By contrasting the historical and the modern aromatherapeutic use of an essential oil with the chemistry of the chosen oil a deeper picture of how to use this oil emerges." (ACNT Aromatherapy Chemistry and Pharmacology Module Outline, 2009)

East Indian Sandalwood (*Santalum album)*

The essential oil being presented in this assignment is East Indian Sandalwood. The botanical name for this popular oil is *Santalam album,* and it is from the Santalaceae group botanical family. Battaglia (2007, p.263) states it is a small evergreen tree up to 9m. It is native to and cultivated in the tropical regions of Asia such as India, Sri Lanka, Malaysia, Indonesia and Taiwan. "India is the main producer of Sandalwood oil" (Leung A, 1996; cited in Battaglia 2007).

http://www.hesekiel37.de/assets/images/144-Santalum-album.gif

The East Indian Sandalwod tree is a root parasite. "A sandalwood seedling can survive only by becoming attached to the roots of other plants. Once the roots are well attached to an adjoining plant, the sandalwood tree is then also able to obtain nutrients directly from the soil. Over 30 species can nourish sandalwood; these include teak, clove, bamboo and the tropical guava tree." (Weiss 1997, as cited in Battaglia 2007).

"The essential oil is principally contained in the heartwood and larger roots. Heartwood formation accelerates rapidly from 20 years and is at its prime in trees 30 to 60 yeards old". Weiss also discusses the harvesting of Sandalwood for oil and timber "involves felling the tree by uprooting, not cutting the trunk. Only mature trees are harvested. The Indian Government has strict regulations governing harvesting of Sandalwood" (Weiss 1997, as cited in Battaglia 2007) which I will discuss further later on.

“To manufacture the oil, only the heartwood of trees, over 30 years old should be used. If younger trees are used, not only do you end up with an inferior oil, but the yield is considerably less.” (Chana J, 1994; 6(4): 11-13; as cited in Battaglia 2007).

To extract the oil,“it is cut and distilled and the yellowish wood is sold in thin scrapings. It is extracted from the chipped heartwood by steam distillation and yields 4-6.5%. The oil has a woody, exotic smell, subtle and lingering and the color is pale yellow to pale gold.” (Esoteric Oils website, 2009).

“The billets of branch and root are first coarsely chipped and then ground to a fine powder. Steam distillation, the most common method of essential oil production, involves the flow of steam into a chamber holding the raw plant material. The steam causes small sacs containing essential oil to burst. The oil is then carried by the steam out of the chamber and into a chilled condenser, where the steam once again becomes water.

The crude sandalwood oil floating on the distillate surface is skimmed off, separated from the remaining liquid and scum impurities, and then filtered. We have taken extra care for the purity and then it is heated at a temperature of 90 degrees which removes the water content after which it is filtered and finally packed in export packing.” (Natural Aromatics Limited website, Tanzania, 2009).

Sandalwood chips
Picture reference: Naresh Group

Main chemical constituents

The main chemical constituents in Indian Sandalwood are “Santalol, Santyl acetate and Santalene” (Esoteric Oils, 2009).

In Battaglia’s book, he references Chana advising of the chemical composition of Indian Sandalwood, listing the varying chemical constituents of the oil if the tree is harvested at 10 years and then comparing to if a tree is harvested at 30 years old.

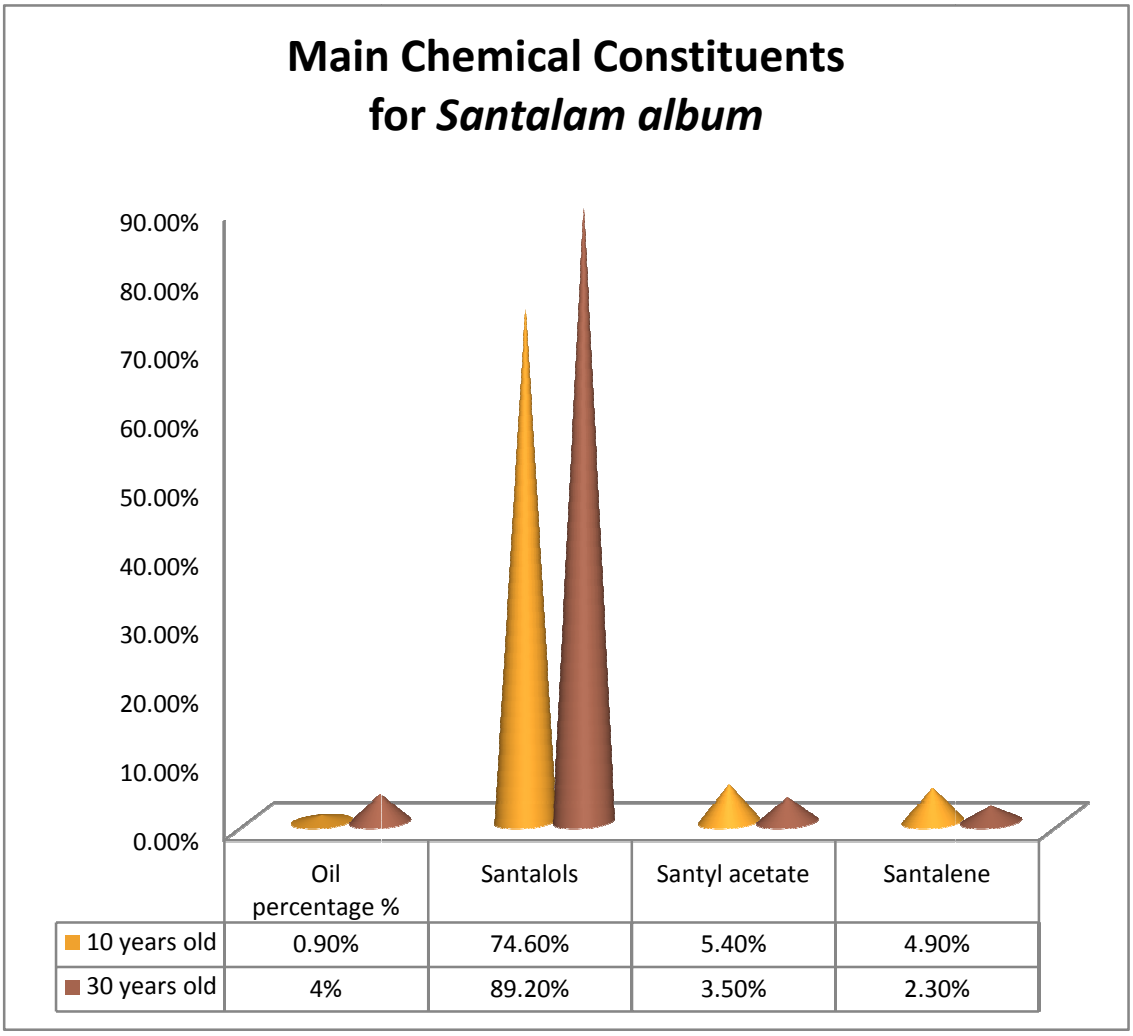
The results are interesting, as you can see below in the graph, the Santalol content of a 10 year old *Santalam album* is 74.6%, and the 30 year old *Santalam album* has an 89.2% content.

The oil percentage of a 10 year old tree is 0.9%, and of a 30 year old tree is 4%.

Interestingly though, the Santyl acetate and Santalene amounts in a 10 year old tree are slightly more than in a 30 year old tree (Santyl acetate in a 10 year old tree being 1.9% more than 30 year old tree, Santalene in 10 year old tree being 2.6% more than in a 30 year old tree).

A typical chemical composition of sandalwood by age of tree

Chana J. *Sandalwood Production*. The International Journal of Aromatherapy 1994; 6(4): 11-13 (as cited in Battaglia, 2007)



	Oil percentage %	Santalols	Santyl acetate	Santalene
10 years old	0.90%	74.60%	5.40%	4.90%
30 years old	4%	89.20%	3.50%	2.30%

I was interested in reading the fact Chana states (Chana J, 1994; 6(4): 11-13; as cited in Battaglia 2007), that the Indian Government has set regulations on the oil's chemical content and the standards require the essential oil must contain a legal minimum of 90% santalols.

This is good news as the worldwide essential oil industry is demanding high quality Sandalwood oil from, however is that quality guaranteed in being supplied throughout the world?

According to M Howes et al in the article titled 'Evaluation of the quality of sandalwood essential oils by gas chromatography–mass spectrometry', they found:

"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." (M Howles et al; Royal Botanical Gardens, Kew, UK, 2004; cited on ScienceDirect website).

Sandalwood Essential Oil
Picture from Agro Products website 2009
(http://www.agriculturalproductsindia.com/essential-oil/essential-oils-sandalwood-oil.html)

Understanding the chemical constituents of *Santalum album*

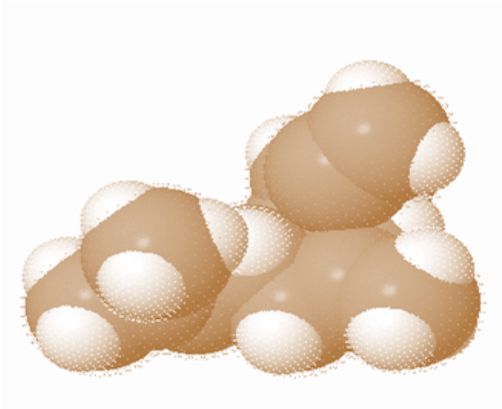
To understand the chemical constituents, it helped me to understand the naming of such chemicals and types of chemicals.

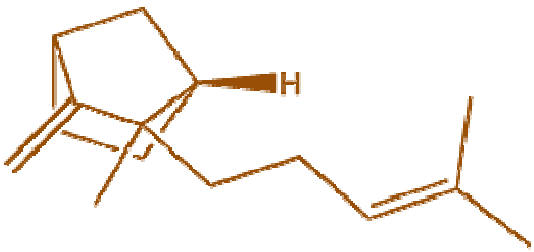
Sesquiterpenes

Sesquiterpenes are "hydrocarbon molecules which have 15 carbon atoms (three isoprene units), and a varying number of hydrogen atoms. There are no oxygen atoms. Being terpenes, sesquiterpenes also end –ene, and, like the monoterpenes, the rest of the name is derived either from the type of plant it was found in, or from the country it was found in. For example, alpha-pinene was first found in pine oils (*Pinus sp.),* and chamazulene was first found in Chamomile oil. Some sesquiterpenes occur in only one or a few oils, for example cedrene in the Cedarwood oils and Santalenes in Sandalwood oil" (Bowles J, 2003, p.60).

Beta-santalene

Below are examples of the Beta-santalene molecule, a sesquiterpene. There is little information available on the actual beta-santalene itself, but rather more information on sesquiterpenes as a group.





"Sesquiterpenes are not soluble in water, though they do dissolve readily in other oils and non-polar solvents. Due to their larger size they do not dissolve as readily in ethanol as monoterpenes" (Bowles J, 2003, p.61).

Because sesquiterpenes are not as volatile as monoterpenes (for example, Sandalwood is not as volatile as a citrus oil such as Lemon), due to the "higher molecular weight and higher boiling points" (Bowles J, 2003, p.61), this also means that they are used as middle or base notes, rather than the very obvious top notes in perfumery.

Bowles explains that most of the 'woody' oils tend to be sesquiterpenoid in character, meaning they are made of high amounts of sesquiterpenes and sesquiterpanols.

In regards to the therapeutic effects of sesquiterpenes, "Sesquiterpenes with several double bonds are supposed to be good for reducing inflammation caused by stings and bites, and for histaminic reactions." (Penoel & Franchomme, 1990; cited in Bowles J, 2003, p.61).

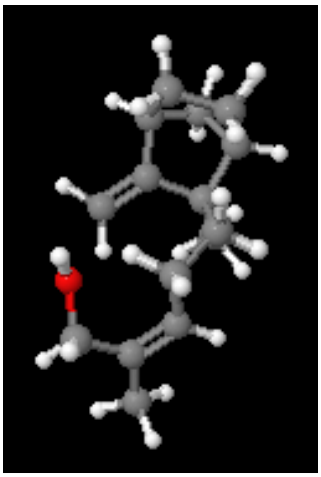
Sesquiterpenols

"Are derived from sesquiterpenes by the addition of an –OH group; often both are present in the same oil. Different plants create special sesquiterpenols which become characteristic of that plant. Examples are patchoulol, which is only found in Patchouli oil, and the santalols found in Sandalwood oil. The structures often have two or three closed rings, which add to the complexity of the molecule. Oils that contain high proportions of sesquiterpenols are usually fairly viscous and slow flowing." (Bowles J, 2003, p70).

This can help explain why Sandalwood oil is thicker in consistency than, for example, Ylang Ylang, *Cananga odorata*, (that has 2% farnesol (Bowles, 2003, p.72), but less resinous than Patchouli (*pogostemon cablin* that has 40% patchoulol, (Bowles, 2003, p.72)), another sesquiterpenol.

Bowles advises that Sesquiterpenols are both soluble in vegetable oils and alcohol, however are not soluble in water, even though they have an –OH group, they also have a long carbon chain. They are also named from their parent sesquiterpene, which explains why alpha and beta santalol are named from their parent sesquiterpene, santalene.

Beta santalol



East Indian Sandalwood has 20% beta-santalol (C15H24OH bicyclic, unsaturated (primary alcohol) (J Bowles, 2003, p.72).

Molecular structure of Beta santalol
Picture reference: The Good Scent Company website (http://www.thegoodscentscompany.com/data/rw1377041.html)

Therapeutic effects of sesquiterpenols:

Joy Bowles writes about Sandalwood and its therapeutic anti-viral properties, "Sandalwood is nearly all sesquiterpenes and sesquiterpenols, santalenes and santalols. Benencia and Courreges (1999) tested it against Herpes simplex I and II *in vitro* and found that the oil inhibited replication of both viruses, but did not kill them. It was less effective at high viral load. This may mean that Sandalwood oil could be used as a preventative for cold sores." (Bowles, 2003, p.75).
"Sandalwood oil is reported to have diuretic and urinary antiseptic properties. Clinical trials have identified that a-santalol and b-santalol have a sedative effect. "The oil has also been reported to significantly decrease the incidence of papillomas" (Battaglia, 2007; p.264).

Essential oil containing high percentages of sesquiterpenols:

Sandalwood (India) *Santalum album*	Cis-alpha-santalol 50%	Cis-beta santalol 20.9%	Epi-beta-santalol 4.1%

Data from Bowles, 2003 (p.76, Table 4.4).

The potential for Santalol's therapeutic effects was brought to attention in 2003 in a study on Santalol being possibly used as a Chemo-preventative on the skin by the American Association for Cancer Research (AACR). Below are three separate excerpts from study results from a larger document explaining these clinical tests on Santalol and its possible link with prevention of skin cancer:

"Studies from our laboratory have indicated skin cancer chemopreventive effects of sandalwood oil in CD-1 mice. The purpose of this investigation was to study the skin cancer chemopreventive effects of α-santalol, a principal component of sandalwood oil in CD-1 and SENCAR mice. α-Santalol was isolated from sandalwood oil by distillation under vacuum and characterized by nuclear magnetic resonance and gas chromatography-mass spectrometry.

"α-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.

"α-Santalol could be an effective chemopreventive agent for skin cancer. Additional experimental and clinical studies are needed to investigate the chemopreventive effect of α-santalol in skin cancer." (Dwivedi et al; Cancer Epidemiology Biomarkers and Prevention Journal (2003).

Aldehydes
"Aldehydes are characterised by a carbonyl group on a terminal carbon atom. A carbonyl group is an oxygen atom double-bonded to a carbon atom (C=O). The fourth bond is always a hydrogen atom. They are derived from primary alcohols by a process called oxidation" (Bowles J, 2003, p.80).

It is possible also to get sesquiterpenoid aldehydes. Sandalwood oils (*Santalum album* and *Santalum spicatum*) have santalals for example." (Bowles J, 2003, p.81).

Other information on Santalals is limited, although there is new information from a Japanese study "new antitumor sesquiterpenoids from Santalum album of Indian origin" (Hoon Kim et al, 2006) researching Santalals perhaps being useful as an anti-carcinogenic agent.

David Oller lists the chemical components of *Santalum album* on the Scents of the Earth website as:

"Sesquiterpenes; Sesquiterpenols; Sesquiterpenals; (includes 80 to 90% terpeniod alcohols including a and B-santalols (67%), which is a mixture of two primary sesquiterpenic alcohols) santalic and teresantalic acid, aldehyde, pterocarpin and hydrocarbons, isovaleric aldehyde, santene, santenone." (Oller, 2009).

Therapeutic use of the oil historically

Sandalwood is well known for its uses in Indian traditions, it is even "mentioned in the one of the oldest pieces of Indian literature, the Ramayana (written around 2,000B.C.). Sandalwood has nearly fifteen different names in various Indian languages, "chandan(a)" being the Hindi name." (Ramanathan 1997).

"Ayurvedic healers either used powdered Sandalwood or the burning of Sandalwood in their ancient practice" (Oller, 2009). It is also part of the ceremonial blessing in Hinduism, for example, when someone is initiated into their Mantra and on special festivities. Often in India, you can smell Sandalwood burning in the form of incense (made from Sandalwood powder), by Hindus paying reverance to one of their 3 million Gods in Hinduism.

"Burning incense is a tradition that dates back thousands of years, in practically all of earth's ancient civilizations, and is well known for it's mood-altering qualities. The word *incense* is derived from the Latin verb incendere, 'to burn'. It has been used to accompany prayer, to worship the Gods, purify the air, release negative vibrations, induce self-awareness and to uplift the emotional state." (The History of Incense, Spiritual Sky website, 2002).

"There are many references to incense in the Old and New Testament and the Roman Catholics still use incense at mass and in many other of their rituals. It symbolizes the sacredness of a person or occasion, and their prayer as it rises to God." (Spiritual Sky, 2002).

One of the other benefits of Sandalwood, in modern and ancient times, is that it is a scent that can serve both genders well. It is not a floral, so not to feminine for the males, and it still manages to intrigue females with its woody, earthy tones. "The neutral flavor of Sandalwood is perfect for meditation and healing. Sandalwood is often a favorite with men as they enjoy it's subtle fragrance. It is calming, balancing and harmonizing." (Spiritual Sky, 2002).

East Indian Sandalwood Tree

Sandalwood ... is used as a paste that the holy men of India (the Sadhus) place on their foreheads (see photo opposite). (All you need to know about Hinduism website, 2009).

One version of why they do this is to symbolise Shiva (Hindu God of Destruction's trident). Another is the 3 lines representing the Gunas, the 3 energies of the universe, tamas (lazy), rajas (dynamic) and sattva (meditative), balance being the energy they are aiming for to gain total inner peace, enlightenment (Samadhi).

Therefore , this would explain the ancient use of Sandalwood for being recognised as an important gift from nature helping people to reach the state of meditation, even thousands of years ago.

Sadhu (Holy Man)
Picture from University of Southern Maine website
(http://www.usm.maine.edu/gany/AnthroMinor.htm)

Known as 'Bai tan xiang' in China, 'Byaku-dan' in Japan, Sandalwood has also been known not only in ancient Sanskrit texts and manuscripts but also ancient Chinese ones. There is an old Buddhist scripture that states "*None but the Mali Mountains contain Sandalwood*."

"The oil was used in religious ritual, and many deities and temples were carved from its wood. The wood is soft to carve and is frequently used in sacred fragrant carvings. The ancient Egyptians imported the wood and used it in medicine, embalming and ritual burning to venerate their gods. In Buddhism, it is considered to be one of the three incenses integral to Buddhist practice, together with Aloes wood and Cloves".

"Depression, anxiety and insomnia were thought to be improved by sandalwood. It was believed to promote spiritual practices, peaceful relaxation, openness and "grounding." It is used in many death ceremonies to help the crossing over, and to comfort mourners. It is also used in many forms of initiation rites to open the disciples mind to receive consecration. In the Zoroastrian Temples it burns in there sacred fires to soothe the troubles of all humanity. It is used by the Jewish, the Buddhist, the Hindus, as well as almost every other belief system for its vast diversity in attributes." (Oller D, 2009).

Modern Aromatherapeutic use of the oil

Sandalwood can be used to treat many conditions such as:

- **Lymphatic system -** Venous and lymphatic stasis such as varicose veins and swollen lymph nodes. Holmes suggests this may be due to the sesquiterpene alchohols which have an anti-inflammatory effect (Holmes 1994; as cited in Battaglia 2007).
- **Nervous system** – "Sandalwood oil has a relaxing effect on the nerves and may be used for hot, agitated emotional states leading to conditions such as headaches, insomnia and nervous tension" (Battaglia, 2007).
- **Respiratory system** – Can treat respiratory tract infections, especially when its "soothing, demulcent effects are required". Battaglia lists four references where it is said Sandalwood can help for "chronic bronchitis involving a chronic dry cough" (Mojay 1996; Davis, 1999; Lawless; 1992; Holmes 1989; as cited in Battaglia 2007).
- **Genitourinary** - Has been used for years for genitourinary tract infections (e.g. Cystitis and gonorrhoea). (Mojay 1996; Davis, 1999; Lawless; 1992; Holmes 1989; as cited in Battaglia 2007). "Sandalwood is an astringent and helps to resolve mucous congestion. Sandalwood oil helps to restore the mucous membrane and minimise the risk of infection" (Battaglia 2007).
- **Integumentary system** – "Applied to the skin, sandalwood oil is soothing, cooling and moisturising and primarily used for dry skin conditions caused by loss of moisture and skin inflammations. It may be used to relieve eczema and psoriasis and for the treatment of oily skin and acne" (Mojay 1996; Davis, 1999; Lawless; 1992; as cited in Battaglia, 2007).
- **Anti-viral** (herpes simplex/cold sores) (Bowles, 2003, p.75)

Below, I have compared both Scents of Earth website (2009)and Battaglia's (2003) lists of which therapeutic properties Sandalwood oil has:

Therapeutic properties of *Santalam album*	**Scents of Earth**	**Battaglia**
Antidepressant	☑	
Antispasmodic		☑
Antiseptic	☑	☑
Antinflammatory		☑
Aphrodisiac	☑	
Antiphlogistic		
Astringent	☑	☑
Calming	☑	
Carminative		☑
Demulcent		☑
Disinfecting	☑	
Diuretic	☑	☑
Emollient		☑
Expectorant	☑	☑
Restoring	☑	
Sedative	☑	☑
Soothing	☑	
Stimulant	☑	
Tonic	☑	☑

Battaglia has listed the possible modes of administering treatment with *Santalum album* oil*:*
"Topical application - massage, compress, bath, sitz bath, douche, ointment, skin care. Inhalation - direct inhalation, diffuser, oil, vapouriser, steam inhalation" (Battaglia, 2007).

Sandalwood is not only known for its therapeutic qualities, but also for its scent. Essential oils and attars may have also been used in Indian medicine, but were popularized in the west by the perfume industry and so became applied medicinally in the western world after the 1920's by French aromatherapists. "The word attar is derived from an old Persian word meaning 'to smell sweet' (Santosha website, 2009). Well known in the Middle East, Persia and India for thousands of years attars have only recently been popularly introduced in the West. (Santosha website, 2009).

"In India, essential oils are steam or hydro-distilled and the condensing vapours are allowed to condense into vats of Sandalwood (*Santalum album*) oil to form attars. The Sandalwood oil acts as a fixative for the more volatile essential oil constituents, so attars can be applied directly to the skin as perfumes or meditation blends." (Bowles J, 2003, p.169).

"Like a fine wine, a true, sandalwood-based attar actually improves with age." (Tigerflag Perfumery website, 2009).

Sandalwood incense and chips
Picture from Kawiseraya website:
(http://www.kawiseraya.com/images/sandalwood%20incense1.jpg)

Comparison and contrast of the modern and historical therapeutic use of the oil with the findings of the active constituents

The ancient uses of Sandalwood for incense, worship, meditation and attaining inner peace have seeped into modern society in many different ways. For those who practice their religion or ancient spiritual practices such as yoga and meditation, Sandalwood is still now, thousands of years later, a very familiar and much loved smell. Meditation is still very much a part of many people's lives today, especially with growing stress and anxiety levels and the busy world we live in, if we have natural wonders such as East Indian Sandalwood essential oil with its' sedative, meditative properties, they are bound to be not only popular, but successful tools in bringing about inner peace that is still as necessary now, as it was in the days of the ancient sages.

Due to its emollient properties, Sandalwood is still very much used for skin care, you just have to drop into a health food shop or natural beauty place to spot the Sandalwood in its products for its earthy scent and skin healing therapy.

Even though Sandalwood is known throughout the ancient times, I still see Sandalwood as being a main oil of the modern times as essential oils have healing properties that don't age. Our health issues may change over the ages, yet the need for balance, 'homeostasis', and inner peace is an ongoing journey for humans, therefore *Santalum album* essential oil has played an important part in healing the ancient world and will continue to do so with these busy, stressful and challenging modern times.

Three conditions in which you could use this oil

1) A sitz bath to treat a **genitourinary infection**, seeing chemically it has been linked to aiding in healing the herpes virus (Bowles, 2003, p.75).

Sandalwood is an antiseptic and anti-inflammatory oil and has a "pronounced effect on the mucus membranes of genito-urinary tract" (Esoteric oils, 2009).

The sitz bath is cooling for inflamed conditions, and allows the oils to heal quickly. The added bonus is that seeing Sandalwood has a calming effect and enhances meditation, this way, the healing process can be hastened as the person loses their worries and discomfort.

2) Treat dry **skin conditions** such as eczema with East Indian Sandalwood, as it is an anti-inflammatory condition, as well as an emollient so it will take the heat and agitation away from the skin, and help produce healthy skin cells.

Sandalwood oil relieves itching and inflammation of the skin, and is most effective in relieving dehydrated skin, making it great for anti-ageing skincare - and the astringent action has a great toning effect and is also used with great results in oily skin conditions and to prevent the skin from forming ugly scars and for fighting dry eczema." (Esoteric oils, 2009).

The oil is suitable for both sexes as it doesn't smell too feminine, so males and females can be assisted with the use of *Santalum album*.

3) Use for **Stress or anxiety**. Sandalwood's woody, earthy scent assists relaxation, taking worries away and has a grounding effect on a person. East Indian Sandalwood encourages a deeper, meditative state, increasing the parasympathetic nervous system of a person, rather than a sympathetic nervous system response. When the sympathetic nervous system is firing, the immune system is under pressure and therefore the body is unable to heal as effectively as it potentially can. Therefore, the more stressed a person can become, the unhealthier in mind and body they become, and so the viscous cycle begins. A sedative oil such as *Santalum album* assists a person in tapping into the parasympathetic nervous system more often throughout their daily life, ensuring better health and well-being.

This oil works as an expectorant, hence aids a person in deeper breathing (explaining why it is so prevalent in meditation). Deeper breathing in the yogic practices of over 5000 years have proved that a brighter mind and healthier body can be achieved, relieving the person of stress and anxiety by engaging the parasympathetic nervous system.

"This relaxing oil has a harmonizing and calming effect which reduces tension and confusion and is ideal for use in depression, hectic daily lifestyles and states of fear, stress, nervous exhaustion, chronic illness and anxiety." (Esoteric oils, 2009).

East Indian Sandalwood Tree
Picture from Aromatherapy Wellness website
(www.aromatherapywellness.com)

The use of Sandalwood essential oil in many traditions and cultures from meditating seers and sages thousands of years ago, to our more scientifically advanced modern times, shows the depth of the therapeutic use of Sandalwood oil and Aromatherapy in general. This powerful natural modality has helped millions of people around the globe over several millennia to find equilibrium, balance of the body, mind and spirit.

REFERENCES

ACNT Aromatherapy Chemistry and Pharmacology Study Guide, 2009

All you need to know about Hinduism website, 2009. (http://history-of-hinduism.blogspot.com/)

Battaglia S, *The Complete Guide to Aromatherapy*, The International Centre of Holistic Aromatherapy, Brisbane, 2007, pages 263.

Chana J, *Sandalwood Production*; The International Journal of Aromatherapy 1994; 6(4): 11-13 (cited in Battaglia 2007).

Davis P, Aromatherapy: An A-Z. 2nd edn. The C.W. Daniel Company Limited, Great Britain, 1999; as cited in Battaglia 2007.

Dwivedi et al; *Chemopreventive Effects of α-Santalol on Skin Tumor Development in CD-1 and SENCAR Mice,* Cancer Epidemiology Biomarkers and Prevention Journal; February 1, (2003) *12,* 151 (http://cebp.aacrjournals.org/content/12/2/151.abstract)

Esoteric Oils, Republic of South Africa, website: (http://www.essentialoils.co.za/essential-oils/sandalwood.htm#Extraction); last viewed 26th September, 2009

Hoon Kim, Ito, Hatano, Takayasu, Tokuda, Nishino, Machiguchi and Yoshida, "New antitumor sesquiterpenoids from Santalum album of Indian origin" Tetrahedron, Volume 62, Issue 29, 17 July 2006, Pages 6981-6989

Holmes P, *The energetic of western herbs Vol II,* Artemis Press, *USA,* 1989; as cited in Battaglia, 2007

Howes M et al; 'Evaluation of the quality of sandalwood essential oils by gas chromatography–mass spectrometry', Royal Botanical Gardens, Kew, UK, 2004; published on ScienceDirect website (http://www.ncbi.nlm.nih.gov/pubmed/14989484)

Lawless J, *The encyclopaedia of essential oils,* 1992; as cited in Battaglia, 2007

Leung A, *Encylopedia of common natural ingredients used in food, drugs and cosmetics*. 2nd edn, John Wiley and Sons Inc, USA, 1996; (cited in Battaglia 2007).

MARONGIU B, et al; Dipartimento di Scienze Chimiche, Università degli Studi di Cagliari, Cittadella Universitaria, St Prov. Monserrato-Sestu, km. 0.770, 09042 Monserrato (CA), ITALIE

Mojay G, *Aromatherapy for healing the spirit.* Hodder and Stoughton 1996; as cited in Battaglia 2007.

Natural Aromatics Limited, Tanzania, website: (http://www.naturalaromatic.com/sandalwood-oil-of-different-species.html), last viewed 27th September, 2009

Oller David, Sandalwood Information, Scents of Earth – Aromatic Treasures from Ancient Lands - website, 2009 (http://www.scents-of-earth.com/sandalwood1.html)

Ramanathan Cindy, Indian Sandalwood Trade, TED Case study, from American Education website 1997, (http://www1.american.edu/TED/sandalwd.htm)

Santosha website (http://www.santosha.com/Attars-Oils-Perfumes_c_266.html), 2009.

Spiritual Sky, New Zealand, 2002 (http://www.spiritualskyincense.com/history-of-incense.htm)

Tigerflag Perfumery website (http://www.tigerflag.com/about-attars-and-perfumes.html), 2009.

Weiss, EA, *Essential oil crops*, CAB International, UK 1997; (cited in Battaglia 2007).

PICTURE REFERENCES:

Agro Products website 2009
(http://www.agriculturalproductsindia.com/essential-oil/essential-oils-sandalwood-oil.html)

B Santalol: The Good Scent Company website 2009
(http://www.thegoodscentscompany.com/data/rw1377041.html)

Molecule picture: Pherobase website 2009:
(http://www.pherobase.com/database/kovats/kovats-detail-beta-santalene.php)

Santalum album picture*: (*http://www.hesekiel37.de/assets/images/144-Santalum-album.gif)

Sandalwood chips, Naresh Group Importers:
(http://nareshgroup.tradeindia.com/Exporters_Suppliers/Exporter16349.256402/Finished-Sandalwood-Chips-for-Export.html)

Sandalwood incense from Kawiseraya website 2009:
(http://www.kawiseraya.com/images/sandalwood%20incense1.jpg)

Sandalwood tree on reference page: Aromatherapy Wellness website
(www.aromatherapywellness.com)

Sadhu (Indian holy man with Sandalwood paste on forehead) from University of Southern Maine website: (http://www.usm.maine.edu/gany/AnthroMinor.htm)