



## Research article

**Volatile oil characterization of *Santalum spicatum* (R.Br.) A.DC.****Brajesh Kumar Saxena<sup>1</sup>, Nadeem Akbar<sup>2</sup>, Sunil Kumar Yadav<sup>2</sup> and Sudhir Kumar Srivastava<sup>1\*</sup>**<sup>1</sup>Department of Chemistry, D.A.-V. P.G. College, Civil Lines, Kanpur, Uttar Pradesh, India<sup>2</sup>Quality Assessment Laboratory, Fragrance & Flavour Development Center, Kannauj, Uttar Pradesh, India\*Corresponding Author: [srivastavasudhir3@gmail.com](mailto:srivastavasudhir3@gmail.com)

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**Abstract:** The heartwood of *Santalum spicatum* was collected from local distillers and essential oil was extracted by steam distillation method. The chemical composition of essential oil was determined using a gas chromatography flame ionization detector (GC-FID) and a mass-selective detector (GC-MS). In the analysis, 22 constituents were identified and among 11 constituents have commercial value. These were  $\beta$ - bisabolene (1.08%),  $\beta$ - santalene (0.80%),  $\alpha$ -santalyl acetate (2.58%),  $\alpha$ -santalol (1.19%), cis- $\alpha$ -santalol (4.69%), trans-bergamotol (1.28%), cis- $\alpha$ -santalol (8.40%), trans- $\beta$ -santalol (2.22%), lanceol (37.82%), nuciferol (17.62%) and spirosantalol (1.02%).

**Keywords:** Essential oil - Aroma - Sesquiterpenes - Steam distillation.

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**INTRODUCTION**

Sandalwood is one of the most highly valuable aromatic plant species in the world belonging to the family Santalaceae and the genus *Santalum*. It is highly rated for its pleasant, sweet, persistent aroma and fixative property (Arun *et al.* 2012). There are around eighteen sandalwood species belonging to the genus *Santalum* which are; *S. spicatum* (R.Br.) A.DC., *S. album* L., *S. lanceolatum* R.Br., *S. freycinetianum* Gaudich, *S. yasi* Seem., *S. haleakalae* Hillebr., *S. ellipticum* Gaudich., *S. involutum* H. St. John., *S. boninense* (Nakai) Tuyama, *S. insulare* Bertero ex A.DC., *S. austrocaledonicum* Vieill., *S. macgregorii* F.Muell., *S. murrayanum* C.A.Gardner, *S. obtusifolium* R.Br., *S. fernandezianum* F. Philippi, *S. salicifolium* Meurisse, *S. acuminatum* A.DC. and *S. paniculatum* Hook. & Arn. Five species of sandal wood are found in Australia. Two species are commercially important, *Santalum spicatum* and *Santalum lanceolatum* (Dhanushka *et al.* 2012). The steam distilled *Santalum spicatum* has chemical constituents very much similar to the Indian *Santalum album*. There is the only difference in the percentage of constituents and their sensory odour profile (Liu *et al.* 1997, Gunkel & Fraser 2010). Indian sandalwood oil has a total santalol percentage of about 90% while it contains 25–30% only. In sensory odour evaluation, the top note of Indian sandalwood is more pleasant and accepted by the perfumers and end users. Australian sandalwood has a more resinous, drier and less sweet top note. Due to the woody odour profile of both the oils, are being used in the base note of perfumery products. Australian steam distilled sandalwood oil can be used the same as Indian sandalwood in aromatherapy (Valder *et al.* 2003, Jones *et al.* 2004).

Western Australian sandalwood or *S. spicatum* was originally found across a large area of Western Australia from the arid interior to the woodlands. It is a small tree that grows to 20 feet tall: Australian sandalwood begins to bear fruit at 5 to 10 years of age, with flowering beginning in March or April. Trees mature much faster where there are higher levels of moisture than in the dry regions. Early over-harvesting and the conversion of forest to farmland in the regions with higher rainfall has eliminated most of the sandalwood trees in the area. Replantation is being started in the region where the higher rainfall provides a better chance of success.

The brown part or heartwood of the stem is used for commercial distillation of the oil. The oil yield varies from 2.0 % to 3.0%. Its oil is extensively used in the production of perfumery compounds and traded on account of its pleasant, woody, sweet odour and is also a good substitute of Indian sandalwood oil used in perfumes and

natural Indian attar. The de-oiled powder is also used in incense stick (*agarbatti*), incense burner (*havansamigri*) and in low-cost cosmetic products. In the present work, we analysed essential oil of *Santalum spicatum* of Western Australian origin by physiochemically and GC-MS to evaluate the quality of the oil. Physical and chemical parameters of essential oil *Santalum spicatum* like optical rotation, specific gravity, refractive index, solubility, acid value, ester value were analysed and compared with values of Indian *Santalum album* oil (Table 1). Several constituents were also determined by GC-MS as  $\beta$ -bisabolene (1.08%),  $\beta$ -santalene (0.80%),  $\alpha$ -santalyl acetate (2.58%),  $\alpha$ -santalol (1.19%), cis- $\alpha$ -santalol (4.69%), trans-bergamotol (1.28%), trans  $\alpha$ -santalol (0.40%), cis- $\beta$ -santalol (8.40%), trans-  $\beta$ -santalol (2.22%), lanceol (37.82%), nuciferol (17.62%), spirosantalol (1.02%), trans nuciferol (0.42%) (Braun *et al.* 2003).

**Table 1.** Physico-Chemical properties of essential oil of *Santalum spicatum* (R.Br.) A.DC.

S.N.	Properties	Value	Reference value (Indian sandalwood oil)
1.	Optical rotation	-4.10°	-15 to -20°
2.	Specific gravity at 27°C	0.9580	0.9635 to 0.9775
3.	Refractive index at 27°C	2	1.5000 to 1.5070
4.	Solubility in 70% Ethyl alcohol	Soluble in 3 Volume	Soluble in 5 Volume
5.	Acid value	2	<1
6.	Ester value	12	Max. 10
7.	Ester content	5	7

## MATERIAL AND METHODS

The wood of *Santalum spicatum* was collected from local distillers and essential oil was extracted by steam distillation method. The essential oil was first analysed for the determination of physical and chemical properties. All the natural essential oils contain fixed and specific physical and chemical properties. Further, the oil of *Santalum spicatum* was also analyzed for the determination of valuable components using Hewlett Packard 5890 series II gas chromatograph equipped with flame ionization detector (FID) and Carbowax 20 run polar fused silica capillary column (30 m × 0.32 mm.). The injector and detector temperature were maintained 210°C and 220°C, respectively. 1.5 ml/min required to flow rate of Nitrogen gas used as carrier gas. The sample volume of 0.1  $\mu$ l with the split less mode of injection was used (split ratio 60:1). Initial Oven temperature was programmed at 130°C, held for 5 minutes, then raised to 185°C at the rate of 2°C min<sup>-1</sup> and held for 5 minutes, finally raised to 230°C at the rate of 8°C min<sup>-1</sup> and was held for 20 minutes. The temperature of the Injector and detector was maintained at 250°C and 270°C respectively. The components were identified by comparing the retention time with those reported in the literatures. The major percentage of components in the oil can be identified by Gas liquid Chromatography by peak area.

The chemical composition of the oil was also determined using GC-MS (Agilent), injection temperature 230°C, oven temperature 70°C, column head pressure 10 psi, EI ionization 70 ev, with interface and source temperature 250°C. Essential oil of Indian sandalwood *Santalum album* is also collected from local distillers for comparison of quality parameters in terms of physical, chemical, instrumental properties as well as odour profile. The locally collected essential oil was also extracted by the steam distillation method. The constituents were identified by comparing with the NIST and Fragrance and Flavour library.

## RESULTS AND DISCUSSION

The wood of *Santalum spicatum* of the West Australian region contains 2.0 % essential oil in lab by hydro distillation and 2.5% in the steam distillation method. There were founds 22 constituents as major and minor (Table 2).The pleasant woody smell is due to the presence of sesquiterpenes derivatives as santalene, bergamotene, santalol, bergamotol, lanceol and nuciferol in the oil. Essential oil of Indian *Santalum album* is very much different in the percentage of constituents and in sensory odour evaluation. The gas chromatographic studies are revealed two major peaks which were identified as lanceol and nuciferol respectively. Total santalol percentage is very low *i.e.* 25% in West Australian sandal oil while it was found around 90 % in oil of Indian sandalwood. The purity and quality of the oil was also assessed in terms of specific gravity, refractive index, acid value and ester value that serves to detect adulteration as well as for identification of valued oils. Physical property like optical rotation was found only -4° in place of -15°. The specific gravity of West Australian sandalwood oil was found to be 0.9580 and shows that oil is very much thinner and lighter than water but in other properties, it was similar to Indian sandalwood oil. Indian Sandalwood oil has a high level of freshness as it has a very low acid value less than.

**Table 2.** GC-MS analysis of essential oil of *Santalum spicatum* (R.Br.) A.DC.

S.N.	Components identified	Area %
1.	$\alpha$ - cedrene	0.25
2.	$\beta$ -bisabolene	1.08
3.	$\alpha$ - santalene	0.44
4.	$\beta$ - santalene	0.80
5.	Trans-bergamotene	0.57
6.	Epi- $\beta$ - santalene	0.38
7.	$\alpha$ -santalyl acetate	2.58
8.	$\beta$ - santalyl acetate	1.02
9.	$\beta$ - bisabolol	1.93
10.	$\alpha$ -santalol	1.19
11.	cis- $\alpha$ -santalol	4.69
12.	Trans-bergamotol	1.28
13.	Trans- $\alpha$ -santalol	0.40
14.	Cis- $\alpha$ - bergamotol	0.11
15.	Epi - $\beta$ - santalol	0.17
16.	Cis- $\beta$ -santalol	8.40
17.	Nuciferol acetate	0.94
18.	Trans- $\beta$ -santalol	2.22
19.	Lanced	37.82
20.	Nuciferol	17.62
21.	Spirosantalol	1.02
22.	Trans nuciferol	0.42

## CONCLUSION

It is also concluded on basis of published papers, market research and end-users people like more oil of Indian origin (*Santalum album*) due to its sweet, pleasant, woody odour and high percentage of sesquiterpenes alcohol (santalol contents). Market rates of essential oil is depended on the presence of a high percentage of some particular components. The Australian Sandalwood industry is set to dominate world supply of sandalwood. Sandalwood oil from African countries such as Tanzania, Uganda, Sudan, Camaroon and Rwanda is also available in market but it is inferior in quality as well as odour value.

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