

Sandalwood Oil



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Output from ACIAR funded Sandalwood Project (FST/2002/097) in collaboration with Vanuatu Department of Forests, Queensland Department of Primary Industries and Fisheries, and Queensland Department of State Development

Development of High Quality Sandalwood Oil

Recent field survey of natural populations of sandalwood in Vanuatu and Cape York (Queensland, Australia) has uncovered a range of trees that possess exceptional oil qualities. Through planned domestication activities these trees offer the potential for expanding the planted sandalwood resource to meet the qualities as outlined in the International Standard for sandalwood oil¹. This new development opens a way forward for local communities to make a greater contribution to the sandalwood industry through planting of these superior varieties. Sandalwood agroforestry has the potential to reduce the current pressures on already depleted natural resources in these countries. The sandalwood oil industry also stands to benefit through future access to a consistent supply of high quality oil, which is required for developing premium-branded products.

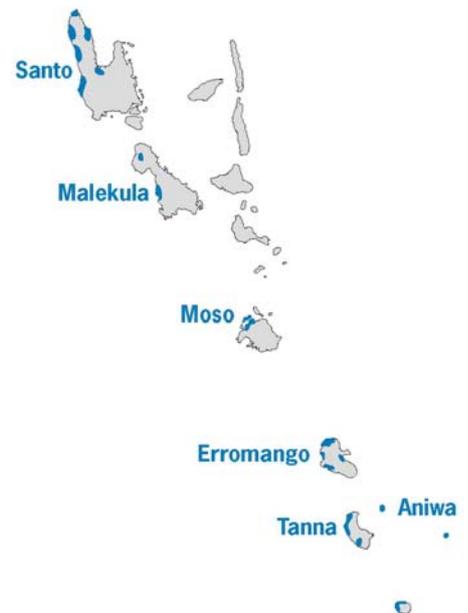


Vanuatu

Individual sandalwood (*Santalum austrocaledonicum*) trees were assessed and wood core samples collected from nine populations on six islands (Santo, Malakula, Moso, Erromango, Tanna and Aniwa) across Vanuatu.

A total of 28% of the trees sampled in the two northern islands produced a heartwood oil meeting the international standard (>41% α -santalol and >16% β -santalol). The selected trees from the remaining southern populations had a mean of 31% α - and 17% β -santalol.

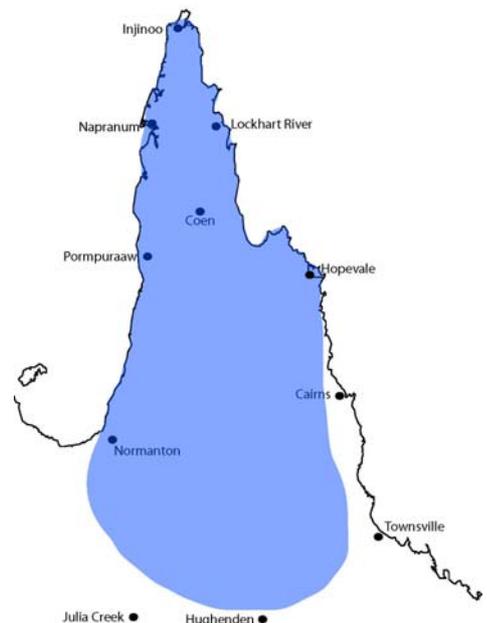
Mean heartwood oil concentration across all trees was 2.2%. Approximately 12% of the trees sampled had a concentration greater than 4%.



Cape York

Wood core samples were collected from five populations of sandalwood (*S. lanceolatum*) across Cape York. The indigenous participants have requested that, at this stage, the identity of the sites be kept confidential to ensure that indigenous rights are protected. The five sites sampled are currently identified as Population A, B, C, D and E

Many of the wood cores sampled in Cape York contained oil with low levels of santalol. However two population included individuals with high levels of santalol. The selections from these populations have a mean oil concentration of 3%, with 39% α -santalol and 16% β -santalol. These values are comparable with other species of sandalwood considered to have high quality oil.



¹ISO (2002) 'Oil of sandalwood (*Santalum album* L.)' ISO 3518:2002 (E), Geneva.

Santalum austrocaledonicum in Vanuatu

Survey

Heartwood cores were collected from 218 trees in Vanuatu. The heartwood oil was ethanol extracted and the oil components were separated and identified using analytical gas chromatography mass spectrometry (GCMS). Oil concentration was estimated using tetradecane internal standard.

Oil Characterisation

One of the key results of this study has been the discovery of continuous variation in all the major essential oil constituents across all the samples

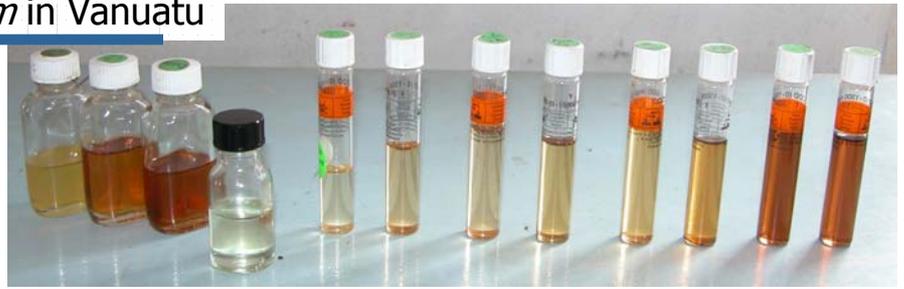


Variation in heartwood colour from trees sampled in Vanuatu

collected. The continuous variation in the ratio of santalols:non-santalols, indicates that there is no evidence to support previous claims of different chemotypes in *S. austrocaledonicum*

Another important result from this project is the evidence that the sandalwood trees of the northern islands (Santo & Malakula) are of highest quality having a greater proportion of trees with high santalol content than southern islands. A total of 28% of the trees in each northern island have oil quality that exceeds the International Standard.

The level of santalol in the trees from the southern islands was considerably lower than from the north. However, the variation present has allowed selection of the top 16% with a mean of 31% α - and 17% β -santalol.



Oil colour variation in steam distilled oil from *S. austrocaledonicum*.

Oil Concentration

Significant variation was found for heartwood oil concentration within and between populations with a mean of 2.2% across all trees sampled. This concentration was substantially lower than currently found by industry in Vanuatu (3.0-4.6%). This difference could be attributed to the small sample size compared with bulk industry samples. The relative oil yields, however, are indicative of real relationships and the variation indicates the potential for improvement in oil yield.

Trees from Malakula had significantly greater mean essential oil concentration (3.5%) than the other populations. Overall, approximately 12% of trees were found to have an oil concentration greater than 4% and individual trees from all populations, except Tanna, were represented.

Heartwood

Significant variation in heartwood colour was observed between trees but it had no predictable effect on oil constituents, and is therefore not a reliable indicator of oil quality. Wood colour can have an effect on the colour of oil extracted, but the removal of undesirable oil pigments can be achieved in industry by further purification.

Mean percentage heartwood was 27% across trees sampled. The variation

| | Santalol | |
|----------------------|------------|-----------|
| | α - | β - |
| Grafted Seed Orchard | | |
| Northern | 38% | 20% |
| Southern | 31% | 17% |
| Combined | 33% | 18% |

Mean percentages of santalol in the three grafted seed orchards in Vanuatu

within each site for this character was not correlated with trunk diameter indicating a degree of genetic control. With a range from 1-73% across all trees there is considerable scope for improving heartwood percentage

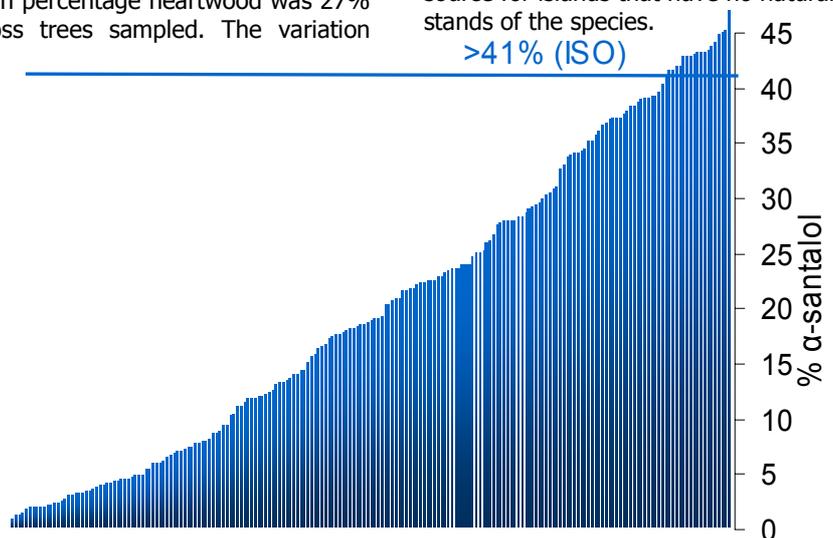
Oil Improvements in Vanuatu

An improvement programme has been developed to capture those individual trees with high oil concentration and oil quality through clonal propagation.

A multiple population breeding strategy will be employed using replicated grafted seed orchards, which will maintain the integrity of the northern and southern island differences through separate seed orchards for these regions.

A third seed orchard combining selections from both regions will also be established to maximise the level of genetic diversity in the planted resource for islands that have no natural stands of the species.

>41% (ISO)



Continuous variation in % α -santalol in *S. austrocaledonicum* heartwood oil in Vanuatu.

Santalum lanceolatum in Cape York

Survey

Heartwood cores were collected from 125 trees across 5 sites in Cape York. The heartwood oil was ethanol extracted and the oil components were separated and identified using analytical gas chromatography mass spectrometry (GCMS). Oil concentration was estimated using tetradecane internal standard. Comparison of oil concentration measurements between water distilled (6.4%) and ethanol extracted (6.1%) oil from an homogenized sample indicated consistency between the two methods.

Oil Characterisation

Continuous variation was found for all major oil constituents, which discounts any chemotype division in *S. lanceolatum*. The oil samples of Cape York were generally high in nuciferol and curcumenol and no population had a mean, which conformed to the international standard for sandalwood oil, which confirms existing knowledge of the oil profile of *S. lanceolatum*.

'Population A' however, had a greater proportion of trees with a high percentage of santalols than the remaining populations. This population had 6 individuals that met the requirements of the international standard. This result was unexpected given that the current perception is that *S. lanceolatum* has the lowest santalol



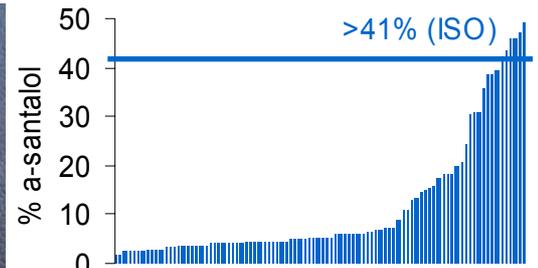
Trunk cross-section of *S. lanceolatum* from Cape York.

Heartwood

Each population had significant tree-to-tree variation in percentage heartwood. Percent heartwood was not correlated with trunk diameter. The data collected indicates that percent heartwood could be a function of genotype, age and growth rate. Some improvement in heartwood percentage may therefore be possible considering the variation across all sites (2-81%).

Oil Improvements in Cape York

The nine selected individuals representing a selection intensity of approximately 7% have a combined mean oil concentration of 3%, with 39% α -santalol and 16% β -santalol,



Continuous variation in % α -santalol in *S. lanceolatum* heartwood oil in Cape York.

which is a substantial improvement on the mean of all trees sampled (2.0, 10.6 and 7.0% respectively). The profile of each selection is seen in the table below.

These trees represent a very good resource for the initial improvement of *S. lanceolatum* in Cape York. Further surveys will be undertaken in the coming months to identify other trees producing heartwood oil with a high percentage of α -santalol.

The level of variation in oil quality offers great potential for the domestication of high quality, drought tolerant sandalwood. This is of significant importance to the Australian sandalwood oil industry, and could be developed as a commercial opportunity for indigenous communities of Cape York.

The trees selected for this improvement programme will be established as a grafted orchard to provide the resource for producing superior clones for immediate use in commercial indigenous agroforestry projects. The orchard will also produce out-crossed seed used for further selection and improvement of the species.



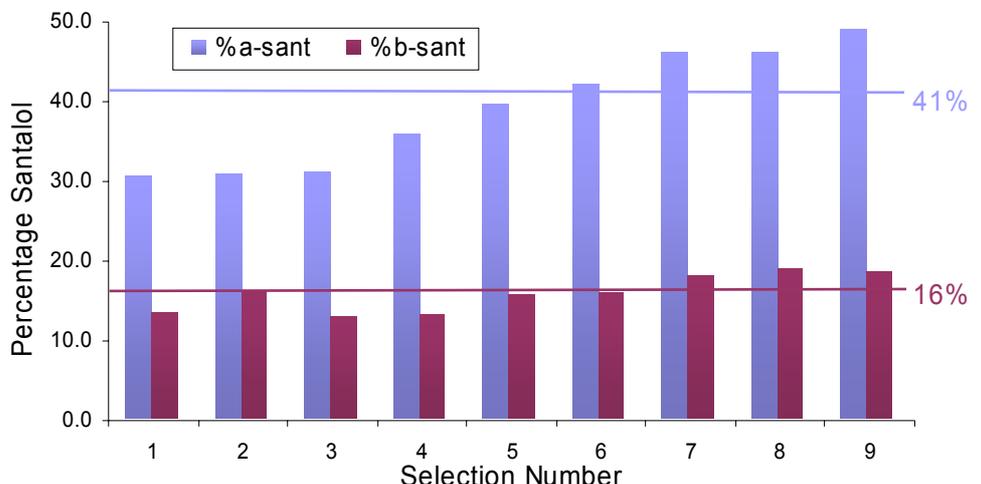
Sandalwood core with sapwood (pale yellow), developing heartwood (light red) and 'true' heartwood (brown).

level for all sandalwood species.

Oil Concentration

While the mean oil yield across the five populations of *S. lanceolatum* was 2.0%, there is considerable tree-to-tree variation in oil concentration, which offers the opportunity for improvement through selection.

The highest yielding individuals (selection intensity of 10%) have a mean oil yield of 4.1% which is comparable to the oil yields reported for *S. austrocaledonicum* and *S. yasi*. There was no relationship between concentration and the level of santalol.



Percentage α - and β -santalol in selections of *S. lanceolatum* in Cape York. (ISO 3518:2002(E) minimum levels: 41% for α - and 16% for β -santalol)

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