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Quality Analysis of Cultivated Sandalwood Trees from the Wheat Belt Region of Western Australia for ASN

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Plantation Sandalwood trees (*Santalum spicatum* R.Br.) cultivated by the Australian Sandalwood Network (ASN) was supplied to analyse the quality and provide a brief market potential report upon the findings. This report is covering the general laboratory findings with brief technical discussion followed by market analysis for the potential of similar wood.

Methodology

Harvested trees were colour coded and de barked by Australian Sandalwood Network (ASN). Samples were received and stored at Wescorp Sandalwood (WS) storage area. Specific areas to sample were identified and biscuits were cut using a saw then numbered and photographed for future reference.

Table 1: Description of the samples

Colour code	Age of the Tree	Location/ plantation
Green		
Pink		
Blue		
White		

Heartwood formation was measured and area percentage was calculated at the best transverse section. Sapwood was not removed following the standard practise in Western Australian sandalwood industry. Whole sample was size reduced in a pilot scale hammer mill, particles between 4-40 mesh size were selected.

Samples were hydro-distilled using Dean-Stalk method and dried over anhydrous sodium sulphate, percentage yield was calculated as weight percentage.

Oils samples were analysed for the chemical composition using gas chromatographic (GC) analysis using a 5% diphenyl 95% dimethyl polysiloxane column. Identified compounds were quantified using area normalisation method. Any further details such as method, sample preparation and chromatographs of GC could be provided upon request.

Results

Samples were selected to represent the different morphological parts of the tree. Areas with potential heartwood growth were targeted rather than an overall general sampling.

Table 2: Sample list of harvested trees

Tree colour code	Part of the tree	Height from ground level*	Project sample	WS catalogue
Green	Butt	0cm	ASN_1	WS/09/025
	Upper Root	- 15cm	ASN_2	WS/09/026
	Lower UCL –branch A	+30cm	ASN_3A	WS/09/027
	Lower UCL – branch B	+30cm	ASN_3B	WS/09/028
Pink	Butt	0cm	ASN_4	WS/09/029
	Lower UCL	+15cm	ASN_5	WS/09/030
	Upper Root	-15cm	ASN_6	WS/09/031
Blue	Butt	0 (+5cm to -5cm)	ASN_7	WS/09/032
White	Butt	0 (+5cm to -5cm)	ASN_8	WS/09/033

*Height from ground level denotes the centre of the biscuit.

Photographs of the samples selected were attached in the appendix I. Photographs of transverse section used to measure heartwood percentage is attached on appendix II.

Table 3: Occurrence of heartwood and sapwood in percentage quantities

Sample	WS cat.	Heartwood	Sapwood
ASN_1	WS/09/025	50.43%	49.57%
ASN_2	WS/09/026	38.73%	61.27%
ASN_3A	WS/09/027	42.98%	57.02%
ASN_3B	WS/09/028	46.06%	53.94%
ASN_4	WS/09/029	62.81%	37.19%
ASN_5	WS/09/030	49.93%	50.07%
ASN_6	WS/09/031	55.38%	44.62%
ASN_7	WS/09/032	NA	NA
ASN_8	WS/09/033	44.60%	55.40%

Table 4: Volatile oil content analysis and the chemical composition

Sample	**ASN_1**	**ASN_2**	**ASN_3A**	**ASN_3B**	**ASN_4**	**ASN_5**	**ASN_6**	**ASN_7**	**ASN_8**
Percentage yield % (w/w)	0.95	0.72	0.90	0.93	1.10	1.13	1.32	0.62	0.03
	Percentage Composition(%of total volatile)								
cis-α-trans-bergamatol	0.97	1.47	1.09	1.66	1.10	1.57	0.96	1.34	1.49
cis-α-santalol	41.13	35.00	34.90	27.63	31.50	17.00	37.99	7.94	24.54
epi-α-bisabalol	11.38	9.35	9.82	7.97	10.99	6.75	12.87	6.42	7.95
epi-β-santalol	2.02	1.59	2.10	1.46	1.68	1.15	1.90	0.55	1.34
cis-β-santalol	16.27	13.74	13.58	11.18	11.63	6.39	14.47	3.07	8.98
cis -nuciferol	3.03	4.92	7.50	11.06	10.52	19.11	5.63	20.19	12.37
E,E- farnesol	8.06	13.10	10.00	18.36	12.75	22.54	7.80	18.85	10.96
cis -lanceol	0.39	0.31	0.80	0.79	0.45	0.80	0.50	1.48	0.73

Discussion

All the provided samples are clearly recognised as young trees with low heartwood formation. Sapwood contributed to the majority of the total weight and timber. It has been reported that *S. spicatum* has a decrease in santalol levels and oil composition towards the longitudinal growth (Piggot *et al.* 1997, Brand *et al.* 1999). The biscuits were selected from the ground level (butt) of the tree and also from usual 150mm or 300mm distances from the ground level as practised in sandalwood industry.

Sapwood wasn't removed as mentioned in methods, instead followed the standard industrial practice. Actual oil content in heartwood should be much higher than the given values as it is a mix of sap and heartwood. *S. spicatum* sapwood contains a minute quantity of oil and its composition isn't much different to that of heartwood (Hettiarachchi, 2008). Visual identification of sapwood to heartwood was previously practised by several researchers. Density of the heartwood will increase with the age of the tree when compared to the sapwood, further more it's the volume or the bulk of sapwood which will affect the industry more than the actual weight of the sapwood.

Last two samples seem to be fairly younger than the former two harvested trees. Blue coded tree has not formed heartwood but presence of circular formation could be seen. Trees of this age will produce a negligible amount of oil upon distillation which is of very poor quality.

Green coded tree found to be the best quality tree among the four, followed by the pink coded tree. First one has given very high quality oil with significant yields at 300mm (1 ft) above the ground level even its branched. Root material was better in quality than the logs as predicted. White coded tree, which appears younger than the previous two still contained very good quality.

In conclusion we could identify these trees could provide better quality timber. In a future study several more biscuits to be cut from further up in known distances to be analysed. That could give a better picture of total quality heartwood which could be harvested from these trees, then to be matched against their age.

Market Potential

The unique quality of the S. spicatum is that to produce good quality oil you don't have to remove the sapwood from the product before you pre-grind and do the oil extraction. This is not the case with other sandalwood species as the sapwood oil is detrimental to the heartwood oil.

Another important difference between the S. spicatum sapwood and other sandalwood sapwood is the difference in aroma each one gives off when burnt in agarbatti. Other sandalwoods have a very "nothing" aroma in the sapwood, whereas the spicatum gives off a "pepper" aroma that the market would prefer not to have. This is why the market will pay marginally more for other sandalwood sapwood than spicatum sapwood. Never the less, spicatum sapwood still has an established market which Wescorp are supplying. The attraction is that it is still sandalwood (used as a filler) and the golden colour of the spicatum sapwood (if kept out of light) is better looking than the "mouldy" white colour of the other sandalwoods.

In the older sample (green ribbon) the alpha is very good with the Butt reaching 41%. This is very high when compared to a typical sandalwood tree harvested from the pastoral regions of the Goldfields. The average Butt oil alpha from the Goldfields would generally be around 25%. The green ribbon farnesol is favourably low too.

The pink ribbon sample showed typical qualities of an older Goldfields tree with the Roots giving both a higher yield and quality of santalol than the Butt of the same tree.

The obvious difference is the yield when compared with the Goldfields. A butt from the Goldfields will generally give you around 3%, while the samples are around 1%. This is to be expected due to the age of the samples and volume of sapwood compared to the heartwood.

Yield affects the aroma that can be produced from the sandalwood when it is burnt in the agarbatti industry. Low yields significantly effect the value of the product even if the quality of the oil is excellent as displayed in the pink and green samples.

Because of the low yields, we would expect the sandalwood to be far too young to harvest and we look forward to seeing the same type of samples in another 10 years when we believe the yield should at least double. The most important finding is the quality of the oil and the future looks very exciting for plantation S. spicatum from the wheatbelt.

If Wescorp was to buy these older samples produced and it was in large quantities with regular supply, then we could pay the farmers $1,000 per tonne de-barked, delivered to our factory. The pink ribbon tree weighed a total of 40kg be-barked. This makes this tree worth $40. The green ribbon tree weighed a total of 28kg debarked and is therefore worth $28.

Wescorp does not know how old the trees are from the samples, but we would expect a significant increase in value with 10 more years of growing and particularly with that type of santalol and improvements in the yield to at least 2%.

The other two trees delivered to our factory were the blue ribbon which was much younger and had a total de-barked weight of 5kg, while the white ribbon tree weighed 10kg.

If, in 10 years time the yield of the older trees reached 2% as expected and they maintained the existing santalol quality, then the value to the farmer should be closer to $6,000 per tonne at today's prices. We expect the delivered weight to have doubled in that time and therefore the tree that had the pink ribbon would be worth $480. A significant increase for 10 years of patience and seed production.

A very important factor plantation growers need to always keep in mind is the potential of the Wheatbelt Plantation S. spicatum "carving log". Because the current S. spicatum wood is coming from dryer pastoral areas and are typically slow growing, they are not suitable for carving as they crack and fault before and after they are carved. This is a unique market and supply from current species used in carving is diminishing very quickly.

Wescorp feel that relatively fast growing wheatbelt sandalwood maybe able to be used in the carving market. To achieve this they must be of very good straight form with no branch history showing and very little sapwood. The current ones have all of the sapwood removed and the ends sealed immediately after harvest. They should be typically 120mm of pure heartwood and a minimum length of 350mm.

The market is currently paying 60% more for carving logs than oil producing Roots, Butts and Logs. In India, they pay around US$42 per kg for oil producing 60 year old S. album with the sapwood removed. The alpha will be over 50% and the yield will be over 6%. For the same product but presented as a carving log to the carving log specifications will sell for US$72 per kg.

The carving wood market for spicatum is still unknown, but we feel it has great potential when the tree is allowed to reach a mature age and shows alpha levels like the green ribbon tree that ASN asked Wescorp to test.

Wescorp would like to thank the ASN for giving us the opportunity to evaluate their samples and look forward to working with them and their passionate members in the future.

Appendix I

Photographs of the samples identified for analysis

Figure 1: Upper log of the Green Coded Tree

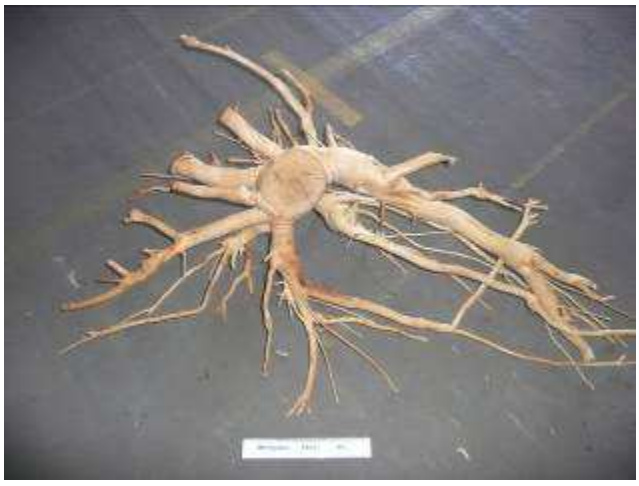

Figure 2: Root System and Butt of the Green Coded Tree

Figure 3: Upper logs (branched) of Pink coded tree

Figure 4: Root System with the Butt of the Pink Coded Tree

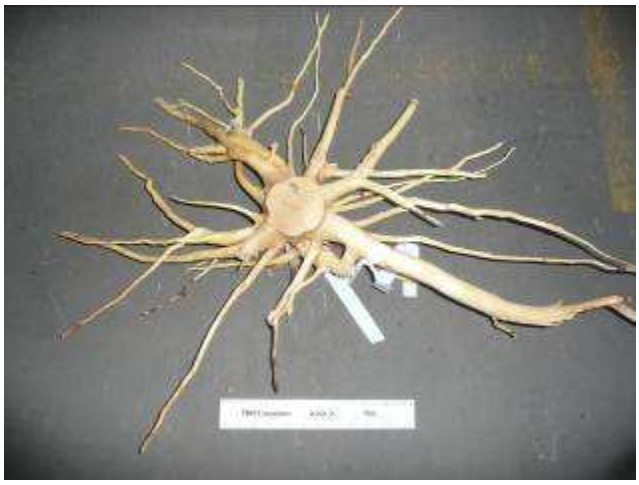

Figure 5: Root System with the Butt of the Pink Coded Tree

Figure 6: Root System with the Butt of the Pink Coded Tree

Appendix II

Photographs of the transverse sections use to analyse heartwood content

Figure 7: ASN_1/WS09025

Figure 8: ASN_2/WS09026

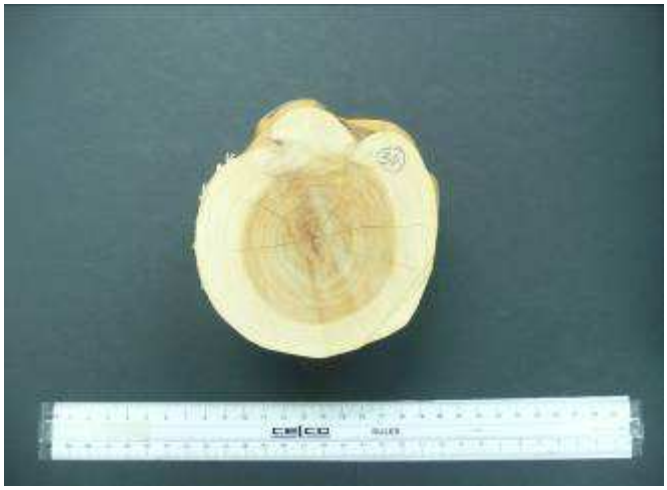

Figure 9: ASN_3A/WS09027

Figure 10: ASN_3B/WS09028

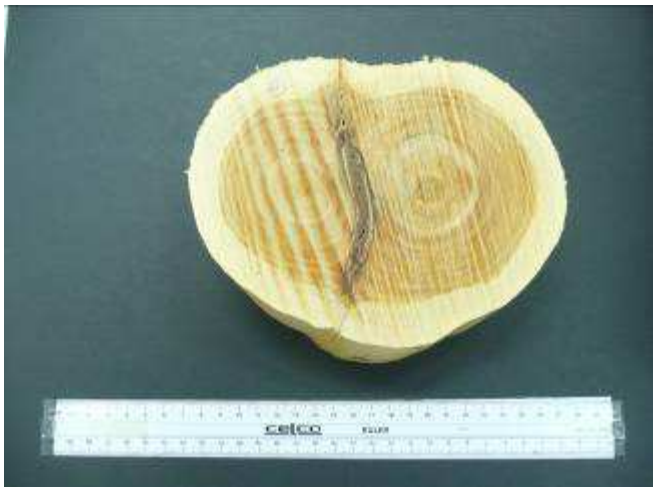

Figure 11:ASN_4/WS09029

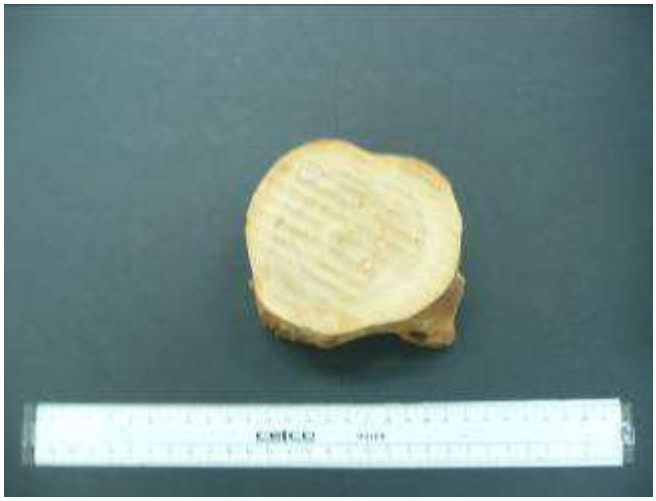

Figure 12: ASN_5/WS09030

Figure 13:ASN_6/WS09031

Figure 14: ASN_7/WS09032

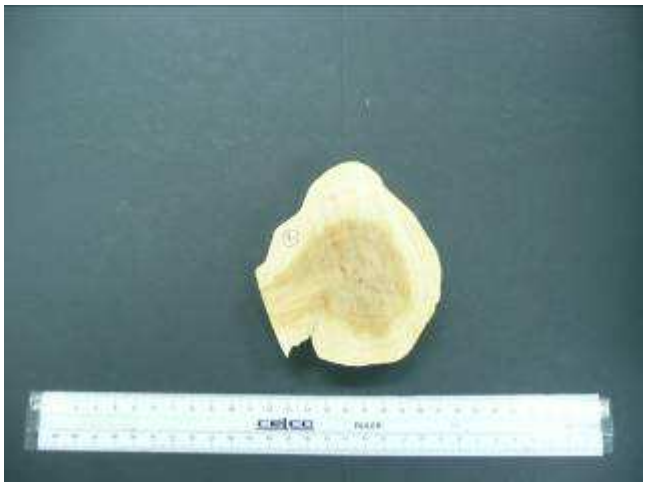

Figure 15: ASN_8 /WS09033