Comparison of West Australian Sandalwood (*Santalum spicatum* R.Br) Seed Oil Extraction Methods

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Introduction

- Western Australian Sandalwood (*Santalum spicatum*) is one among the few endemic sandalwood species native to Australia.
- The tree bears significant amount of fruit per year, which are drupes with large seed.
- Seed kernel have been used by indigenous Australians;

  Dietary supplement

  taken orally as a cure for rheumatoid arthritis

  topically applied (rubbed) for cold and stiffness

Chemical Properties

- Seed kernels consist ~50% of a drying fixed oil.
- This oil is comprised of several fatty acids including oleic, linoloic, α-linoloic, steroic etc.
- An unusual fatty acid **ximenynic acid** found to be a major component in the seed oil

Pharmacological Properties (mice dietary experiments)

- 8.5% lesser weight gain
- Less deposition of fat
- Alteration of omega-3 fatty acid by a possible stimulation of Δ9-desaturase in liver.

To meet the global demand for the scented wood sustainable harvesting and cultivation of trees were initiated by the Forest Products Commission (FPC) of Western Australia, which were joined by farmers, indigenous communities and private organisations. Seeds can provide financial benefits for the growers until the trees are ready for harvesting.

Figure 1:Unripe and ripe fruits of *Santalum spicatum* (N. Butler, Wescorp Sandalwood)

Methodology

Following methods were experimented for oil extraction from seed kernel

Cold press: using a filter press with 1-3ton/m^2 pressure

Extrusion: screws were used in ambient, chilled and heated atmospheres

Enzyme treatment : Size reduced sample was incubated with protease, cellulase and pectinase prior to extrusion or press

Chemical treatment: Acid, salts and acetone was used prior to extrusion or press

Solvent extraction: *n*-hexane was used to macerate (Soxhlet was used in laboratory scale)

Solvent extraction followed by degumming: Above hexane extract was treated with acetone

Super critical carbon dioxide extraction (SFE)

Results & Discussion

Table 1:Yeilds and oil characters of extraction methods

Method	Yield	Character of oil	Comments on process
Cold press	Nil	-	Gum material stick to the filters and press, elastic mass
Extrusion	<1%	Contains gum, water and organic sediment	Gum mass will extrudes, no separation of oil
Enzyme treatment	<1%	Contains gum, water and organic sediment	No improvement
Chemical treatment	<1%	Contains gum, water and organic sediment	No improvement
Solvent extraction	45-50%	Contains gum, almost semisolid	Oil with gum was obtained, negative properties on oil
Solvent extraction with degumming	35-45%	Clear, transparent, yellowish with nut like odour	Residual solvents, additional process, oxidation, hazards
SFE(CO_2)	35-40%	Clear, transparent, golden with nut like odour	Expensive process, technical expertise

Solvent extraction and Supercritical extraction are found to be the only methods which yield a significant amount of oil.

Table 2:Comparison of solvent and SCFE extractions methods

	SFE	Solvent
Product contamination	Nil	Residual solvents
Environmental hazards	Negligible	High with solvent waste
Acid value of oil	1.88	3.65
Iodine value	100	76
α-Tocopherol in oil	17mg/100g	2mg/100g
Oxidation of oil	negligible	significant
Plant cost	Very costly	affordable
Process cost	Affordable	Costly
Technical expertise	Essential	Moderately needed
Occupational Hazards	Compressed gases	Highly inflammable
Exhaust kernel	Readily usable	Solvent contaminated

Results depict that better quality oil and industrial advantages could be achieved by SFE.

Potential buyers are benefited by using residual free more stable oil.

Initial investment cost and technical expertise are major draw backs of super critical extraction.

Repeated extractions were made (pilot scale) to get oil with uniform quality, properties of the oil is given as follows;

Character of the Oil

A clear, yellow or golden-yellow, transparent liquid, sparingly soluble in ethanol (96 per cent), miscible with n-hexane.

It has a relative density of about 0.9198, viscosity of 71mm^2s^{-1} and solidifies at -11°C.

Acid value : 0.2

Peroxide value : 1.5

Unsaponifiable matter: 1.1 per cent

Saponification value: 197

Iodine Value: 101

Composition of fatty acids

Saturated fatty acids of chain length less than C_{16} <0.1 per cent,

Palmitic acid 16:0 **:** 3.0 – 3.5 per cent

Palmitoleic acid 16:1 (n-7) **:** 0.2 – 1.0 per cent,

Stearic acid 18:0 **:** 2.0 – 3.5 per cent

Oleic acid 18:1 (n-9) **:** 50.0 - 53.0 per cent

Linoleic acid 18:2 (n-6) **:** 1.7 – 2.0 per cent

α-linoleic acid 18:3 (n-3) **:** 2.5 – 3.5 per cent

Stearolic acid 18:1 (9a) **:** 1.0 – 2.0 per cent,

Ximenynic acid 18:2 (9a, 11t) **:** 28.4 – 36.2 per cent

Tocopherol (Vitamin E) composition

α-Tocopherol **:** 17mg in 100g of oil

Conclusion

Supercritical carbon dioxide extraction was found to be the method of choice.

Sandalwood seed oil was found to match with the oils used in widely used cosmetics and nutraceuticals, with high concentrations of Ximenynic acid and other poly-unsaturated fatty acids were observed.

Future research

- Industrial feasibility of the method is currently under study.
- Potential uses as a nutraceutical or a cosmetic agent will be studied with interested groups.

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† Wescorp Sandalwood is the agent for Forest products Commission of Western Australia for processing and exporting Western Australian Sandalwood. Currently more than half of the sandalwood in the global market are handled through this venture. Seed oil research is one of the major projects taken up by Wescorp Sandalwood to improve the sustainability of industry.