Brazilian Rosewood Oil: Sustainable Production and Oil Quality Management*

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The essential oil industries worldwide are presently dependent upon the unsustainable harvesting of wild forest trees. Many areas of the world's natural forests have suffered serious losses to their ecosystems through extraction of timber. However, a far more serious problem is degradation through conversion of the land to other uses. For instance, in the 5 million square kilometer Brazilian Amazon forest, approximately 12% of the forest has been lost to other uses since the 1960s and, subsequently, some 50% of this land has been abandoned.

In a project begun in 1989, the United Kingdom's Overseas Development Administration (ODA) and Brazil's Para Faculty of Agricultural Sciences (FCAP)—located in Belem at the mouth of the Amazon River—cooperated in research to identify crop packages appropriate for sustainable management in the frail soils of the Amazon region. Ideally these crop packages could be employed in both settled farming and in the rehabilitation of degraded forest land. One of the crops evaluated was Brazilian rosewood tree, which was selected for several reasons:

- It is the source of a long-established item of commerce.
- Production is based on the "mining" of wild forest trees and concern has been expressed by producers, users and environmentalists about future sustainability.
- Earlier work by the Amazonian Research Institute and by some distillers indicated a domestication potential.
- The technologies required for rosewood domestication were likely to have a relevance to other native trees.

This article gives a status report on the Brazilian rosewood oil industry, then reveals the project's findings regarding the oil's characterization and the tree's propagation and field management. Detailed scientific papers on various components of the project are in preparation by FCAP.

The Rosewood Oil Industry

A brief history: Commercial production of rosewood oil developed early in this century in South America. It was

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based on harvests of wild-growing trees of the *Aniba* species. These trees, slow-growing evergreens of the Lauracaea family, are indigenous over a wide range of the Greater Amazon region. The oil is obtained by steam distillation of trunkwood in yields averaging 1% from the favored Brazilian species *Aniba rosaeodora* and *A. ducke*. The major component of the oil is racemic linalool.

Rosewood was once the fragrance industry's principal source of racemic linalool. Production and exports of South American rosewood oil peaked at around 500 tons annually in the early 1960s. At that time, there were up to 50 distilleries and the annual timber extraction rate was around 50,000 tons. Brazil was the dominant producer.

The introduction of synthetic linalool to the market in the late 1960s led to a rapid decline in demand for Brazilian rosewood oil in the cheap fragrance sector. The re-emergence of supplies of the leaf and wood oils of Ho from China also resulted in the loss of the middle sector of the market, a sector in which users require a modestly priced natural linalool (e.g., for extending lavender/lavendin oils).

Demand for Brazilian rosewood oil stabilized at about 100 tons per annum in the mid 1980s and, subsequently, production has been geared closely to market needs. Its place in the market, at a price ranging around US$25/kg, FOB, is principally as an ingredient for top-of-the-line perfumes from North America and Western Europe. (Chinese Ho wood and leaf oils, approximately 80 tons annually, sell for US$11-14/kg. Synthetic linalool, priced at approximately US$12/kg, commands the mass market.)

Current production and exporting: Today, as the sole source country for rosewood oil, Brazil hosts ten rosewood producers. Two have static distilleries in the city of Manaus on the Amazon River, and the others operate static or transportable units elsewhere in Amazonas state.

Of the four regular exporters, one simply purchases oil from producers, two purchase oil and also produce it themselves at their distilleries in Manaus, while the fourth exports only its own output. Only some 65% of annual oil production is exported direct from Manaus. The remainder is sold in São Paulo and Rio, mainly to the local branches of multinational fragrance houses.

Current harvesting and distillation operations: Harvesting occurs along the banks of navigable rivers, which provide the only means of bulk transportation in Amazonas state. Because of past harvesting, trees taken now are smaller (usually 15-30 cm dbh versus minimum 1 m in the past) and farther (up to 30 km) from the river banks. As in the past, workers cut the trunks into 1-meter lengths and carry them manually through the forest to the river bank.

Some of the cut timber is transported by boat down river to static distilleries, but most is processed at the river bank in distilleries that are shipped up river by barge as close as possible to the harvesting area. Production operations are seasonal. It is only possible to move boats far up river in the rainy season, while the harvesting occurs in the six-month dry season.

All of the rural distilleries are now old. The charge capacity of the individual vessels is 0.2-1.0 ton of mechanically chipped wood. Distillation time is 2-5 hours, according to vessel size and boiler power. Yields of oil are 0.7-1.2% depending on the collection area, species and the mix of trunk and branch. Spent charge is employed as a boiler fuel. An average-size field distillery, producing 10 tons of oil annually, requires 20 staff, the majority engaged in wood handling.

Oil quality: Species and collection area are known to affect both the content and the optical activity of the linalool in rosewood oil. But because of the increasing difficulty of harvesting the preferred *A. rosaeodora* and *A. ducke* trees, some producers have been tempted to include greater proportions of less favored *Aniba* species. Buyers have complained recently about divergences from normal quality in the oil. Some people in the industry believe these quality changes are caused by increasing use of less favored *Aniba* species.

Concerns within the industry: The consensus view in the Brazilian industry is that supplies of raw material will be adequate for market demand in the mid-term, but existing problems will worsen in the long-term. The major concern is profitability, which is negatively affected by several factors:

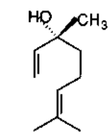
- Brazilian governmental restrictions on tree felling.

Table I. Linalool contents and optical rotation values

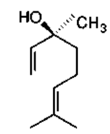
Sample	Linalool content (%)	Optical rotation value
commercial rosewood oils	70 to 90	−4° to +5°
wood oils of individual trees at Curua Una	87 to 92	−5.9° to +12.6°
leaf oils from Curua Una	73 to 78	+7.1° to +7.6°
commercial Chinese Ho wood oil	97.5	−17.0°
commercial Chinese Ho leaf oil	95.7	−17.3°

Table II. Comparative linalool enantiomer properties

Sample	Linalool enantiomer composition (%) by chiral GC		Optical rotation value of the oil
	laevo (−)	dextro (+)	
rosewood from Curua Una:			
leaf oil (mixed tree lot)	22.2	77.8	+8.3°
wood oil from tree No. 21	10.0	90.0	+12.6°
wood oil from tree No. 20	65.5	34.6	−5.9°
synthetic linalool	44.6	55.4	0.0°
Chinese Ho leaf	100.0	0.0	−17.0°



(3R)-(−)-linalool
Aroma: woody, lavender-like



(3S)-(+)-linalool
sweet, citrus-like

- Decreasing accessibility of trees.
- Increasing labor costs (as the rural population moves to cities).
- The need to advance cash to forest workers six months before receiving a return.

The majority of rosewood oil producers regard the traditional method of wild tree harvesting as outmoded and would prefer to draw on plantations to meet long-term demand.

Wood Oil

As part of the joint ODA/FCAP project, pilot-scale distillation trials were carried out on a derelict plantation at Curua Una in southern Para with individual *A. rosaeodora* trees with stem diameters not exceeding 10 cm.

Oil content: Oil yields from trunk and thick branchwood ranged from 0.9-2.6%. This variability could be significant for selection and breeding purposes. Young, small diameter trunks and branchwood provided higher oil yields than larger, more mature trees (normal average of 1%). This suggests that short-rotation cultivation of trunkwood could be the optimal, most economically attractive system for the production of traditional type rosewood oil.

Oil properties: The trunkwood oil compositions of the young trees was broadly similar, both qualitatively and quantitatively, to that of commercial rosewood oil. However, their optical rotation values spanned a greater range than is found in commercial oils (Table I).

Chiral gas chromatography analysis revealed that all trees contained a mixture of laevo (−) and dextro (+) linalool, but particular enantiomers dominated in individual trees (Table II). Since ten-year-old trees could not be regarded as juvenile, these tree-to-tree differences must be genetic in origin and have considerable implications for breeding and the production of oils with specific aroma characteristics. Linalool in which the laevo enantiomer is 50% or greater is woody, lavender-like; dominance of the dextro enantiomer gives a more sweet, petitgrain note.

Leaf Oil

Pilot-scale distillations also were undertaken with leaf and stem material from the coppiced plantation trees at Curua Una. "Coppicing" is the procedure of cutting the main stem close to the ground in order to encourage regeneration of multiple stems and a high production of leaves.

Oil content: Oil yields on a fresh-weight basis were about 1%, which is commercially acceptable. The leaf used was very mature and it is possible that higher yields could be obtained from juvenile leaf of a true coppice. Because material from different trees was bulked for the distillations, it is not yet possible to assess the extent of tree variability in terms of oil yield or composition.

Oil properties: The leaf oil differed in aroma from the traditional trunkwood oil and exhibited a citrus-like topnote. Gas chromatography analysis (Table III) showed the leaf oils to contain 73-78% linalool, about 10% less than in wood oil, and a differing qualitative composition of minor, mainly sesquiterpene, components. The leaf oils contained no traces of camphor, a Ho oil constituent that is disliked by perfumers.

The optical rotation value of all the leaf oils was strongly positive and chiral GC analysis revealed that the linalool composition was a mixture with the dextro-enantiomer predominating (Table II). This explained the aroma properties.

Rosewood leaf oils of this type might find a market in mid-range fragrance applications. However, the industry would prefer to develop a leaf oil with a dominance of laevo-linalool, since its aroma would then be more woody and comparable to Ho oils, but lacking the undesirable camphor note. This might be done by germplasm selection. Fortunately, there is still great diversity in the germplasm base because there are large tracts of wild rosewood deep within inaccessible parts of the Amazon forest.

Tree Propagation

A vegetative propagation method for clonal multiplication of elite germplasm was evaluated. In this method, a section of branchwood approximately 50 cm long and 6 cm

Table III. Partial and tentative comparison of composition differences between leaf and wood oils of rosewood and Ho

GC peak retention time (minutes)	% Abundance of individual peaks in GC trace[a]: Rosewood (trunk/branch) Commercial samples	Rosewood (trunk/branch) Curua Una samples	Rosewood Curua Una leaf oils	Ho oils: Leaf	Ho oils: Wood	Tenative identification by GC/MS[b]
4.17	0.08-0.20	0.03-0.20	*-0.06	0.10	*	cis-β-ocimene
5.50	0.40-0.44	*-0.10	*-0.03	0.08	0.01	β-pinene
6.50	*-0.50	0.04-0.06	0.06-0.10	0.03	0.31	myrcene
7.38	0.44-0.55	0.10-0.56	0.10-0.15	0.04	0.23	limonene
7.70	0.44-0.80	*	0.03-0.04	0.18	0.51	1,8-cineole
8.63	*-0.06	0.03-0.07	0.03-0.05	0.04	0.40	trans-β-ocimene
9.55	0.06-0.09	*-0.03	*-0.03	0.02	0.05	p-cymene
14.55	1.10-5.80	1.00-1.68	1.20-1.80	0.25	0.33	cis-linalool oxide
15.47	1.10-5.20	0.90-1.60	1.00-1.54	0.47	0.47	trans-linalool oxide
15.90	0.10-0.13	*-0.90	1.40-2.70	*	*	cyclosatirine
17.10	*-0.08	0.03-0.09	*	0.57	0.10	camphor
18.22	72.00-83.00	87.00-92.00	73.00-78.00	97.47	95.65	linalool
19.07	0.20-0.28	0.10-0.26	0.14-0.53	0.05	0.12	terpinen-4-ol
19.75	0.10-0.16	0.10-0.20	0.40-0.54	0.33	0.12	Ho-trienol
21.48	0.34-0.42	0.20-0.37	0.10-0.50	*	*	γ-selinine
22.98	0.60-1.70	0.30-0.90	4.50-6.00	*	*	eremophiline
23.27	0.58-0.90	0.30-0.70	3.10-4.40	*	*	unknown
24.37	0.10-0.60	0.10-0.27	0.13-0.25	*	*	epoxy-linalool
25.43	0.10-0.42	0.03-0.27	0.04	*	*	linalool-oxide-D, pyranoid
31.87	0.10-0.30	0.10-0.15	0.80-0.95	*	*	caryophyllene oxide
35.00	0.15-1.00	*(?)	0.35-0.62	*	*	spathulenol
41.65	0.30-0.33	0.25-0.59	0.62-0.79	*	*	benzyl benzoate

[a] Percentage based on dividing the area under the individual peak by the total area under all peaks
[b] from a database at the National Resources Institute
* = absent or only a trace present

in diameter is removed from a mature, wild forest rosewood tree. At the nursery, the branch is inserted in a bed of stones within a plastic sheeted, non-misted propagation chamber. After several months, the branch, still unrooted, produces many "juvenile shoots" that can be removed and rooted as conventional cuttings with a good success rate.

Field Management

Good success was found in transplanting self-sown seedings from wild forest areas to open fields. This technique produces faster growth than traditional Amazonian planting methods and may be significant for plantings on degraded forest land. The open-field trials suggest that such planting will produce distillable trees (trunks 10-15 cm in diameter) within ten years, and trees ready for their first leaf coppicing treatment in three years.

Predictions

In the long term, Brazilian rosewood oil will come primarily from plantation-grown trees. Trunkwood will be harvested on a ten-year cycle; wood oil yields and quality can be improved by proper selection of breeding stock, and tailored to a buyer's preference for composition/aroma (i.e., designer oils). Leaf oil produced by a coppice system will be most successful if tree selection results in a laevo-linalool product.

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Reference

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