Material review

The Developing Tea Tree Oil Industry in Guangxi Province, P.R. China*

The GFRI's work to become the world's leading producer of tea tree oil

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The terpinen-4-ol type of tea tree oil [ISO standard 4730:2004, *Oil of Melaleuca; Terpinen-4-ol type (tea tree oil)]* is a rare example of a transformation from a minor to a very significant volume item of international trade. Large-scale production commenced in Australia during the 1980s and recent international consumption of the oil has been estimated as 300-400 tons annually.[1] While production has developed subsequently elsewhere in the world, Australia holds about 99 percent of the tea tree oil market today and is regarded as the benchmark supplier for quality.

Commercial development of the terpinen-4-ol type of tea tree oil was started in Guangxi Province, P.R. China in the mid-1990s. However, poor selection of planting material and other factors in this initial development phase led to the offering of an oil of indifferent quality to the world market.

In 1998, the Guangxi Forestry Research Institute (GFRI) initiated an R&D program to systematically improve the production technology for tea tree oil and its further processed derivatives. This involved examining and further refining the best practices of the Australian industry for the local conditions.[2]

Today, production of tea tree oil in Guangxi is 60-80 tons per annum, of which 40-50 tons of high quality oil (40-50 percent terpinen-4-ol and < 3 percent of 1,8-cineole) are produced by the GFRI from forestry plantations of selected planting stock.

Guangxi is now poised for a large expansion of production of high quality tea tree oil and only awaits a stabilization of the international market, which has suffered in recent years from over-production by Australia. On entering this next phase, Guangxi is confident of capturing a sizeable share of the international market from Australia through the combination of product quality with very competitive production costs.

A Brief History of Tea Tree in Guangxi

Guangxi, located at 20°54′~26°24′ N and 104°24′~112°04′ E, has similar climatic and site conditions to the areas of natural occurrence and of commercial production of tea tree (*Melaleuca* species) in Australia.

Guangxi Province, People's Republic of China **F-1**

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China first introduced *Melaleuca* species about 100 years ago, along with eucalypts. Initially, the introduced *Melaleuca* were mainly decorative species that were commonly planted in arboretums and parks in Guangdong and Guangxi. During the1970s, cajeput oil production was undertaken from *Melaleuca leucadendron*, but this development did not prosper because of inadequate research and poor yields.

The success of the Australian tea tree oil industry prompted some overseas Chinese and students in 1996 to plant small quantities of *Melaleuca* seeds from Australia in the Huizhou and Gaoyao areas of Guangdong and in the Pingnan and Qinzhou areas of Guangxi. This seed base was unselected, represented only a narrow range of the diversity found in Australia and was mostly of obscure identity. The oil produced from the harvested leaf and stem of this planting phase was obtained in low yields and possessed a low, sub-standard terpinen-4-ol content. These deficiencies hindered the development of a successful tea tree oil industry in Guangxi.

In order to address these constraints, the Guangxi Forestry Research Institute (GFRI) commenced a thorough R&D program on tea tree oil in 1998. This embraced the introduction of seed stock of *Melaleuca alternifolia*, *M. dissiliflora* and *M. linariifolia*, screening and selection for propagation of elite cultivars, plus the techniques for breeding, cultivating and processing. Six years of this work has led to the establishment of commercial scale production of high quality oil and the basis for future expansion of the tea tree industry in Guangxi.

Elite Tree Selection, Breeding and Clones by the GFRI

The GFRI research on *Melaleuca* seed obtained from Australian wild plants has revealed the great diversity and variability in leaf oil properties between species and within provenances. Selected clones and individual trees could be picked directly by applying scientific selection criteria.

Individual plants within the same family exhibit considerable variability in the main components of the essential oil with 1,8-cineole contents of 2.8-76.3 percent and terpinen-4-ol contents of 1.1-41.5 percent. This germplasm screening of the natural *Melaleuca* resource allows categorization into three chemical types: those mainly containing terpinen-4-ol, those in which 1,8-cineole dominates and intermediate types.

The GFRI has selected 50 high oil yielding clones of two chemotypes:

- terpinen-4-ol contents as high as 40 percent and with the 1,8-cineole content below 3 percent
- 1,8-cineole contents as high as 75 percent

Seedling propagation techniques for *Melaleuca* have become mature and seedling production is now carried out routinely on a large scale. The GFRI has developed practical cultivation techniques based on local methods and nursery conditions. Challenges in sowing, young seedling management, transplanting, container seedling management, etc. have been solved. Clonal propagation techniques have been developed for vegetative (cuttings) and tissue-culture approaches. The survival rate for cuttings is more than 95 percent.

Creation of a Plantation Resource

In recent years, the Guangxi provincial government has carried out scale re-forestation programs in the counties of Fusui, Wuming, Yongning, Qinzhou, Pingnan and Laibin. This original plan included the planting of 500 ha for tea tree oil production. However, the development was scaled down to the current 200-300 ha because of the depressed world market price for the oil and the need to remove some of the first plantings of unselected stock.

Tea tree plantations are mainly located in low hill areas where the soil is fertile, loose and with good water retention and a gradient of no more than 20°, which permits the use of agricultural machinery. Planting is in comparatively concentrated areas and the main method of cultivation is corporate intensive forestry. Some

developments have adopted the "company plus farmer" approach, encouraging nearby farmers to plant on cash crop or sugarcane land with seedlings provided by the companies, which then purchase harvested leaf from the farmers. However, the scale of planting by farmers is low.

The plantation established and managed by the GFRI covers 160 ha, is the largest in Guangxi and utilizes the most advanced techniques for profitable production of high quality oil (T-1).

Plantation data for Guangxi (2004) **T-1**

Total area planted	up to 300 ha
GFRI plantation area	160 ha
Plant density	22,000 to 33,000/ha
Trees at 2 years of age:	
- Basal diameter	4-6 cm
- Height	2-4 m
- Crown diameter	40-100 cm
Leaf/stem harvest yields:	1 to 3 kg/plant; 22.5 to 45 tons/ha/year

Commercial Tea Tree Oil Production

Production of tea tree oil in Guangxi today is predominantly the activity of commercial scale distilleries that have the capacity to process 10 to 30 tons of harvested leaf and stem daily. There are only a few distilleries using rustic equipment.

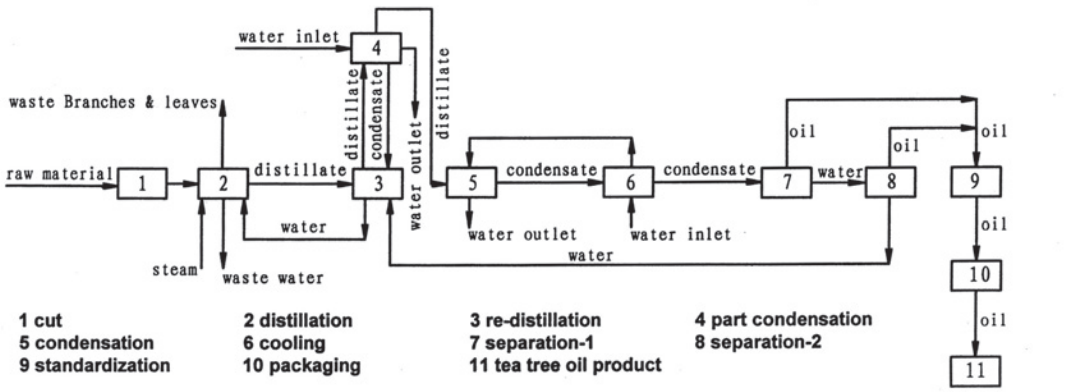
Recent tea tree oil production by Guangxi **T-2**

Total annual output	60 to 80 tons
By GFRI	40 to 50 tons

Today, the GFRI is the major tea tree oil producer in Guangxi and accounts for about two-thirds of the province's total (T-2). The techniques employed by the GFRI (illustrated in F-2) are the most advanced, yet highly practical and suitable for ready adoption by most other tea tree oil producers in Guangxi. The process includes:

1. Harvested tea tree stems are reduced to 20 cm lengths by a simple cutting machine and are placed in a basket.
2. When full, the basket is loaded by means of a hoist into the distillation vessel.
3. Steam is introduced into the vessel from an external boiler and the distillate vapors pass through a multistage tubular condenser system.
4. In the collection vessel, the oil is recovered oil as the floating upper phase. The separated water condensate is recycled to the distillation vessel to allow cohobation recovery of residual un-separated oil.
5. Distillation vessels of differing sizes are employed to

The GFRI process chart for tea tree oil production **F-2**



match the flow of plant raw material. Usually, two or three distillation vessels are run in sequence or in parallel in order to maximize utilization of the available steam and condensation facilities.

Because a re-distillation technique and corresponding facilities are used, components with high water-solubility properties, such as terpinen-4-ol and α-terpineol, can be further recycled to improve the oil yield and product quality. Simultaneously, the oil content in the water waste is lessened, reducing environmental pollution from the distillation process. Typical oil yields and the quality of the oil from the GFRI process are shown in T-3 and T-4.

Typical oil yields for the GFRI process **T-3**

For 1 year old plants	Oil yields, % (w/w)
Whole plant (fresh)	Fresh: 0.91
Crown (stem diam. ≤ 1.5 cm)	Fresh: 1.35 Air dried: 3.37

Properties of tea tree oil produced by GFRI in 2003 **T-4**

Relative Density, deq4	0.8910
Refractive Index, neqD	1.4791
Optical Rotation, 25°C	+8.60°
GC assay (by ISO4730-1996 method):	
α-pinene	2.1%
α-terpinene	8.7%
1,8-cineole	2.0%
γ-terpinene	19.4%
p-cymene	3.0%
terpinolene	3.2%
terpinen-4-ol	41.4%
α-terpineol	3.3%

Development of Further Processed Products

The development of further processed products from Guangxi tea tree oil is still at an early stage. The GFRI has developed

water-soluble tea tree oil, deodorized tea tree oil and natural terpinen-4-ol, among other products.

Some products have gone into the stage of bulk production and their quality specifications are as follows:

- Natural terpinen-4-ol (≥ 98 percent): possesses a pleasant herbaceous, peppery odor
- Tea tree oil solution (oil content 10-25 percent): a clear light yellow liquid with characteristic tea tree oil odor, dissolves in water at any proportion (20°C), pH 4.5-7.0
- Deodorized tea tree oil: a colorless to light yellow oily liquid, a mild scent with no unpleasantly pungent odor, terpinen-4-ol content ≥ 40 percent, 1,8-cineole content ≤ 0.05 percent.

The Future

The experience gained since the mid-1990s has demonstrated that Guangxi Province is a highly suitable location for the cultivation of tea tree oil and for the production of its essential oil. The development of elite planting stock, combined with advanced techniques for cultivation and processing, allows Guangxi to offer to the market tea tree oil of a quality matching that of Australia.

When conditions on the international market for tea tree oil improve, the combination of technological know-how, together with the availability of land for establishing new plantations and very competitive production costs, will encourage an expansion of production of tea tree oil in Guangxi and its emergence as a major supplier to the world market.

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