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Piper hispidinervum: A Sustainable Source of Safrole

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Piper hispidinervum (C. DC.), Piperaceae, is a promising source of sassafras oil, the source of safrol, currently derived from endangered plants of the Lauraceae such as *Ocotea pretios* Ness (Mez.), *Cinamomum petrophilum*, *C. mollissimum*, and *Sassafras albidum* Nutt. The essential oil of *P. hispidinervum* contains high levels (83–93%) of safrole in leaves which can be easily extracted by hydrodistillation.

SAFROLE

Safrol a phenolic ether (Tyler et al. 1982), is a colorless or slightly yellow liquid, $C_{10}H_{10}O_2$, molecular wt 162.18, with density of 1.096 at 20°C, and melting point about 11°C. The oil is insoluble in water, very soluble in alcohol, miscible with ether and chloroform. The DL_{50} (oral) is 1.950 mg/kg in rats and 2.350 mg/kg in mice (Budavaris 1989).

Sassafras oil is important to several products. It was used as an ingredient in popular beverages, such as "pinga com sassafras" in Brazil, and was once used as an ingredient for "root beer" in the United States. It has been used as a topical antiseptic and pediculicide, but it may be carcinogenic.

Safrole is an important raw material for the chemical industry because of two derivatives: heliotropin, which is widely used as a fragrance and flavoring agent, and piperonyl butoxide (PBO), a vital ingredient of pyrethroid insecticides. Natural pyrethrum in particular would not be an economical insecticide without the addiction of PBO as a synergist and the future of the natural pyrethrum industry is linked to the continued availability of PBO. Safrole has many fragrance applications in household products such as floor waxes, polishes, soaps, detergents, and cleaning agents.

Markets and Demand

Japan, Italy, and the United States are the most important markets for sassafras oil, and the total annual demand is estimated to be around 2,000 tonnes. Brazil has manufacturing capacity for both heliotropin and PBO (equivalent to about 500 t of sassafras oil), although a shortage of domestically produced oil has led to importations of oil from China. The worldwide sassafras oil price is US$4 to 6/kg.

The demand for sassafras oil is determined by the market for heliotropin and PBO. Heliotropin consumption is increasing, particularly in Eastern Europe, Asia, and some developing countries, and sassafras oil is the favorite raw material for its manufacture. If price rises markedly, synthetic heliotropin would become more attractive.

Sources

In Brasil, sassafras oil has been extracted commercially from *Ocotea pretiosa*, a perennial tree native to coastal tropical rainforests from Bahia to Santa Catarina, in Mata Atlantica. This species is also found in Colombia and Paraguay (Rizzini and Mors 1995). This was based on a discovery in l939 that wood distillation from a large tree in the state of Santa Catarina yielded a rich source of sassafras oil, containing 84% safrole. These trees were indiscriminately harvested, placing this species on the endangered list. Until the 1960s, Brazil was the major exporter of sassafras oil in the world, but production has declined with the depletion of this natural resource. Governmental restrictions in the late 1980s have resulted in a further decline in production and in the falling level of Brazilian exports. No significant replanting has ever occurred.

Vietnam has been exported sassafras oil since 1990 from wild trees of *Cinnamomum camphora*, but supplies from this source may be relatively short-lived. Current exports are estimated to be several hundred tonnes/year.

PIPER HISPIDINERVUM AS A SAFROLE SOURCE

In the early 1990s, certain forest shrubs of the Piperaceae, indigenous to the humid forests of Central America and Greater Amazonia, were found to contain high levels of safrole in their leaves. The Brazilian Amazon contains a wide variety of *Piper* species but attention had focused on *P. hispidinervum* and *P. callo-*

sum, two species with high safrole content. Subsequently, *P. callosum* has been dropped in the research work in favor of the more promising *P. hispidinervum.* This effort was carried out by Museu Paraense Emilio Goeldi in Belém in collaboration with the Center for Agroforestry Research (CPAF-EMBRAPA) in Acre.

Piper hispidinervum known as "pimenta-longa" in Brazil, has been described by Yunker (1972). It is a nodose, branching shrub with rather slender upper internodes, somewhat angular, mostly 1–3 cm long, glabrous or very sparsely pubescent, somewhat glandular dotted. Leaves are oblong-lanceolate or elliptic-oblong, with attenuately acuminate apex and inequilateral base. This species resembles *Piper aduncum* L. to some extent but differs in its scarcely scabrous leaves, glabrous stem, and short peduncle (Yunker 1972). Coppen (1995) suggests that this species is distributed throughout South America, and is especially prominent in the state of Acre in Brazil and may extend into Amazonas.

The species is most frequently found on degraded forest, bordering primary forest or farm land where it occurs as a colonizing "weed," either as a pure stand or along with other *Piper* species. On natural sites, plants develop initially into bushes and at an early stage they appear to inhibit growth of competing vegetation. As the plants age they become more tree-like, up to 10 m tall.

Pilot-scale distillations have been conduced to determine oil quality and yields and permit estimation annual productivity on a per hectare basis. The safrole content of the oil in unselected stock is about 85%, but a improvement to more than 90% is possible through selection. Leaves of *P. hispidinervum* in experimental plots of CPAF-EMBRAPA (Acre) contained 3% essential oils of which 93% is safrole.

Management and Culture

Mixed planting of *P. hispidinervum* with cash tree crops is a practical possibility and would be economically attractive as leaf harvesting would permit an early cash return. Another production possibility is sustainable management in natural vegetation since it occurs in high populations in several open areas bordering primary rainforest. Reforestation projects, in natural or deforested gaps, could take advantage of the vegetative and productive potential of *P. hispidinervum* since it is a pioneer species.

Piper hispidinervum offers excellent conditions for cultivation in areas with facilities for harvest, transport, and industrialization (Chaves 1994). Trials have been established at several sites in Brazil using both rooted cuttings and seedlings designed to provide information in both growth characteristics and biomasss yields (leaf + stem) under various planting and management regimes. Studies undertaken in laboratories of the Department of Horticulture, FCA–UNESP, Botucatu, demonstrated that this plant is positively photoblastic with 50% germination under sunlight but none in the dark.

Crop density studies in Acre state by Sousa et al. (1997) indicate that the highest biomass production was achieved at spacing of 70 × 70 cm. Essential oil yield was 0.3% in branches and 4.0% in leaves; safrole content was not evaluated.

Disease Susceptibility

In the early 1960s, Japanese immigrants to Brazil colonized the state of Pará, and initiated the culture of black-pepper (*Piper nigrum* L.) but it was an agronomic and economical disaster, due to fusarium disease caused by *Fusarium solani* f. sp. *piperis*. Poltronieri et al. (1997) evaluated the resistance of seedlings of *P. hispidinervum* to different isolates of this pathogen, and demonstrated resistance, indicating the possibility of commercial cropping in areas where black pepper had been decimated by the fusarium disease.

Cercospora is a potential pathogen of *P. hispidinervum.* In Xapuri (Acre state), plants infected by *Cercospora* had a reduction of 21% in essential oil produced, but the safrole content was unaffected (Siviero and Pimentel 1997).

FUTURE PROSPECTS

Forest preservation in developing countries is a controversial issue that involves many different interests. The worldwide demand for raw materials, such as safrole, offers an opportunity to these countries that have a source of products in their natural forests.

Forest preservation is best linked to local populations maintenance. In this context, *P. hispidinervum is* more than a new safrole source. The economical exploration of its productive potential could be an important

step to assist in the maintenance of the Amazon rainforest, providing a new livelihood option. This might include culture as a crop but also sustainable management in natural vegetation, since this species occurs in high populations in several open areas such as in natural gaps in the forest and in areas bordering the primary rainforest. An integrated project based on this species among research institutes, universities, governmental, and non-governmental institutions could produce a sustainable alternative crop for the tropical rainforest.

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