AROMATIC PLANTS

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Summary

The production and consumption of essential oils, because of their multipurpose application is increasing continuously: essential oils are used in perfumery, the food industry, households, condiments, making sweets, beverages as well as pharmaceutical and aromatherapeutic products of plant origin. Occurrence of essential oils, or volatile oils, is very widespread in the plant kingdom. They are synthesised and accumulated in oil cells, in secretion ducts or cavities or in grandular hairs of plants. The ancient Greeks and Romans knew the majority of them because of their multipurpose utilisation. Today, according to market data, essential oils are produced on a large scale and commercialised from about 400 species, from 67 plant families. Hundreds of essential oil plants are collected or cultivated in all part of the world, including tropical, Mediterranean and temperate regions. This article contains data about the chemical characteristics, distribution and production of essential oils as a whole, and more detailed description is given about species of eight genera, three of tropical (lemongrass, eucalyptus, tea-tee and related species), three of Mediterranean (bitter orange, lavender, rose) and two of temperate origin (peppermint, lovage).

1. Introduction

The occurrence of essential oils, or volatile oils, is very widespread in the plant kingdom. As their second name implies, they are volatile in steam. They are accumulated in oil cells, in secretion ducts or cavities or in grandular hairs of plants. Plants bearing essential oils were known, or even utilised in religious ceremonies or for personal use, adornment and flavouring foods long before recorded history. In India hundreds of aromatic substances including cinnamon, ginger and sandalwood were recorded in Vedic literature around 2000 BC. Essential oil crops were very popular in dynastic Egypt, too, and traces of the essential compounds could be detected in the funerary jars and cosmetic pots found in the Pharaohs' tombs. The Greeks took and applied the Egyptian knowledge, which was developed further by Romans. In the "De materia medica" written by Dioscorides, some six hundreds plants and aromatics were detailed. Hippocrates (460 BC) prescribed perfumed fumigation and fomentation. Romans distinguished three basic perfumery types at that time: solid unguent "ladymata", scented oils "ladysmata" and perfumed powders "diapasmata". The European application of essential oils has developed from that ancient tradition, supported by knowledge that came from Persia, Far Eastern countries, and the New World.

The production and consumption of essential oils, because of their multipurpose application is increasing continuously: essential oils are used in perfumery, the food industry, household industry, condiment industry, and in making sweets and beverages, as well as pharmaceutical and aromatherapeutic products of plant origin. International market studies predicted consumption of flavours and fragrances to be about 8 billion US$ at the beginning of the twenty-first century.

2. Chemical structures and extraction of essential oils

An essential oil is a mixture of chemical compounds, commonly containing 40 to 80 monoterpenoids, sesquiterpenoids and diterpenoids, and many in relative small proportions. Some representatives of essential oil compounds are shown in Figure 1.

The composition of essential oils, which are produced by specialised plant cells ´in vivo´ and the quality of the extracted products, differ in the majority of cases. The chemical composition of the essential oils which are commercialised, depends on their method of production. In the course of the isolation procedure some of the compounds disappear, some change in structure, or suffer decomposition. The most widely used procedure for extracting essential oils from the plant is *steam, or water distillation*. The distillation of volatile oils by means of water or steam has long been practised (see Figure 2), but modern plants possess many advantages over the older stills, in which charring and undesirable decomposition of the oil often took place.

Solvent extraction processes may be used for plants which contain small amounts of essential oil, particularly those which dissolve in water very easily, or for plants accumulating aromatic compounds which are partly volatile. For extraction different solvents, like alcohol, hexane, benzene, toluene, petrol, etc. can be used. *Enfurage* is a special form of extraction. In this procedure glass plates are covered with a thin layer of

fixed oil or fat upon which the fresh flowers are spread. The volatile oil gradually passes into the fat and the exhausted flowers are removed and replaced by a fresh supply. In the digestion process the flowers are gently heated in melted fat until exhausted. The volatile oil is obtained from the fat by three successive extractions with alcohol. More recently SFE (Supercritical Fluid Extraction) is used for separation of volatile oil. The method is based on the good solubility of volatile compounds in CO_2, kept in supercritical fluid phase using special conditions of pressure and temperature. *Cold pressing* is a well-known procedure for extraction of scent materials. This method can be used for extracting the essential oils from the fresh fruits of plants belonging to the genus *Citrus*.

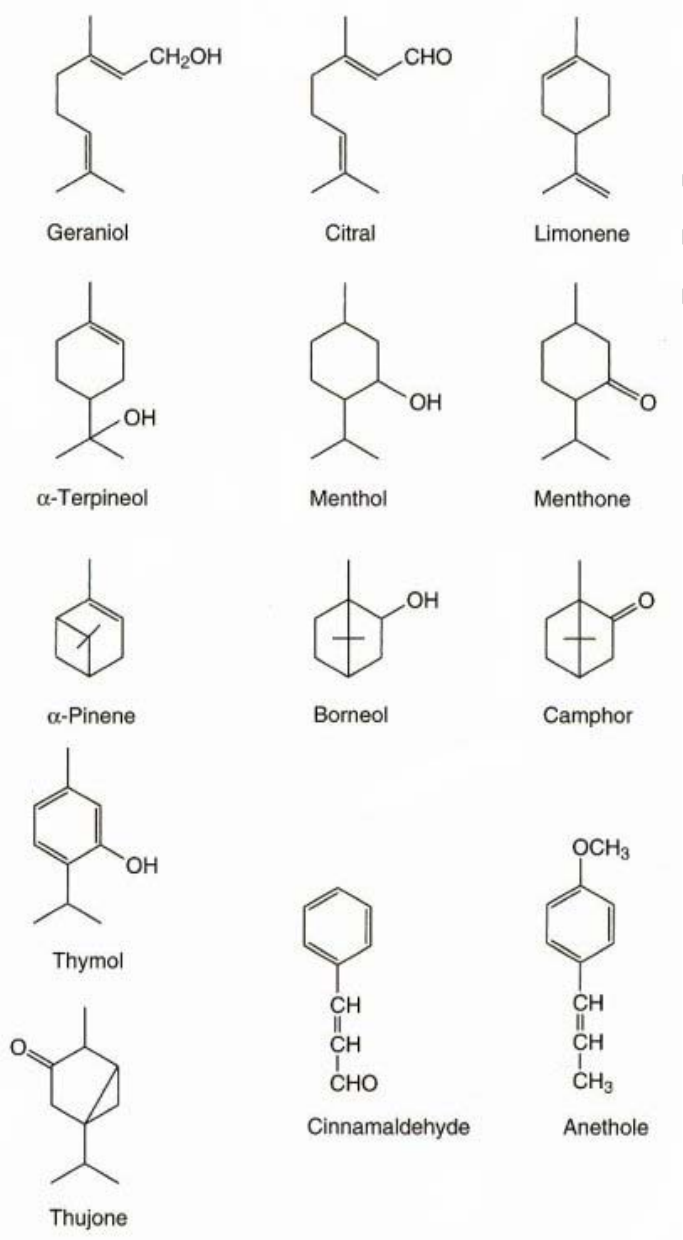

Figure 1. Characteristic chemical structures of essential oils accumulated by plant species

Figure 2. Simple and common extraction method of plant flavours used in aromatherapy, even nowadays, in Laos, (photo: Bernáth, J.)

3. Species of main importance used for production of essential oils

The occurrence of essential oils is very widespread in the plant kingdom. According to market data, there are about 400 species, from 67 plant families, from which essential oils are produced on a large commercial scale. The most important families from this point of view are Asteraceae (syn. Compositae), Lamiaceae (syn. Labiateae) and Apiaceae (syn. Umbelliferae). Each of them includes more than 15 species producing essential oils on a large scale. Other families of great importance are Fabaceae, Rutaceae, Lauraceae, Cupreassaceae, Pinaceaea, Zingiberaceae, Myrtacea, Rubiaceae and Burseraceae.

The species used for essential oil production can be categorised by the regions they come from. Analysing the climatic and ecological condition of the production sites, tropical, Mediterranean ad temperate crops can be distinguished. Some of the species characteristic of the above mentioned regions are listed in the Table 1.

Common names	**Scientific name**	**Main components of essential oil**
Essential oil producing species of tropical origin		
Cananga (ylang-ylang)	Cananga odorata	linalool, beta-caryophyllene, farnesene
Pelargonium (geranium)	Pelargonium spp.	linalool, isomenthone, citronellol,geraniol, citronellyl formate
Citronella	Cymbopogon spp.	citronellal, citronellol, geraniol

Lemongrass	Cymbopogon citratus Cymbopogon flexuosus	neral, geranial,
Palmarosa (gingergrass)	Cymbopogon martinii	linalool, geranyl acetate, geraniol
Vetiver	Vetiveria zizamoides	vetiverol
Patchouli	Pogostemon cabin	patchoulol, norpatchoulenol, azulene
Camphor	Cinnamomum camphora	camphor, safrole, cineol
Cassia	Cinnamomum cassia	cinnamaldehyde
Cinnamon	Cinnamomum verum	eugenol, beta-caryophyllene,
Sassafras	Sassafras albidum	safrole, phellandrene, pinene
Cubeba	Litsea cubeba	citral
Nutmeg	Myristica fragrans	alpha-pinene, beta-pinene, sabinene
Clove	Syzygium aromaticum	eugenol, beta-caryophyllene
Eucalyptus	Eucalyptus spp.	cineole, phellandrene, piperitone
Melaleuca	Melaleuca alternifolia	terpinen-4-ol, gamma-terpinene
Cajuput	Melaleuca cajuputi	cineole
Jasmine	Jasminum spp.	benzyl acetate, phytol, isophytol
Pepper	Piper nigrum	limonene, sabinene, pinene, caryophyllene
Lime	Citrus aurantifolia	limonene, gamma-terpinene, alpha-terpinrol
Sweet orange	Citrus sinensis	limonene, myrcene
Sandalwood	Santalum album	santalol, santalyl acetate, santalene
Ginger	Zingiber officinale	monoterpenoid and sesquiterpenoid hydrocarbons, zingiberene, geraniol, nerol
Essential oil producing species of Mediterranean origin		
Myrte	Myrtus communis	alpha-pinene, limonene, linalool
Rose	Rosa damascena	stearoptene, nerol, geraniol, citronellol
Bitter orange	Citrus aurantium	linalool, linalyl acetate, geraniol, limonene
Bergamot orange	C. aurantium subsp. bergamia	linalyl acetate, linalool, d-limonene, pinene
Lemon	Citrus limon	limonene, beta-pinene, gamma-terpinene
Fennel *	Foeniculum vulgare	anethole, fenchon, methyl chavicol
Lavender*	Lavandula spp.	linalyl acetate, borneol, camphor, geraniol
Sage*	Salvia officinalis	thujone, cineol, camphor, borneol
Garden thyme*	Thymus vulgaris	thymol, carvacrol, borneol, cymen
Clary sage*	Salvia sclarea	linalyl acetate, sclareol, linalool, nerol, pinene, thujone, borneol
Coriander**	Coriandrum sativum	alpha-linalool, geraniol, geranyl-acetate
Dill**	Anethum graveolens	d-carvone, d-limonene, phellandrene
Anise	Pimpinella anisum	methylcavicol, anisaldehyde, aniscetone
Angelica	Angelica archangelica	alpha-pinene, alpha-phellandrene, camphene
Lovage	Levisticum officinale	n-butylidene phtalide, alpha-terpineol, carvacrol, eugenol
Caraway**	Carum carvy	d-carvone, limonene, dihydrocarvone

Pepermint	Mentha piperita	menthol, menthone, pinene, menthyl acetate
Spearmint	Mentha spicata	l-carvone
Camomile**	Matricaria recutita	chamazulene, alpha-bisabolol, pharnesene, bisabolol oxide
Tarragon	Artemisia dracunculus	methyl chavicol, anethole, camphene, ocimene, sabinene, anisol

* Cultivated in the temperate regions, too
** Cultivated in the Mediterranean, too

Table 1. List of species used for production of essential oils on a relatively large scale

4. Essential oil producing species of main importance from the tropics

4.1. Lemongrass

History*:* There is no information about the original use of lemongrass (*Cymbopogon citratus* DC. and *C. flexuosus* Steud.). Probably lemongrass and its essential oil were utilised by natives in Asia for flavouring foods, and making curries. Fresh leaves were crushed in water to produce hair-wash, or other odorising agents.

The first information on oil distillation came from Kerala (India). The first primitive stills were installed there in the 1880s, and this developed into a considerable local industry.

The plant was introduced into many other countries and is produced on a large-scale, even nowadays.

Many other related species of the genus are used for essential oil production. The most important species are citronella (*C. nadus* L. and *C. winterianus* Jowitt.) and palmarosa (*C. martinii* Roxb.).

Distribution: Two species of *Cymbopogon* are used for production of lemongrass oil: *C. citratus* and *C. flexuosus*. The original, indigenous populations of *C. citratus* are unknown. All of its cultures are the result of introduction, which was rather successful.

The plant is cultivated on a large-scale in South America, Java, the Far East, and Madagascar, to a lesser extent in Philippines, China, India, Bangladesh, and Burma, and on a small scale in many other countries (e.g. Australia, Guatemala, southern Russia).

The other species *C. flexuosus* is said to be of Indian origin and is cultivated on a large-scale in India (Figure 3.), in Kerala State, as well as in Indonesia and Madagascar on a smaller extent.

Figure 3. Cultivation of lemongrass *C. flexuosus* in India, Bangalore (photo: Bernáth, J.)

Description: Both species are tufted perennial grasses belonging to the family Gramineae. Roots are extensive, but not deeply penetrated into the soil. The stems are up to 3 m high, light to medium green colour in *C. citratus. C. flexuosus* has two types, one with apple-green stem (almost white), the other with a stem of reddish colour. Leaves of both species are long and narrow (1m x 3 cm), light to medium green. Cultivated *C. citratus*, in contrast to other species, seldom flowers, normally.

Active agents: Both species are cultivated for the essential oil, the accumulation level and quality of which depend on species and location of cultivation. According to the literature, over 100 compounds have been detected in lemongrass oil. The main compound is geranial, which is a rather characteristic constituent, taking about the half of all components (its ratio varies from 45 to 58%). The presence of neral is important too, showing 25 to 30% of accumulation. Other compounds, which are accumulated by the species in considerable amounts, are myrcen, borneol, geraniol, limonene, and geranyl acetate. The oil of both species has a pronounced fresh lemony odour. The oils of West Indian origin are usually less strong in odour because of its lower citral content, while East Indian is considered to be fresher, lighter and sweeter.

Utilisation: The lemongrass oil is mainly used as a source of citral (neral, geranial). Demand for the whole oil has expanded with its use as a component of deodorants, waxes, polishes, detergents and insecticides. It is also used for flavouring human foods. Its fungicidal potential, and antibacterial activities are also utilised in phytomedicines and aromatherapeutic products.

Cultivation: Both species are tropical grasses that grow well in sunny warm, humid conditions, basically in the tropics. They need at list 2500 to 3000 mm rainfall,

annually. As a result of long, dry periods the oil content may decrease. A daytime temperature of 25 to 30 ^{o}C is considered the optimum for maximum oil production, with no extremely low night temperatures.

Cymbopogon can be grown on a range of soils, typically around neutral pH. *C. flexuosus* is normally propagated from seed, while roots propagate *C. citratus*. For obtaining roots the usual method is to divide clumps from an existing or exhausted plantation following cutting. One fully mature healthy plant will yield 50 to 200 splits.

The first harvest of both species usually takes place 6 to 8 month after planting. They are cut three to six times annually, over 4 to 8 years of plantation. The cutting interval depends on the ecological conditions of the cultivation site. The annual herbage yield in the second year of plantation is about 15,000 to 20,000 kg/ha in the case of *C. flexuosus* and about double, 30,000 to 50,000 kg/ha of *C. citratus*. The oil yield from fresh herbage is usually 0.2 to 0.5%.

Lemongrass oil is extracted by steam distillation, but the exact methods vary greatly, depending on traditions and facilities of the countries.

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Biographical Sketch

Prof. Dr. Jenő Bernáth was born in Rimaszombat in 1944. He obtained his first academic qualification at the University of Agriculture, Gödöllő in 1966. Between 1967 and 1992 he was employed by the Research Institute for Medicinal Plants (Budakalász, Hungary), at first as a research worker and later as scientific director. In 1989 he was invited to be an honorary professor of the University of Szeged and in 1992 full professor of the Faculty of Horticulture, Department of Medicinal and Aromatic Plants (BKA University, Budapest). In 1985 on the basis of his scientific activity he was awarded a Doctor Degree of the Hungarian Academy of Sciences (Budapest).

His scientific activity is demonstrated by his publication of 32 books and book-chapters, 239 scientific articles and about 150 scientific lectures. Between 1974 and 2004 he acted as the editor of the international journal Herba Hungarica and Acta Horticulturae (ISHS - International Society of Horticultural Sciences) and editor of the Newsletter of Medicinal and Aromatic Plants (supported by FAO). He was invited to be a member of the editorial board of the Journal of Spices, Herbs and Medicinal Plants (USA). He has contributed to the creation of 11 new medicinal plant cultivars, two of them registered in Germany.

Between 1974 and 2004 he was chairman of the medicinal plant working groups of International Pharmaceutical Federation (FIP), International Soceity of Horticultural Sciences (ISHS), European Co-operative Programme of Crop Genetic Resources Networks (ECP/GR) and became President of the International Council of Medicinal and Aromatic Plants (ICMAP).