Methyl Eugenol: Its Occurrence, Distribution, and Role in Nature, Especially in Relation to Insect Behavior and Pollination

Authors: Tan, Keng Hong, and Nishida, Ritsuo

Source: Journal of Insect Science, 12(56) : 1-60

Published By: Entomological Society of America

URL: https://doi.org/10.1673/031.012.5601

Journal of Insect Science
www.insectscience.org

Methyl eugenol: Its occurrence, distribution, and role in nature, especially in relation to insect behavior and pollination

Keng Hong Tan[1a*] and Ritsuo Nishida[2b]

[1]Tan Hak Heng, 20, Jalan Tan Jit Seng, 11200 Penang, Malaysia
[2]Laboratory of Chemical Ecology, Graduate School of Agriculture, Kyoto University, Kyoto, 606-8502, Japan

Abstract

This review discusses the occurrence and distribution (within a plant) of methyl eugenol in different plant species (> 450) from 80 families spanning many plant orders, as well as various roles this chemical plays in nature, especially in the interactions between tephritid fruit flies and plants.

Keywords: allomone, attractant, *Bactrocera*, chemical ecology, floral fragrance, insect pollinators, plant–insect interactions, plant semiochemicals, sex pheromone, synomone, tephritid fruit flies
Abbreviations: ME, methyl eugenol; **RK**, raspberry ketone
Correspondence: [a] tan.kenghong@yahoo.com, [b] ritz@kais.kyoto-u.ac.jp, *Corresponding author
Editor: Todd Shelly was editor of this paper.
Received: 28 April 2011, **Accepted:** 27 August 2011

ISSN: 1536-2442 | Vol. 12, Number 56

Cite this paper as:
Tan KH, Nishida R. 2012. Methyl eugenol: Its occurrence, distribution, and role in nature, especially in relation to insect behavior and pollination. *Journal of Insect Science* 12:56 available online: insectscience.org/12.56

1. Introduction

Plants produce a huge array of chemicals, numbering tens of thousands, primarily for defense against herbivores and pathogens as well as for production of floral fragrance to attract pollinators. Among them is a class of phenolics that consists of a group of compounds known as phenylpropanoids. The phenylpropanoids have numerous functions in plants, ranging from structural constituent, growth, and reproductive biochemistry and physiology to chemoecological interactions with microbes, animals (particularly insects), and neighboring plants.

Methyl eugenol (ME) CAS No. 93-15-12 (Figure 1) is a phenylpropanoid chemical with many synonyms: 4-allylveratrole; 4-allyl-1,2-dimethoxybenzene; eugenyl methyl ether; 1,2-dimethoxy-4-(2-propenyl)benzene; 3,4-dimethoxy-allylbenzene; 3-(3,4-dimethoxyphenyl)prop-l-ene; O-methyleugenol; and methyl eugenol ether. It is directly derived from eugenol, a product from phenylalanine (an essential amino acid) through caffeic acid and ferulic acid via 'the shikimate pathway' (Herrmann and Weaver 1999). It is a common phenylpropanoid found in many plant species, particularly in spices and medicinal plants. Furthermore, this chemical can be converted to other useful phenylpropanoids either to elemicin or myristicin, and then, in the latter compound, to dillapiole, via the regulation of two genes in *Perilla frutescens* (Lamiaceae) (Koezuka et al. 1986).

Synthetic ME has been used extensively: a) as a flavoring agent in many types of processed food, soft drinks, and sauces; b) in perfumery; and c) as an essential oil in aromatherapy. From an entomological perspective, synthetic ME has been successfully used in: a) fruit fly surveys (Tan and Lee 1982) and quarantine detection (see reviews by Metcalf and Metcalf 1992; Vargas et al. 2010); b) estimation of native fruit fly populations (Steiner 1969; Newell and Haramoto 1968) and survival rates in natural ecosystems (Tan 1985; Tan and Jaal 1986); c) determining the relationship between fruit phenology and native fruit fly population dynamics (Tan and Serit 1994); d) monitoring movement of native fruit flies between different ecosystems (Tan and Serit 1988); and e) control of tephritid fruit flies (Diptera: Tephritidae) via male annihilation technique through mass trapping (see review by Vargas et al. 2010).

2. Methyl eugenol in nature

The role of ME in citronella grass, *Cymbopogon nardus* (Poaceae), in the strong attraction of *Dacus* (currently *Bactrocera*) fruit flies which also visited other plant species including flowers of papaya and *Colocasia antiquorum*, was first discovered almost a century ago (Howlett 1915). Sixty years later, ME was found to be the most active attractant for the oriental fruit fly, *Bactrocera dorsalis*, when compared with 34 chemical analogs (Metcalf et al. 1975). Since then, about 20 plant species from 16 families were reported to contain ME, and the role of chemicals as plant kairomone in dacine fruit fly ecology has been discussed (Metcalf 1990; Metcalf and Metcalf 1992). Additionally, eight plant species containing 0.1-17.9% ME as a natural constituent, and another seven plant species with ME but without quantitative data, were reported by De Vincenzi et al. (2000). Prior to this review, it was reported that a) ME was present in 20 angiosperm and 3 gymnosperm families (Schiestl 2010); and b) ~350 plant species belonging to 61 families possessed ME as a constituent component and/or as a component of floral fragrance (Tan et al. 2011).

2.1. Occurrence of methyl eugenol

From an intensive literature search conducted over the first half of 2011, an additional ~100 were added to the 350 plant species to yield a total of over 450 species from 80 families spanning 38 plant orders that contain varying amounts of ME in essential oils from leaves, roots, stems, flowers, or whole plant extracts. The compiled species are presented here in two separate tables. Table 1 shows over 370 species of plants listed alphabetically from 62 families (one fern, two gymnosperms, four monocots, and 55 dicots) having ME content varying from a trace quantity to 99% of essential oils detected in various plant organs, except flowers (which will be presented in Table 2 in section 3.4). The large number of families involved indicates that biosynthesis of ME evolved independently in many of the Plantae orders and families. Families that are represented by 10 or more species in Table 1, in decreasing order, are Asteraceae (47), Apiaceae (44), Lamiaceae (38), Lauraceae (34), Aristolochiaceae (32), Rutaceae (23), Myrtaceae (20), Poaceae (12), Cupressaceae (10), Euphorbiaceae (10), and Zingiberaceae (10). The ME content varies greatly within and between species as well as within and between the plant families. Several species have ME content over 90% in essential oils, namely *Croton malambo* (Euphorbiaceae), *Cinnamomum cordatum* (Lauraceae), *Melaleuca bracteata*, *M. ericifolia*, *M. leucadendra*, *M. quinquenervia*, *Pimenta racemosa* (all Myrtaceae), *Piper divaricatum* (Piperaceae), and *Clusena anisata* (Rutaceae). Furthermore, 68 species possess ME content between 20 and 90% in essential oils of either a whole plant or a part thereof (Table 1). These plant species are likely to involve ME in their chemical defense against pathogens and/or insect herbivores. Most of the plant species listed in the table are either spices, medicinal plants (many with ethnopharmacological properties), or plants of economic importance, especially in the production of essential oils for aromatherapy and perfumery. As such, many more plant species, currently with little or no anthropocentric importance, may contain ME and await discovery and/or chemical analysis.

Methyl eugenol, as a constituent in leaves, fruits, stems, and/or roots, may be released when that corresponding part of a plant is damaged as a result of feeding by an herbivore. If present in sufficiently high concentration, it will immediately deter the herbivore from further feeding on the affected part (see section 3.2.3). In this case, ME acts as a deterrant or repellant. In many plant species, ME is present along with varying amounts of eugenol—ME's immediate precursor (see section 3.4.2.2 B). Both the compounds are found in most spices.

For plant species with low ME content, this component may be detected only in certain developmental stages. This is demonstrated by the sweet marjoram, *Origanum majorana* (Lamiaceae), in which ME was detected during the early vegetative and budding stages of four growth stages investigated (Sellami et al. 2009). Similarly, ME was detected in *Artemisia abrotanum* (Asteraceae) only during the emergence of runners and mass flowering phases among four studied (Table 1). Nevertheless, in *Artemisia dracunculus* ME was detected at 6.06, 6.40, 38.16, and 7.82 % of essential oil weight during emergence of runners, budding, mass flowering, and seed ripening phases, respectively (Khodakov et al. 2009).

A native Mediterranean plant species with ethnopharmacological properties, *Erodium cicutarium* (Geraniaceae), was shown to contain a relatively high content of ME (10.6%) in leaf hexane extract (Lis-Balchin 1993). Nevertheless, out of approximately 170 chemical components, many of which existed in trace quantities, ME was not detected in some specimens of the same species (Radulovic et al. 2009). This finding probably reflects geographical variation among varieties or populations and not different extraction methods or chemical analyses.

High variation within a plant species in terms of ME content may lead to the identification of distinct chemotypes. To further illustrate varietal differences in plant species, two common *Ocimum* species (Lamiaceae), *O. basilicum* and *O. sanctum*, which are frequently used for culinary and medicinal purposes in Southeast Asian countries in particular, show distinct variations in terms of ME content. 19 accessions/varieties of *O. basilicum* (sweet basil), two wild and 14 cultivated as ornamentals in Sudan, two from Germany, and one from United Arab Emirates, had varying contents of phenylpropanoids—eugenol, ME, and methyl cinnamate—in combined leaf and flower essential oils. As indicated by peak area in essential oils, 12 varieties had highly variable content of eugenol from 0.05 to 43.3%, and for methyl cinnamate, 11 varieties had content from 1.9 to 42.4%, of which seven had over 15%. However, only one variety had 8.7% ME without the other two phenylpropanoids, and three had ME in trace amounts (Abduelrahman et al. 2009). Nevertheless, two varieties of the sweet basil found in Malaysia had no eugenol, but ME content was at 5.6-12.3% in leaf and 3.2-11.1% in inflorescence essential oils (Nurdijati et al. 1996).

Ocimum sanctum (holy basil) also varies considerably in terms of ME and eugenol contents in leaf and inflorescence essential oils. Seven varieties of holy basil in Malaysia and Indonesia can be grouped into three chemotypes based on the phenylpropanoid content in leaf essential oils: two as eugenol chemotypes with 66-73% eugenol and 0.5-3.1 % ME, four ME chemotypes with 78-81% ME and 2.7-5.8 % eugenol, and one ME–eugenol chemotype with 52% ME and 27% eugenol (Nurdijati et al. 1996). The phenylpropanoids in the leaves of both sweet and holy basils are not released naturally. They are stored in the numerous oily glands (characteristic of Lamiaceae (formerly Labiatae)). More glands per unit surface area are found on the lower surfaces of leaves in the basils. Healthy leaves on a plant do not attract male *Bactrocera* fruit flies (see 3.3.1. Insect attractant). However, when any part of the plant (especially the leaves) is damaged or squashed, many male fruit flies are attracted to the damaged part, indicating the release of ME and eugenol. Further, it is very interesting to note that the *O. sanctum* leaf (chemotype unspecified) essential oil has lipid–lowering and anti–oxidative effects that protect the heart against hypercholesterolemia in rats fed with a high cholesterol diet (Suanarunsawat et al. 2010).

Additionally, another species of *Ocimum* in Brazil, *O. selloi*, has two chemotypes. Leaf and flower essential oils of chemotype A contained estragole (methyl chavicol) at 80.7 and 81.8% with ME at 0.79 and 1.13% of peak area, respectively, while chemotype B had ME as the major component at 65.5 and 66.2% of peak area in leaf and flower essential oils, respectively, and with no trace of estragole (Martins et al. 1997).

The same species of plant grown in different countries may show high variation in chemical constituents. This was well illustrated by *Alpinia speciosa* (Zingiberaceae) in which leaves collected from Japan contained ME, estragole, and (E)-methyl cinnamate at 2.9, 4.6, and 24.1% of essential oil. The phenylpropanoids were not detected in leaves that originated from Amazonia (Brazil), Martinique (French West Indies), Rio Grande (USA), and China and Egypt (Prudent et al. 1993).

Furthermore, within a variety of a plant species, the quantity of ME may also vary depending on the plant tissue and on the time of harvest. This is elucidated by *Myrtus communis* var. *italica* (Myrtaceae) grown in Tunisia. The quantity of ME varied from 0.4 to 1.9% of leaf essential oil, with > 1% for October, November, and March over a period of 12 months. The monthly ME content of stem oil varied between 0.8 and 3.6%, with January and April > 3%. However, fruits had monthly ME content of 1.1-1.3% for August and September, which then rose to 3% in subsequent months and remained between 3.1-3.6% from October to January (Wannes et al. 2010).

Even during storage, the major components of essential oils may change considerably. This is shown by *Agastache foeniculum* (Lamiaceae), which contained five major components. During storage of the plants for 17 days, estragole decreased from 63.2 to 50%, with a corresponding increase of ME from 28.6 to 41% in plant essential oil (Dimitriev et al. 1981).

It was shown that green parts of *Proiphys amboinensis* (Amaryllidaceae) leaves contained a trace quantity of ME, and during browning of a leaf, the yellow and brown parts contained 0.1 and 0.2-0.3 µg/mg of leaf, respectively, that attracted many male fruit flies (Chuah et al. 1997). The attraction phenomenon has never been observed in the normal browning of the leaves, except on one occasion after a raining shower when an infected leaf attracted many male fruit flies (ME–sensitive *Bactrocera* species) that fed along a yellow–brown border between the green and yellow to brown parts (Figure 2, unpublished observation). The attractant in the browning phenomenon may be induced or produced by microbes as a result of an infection, and this certainly warrants further investigation.

Besides large variation within species, differences between species within a genus frequently occur. For example, the genus *Heterotropa* (Aristolochiaceae) possesses species with ME content ranging from 0.1 to 50% of volatile oil. Many of the 27 species have ME content below 5% of volatile oil, except for *H. fudzinoi* (11%), *H. muramatsui* (20%), and *H. megacalyx* (50%). Eleven species of *Artemisia* (Asteraceae) have ME in trace quantities (e.g., *A. campestris*), whereas *A. dranunculus* has an ME content of 35.8%. Similarly, high variation in ME content exists for genera *Ocimum* (Lamiaceae), *Cinnamomum* (Lauraceae), and *Melaleuca* (Myrtaceae), in which most species are known to have relatively high ME content (Table 1). Strangely, many species in the genus *Croton* (Euphorbiaceae) contain ME in aerial parts (stems and leaves) except *Croton micrans*, which has ME in flowers but not in leaves (Compagnone et al. 2010).

It was found that shading from the direct sunlight also affected the content of phenylpropanoids in leaves. *Ocimum selloi* seedlings from the same population grown under normal sunlight and two different shadings, blue and red, showed a change in two phenylpropanoids, estragole and ME. The leaf estragole content under full sunlight, blue shading (with transmittance of 400-540 nm), and red shading (with transmittance of > 590 nm), was 93.2, 87.6, and 86.1% (relative percentage of peak area), respectively. While for leaves, the ME content was 0.6% under full sunlight and 1.1% under both types of shading (Costa et al. 2010).

2.2 Distribution of ME in various plant organs

The distribution of ME among plant organs is never even as illustrated by many of the species listed in Table 1. A Brazilian folk medicine plant, *Kielmeyera rugosa* (Caryophyllaceae), possesses ME only in flowers and not in leaves and fruits; the showy flowers are pollinated by large bees (Andrade et al. 2007). *Valeriana tuberosa* (Valerianaceae), a medicinal plant used as a mild sedative, commonly found in Greece, has eugenol and ME in similar quantities (~0.45% of oil) in inflorescences but none in roots, stems, or leaves (Fokialakis et al. 2002).

Another medicinal plant, bay laurel *Laurus nobilis* (Lauraceae), is known to have antibacterial, antifungal, anti–inflammatory, and anti–oxidative properties. It was reported to contain ME in all its aerial parts but in different quantities, such as 3.1, 11.8, 4.7, and 16 % of flower, leaf, bark, and wood essential oils, respectively (Fiorini et al. 1997). Recently, 10 populations of wild bay laurel found in Tunisia had ME at 13.1-33.6, 6.6-17.8, 1.0-16.8, and 3.9-14.3 percentage composition of essential oil in stems, leaves, buds, and flowers, respectively (Marzouki et al. 2009). In another study on the same species, plants from Turkey had ME content that varied considerably between old and young leaves at 1.2 and 0.2% of volatile composition, respectively, while buds had 0.3% and fruits had 0.1% ME, with no ME detected in flowers (Kilic et al. 2004). Additionally, flowers of *Myrtus communis* var. *italica* (Myrtaceae) contained ME at 4.02% of the essential oil as one of seven major components, but as a minor component in leaves and stems at 0.38 and 0.22% of the essential oil, respectively (Wannes et al. 2010)

The amount of ME emitted from flowers of carob tree, *Ceratonia siliqua* (Fabaceae), varies considerably. Whole hermaphrodite flowers did not emit ME, male flowers emitted 2.8% ME of total volatiles, and female flowers of cultivars Galhosa and Mulata emitted 32 and 1.5% of total volatiles, respectively. In this species, the stamens and stigmas did not emit ME, but the nectar disk (source of most volatiles) of hermaphrodite, male, and female flowers emitted 0.8, 1.7, and 4.7-5.7% ME of total volatiles, respectively (Custodio et al. 2006). Whole flowers of *Clarkia breweri* from some plants emit eugenol, isoeugenol, ME, and methyl isoeugenol, while those for other plants do not emit ME and methyl isoeugenol. For flowers that emit all the four phenylpropanoids, the petals emit on average ME, methyl isoeugenol, and eugenol approximately 2.5, 1.8, and 0.5 µg/flower/24 hours, respectively, without any isoeugenol. In contrast, pistils and stamens emit only a single component of methyl isoeugenol and ME in very low quantities (Wang et al. 1997). This and the preceeding examples clearly show that the phenylpropanoids are distributed or released unevenly among different parts of individual flowers. All these species show that distribution or release of ME varies even in different parts of individual flowers.

Fruit of *Myrtus communis* var. *italica* showed variation in many of its 48 volatile components during development and ripening.

As to its ME content, it increased slightly during the initial stage of development when the fruit was green in color from 1.14 to 1.26 % (wt/wt) during 30 to 60 days after flowering. Then, ME concentration increased two–fold when the fruits were pale yellow from 3.05-3.30% during 90-120 days after flowering. A slight increase was noted when the fruits ripened and turned dark blue (Wannes et al. 2009).

Calamus or sweet flag, *Acorus calamus* (Acoraceae), is a unique medicinal plant in that, unlike many other species in which ME is mainly found in aerial parts, it has ME in the roots. In this species, aerial parts contained only about 1% ME but root essential oil contained up to 80% ME, particularly in the European and Japanese samples (Duke 1985). In this species, the high ME content may be used as chemical defense against root–feeding insects or nematodes.

The distribution of ME within a plant is clearly uneven. In many species, ME may be detected in a specific plant part but not in other parts. Intraspecific chemical variation may be the result of several phenomena, namely: a) adaptation to different pollinator species, b) random genetic drift, c) adaptation to disruptive learning processes in pollinators among non–rewarding flowers, and d) introgression effects involved in hybridization (Barkman et al. 1997). Another possible phenomenon is the selection pressure exerted by herbivores, microbes, and nematodes in their interactions with plants (see section 3.2).

3. Role of methyl eugenol in plants

There are two main theories on the evolution of secondary plant metabolites. First, due to oxidative pressure and the possibility of photo–damage, plants might have developed secondary plant metabolites with antioxidant properties, namely flavonoids, to prevent cellular damage by highly reactive chemicals (Close and McArthur 2002; Treutter 2005). The second theory states that it arose from the relationship between plants and various groups of herbivores or pathogens (Dicke and Hilker 2003; Franceschi et al. 2005), and this latter view is further substantiated in this review.

3.1. Induction of phenylpropanoid biosynthesis due to stress

Phenylpropanoids form a large subclass of chemical compounds within the class of phenolics. All of them are derived from cinnamic acid/p–coumaric acid, which in turn is derived from phenylalanine, an essential amino acid, catalyzed by an enzyme, phenylalanine ammonia lyase (see 3.4.2.B below). This enzyme is the branch–point enzyme between primary (shikimate pathway) and secondary (phenylpropanoid) metabolisms. Many simple and complex phenylpropanoids may be induced in plants by external stresses, such as high ultra–violet light, pathogen attack, and physical wounding, such as that caused by herbivory (see review by Dixon and Palva 1995). The cytochrome-p450s-dependent oxygenases, belonging to a large plant gene family, are involved in primary metabolism, such as in steroid and phenylpropanoid biosynthesis, and secondary metabolism. A similar phenomenon also exists for O-methyltransferase enzymes that are involved in primary metabolism, namely lignin synthesis and secondary metabolism, such as phenylpropanoid biosynthesis (Pichersky and Gang 2000).

Essential oils of three untreated orange varieties of *Citrus sinensis* (Rutaceae)—Hamlin, Pineapple and Valencia—did not contain any ME. But, when treated with abscission agents to loosen fruits for mechanical harvesting, six phenylpropanoids, namely eugenol, ME, (E)- and (Z)-methyl isoeugenol, elemicin, and isoelemicin, were detected for the first time. Among these compounds, ME was the most abundant component present at 42 ppb in orange juice from the treated fruits (Moshonas and Shaw 1978). This study clearly shows induction of phenylpropanoid biosynthesis in fruit under stress. The role of ME in the treated orange is unclear, however.

3.2. Defense

Plants produce a large diversity of chemical compounds to deter phytophagous organisms, especially against insect herbivores and/or pathogens. These chemicals may exist as plant primary constituents or as secondary by–products/metabolites. They have diverse biochemical and physiological activities against a) pathogenic microbes, b) competitive/neighboring plant species, and c) herbivores. Plant chemical constituents that are not secreted naturally, and affect animal behavior in self–defense by acting as a toxicant, antifeedant, deterrant, irritant, repellant, and/or growth regulator, act as para–allomones (an allomone is a naturally secreted chemical that benefits only the releaser in an interaction between two species of organisms).

3.2.1. Microbes. Essential oils and ME have been known for a long time to possess antifungal activity. ME and eugenol have similar antifungal activity against seven species of fungus at 2.0 mM concentration (Kurita et al. 1981). The essential oil of *Echinophora sibthorpiana* (Apiaceae) contains ME, and the oil (~0.1%) or ME alone (at 0.05-0.1%) showed some inhibitory activity against fungi and bacteria (Kivanc 1988). At temperatures 5-15 °C, l000 ppm ME delayed mold's initiation of mycelium and spore development in 32 strains: four of *Aspergillus ochraceus*, two *A. niger*, 16 *Penicillium clavigerum,* and 10 *P. expansum* (Kivanc and Akgul 1990). Furthermore, sprays of 0.5% ME on peanut pods and kernels prevented colonization of *Aspergillus flavus*, common mold, and inhibited aflatoxin synthesis in the fungus. Consequently, it was suggested that ME be used to prevent infestation of the fungus in peanuts (Sudhakar et al. 2009).

Fruit essential oil of emblica, *Phyllanthus emblica* (Euphorbiaceae), that contained 1.25% ME among eight major components had high antimicrobial activity against contaminating microbes, such as: a) Gram–positive bacteria, e.g., *Bacillus subtilis* and *Staphylococcus aureus*; b) Gram–negative bacteria, e.g., *Escherichia coli*, and *Salmonella*; c) molds, e.g., *Aspergillus niger* and *A. oryzae*; and d) the budding yeast, *Saccharomyces cerevisiae*. The antimicrobial activity of the oil was mainly due to the presence of ME, β-caryophyllene, β-bourbonene, and thymol (Zhao et al. 2007). Recently, another fruit essential oil of *Eugenia singampattiana* (Myrtaceae) had major constituents, namely, α-terpineol (59.6%), camphene (12.1%), ME (11.5%), and α-pinene (4.7%). A minimum inhibitory concentration (MIC) at 0.2 μL/mL of the essential oil yielded complete inhibition against *Candida albicans* (a form of yeast that causes infections such as "thrush") (Jeya Johti et al. 2009).

The growth of a strain of *Campylobacter jejuni*, a major bacteria species causing gastroenteritis in humans worldwide, was inhibited by essential oil of carrot, *Daucus carota* (Apiaceae), as well as individual component of ME and elemicin at a MIC of

250 μg/mL, which was slightly less effective than methyl isoeugenol at MIC of 125 μg/mL (Rossi et al. 2007).

3.2.2. Nematodes. The pinewood or pine wilt nematode, *Bursaphelenchus xylophilus*, is very damaging to matsutake mushroom cultivation in addition to causing pine wilt. Nematicidal activities against the nematode were demonstrated with LC_{50} (lethal concentration that induces mortality in 50% of test organisms) values for geranial, isoeugenol, methyl isoeugenol, eugenol, and ME at concentration of 0.120, 0.200, 0.210, 0.480, and 0.517 mg/mL, respectively (Park et al. 2007).

3.2.3. Antifeedant. Plant ME in the growing bud of *Artemisia* capillaries was found to inhibit feeding (100% antifeeding activity on 2 cm diameter leaf disc) by larvae of the cabbage butterfly, *Pieris rapae* subspecies *crucuvera* (Katsumi 1987). In addition, ME was the most potent of seven eugenol analogs in essential oil of *Laurus nobilis* against a noctuid moth white–speck, *Mythimna unipuncta* (Muckensturm et al. 1982).

A fresh water aquatic plant *Micranthemum umbrosum* (Scrophulariaceae) possesses elemicin, a phenylpropanoid as one of two chemicals used in chemical defenses against herbivores, which acts as an antifeedant against generalist consumers such as crayfish (*Procambarus acutus*). To determine the structure–activity relationship among eight naturally occurring phenylpropanoids, bioassays were conducted and showed that ME was most active and much more effective than either eugenol or elemicin in deterring feeding by crayfish (Lane and Kubanek 2006).

3.2.4. Insects. Of the nine major constituents of essential oils, benzene derivatives (eugenol, isoeugenol, ME, safrole, and isosafrole) are generally more toxic and repellent to the American cockroach, *Periplaneta americana*, than the terpenes (cineole, limonene, p-cymene, and α-pinene). Furthermore, ME was most effective in terms of knockdown activity, as well as repelling and killing effects (Ngoh et al. 1998).

Toxicity of ME against larvae of the tobacco armyworm, *Spodoptera litura*, was found to be significant. Larvicidal activity of a residual ME (15 μg/leaf cm^2) was 36.0 ± 15.3% and 76.6 ± 11.5% for 24 and 48 hours of exposure, respectively (Bhardwaj et al. 2010). However, as to mosquitocidal impact, ME, found only in leaves of *Magnolia salicifolia* (Magnoliaceae), induced 100% mortality at 60 ppm against 4^{th} instar larvae of the yellow fever mosquito, *Aedes aegypti*, which is responsible for the spread of dengue fever and Chikungnya viruses (Kelm et al. 1997).

In a fumigation study comparing the toxicity of more than a dozen monoterpenes against the rice weevil, *Sitophilus oryzae* (Coleoptera: Curculionidae), ME and eugenol were moderately toxic compared to the most toxic compound tested, menthone (Lee et al. 2001). The latter was the main chemical component in *Mentha arvensis* (Lamiaceae) var. *piperascens* essential oil, which in turn was the most toxic among 16 medicinal and spice plants tested. Nonetheless, ME was the most potent inhibitor against the acetylcholine esterase (Lee et al. 2001), an enzyme responsible for the hydrolysis of the neurotransmitter acetylcholine, which can eventually lead to paralysis. Similarly, fruit essential oil of *Illicium simonsii* (Aquifoliaceae) that contained β-caryophyllene (10.30%), δ-cadinene (9.52%), and ME (8.94%) as major components had strong fumigant and contact toxicities against adults of the maize weevil, *Sitophilus zeamais*, with LC_{50} values of 14.95 mg/L air and 112.74 µg/adult, respectively (Chu et al. 2010). Fumigant and repellant effects, leading to almost 100% mortality within 24 hours, were observed on adult brown plant hoppers, *Nilaparvata lugens*, feeding on rice seedlings placed over a filter paper containing ME residue at ~0.15mg/cm^2 (Tan, unpublished data).

It is interesting to note that ME as a fumigant was also very toxic to two global pest fruit fly species—the Mediterranean fruit fly, *Ceratitis capitata*, and the melon fly, *Bactrocera cucurbitae* (a cue–lure/ raspberry ketone [RK] responsive species)—compared with basil oil, linalool, estragole, and (E)-anethole, all of which showed no knockdown effect at 0.75% concentration (Chang et al. 2009). After two hours of exposure to ME at concentrations of 0.5 and 0.75%, mortality/ knockdown was 96 and 100% against *C. capitata* and 98 and 97% against *Ba. cucurbitae*. However, ME was less toxic as a fumigant, even though it was a strong attractant, to the oriental fruit fly, *Ba. dorsalis*. Concentrations of 10-100 % induced 35-53% mortality/knockdown against this species (Chang et al. 2009).

3.3. Chemical cue

Certain insect species have adapted to using ME as a stimulant or attractant to locate plant host or source for pharmacophagy (consumption of non–nutritive and non–essential chemicals).

3.3.1. Insect attractant. Some insect species are known to be attracted to ME for unknown reasons, while others may be attracted and stimulated to undergo pharmacophagous feeding.

3.3.1.1. Pest insect species. Two scarabid pest species, *Cetonia aurata aurata* and *Potosia cuprea*, were captured in traps baited with a known attractant consisting of ME, 1-phenylethanol, and (E)-anethole (1:1:1). However, the numbers trapped were significantly increased for both the species with the addition of a synergist, either geraniol or (+)-lavandulol (Vuts et al. 2010).
Larvae of the rice stem borer, *Chilo suppressalis*, are attracted to "oryzanone" (p-methylacetophenone), and ME among 30 compounds related to the "oryzanone" also attracted the larvae (Kawano and Saito 1968). Although ME is not present in rice plants, it may be interesting to evaluate the impact of ME on stem borer physiology and behavior.

Two *Dacus* (currently *Bactrocera*) (Diptera: Tephritidae) species of fruit flies were first discovered to be attracted to citronella grass *Cymbopogon nardus* used as a mosquito repellant (Howlett 1912). Subsequently, ME was positively demonstrated to be solely responsible for the attraction (Howlett 1915). Since then, voluminous publications related to fruit fly attraction to ME have appeared. It should be pointed out at this juncture that all *Bactrocera* species may be categorized into three groups based on their response to two potent attractants: cue–lure, a synthetic analog of RK (195 species cue–lure responders, this chemical being a synthetic of RK) and ME (~84 ME responders), and non–responders to the attractants (28 species confirmed and 258 species listed under "lures unknown") (IAEA 2003). The effects of the attractants on sexual behavior of *Bactrocera* fruit flies have recently been reviewed (Shelly 2010).

ME acts as a precursor or booster to male fruit fly sex pheromonal component(s) in the rectal gland of certain *Bactrocera* species (Nishida et al. 1988, 1990, 1993; Tan and Nishida

1995, 1996, 1998). Plant ME, when released, attracts only male fruit flies, although there are two reports of wild females being attracted into traps baited with poisoned synthetic ME (Steiner et al. 1965; Verghese 1998). The attraction of females was probably due to a chemical contamination—perhaps male sex pheromonal components from spontaneous ejaculation induced by the poisoned bait prior to death of captured males. In contrast, no female *Bactrocera dorsalis* or *Ba. umbrosa* was ever attracted to or captured in ME–baited clear–traps, without an insecticide, used in the 'capture–mark–release–recapture' technique to capture thousands of live wild males for ecological and population studies in areas with high fruit fly infestation (Tan 1985; Tan and Jaal 1986; Tan and Serit 1988, 1994). These field studies further confirm that pure ME is a male attractant, although ME did induce an electrophysiological response in the antennae of *Ba. dorsalis* females (Siderhurst and Jang 2006) that may be translated into a negative rather than positive attraction response under natural conditions. Male fruit flies do not directly cause harm or damage to plants by just feeding on ME.

Several putative and ME–sensitive sibling species of the *Bactrocera dorsalis* complex, such as *Ba. carambolae*, *Ba. caryeae*, *Ba. dorsalis*, *Ba. invadens*, *Ba. kandiensis*, *Ba. occipitalis*, *Ba. papayae*, and *Ba. philippinensis* form the most serious group of pests of fruits and vegetables. Males are strongly attracted to and compulsively feed on ME, which acts as a) a sex pheromone precursor in *Ba. dorsalis* and *Ba. papayae*—the latter shown to be neither distinct biological nor genetic species from the former (Naeole and Haymer 2003; Tan 2003; Zimowska and Handler 2005), in which ME is converted mainly to (E)-coniferyl alcohol and 2-allyl-4,5-dimethoxyphenol (Nishida et al. 1988; Tan and Nishida 1996, 1998; Hee and Tan 2004); and b) a booster component to endogenously produced sex pheromone in *Ba. carambolae*, where it is biotransformed to only (E)-coniferyl alcohol (Tan and Nishida 1998; Wee et al. 2007). Recently, it was reported that the extremely invasive species in Africa, *Ba. invadens*, and in the Philippines, *Ba. philippinensis*, convert consumed ME to the same ME metabolites in similar ratio as *Ba. dorsalis*, and they belong to the same species clade, while *Ba. zonata* biotransformed ME to 2-allyl-4,5-dimethoxyphenol and (Z)-coniferyl alcohol, and *Ba. correcta* to (Z)-3,4-dimethoxycinnamyl alcohol and (Z)-coniferyl alcohol (Tan et al. 2011 a,b).

Consumption of ME has been shown to significantly improve male mating competitiveness in *Ba. dorsalis* (Shelly and Dewire 1994, 2000; Tan and Nishida 1996, 1998), *Ba. carambolae* (Wee et al. 2007), *Ba. correcta* (Orankanok et al. 2009), and *Ba. zonata* (Quilici et al. 2004; Sookar et al. 2009). Wild fruit fly males have easy access to natural sources of ME (Tan 2009). Therefore, it would be desirable to feed sterile males with ME in order to compete with wild males "on a level playing field", before mass release so as to enhance mating success in a sterile insect technique (SIT) program (Shelly et al. 2010).

3.3.1.2. Beneficial insect species. The green lacewing, *Ankylopteryx exquisite*, was attracted to ME–baited traps set up in two locations in central Taiwan in large numbers (350-800 adults/trap/two weeks during July) (Pai et al. 2004). Additionally, adults of another lacewing, *Chrysopa basalis*, were captured in plastic traps containing ME (Suda and Cunningham 1970). The reason for their attraction to ME for these predatory insects is still unclear. This is also the case for the weak attraction of honeybees, *Apis mellifera*, to traps baited with ME in high elevation native forest in Hawaii. The number captured varied with seasons, and it was found that more honeybees were captured in March and between June and August (Asquith and Burny 1998). The numbers trapped certainly did not reflect capture due to chance. Therefore, could the worker honeybees be mistakenly guided into ME traps through previously learned odor of ME resembling floral fragrance of golden shower or other flowers (see below)? Perhaps this question may be satisfactorily answered through proper electrophysiological and chemoecological investigations.

3.4 Methyl eugenol in flowers—ME as attractant and floral reward

Many plants, besides fending off insect herbivores, may require insects to assist in pollination. Recently, Knudsen et al. (2006) reviewed many aspects of floral scent with respect to variation within and between congeneric species belonging to a genus. They listed 12 common compounds, namely limonene, (E)-ocimene, myrcene, linalool. a- and b-pinene, benzaldehyde, methyl 2-hydroxybenzoate, benzyl alcohol, 2-phenylethanol, caryophyllene, and 6-methyl-5-hepten-2-one that are detected in floral scent from over 50% of seed plant families, and also provided a list of 1719 compounds identified from floral fragrances. ME was among the compounds listed and was detected in 21 plant families. Nonetheless, many more plant species produce flowers that possess ME that may be released as a component in floral fragrance. Table 2 shows ~122 species from 42 plant families, many of which (~85 species from 22 families) have ME detected exclusively in flowers or floral fragrances. This further substantiates the notion that synthesis of floral ME evolved independently in different plant families and orders. However, 27 species, namely *Cuminum cyminum*, *Daucus carota*, *Pimpinella affinis*, and *Scandix iberica* (Apiaceae), *Achillea conferta*, *Solidago odora*, and *Tagetes lucida*, (Asteraceae), *Borago officialis* (Boraginaceae), *Medicago marina* (Fabaceae), *Agastache foeniculum*, *Ocimum basilicum*, *O. gratissimum*, *O. sanctum*, *O. selloi*, *O. suave*, and *Rosemarinus officionalis* (Lamiaceae), *Laurus nobilis* (Lauraceae), *Michelia alba* (Magnoliaceae), *Myrtus communis* and *Syzygium aromaticum* (Myrtaceae), *Piper betel* (Piperaceae), *Cymbopogon flesuosus* (Poaceae), *Rosa damascena* and *R. hybrida* (Rosaceae), *Tamarix boveana* (Tamaricaceae), *Daphne genkwa* (Thymelaceae), and *Lippia alba* and *Lippia schomburgkiiana* (Verbenaceae) also have ME detected in other plant parts (Tables 1 and 2).

Except for several species, neither the role of ME in flowers nor the attraction of fruit flies was mentioned in the published articles. However, if ME is released naturally in an area where *Bactrocera* fruit flies are present, the flowers would have attracted the ME–responsive *Bactrocera* species.

Much of the published work on floral chemical composition with detected ME did not indicate the type of floral visitors or pollinators. While some species of *Dianthus* (Caryophyllaceae) had flowers that bloom at night, these flowers attracted nocturnal insects, such as moths, and bats as visitors/pollinators (Jurgens et al. 2003). Mediterranean flowers of *Dianthus arenarius*, *D. monspessulanus*, *D. superbus*, and *Silene officinalis* are whitish in color and strongly scented (especially during the night), indicating pollination by night–active flower visitors. Another species, *Silene latifora*, in the same family bears night flowers. The flowers from a European population had no detectable ME, whereas those collected from some plants in a North American population had detectable ME. However, the flowers did not exclude diurnal flower visitors, because unlike some nocturnal *Silene* species, they did not close or wilt during the day following anthesis. Nevertheless, there were clear differences in the floral scent of diurnal butterfly–flowers and moth– or hawkmoth–pollinated nocturnal species. According to Jurgens et al. (2003), the phenylpropanoids such as ME, methyl isoeugenol, elemicin, (Z)-asarone, and (E)-asarone were only found in the nocturnal *Dianthus* species.

Flowers from other families, similar to those of the family Caryophyllaceae, may attract other insects in regions/countries without ME–responsive *Bactrocera* species. Therefore, these flowers are not specifically adapted to fruit fly pollinators even though they possess ME.

3.4.1. ME in flowers with unknown purpose. From 16 *Clusia* species (Clusiaceae) under four different taxonomic sections, only two species, *C. parviflora* (section Criuva) and *C. renggerrioides* (section Corylandra) possessed floral ME (Nogueira et al. 2001). The role of ME in the two species is still unknown. This is similar to the often–cited flowers of golden shower or Indian labernum, *Cassia fistula*, that contained ME and attracted the oriental fruit fly, *Ba. dorsalis* (Kawano et al. 1968). Recently, the flower essential oil was reported to contain ME at 7.3% of peak areas and trace amount of eugenol; these compounds were not detected in leaf oil (Tzakou et al. 2007). Unfortunately, there is still no report that the attracted fruit flies are either potential pollinators or just visitors.

Cymbopogon flexuosus (Poaceae) exists as four varieties based on the major component among approximately 75 constituents in inflorescence essential oils. The varieties of *C. flesuosus* (var. *arunachalis*, var. *assamensis*, and var. *sikkimensis*) had citral, citronellol, elemicin, and ME as the major component, respectively. The first two varieties did not possess floral ME. The var. *sikkimensis* had 32-34% floral ME, while var. *assamensis* had 0.2-0.4% of essential oils (Nath et al. 2002). As such, the former variety would be more attractive to ME–responsive *Bactrocera* species than the latter. Nevertheless, this attraction of fruit flies as either pollinators or visitors remains to be determined for the two varieties. This is expected as most floral fragrances contain many chemical components (sometimes well over a hundred), and to ascribe the actual role for each of the ingredients, especially those in trace quantities, is extremely difficult, time consuming, and often unrewarding.

In the family Orchidaceae, many species are known to have trace quantities of ME. Since some of them are known to exist in regions with no insect species that are specifically attracted to ME or flowers in the night (Table 2), it is obvious that the ME–sensitive *Bactrocera* species play no role in pollination. However, flowers of the Malayan type of *Phalaenopsis violacea* possess trace quantities of ME and eugenol (Kaiser 1993), and usually attract one to several fruit flies per flower. The trace amount of floral ME is sufficient to attract fruit flies, since ~ 1 nanogram (10^{-9} g) of ME spotted on a silica gel TLC plate placed in the field can attract native male flies of the ME–sensitive species, such as *Ba. dorsalis* (Tan and Nishida 2000). The Bornean type of this orchid species, which is currently placed as a different species, *P. bellina*, has none of the phenylpropanoids (Kaiser 1993), although their flowers appear very similar in terms of color pattern and morphology to the untrained eye. As such, the observed attraction of fruit flies to *P. bellina* was probably due to the presence of 2,6-dimethoxy-4-(2-propenyl)-phenol. This compound was emitted as a component of floral fragrance at a rate of 12.0 ± 8.5 ng/flower/hour (Hsiao et al. 2006). It is an isomer of 2-allyl-4,5-dimethoxyphenol, which is a relatively strong fruit fly attractant and a component of the oriental fruit fly sex pheromone after ME consumption. Interestingly, *P. violacea* has no special adaptation, such as a movable lip as in *Bulbophyllum* orchids (see section 3.4.2.2 B), to aid in the removal of pollinarium (a composite structure of pollinia containing numerous pollens, a tegula/hamulus stipe, and visidium). This is further substantiated by our observations that the ME–sensitive fruit fly males never removed pollinarium from flowers of *P. violaceae*, are mere visitors, and thus do not assist in pollination for this orchid species.

It has been proposed that an additional role of floral fragrance may be in defense to deter or repel insect herbivores/florivores, as many of the floral volatile compounds are also released from leaves in response to herbivore damage (Kessler and Baldwin 2001). This is further substantiated by ME, which is used by plants as a chemical defense as previously discussed in section 3.2. Therefore, floral ME, which appears not to have any specific function in pollination, may be playing a 'silent' role in deterring and/or repelling possible insect florivores.

3.4.2. In pollination. Floral fragrance is presumably for the sole purpose of guiding potential pollinators to perform pollination that results in fertilization of flowers. The presence of ME in floral fragrances, even in trace quantities, may be responsible for attracting potential *Bactrocera* pollinators in the tropical/subtropical regions where the ME–responsive species of fruit flies are endemic.

3.4.2.1. For non–orchid flowers

The fruit fly lily *Spathiphyllum cannaefolium* (Araceae) floral spadix has a high content of ME (Lewis et al. 1988), which attracts many ME–sensitive *Bactrocera* male flies to visit and pollinate the flower by transferring white powdery pollens as the flies feed on the spadix. Plants grown in Penang (Malaysia) often attract one or two fruit fly males (Figure 3) as well as stingless bees (*Trigona* species) for pollination (unpublished observation).

Another Araceae species, *Colocasia esculenta*, which contained ME and eugenol (relative quantities not provided), attracted many male *Ba. dorsalis* fruit flies (> 40) to the spadix and bract (Sinchaisri and Areekul 1985). In this species, only the fruit flies feeding on the spadix will pick up powdery pollens and transfer them to the stigmas on the radix.

Flowers of the cannon ball tree *Couroupita guinanensis* (Lecythidaceae) contained 3% eugenol with a trace quantity of ME in floral essential oil (Knudsen and Mori 1996). Flowers in tropical South America have been observed to attract many male *Ba. carambolae* fruit flies in Suriname (photograph shown by van Sauers-Muller, personal communication, 2010). However, the flowers obtained from trees grown in the Botanical Garden in Penang have eugenol and no detectable ME, and they attract many stingless bees (*Trigona* species) with an occasional *Ba. dorsalis* as a visitor (unpublished observation).

Paraguay jasmine, *Brunfelsia australis* (Solanaceae), commonly known as "Yesterday–Today–and–Tomorrow", has floral fragrances comprised of monoterpenoids (81% of the identified volatile compounds), with ME in trace quantity in young flowers and 0.1% content of mature flowers. But in the scentless mature flowers of a closely related species, *Brunfelsia pauciflora* (Fabaceae), two sesquiterpenes (γ-muurolene and α-copaene) were present with no detectable ME (Bertrand et al. 2006). Similarly, the only species in the Onagraceae family that emits a floral scent containing substantial ME is *Clarkia breweri* (Table 2); its closely related *Clarkia concinna* is virtually scentless with no detectable ME (Raguso and Pichersky 1995).

3.4.2.2. For orchid flowers

Orchids have evolved highly diverse and fascinating mechanisms to attract and entice animals, especially insects, to assist in cross–pollination. In this section, discussion will be confined to orchid flowers that possess or secrete ME that attracts insects to be pollen vectors.

3.4.2.2a. Orchids excluding *Bulbophyllum*. Orchid flowers of *Satyrium microrrhynchum* produce nectar and are visited by several species of flower–visiting insects such as beetles, wasps, and flies, but not various honeybees and solitary bees that are commonly present at the study sites. Two insect species, cetoniid beetles, *Atrichelaphinus tigrina* (both sexes) and a pompilid wasp, *Hemipepsis hilaris* (males), have been shown to be pollinators while the other insect visitors do not carry any pollinarium (Johnson et al. 2007). Linalool is the major chemical component in the orchid fragrance and has been shown to attract the pollinators. Although seven phenylpropanoids with ME (at 1.83-4.51%) as the highest component were detected in the flowers from one of three populations studied in South Africa, there was no difference in the type of insect visitors/pollinators observed, as ME also stimulated an electrophysiological response in antennae of the cetoniid beetle (Johnson et al. 2007).

The inflorescence of an orchid species, *Gymnadenia conopea*, emits both eugenol and ME at different relative quantities during the day and night (Table 2). It attracts six lepidopteran taxa: three species each of butterflies and moths. Among the lepidopteran visitors caught, two species each of butterflies and moths bore pollinia. This indicates that pollination occurs during the day as well as at night (Huber et al. 2005). Similarly, a closely related species, *Gymnadenia odoratissima*, has 10 lepidopteran taxa, six moth, and four butterfly species as floral visitors, and all the species have been observed to be pollinators confirmed via their bearing of pollinia. There is no overlap of pollinator species between the two orchid species, and eugenol and benzyl acetate, which are among several of the 44-45 volatiles, are physiologically active components in the floral scent of the two species (Huber et al. 2005). In these orchid species, ME is not physiologically active against the lepidopteran species attracted to the orchid flowers and may instead be playing a role in deterring florivores. This certainly warrants further investigation.

3.4.2.2b. Bactrocerophilous *Bulbophyllum* orchids. There are nearly 2000 recognized species of *Bulbophyllum* (Orchidaceae) worldwide. Some species (~30) are known to have adapted to, and are entirely dependent on, *Bactrocera* (Tephritidae: Diptera) fruit flies for pollination without offering the usual nectar as floral reward. These bactrocerophilous *Bulbophyllum* species might have coevolved with the tephritid fruit flies. They basically make use of either RK, detected in *Bu. apertum* (syn. *Bu. ecornutum*) (Tan and Nishida 2005), zingerone in *Bu. patens* and *Bu. baileyi* (Tan and Nishida 2000, 2007), or ME (examples given below) as a floral attractant and reward for male *Bactrocera* fruit flies (Tan 2009). It is interesting to note that zingerone is the only known compound to attract both RK– and ME–responsive *Bactrocera* species, although it is a relatively weak attractant due to its resemblance to both RK and ME chemical structures (Tan and Nishida 2000).

The possible pathway for the biosynthesis of ME found in *Bulbophyllum* is shown in Figure 4. Starting from phenylalanine, it undergoes a series of intermediary steps involving cinnamic acid, ferulic acid, coniferyl alcohol, coniferyl acetate, and eugenol (Figure 4) (Kapteyn et al. 2007; Ferrer et al. 2008). The eugenol is ultimately biotransformed to ME by the addition of a methyl group to the 'para–hydroxy' group of eugenol catalyzed by an O-methyltransferase (Lewinsohn et al. 2000; Pichersky and Gang 2000).

Here only *Bulbophyllum* flowers that possess and release ME as a component of floral fragrance will be discussed to show that the flowers of some species have coevolved, via special floral architectural modifications to enhance fly pollination, with *Bactrocera* male flies. A nonresupinate flower (with lip/labellum above the floral column) of the ginger orchid, *Bu. patens*, possesses a major component of a fruit fly attractant, zingerone, which is weakly attractive to *Bactrocera* males from both ME–responsive species, such as *Ba. carambolae*, *Ba. dorsalis* and *Ba. umbrosa*, as well as RK–responsive species, namely *Ba. caudata*, *Ba. cucurbitae*, and *Ba. tau*, with trace amounts of ME (Tan and Nishida 2000). It has a see–saw lip that is positioned in a plane above the floral column. When an attracted male *Ba. dorsalis* alights on and continues feeding along the lip, an imbalance will occur, and the fly will suddenly be tipped into the column cavity head first. The fly immediately retreats by moving backwards along the lip still in a closed position, and during this movement it removes the pollinia to initiate pollination. This process is repeated when a fly bearing pollinia lands on another flower (Figure 5) to initiate fertilization by depositing the pollinia onto the stigma.

The fruit fly orchid, *Bulbophyllum cheiri*, with non–resupinate and a solitary flower, does not have its sepals and petals fully spread out but just slightly parted when fully in bloom (Figure 6). It releases ME as its sole major volatile component in its floral fragrance, which attracts only male fruit flies (Tan et al. 2002). The concentration of ME in the various floral parts varies from 107, 95, 91, 44, and 41 ppm for lateral sepals, lip, petals, median sepal, and column, respectively (Tan et al. 2002). Further surveys identified seven more related analogs, including eugenol, (Z)-methyl isoeugenol, (E)-methyl isoeugenol, (E)-coniferyl alcohol (CF), 2-allyl-4,5-dimethoxyphenol (DMP), 5-allyl-1,2,4-trimethoxybenzene (euasarone), and (E)-3,4-dimethoxycinnamyl acetate (Nishida et al. 2004). It is interesting that the two major sex pheromonal components of *Ba. dorsalis*, CF and DMP, are also found in the orchid flowers. Many male flies of *Ba. dorsalis* with one or two *Ba. umbrosa* visit a newly bloomed flower in the morning. Usually, the first fly visitor removes the pollinia from the flower (Figures 6 and 7). Here the movable floral see–saw lip plays an important role in suddenly tipping a probing fly into the floral column cavity when an imbalance occurs due to the shifting of the fly's weight. This way the fly, during its retreat, either removes or deposits pollinia on the floral stigma. Headspace analysis of the flower indicates a high ME peak in the morning, a much smaller one between 12:00 and 14:00, and no ME detected after 14:00 (Tan et al. 2002). In spite of this, one or two male *Ba. dorsalis* flies can still be seen on a *Bu. cheiri* flower up until approximately 18:30 (personal observations).

The wine red orchid, *Bu. vinaceum*, bears resupinate (lip/labellum below the floral column) and a solitary flower, which has a spring–loaded lip kept in a closed position to protect its sexual organs, especially the pollinarium with a stiff hamulus (derived from the entire distal portion of the rostellum that is prolonged into a stalk). The major floral volatile components identified are ME, CF, DMP, and (E)-3,4-dimethoxycinnamyl acetate, whereas the minor components are eugenol, euasarone, (E)-3,4-dimethoxy cinnamyl alcohol, and (Z)-coniferyl alcohol. The bouquet of floral phenylpropanoids attracts ME–sensitive species, particularly *Ba. dorsalis* with one or two *Ba. unimacula* in the highlands of Sabah (Tan et al. 2006). An attracted male fly normally lands on one of the petals before climbing onto and forcing the “spring loaded” floral lip that has the highest concentration of the phenylpropanoids, into the open position. This action reveals the floral sexual organs. The architecture of the lip and location of attractants compel the fly to align itself precisely along the lip’s longitudinal axis. As the fly probes and feeds, it passes the point of imbalance, causing the lip to spring back to its normal closed position. This catapults the fly head first into the column cavity, and its dorsum strikes the protruding sticky base of the hamulus and adheres to it. The momentum of the fly and the structural morphology of the long stiff hamulus act in tandem to pry out the pollinia from its anther cover. Pollinarium removal (Figure 8) is a precise and very quick process assisted by the specially modified spring lip, which plays an essential and important role in pollination. In this orchid species, ME is the main component in the floral fragrance and plays a pivotal role in the true mutualism between the flower and fruit fly pollinator, in which both receive reproductive benefits. Interestingly, both CF and DMP detected in the flowers are also sex pheromonal components of male *Ba. dorsalis* after consuming ME. Although CF and DMP attract and arrest females during courtship at dusk, and thus would serve as specific female attractants, the flower has never been observed to attract female fruit flies, not even during dusk when they are most sensitive to these chemicals (Tan et al. 2006). This evidence, and that of *Bu. cheiri*, may substantiate and indicate the outcome or culmination of a co–evolutionary process between the orchid species and *Bactrocera* pollinators.

The 'raised dot *Bulbophyllum*', *Bu. elevatopunctatum*, has relatively high content of ME 78.5 ± + 21.6 mg (mean + standard deviation; n = 10) per flower as a major floral volatile (unpublished data). The solitary and resupinate flower does not have a spring-– loaded lip like that present in *Bu. vinaceum*, but a simple hinged one kept at an acute angle with respect to the floral column by the fused lateral sepals. When an attracted male fruit fly moves on to the lip that is prevented from moving away from the column to a fully opened position, it will very quickly be jerked into the floral column cavity, thereby hitting the hamulus and dislodging the pollinia from the anther and its cover. Upon its retreat, the fly removes the pollinarium to initiate pollination (Figure 9).

In the aforementioned *Bulbophyllum–Bactrocera* association, each *Bulbophyllum* species has specifically adapted and evolved precise lip mechanism to entice fruit flies and enhance pollination through the offer of ME as an attractant as well as a floral reward. Furthermore, both organisms gain direct reproductive benefits, exhibiting a true mutualism; the orchid flower gets pollinated without having to offer nectar as reward, and the fruit fly boosts its pheromone and defense system as well as its sexual competitiveness by feeding on the ME produced by the flower as floral reward to its potential pollinator.

4. Methyl eugenol and human health

When present in human blood serum after a meal, ME is rapidly eliminated and excreted (Schecter et al. 2004). ME has ill effects on human health as a known carcinogen and mutagen, probably because of its conversion to a hydroxy analog at the allylic position (De Vincenzi et al. 2000). Further, safrole, estragole, and ME found in herbs and spices are weak animal carcinogens as demonstrated by the formation of DNA adducts in cultured human cells (Zhou et al. 2007).

Recent research by Choi et al. (2010) indicated that ME may have positive effects on human health as well. Based on their studies, ME may reduce cerebral ischemic injury through suppression of oxidative injury and inflammation (Choi et al. 2010). The chemical also decreased activation of an enzyme, caspase-3, and the death of cultured cerebral cortical neurons through oxygen–glucose deprivation for one hour. Additionally, it was shown that ME elevated the activities of superoxide dismutase and catalase, thereby markedly reducing superoxide generation in the ischemic brain and decreasing intracellular oxidative stress. Furthermore, ME also reduced the production of pro–inflammatory cytokines in the ischemic brain (Choi et al. 2010).

Studies on rodents showed that minimal ME within a dose range of 1-10 mg/kg body weight, which is about 100-1000 times the anticipated human exposure to ME as a result of spiced and/or flavored food consumption, did not pose a significant cancer risk (Smith et al. 2002). Further, toxicological studies in animals demonstrated that orally administered relatively high–bolus doses of ME resulted in hepatic neoplasms. Nevertheless, the detected level of ME in biomonitoring studies indicated that human exposure was several orders of magnitude lower than the lowest dose utilized in the bioassay (Robison and Barr 2006). Arguably, a single high dose may cause any number of ill or side effects in animals.

Conclusions

In this review, the occurrence of ME in over 450 species of plants belonging to 80 families under 48 orders compiled from numerous published papers is listed. The distribution of ME in various plant organs within a species is definitely uneven and varies greatly according to growth stage as well as plant variety/chemotype. Similarly, even in flowers, the distribution and release of ME by various floral parts can vary considerably depending on the physiological stage and time of day.

The various roles of ME in nature especially related to the chemical defense of plants, such as antifungal, antibacterial, antinematodal, or toxicant roles against pathogens and insect herbivores, as well as its functions as an insect antifeedant/repellant and in pollination are reviewed. In particular, ME has been shown to act as floral synomone in the coevolution of orchid species in the genus *Bulbophyllum* with fruit flies. More research should be conducted to fully understand the biochemical, physiological, and/or chemoecological basis for these bitrophic interactions between plants and insects mediated by ME.

Acknowledgements

We wish to gratefully thank T.E. Shelly (APHIS, USDA, Waimanalo) for encouragement and assistance in reviewing this manuscript, and L.T. Tan of University College London for reading through the initial draft, and A.K.W. Hee for assistance in providing some reference materials.

References

Abdon APV, Leal-Cardoso JH, Coelho-de-Souza AN, Morais SM, Santos CF. 2002. Antinociceptive effects of the essential oil of Croton nepetaefolius on mice. *Brazilian Journal Medical and Biological Research* 35: 1215-1219.

Abduelrahman AHN, Elhussein, SA, Osman NA, Nour AH. 2009. Morphological variability and chemical composition of essential oils from nineteen varieties of Basil (*Ocimum basilicum* L.) growing in Sudan. *International Journal of Chemical Technology* 1: 1-10.

Aboutabl EA, Tohamy SFE, De Pooter HL, De Buyck LF. 1991. A comparative study of the essential oils from three *Melaleuca* species growing in Egypt. *Flavour and Fragrance Journal* 6: 139-141.

Acharya RN, Chaubal MG. 1968. Essential oil of *Anemopsis californica*. *Journal of Pharmaceutical Sciences* 57: 1020-1022.

Adams RP. 1997. The leaf oil of *Juniperus gracilior* Pilger var. *urbaniana* (Pilger & Ekman) R.P. Adams: Comparison with other Caribbean *Juniperus* species. *Journal of Essential Oil Research* 9: 641-647.

Adams RP, Almirall AL, Hogge L. 1987. The volatile leaf oils of the Junipers of Cuba: *Juniperus lucayana* Britton and *Juniperus saxicola* Britton and Wilson. *Flavour and Fragrance Journal* 2: 33-36.

Adams RP, Chu GL, Zhang SZ. 1994. Comparison of the volatile leaf oils of *Juniperus chinensis* L., *J. chinensis* var. *kaizuca* Hort. and cv. *pyramidalis* from China. *Journal of Essential Oil Research* 6: 149-154.

Adams RP, Von Rudloff E, Hogue L, Zanoni TA. 1981. The volatile terpenoids of *Juniperus blancoi* and its affinities with other entire leaf margin of Junipers of North America. *Journal of Natural Products* 44: 21-26.

Adams RP, Zanoni TH, Hogge L. 1984. The volatile leaf oils of *Juniperus flaccida* var. *flaccida* and var. *poblana*. *Journal of Natural Products* 47: 1064-1065.

Adedeji J, Hartman TG, Rosen RT, Ho C-T. 1991. Free and glycosidically bound aroma compounds in hog plum (*Spondias mombins* L.). *Journal of Agricultural Chemistry* 39: 1494-1497.

Adhikary SR, Tuladhar BS, Sheak A, van Beek TA, Posthumus MA, Lelyveld GP. 1992. Investigation of Nepalese essential oils. I. The oil of *Cinnamomum glaucescens*

(Sugandha Kokila). *Journal of Essential Oil Research* 4: 151-159.

Aggarwal VK, Aggarwal SG, Thappa RK, Mehra MS, Dhar KL. 1983. Chemical constituents of *Lovunga scandens* Buch & Ham. *Indian Perfumer* 27: 163-165.

Ahmad VU, Jassbi AR, Pannahi MCS. 1999. Analysis of the essential oil of *Echinophora sibthorpiana* Guss. by means of GC, GC/MS and 13C-NMR techniques. *Journal of Essential Oil Research* 11: 107-108.

Akgul A, Chialva F. 1989. Constituents of the essential oil of *Echinophora tenuifolia* L. subsp. *sibthorpiana* (Guss.) Tutin from Turkey. *Flavour and Fragrance Journal* 4: 67-68.

Akhila A. 2009. Chapter 2. Chemistry and biogenesis of essential oil from the genus Cymbopogon. In: Akhila A, Editor. *Essential oil bearing grasses: The genus Cymbopogon*. pp. 20-106. CRC Press.

Ali NA, Jantan I. 1999. Essential oil of *Cinnamomum tahijanum* Kost. from Sarawak. ASEAN Review of Biodiversity and Environment Conservation (ARBEC), Nov.-Dec. 1999. Available online, http://www.arbec.com.my/pdf/art5novdec99.pdf

Alilou H, Akssirai M, Hassani LMI, Chebli B, El Hak-Moui A, Mellouki F, Rouhi R, Boira H, Blazquez MAB. 2008. Chemical composition and antifungal activity of *Bubonium imbricatum* volatile oil. *Phytopathologia Mediterranea* 47: 3-10.

Alves RJV, Pinto AC, da Costa AVM, Rezende CM. 2005. *Zizyphus mauritiana* Lam. (Rhamnaceae) and the chemical composition of its floral fecal odor. *Journal of Brazilian Chemical Society* 16: 654-656.

Anasari SH, Qadry JS. 1987. TLC and GLC studies on khawi grass oil. *Indian Journal of Natural Products* 3: 10-12.

Andrade EH, Zoghbi MDG, Maia JG. 2001. Volatiles from the leaves and flowers of *Carapa guinensis* Aubl. *Journal of Essential Oil Research* 13: 436-438.

Andrade MS, Sampaio TS, Nogueira PCL, Ribeiro AS, Bittrich V, Amaral MCE. 2007. Volatile compounds of the leaves, flowers and fruits of *Kielmeyera rugosa* Choisy (Clusiaceae). *Flavour and Fragrance Journal* 22: 49-52.

Andrianoelisoa HS, Menut C, de Chatelperron PC, Saracco J, Ramanoelina P, Danthu P. 2006. Intraspecific chemical variability and highlighting of chemotypes of leaf essential oils from *Ravensara aromatica* Sonnerat, a tree endemic to Madagascar. *Flavour and Fragrance Journal* 21: 833-838.

Arrebola ML, Navarro M, Jimenez J, Ocana FA. 1994. Yield and composition of the essential oil of *Thymus serpylloides* subsp. *serpylloides*. *Phytochemistry* 36: 67-72.

Arslan N, Gurbuz B, Sarihan EO. 2004. Variation in essential oil content and composition in Turkish anise (*Pimpinella anisum* L.) populations. *Turkish Journal of Agriculture and Forestry* 28: 173-177.

Asakawa Y, Komatsu T, Hayashi S, Matsura T. 1971. Chemical components of the benzene extract of *Cinnamomum loureiri*. *Flavours of India* 2: 114-119.

Ashafa AOT, Grierson DS, Afolayan AJ. 2008. Effects of drying methods on the chemical composition of essential oil from *Felicia muricata* leaves. *Asian Journal of Plant Science* 7: 603-606.

Askari F, Sefidkon F. 2006. Essential oil composition of *Pimpinella affinis* Ledeb. from two localities in Iran. *Flavour and Fragrance Journal* 21: 754-756.

Asllani U. 2000. Chemical composition of Albanian myrtle oil (*Myrtus communis* L.). *Journal of Essential Oil Research* 12: 140-142.

Asquith A, Burny DA. 1998. Honey bees attracted to the semiochemical methyl eugenol, used for male annihilation of the oriental fruit fly (Diptera: Tephritidae). *Proceedings of the Hawaiian Entomological Society* 33: 57-66.

Atal CK, Bradu BL. 1976. Search for aroma chemicals of industrial value from genus *Cymbopogon*. Part IV. Chandi and Kolar grasses as source of methyl eugenol. *Indian Journal of Pharmacology* 38: 63-64.

Atazhanova GA, Dembitskii AD, Yakovleva TD, Mikhailov VG, Adekenov SM. 1999. About composition of essential oil from *Artemisia filatovae*. *Chemistry of Natural Compounds* 35: 529-531.

Avato P, Smitt UW. 2000. Composition of the essential oils from the roots of *Thapsia maxima* Miller and *T. villosa* L. *Journal of Essential Oil Research* 12: 303-309.

Avato P, Jacobsen N, Smitt UW. 1992. Chemotaxonomy of *Thapsia maxima* Miller. Constituents of the essential oil of the fruits. *Journal of Essential Oil Research* 4: 467-473.

Avato P, Trabace G, Smitt UW. 1996a. Essential oils from fruits of three types of *Thapsia villosa*. *Phytochemistry* 43: 609-612.

Avato P, Trabace G, Smitt UW. 1996b. Composition of the essential oils of fruits from polyploid types of *Thapsia villosa* L.: Chemotaxonomic evaluation. *Journal of Essential Oil Research* 8: 123-128.

Avato P, Fortunato IM, Ruta C, D'Elia R. 2005. Glandular hairs and essential oils in micropropagated plants of *Salvia officinalis* L. *Plant Science* 169: 29-36.

Azuma H, Kono M. 2006. Estragole (4-allylanisole) is the primary compound in volatiles emitted from the male and female cones of *Cycas revoluta*. *Journal of Plant Research* 119: 671-676.

Asuma H, Toyota M, Asakawa Y. 2001. Intraspecific variation of floral scent chemistry in *Magnolia kobus* DC. (Magnoliaceae). *Journal of Plant Research* 114: 411-422.

Azuma H, Toyota M, Asakawa Y, Takaso T, Tobe H. 2002. Floral scent chemistry of mangrove plants. *Journal of Plant Research* 115: 47-53.

Baggaley KH, Erdtman H, McLean NJ, Norin T, Eriksson G. 1967. Chemistry of the order Podocarpales. I. Heartwood constituents of the Huon pine (*Dacrydium franklinii*). *Acta Chemica Scandinavica* 21: 2247-2253.

Barkman TJ, Beaman JH, Gade DA. 1997. Floral fragrance variation in Cypripedium: implication for evolutionary and ecological studies. *Phytochemistry* 44: 875-882.

Barra A, Coroneo V, Dessi S, Cabras P, Angioni A. 2007. Characterization of the volatile constituents in the essential oil of *Pistacia lentiscus* L. from different origins and its antifungal and antioxidant activity. *Journal of Agricultural and Food Chemistry* 55: 7093-7098.

Baser KHC. 2002. Aromatic biodiversity among the flowering plant taxa of Turkey. *Pure and Applied Chemistry* 74: 527-545.

Baser KHC, Kurkcuoglu M. 1998. Composition of the essential oil of *Morina persica* L. flowers. *Journal of Essential Oil Research* 10: 117-118.

Baser KHC, Ozek T, Demirci B, Duman H. 2000. Composition of the essential oil of *Prangos heyniae* H. Duman et M.F. Watson, a new endemic from Turkey. *Flavour and Fragrance Journal* 15: 47-49.

Baser KHC, Demirci B, Duman H. 2001a. Composition of the essential oils of two endemic species from Turkey: *Achillea lycaonica* and *A. ketenoglui*. *Chemistry of Natural Products* 37: 245-252.

Baser KHC, Demirci B, Duman H, Aytac Z, Adiguzel N. 2001b. Composition of the essential oil of *Achillea goniocephala* Boiss. et Bal. from Turkey. *Journal of Essential Oil Research* 13: 219-220.

Baser KHC, Demirci B, Tabanca N, Ozekn T, Goren N. 2001c. Composition of the essential oils of *Tanacetum armenum* (DC.) Schultz Bip., *T. balsamita* L., *T. chiliophyllum* (Fisch. & Mey.) Schultz Bip. var. *chiliophyllum* and *T. haradjani* (Rech. fil.) Grierson and the enantiomeric distribution of camphor and carvone. *Flavour and Fragrance Journal* 16: 195-200.

Basher KHC, Ozek T, Demirchakmak B, Nuriddinov KR, Abduganiev BY, Aripov KN, Khodzimatov KK, Nigmatullaev OA, Shamyanov ED. 1997. Essential oils of some *Artemisia* species from Central Asia. *Chemistry of Natural Compounds* 33: 293-295.

Baslas RK, Kumar P. 1981. Chemical examination of essential oil of *Coleus aromaticus* Benth. *Journal of Indian Chemical Society* 58: 103-104.

Baydar H, Schulz H, Kruger H, Erbas S, Kineci S. 2008. Influences of fermentation time, hydro-distillation time and fractions on essential oil composition of Damask rose (*Rosa damascena* Mill.). *Journal of Essential Oil Bearing Plants* 11: 224-232.

Beauchamp PS, Chea E, Dimaano JG, Dev V, Ly B, Miranda AE. 2009. Essential oil composition of six *Lomatium* species attractive to Indra swallowtail butterfly (*Papilio indra*): Principal component analysis against essential oil composition of *Lomatium dissectum* var. *multifidum*. *Journal of Essential Oil Research* 21: 535-542.

Benitez NP, Leon EMM, Stashenko EE. 2009. Eugenol and methyl eugenol chemotypes of essential oil of species *Ocimum grastissimum* L. and *Ocimum campechianum* Mill. from Colombia. *Journal of Chromatographic Science* 47: 800-803.

Berger RG, Akkan Z, Drawert F. 1990. The essential oil of *Coleonema album* (Rutaceae) and of a photomixotrophic cell culture derived thereof. *Zeitschrift für Naturforschung Section C, Biosciences* 45: 187-195.

Bertrand C, Comte G, Piola F. 2006. Solid-phase microextraction of volatile compounds from flowers of two *Brunfelsia* species. *Biochemical Systematics and Ecology* 34: 371-375.

Bettaieb I, Bourgou S, Wannes WA, Hamrouni I, Limam F, Marzouk B. 2010. Essential oils, phenolics, and antioxidant activities of different parts of Cumin (*Cuminum cyminum* L.). *Journal of Agricultural and Food Chemistry* 58: 10410-10418.

Bhardwaj A, Tewary DK, Kumar R, Kumar V, Sinha AK, Shanker A. 2010. Larvicidal and structure–activity studies of natural phenylpropanoids and their semisynthetic derivatives against the tobacco armyworm *Spodoptera litura* (Fab.) (Lepidoptera: Noctuidae). *Chemistry and Biodiversity* 7: 168-177.

Bhuiyan MNI, Chowdhury JU, Begum J, Azim MA. 2010. Aromatic plants of Bangladesh: constituents of leaf and rhizome oil of *Etlingera linguiforme*. *Dhaka University Journal of Science* 58: 13-15.

Bicchi C, Frattini C, Sacco T. 1985. Essential oils of three asiatic *Artemisia* species. *Phytochemistry* 24: 2440-2442.

Billet D, Favre-Bonvin J. 1973. Constituants de l'huile essentielle de *Vepris madagascarica* (Essential oil constituents of *Vepris madagasscarica*). *Phytochemistry* 12: 1194.

Bohannon WB, Kleiman R. 1977. Myristicin. The major volatile component in Maere seed of *Portenschlagia ramosissima*. *Lipids* 12: 321-323.

Borejsza-Wysocki W, Hrazdina G. 1996. Aromatic polyketide synthases (purification, characterization, and antibody development to benzalacetone synthase from raspberry fruits). *Plant Physiology* 110: 791-799.

Boussaada O, Ammar S, Saidana D, Chriaa J, Chraif I, Daami M, Helal AN, Mighri Z. 2007. Chemical composition and antimicrobial activity of volatile components from captula and aerial parts of *Rhaponticum acaule* DC growing wild in Tunisia. *Microbiological Research* 163: 87-95.

Boutaghane N, Nacer A, Kabouche Z, Ait-Kaki B. 2004. Comparative antibacterial activities of the essential oils of stems and seeds of *Pituranthos scoparius* from Algerian septentrional Shara. *Chemistry of Natural Compounds* 40: 606-607.

Bracho R, Crowley KJ. 1966. The essential oils of some Venezuelan *Croton* species. *Phytochemistry* 5: 921-926.

Brandt JJ, Schultze W. 1995. Composition of the essential oils of *Ligusticum mutellina* (L.) Crantz (Apiaceae). *Journal of Essential Oil Research* 7: 231-235.

Brophy JJ, Jogia MK. 1986. Essential oils from Fijian *Ocimum basilicum* L. *Flavour and Fragrance Journal* 1: 53-55.

Brophy JJ, Lassak EV. 1988. *Melaleuca leucadendra* L. leaf oil: two phenylpropanoid chemotypes. *Flavour and Fragrance Journal* 3: 43-46.

Brophy JJ, Goldsack RJ. 1994. The essential oils of *Choricarpia leptoptala* (F. Muell.) Domin and *C. subargentea* (C.T. White) L.A.S. Johnson (Myrtaceae). *Flavour and Fragrance Journal* 9: 7-10.

Brophy JJ, Davies N, Southwell I, Stiff I, Williams L. 1989. Gas chromatographic quality control for oil of *Melaleuca alternifolia* terpinen-4-ol type (Australian Tea Tree). *Journal of Agricultural and Food Chemistry* 37: 1330-1335.

Brophy JJ, Goldsack RJ, House APN, Lassak EV. 1993. Essential oils of the genus *Doryphora*. *Journal of Essential Oil Research* 5: 581-586.

Brophy JJ, Goldsack RJ, Forster PI. 1994. The essential oils of *Choricarpia leptopetala* (F. Muell) Domin and *C. subargentea* (C.T. White) L.A.S. Johnson (Myrtaceae). *Flavour and Fragrance Journal* 9: 7-10.

Brophy JJ, Goldsack RJ, Fookes CJR, Forster PI. 1995. Leaf oils of the genus *Backhousia* (Myrtaceae). *Journal of Essential Oil Research* 7: 237-254.

Brophy JJ, Goldsack RJ, Forster PI. 1997. Chemotype variation in the leaf essential oils of *Melicope melanophloia* C.T. White (Rutaceae). *Journal of Essential Oil Research* 9: 279-282.

Brophy JJ, Goldsack RJ, Rozefelds AC. 2003. Chemistry of the Australian gymnosperms-part 5: Leaf essential oils of some endemic Tasmanian gymnosperms: *Diselma archeri*, *Lagarostrobos franklinii*, *Microcachrys tetragona* and *Phyllocladus aspleniifolius*. *Journal of Essential Oil Research* 15: 139-142.

Brophy JJ, Goldsack RJ, Hook JM, Fooke CJR, Forster PI. 2004. The leaf essential oils of the Australian species of *Pseuduvaria* (Annonaceae). *Journal of Essential Oil Research* 16: 362-366.

Brophy JJ, Goldsack RJ, Forster PI. 2006. What is the smell of the “fruit salad plant”?: The leaf oil of *Leionema ambiens* (Rutaceae). *Journal of Essential Oil Research* 18: 131-133.

Brophy JJ, Buchanan AM, Copeland LM, Dimitriadia E, Goldsack RJ, Hibbert DB. 2009. Differentiation between the two subspecies of *Antherosperma moschatum* Labill. (Antherospermataceae) from their leaf oils. *Biochemical Systematics and Ecology* 37: 479-483.

Brunke E-J, Hammerschmidt F-J, Schmaus G. 1994. Headspace analysis of Hyacinth flowers. *Flavour and Fragrance Journal* 9: 59-69.

Bueno-Sanchez JG, Martinez-Morales JR, Stashenko EE, Ribon W. 2009. Anti-tubercular activity of eleven aromatic and medicinal plants occurring in Colombia. *Biomedica* 29: 51-60.

Bunralhep S, Palanuvej C, Ruangungsi N. 2007. Chemical compositions and antioxidative activities of essential oils from four *Ocimum* species endemic to Thailand. *Journal Health Research* 21: 201-206.

Buttery RG, Black DR, Guadagni DG, Ling LC, Connolly G, Teranishi R. 1997. California bay oil. I. Constiuents, odor properties. *Journal of Agricultural and Food Chemistry* 22: 773-777.

Bylaite E, Venskutonis RP, Roozen JP. 1998. Influence of harvesting time on the composition of volatile components in different anatomical parts of Lovage (*Levisticum officinale* Koch.). *Journal of*

Agricultural and Food Chemistry 46: 3735-3740.

Caredda A, Marongiu B, Porcedda S, Soro C. 2002. Supercritical carbondioxide extraction and characterization of *Laurus nobilis* essential oil. *Journal of Agricultural and Food Chemistry* 50: 1492-1496.

Carlini EA, De Oliveira AB, Oliveira GG. 1983. Psychopharmacological effects of the essential oil fraction and of the hydrolate obtained from the seeds of *Licaria puchury-major*. *Journal of Ethnopharmacology* 8: 225-236.

Carovic-Stanko K, Orlic S, Politeo O, Strikic F, Kolak I, Milos M, Satovic Z. 2010. Composition and antibacterial activities of essential oils of seven *Ocimum* taxa. *Food Chemistry* 119: 196-201.

Chalchat JC, Chabard JL, Gorunovic MS, Djermanovic V, Bulatovic V. 1995. Chemical composition of *Eucalyptus globulus* oils from the Montenegro coast and east coast of Spain. *Journal of Essential Oil Research* 7: 147-152.

Chang CL, Cho IK, Li QX. 2009. Insecticidal activity of basil oil, trans-anethole, estragole, and linalool to adult fruit flies of *Ceratitis capitata*, *Bactrocera dorsalis*, and *Bactrocera cucurbitae*. *Journal of Economic Entomology* 102: 203-209.

Charles DJ, Simon JE, Widrlechner MP. 1991. Characterization of essential oil of *Agastache* species. *Journal of Agricultural and Food Chemistry* 39: 1946-1949.

Chaumont PJP, Mandin D, Sanda K, Koba K, De Souza CA. 2001. Activités antimicrobiennes in vitro de cinq huiles essentielles de Lamiacées togolaises vis-à-vis de germes representatives de la microflore cutanée. *Acta Botanica Gallica* 148: 93-101. (English Abstract)

Chen Y, Li Z, Li H. 1987a. Analysis of fragrance volatiles of fresh flowers by pre-column absorption and GC/MS. *Chromatographia* 23: 502-506.

Chen Y, Wang R, Xue D, Li Z, Han H. 1987b. Analysis of volatile constituents of *Hedysarum polybotrys* Hand. by capillary gas chromatography-mass spectrometry. *Gaodeng Xuexiao Huaxue Xuebao* 8: 538-541. (in Chinese)

Cheng B-Q, Xu Y, Zheng G, Yu XJ, Ding JK. 1993. Ways of propagating *Cinnamomum tenuipilum* and variations in its leaf essential oil components. *Yunnan Zhiwu Yanjiu* 15: 78-82. (in Chinese) Database: CAPLUS.

Chialva F, Doglia G. 1990. Essential oil constituents of chinotto (*Citrus aurantium* L. var. *myrtifolia* Guill.). *Journal of Essential Oil Research* 2: 33-35.

Chialva F, Monguzzi F, Manitto P, Akgul A. 1993. Essential oil constituents of *Trachyspermum copticum* (L.) Link fruits. *Journal of Essential Oil Research* 5: 105-106.

Chin KW, Sun HL. 1990. Analysis of the phenolic compound in betel quid. *Journal of Chinese Agricultural and Chemical Society* 31: 623-632.

Cho YS, Cho IH, Park HJ, Chun HK. 2006. Analysis of fragrance volatiles of Korean *Rosa hybrida* using gas chromatography-mass spectrometry. *Agricultural Chemistry and Biotechnology* 49: 180-185.

Choi YK, Cho G-S, Hwang S, Kim BW, Lim JH, Lee J-C, Kim HC, Kim W-K, Kim YS. 2010. Methyleugenol reduces cerebral ischemic injury by suppression of oxidative injury and inflammation. *Free Radical Research* 44: 925-935.

Chowdhury JU, Mobarok MH, Bhuiyan MNI, Nandi NC. 2009. Constituents of essential oils from leaves and seeds of *Foeniculum vulgare* Mill. cultivated in Bangladesh. *Bangladesh Journal of Botany* 38: 181-183.

Christensen LP, Jakobsen HB, Paulsen E, Hodal L, Andersen KE. 1999. Airborne Compositae dermatitis: monoterpenes and no parthenolide are released from flowering *Tanacetum parthenium* (feverfew) plants. *Archives of Dermatological Research* 291: 425-431.

Chu SS, Liu SL, Jiang GH, Liu ZL. 2010. Composition and toxicity of essential oil of *Illicium simonsii* Maxim (Illiciaceae) fruit against the maize weevils. *Records of Natural Products* 4: 205-210.

Chuah CH, Yong HS, Goh SH. 1997. Methyl eugenol, a fruit-fly attractant, from the browning leaves of *Proiphys amboinensis* (Amaryllidaceae). *Biochemical Systematics and Ecology* 25: 391-393.

Ciccio JF, Segnini M. 2002. Composition of the essential oil from leaves of *Croton jimenezil* from Costa Rica. *Journal of Essential Oil Research* 14: 357-360.

Close DC, McArthur C. 2002. Rethinking the role of many plant phenolics-protection from photodamage not herbivores? *Oikos* 99: 166-172.

Comai S, Dall'Acqua S, Grillo A, Castagliuolo I, Gurung K, Innocenti G. 2010. Essential oil of *Lindera neesiana* fruit: Chemical analysis and its potential use in topical applications. *Fitoterapia* 81: 11-16.

Compagnone RS, Chavez K, Mateu E, Orsini G, Arvelo F, Suarez AI. 2010. Composition and cytotoxic activity of essential oils from *Croton matourensis* and *Croton micans* from Venezuela. *Records of Natural Products* 4: 101-108.

Cook WB, Howard AS. 1966. The essential oil of *Illicium anisatum* Linn. *Canadian Journal of Chemistry* 44: 2461-2464.

Costa LCB, Pinto JEBP, Castro EM, Alves E, Rosal LF, Bertolucci SKV, Alves PB, Evanglino TS. 2010. Yield and composition of the essential oil of *Ocimum selloi* Benth. cultivated under colored netting. *Journal of Essential Oil Research* 22: 34-39.

Crabas N, Marongiu B, Piras A, Pivetta T, Procedda S. 2003. Extraction, separation and isolation of volatiles and dyes from *Calendula officinalis* L. and *Aloysia triphylla* (L'Her.) Britton by supercritical CO_2. *Journal of Essential Oil Research* 15: 350-355.

Craveiro AA, Andrade CHS, Matos FJA, De Alencar JW. 1978. Anise-like flavor of *Croton* aff. *zehntneri* Pa. et Hoffm. *Journal of Agricultural and Food Chemistry* 26: 772-773.

Craveiro AA, Andrade CHS, Matos FJA, Alencar JW, Machado MIL. 1980. Volatile constituents of *Mangifera indica* Linn. *Revista Latinoamericana de Química* 11: 129.

Crockett SL, Demirci B, Baser KHC, Khan IA. 2007. Analysis of the volatile constituents of five African and Mediterranean *Hypericum* L. (Clusiaceae, Hypericoideae) species. *Journal of Essential Oil Research* 19: 302-306.

Custodio L, Serra H, Nogueira JMF, Goncalves S, Romano A. 2006. Analysis of the volatiles emitted by whole flowers and isolated flower organs of the Carob tree using HS-SPME-GC/MS. *Journal of Chemical Ecology* 32: 929-942.

De Etcheves MDC-P, Gros EG, Retamar JA. 1981. Chemical study of *Croton parvifolius*. *Essenze Derivati Agrumari* 51: 253-261. (in French).

De Fenik J, Ines S, Retamar JA. 1972. Essential oil of *Pseudocaryophyllus guili*. *Anais da Academia Brasileira de Ciências* 44 (Suppl.): 175-180 (in Spanish).

De Feo V, Soria EU, Soria RU, Pizza C. 2005. Composition and in vitro toxicity of the essential oil of *Tagetes terniflora* HBK. (Asteraceae). *Flavour and Fragrance Journal* 20: 89-92.

De Pooter HL, Omar MN, Coolsaet BA, Schamp NM. 1985. The essential oil of greater galangal (*Alpinia galanga*) from Malaysia. *Phytochemistry* 245: 93-96.

De Vincenzi M, Silano M, Stacchini P, Scazzocchio B. 2000. Constituents of aromatic plants: I. Methyleugenol. *Fitoterapia* 71: 216-221.

Degen T. 1998. *Host-plant acceptance by the carrot fly: some underlying mechanisms and the relationship to host-plant suitability*. Ph.D. thesis, Universitat Basel, Basel, Switzerland.

Demetzos C, Angelopoulou D, Perdetzoglou D. 2002. A comparative study of the essential oils of *Cistus salviifolius* in several populations of Crete (Greece). *Biochemical Systematics and Ecology* 30: 651-665.

Dey BB, Choudhuri MA. 1985. Characterization of a few morphological and biochemical parameters to serve as indicators of maximum oil yielding stage of *Ocimum sanctum*. *PAFAI Journal* 7: 11-16.

Diaz D, Pedro P, Dorado VJ. 1986. Chemical constituents of the leaves of *Piper lenticellosum* C.D.C. *Anais da Academia Brasileira de Ciências* 17: 58-60.

Dicke M, Hilker M. 2003. Induced plant defences: from molecular biology to evolutionary ecology. *Basic Applied Ecology* 4: 3-14.

Dighe VV, Gursale AA, Sane RT, Menon S, Patel PH. 2005. Quantitative determination of eugenol from *Cinnamomum tamala* Nees and Eberm. leaf powder and polyherbal formulation using reverse phase liquid chromatography. *Chromatographia* 61: 442-446.

Dimitriev LB, Mumladze MG, Klyuev NA, Kobakhidze SK, Grandberg II. 1981. Dynamics of accumulation and composition of *Agastache foeniculum* during plant growth and storage. *Izvestiya Timiryazeuvsk. S-kh Akademii* 6: 86-91. (in Russian).

Dixon RA, Palva NL. 1995. Stress-induced phenylpropanoid metabolism. *The Plant Cell* 7: 1085-1097.

Dobson HEM, Bergstrom G. 2000. The ecology and evolution of pollen odors. *Plant Systematics and Evolution* 222: 63-87.

Dobson HEM, Bergström J, Bergström G, Groth I. 1987. Pollen and flower volatiles in two *Rosa* species. *Phytochemistry* 26: 3171-3173.

Dobson HEM, Arroyo J, Bergstrom G, Groth I. 1997. Interspecific variation in floral fragrances within the genus *Narcissus* (Amaryllidaceae). *Biochemical Systematics and Ecology* 25: 685-706.

Dominguez XA, Canales A, Garza JA, Gomez E, Garza L. 1971. Medicinal plants of Mexico. XVIII. Constituents of leaves and branches of *Helietta parvifolia*. *Phytochemistry* 10: 1966.

Dotterl S, Wolfe LM, Jurgens A. 2005. Qualitative and quantitative analyses of flower scent in *Silene latifolia*. *Phytochemistry* 66: 203-213.

Dregus M, Engel K-H. 2003. Volatile constituents of uncooked rhubarb (*Rheum rhabarbarum* L.) stalks. *Journal of Agricultural and Food Chemistry* 51: 6530-6536.

Duke JA. 1981. *Handbook of legumes of world economic importance*. Plenum Press.

Duke JA. 1985. *Acorus calamus* L. In: *CRC Handbook of Medicinal Herbs*. pp. 14-15. CRC Press.

Dung NX, Tham NT, Van Khien P, Quang NT, Thi Le H, Leclercq PA. 1997. Characterization of the oils from various parts of *Talauma gioi* Aug. Chev. (Magnoliaceae) from Vietnam. *Journal of Essential Oil Research* 9: 119-121.

Dzamic A, Sokovic M, Ristic MS, Grijic-Jovanovid S, Vukojevic J, Marin PD. 2009. Chemical composition and antifungal activity of *Illicium verum* and *Eugenia caryophyllata*. *Chemistry of Natural Compounds* 45: 259-261.

Ehret C, Maupetit P, Petrzilka M. 1989. New organoleptically important components from Narcissus absolute (*Narcissus poeticus* LJ). *Proceedings of the 11th Essential Oil Congress*. Oxford and IBH Publishing.

Ekundaya O, Laakso I, Adegbola R-M, Oguntimein B, Sofowora A, Hiltunen R. 1988. Essential oil constituents of Ashanti pepper (*Piper guineense*) fruits (berries). *Journal of Agricultural and Food Chemistry* 36: 880-882.

Elamrani A, Zrira S, Benjilali B. 2000. A study of Moroccan rosemary oils. *Journal of Essential Oil Research* 12: 487-495.

EMEA 2005. Public statement on the use of herbal medicinal products containing methyl eugenol. European Medicines Agency, Evaluation of medicines for human use. Available online, http://www.ema.europa.eu/docs/en_GB/document_library/Scientific_guideline/2010/04/WC500089961.pdf

Engle KH, Heidlas J, Tressl R. 1990. The flavour of tropical fruits (banana, melon, pineapple). In: Morton ID, MacLeod JD, Editors. *Food Flavors: Part C, The Flavor of Fruits*. pp. 195-219. Elsevier Scientific Publications.

Esmaeili A, Nematollahi F, Rustaiyan A, Moazami N, Masoudi S, Bamasian S. 2006. Volatile constituents of *Achillea pachycephala*, *A. oxyodonta* and *A. biebersteinii* from Iran. *Flavour Fragrance Journal* 21: 253-256.

Fakhari AR, Sonboli A. 2006. Essential oil composition of *Pimpinella barbata* (DC.) Boiss. from Iran. *Journal of Essential Oil Research* 18: 679-681.

Farag RS, Shalaby AS, El-Baroty GA, Ibrahim NA, Ali MA, Hassan EM. 2004. Chemical and biological evaluation of the essential oils of different *Melaleuca* species. *Phytotherapy Research* 18: 30-35.

Ferraz ABF, Balbino JM, Zini CA, Ribeiro VLS, Bordignon SAL, von Poser G. 2010. Acaricidal activity and chemical composition of the essential oil from three *Piper* species. *Parasitology Research* 107: 243-248.

Ferrer J-L, Austin MB, Stewart Jr. C, Noel JP. 2008. Structure and function of enzymes involved in the biosynthesis of phenylpropanoids. *Plant Physiology and Biochemistry* 46: 356-370.

Flamini G, Cioni PL, Morelli I, Maccioni S, Baldini R. 2004. Phytochemical typologies in some populations of *Myrtus communis* L. on Caprione Promontory (East Liguria, Italy). *Food Chemistry* 85: 599-604.

Fiorini C, Fouraste I, David B, Bessiere JM. 1997. Composition of the flower, leaf and stem essential oils from *Laurus nobilis* L. *Flavour and Fragrance Journal* 12: 91-93.

Firuzi O, Asadollahi M, Gholami M, Javidnia K. 2010. Composition and biological activities of essential oils from four *Heracleum* species. *Food Chemistry* 122: 117-122.

Flamini G, Cioni PL, Morelli I. 2002. Differences in the fragraces of pollen and different floral parts of male and female flowers of *Laurus nobilis*. *Journal of Agricultural and Food Chemistry* 50: 4647-4662.

Flamini G, Cioni PL, Morelli I. 2002. Differences in the fragrances of pollen and different floral parts of male and female flowers of *Laurus nobilis*. *Journal of Agricultural and Food Chemistry* 50: 4647-4652.

Flamini G, Tebano M, Cioni PL. 2008. Composition of the essential oils from leafy parts of the shoots, flowers and fruits of *Eryngium amthystinum* from Amiata Mount (Tuscany, Italy). *Journal of Agricultural and Food Chemistry* 107: 671-674.

Flamini G, Cioni PL, Morelli I, Ceccarini L, Andolfi L, Macchia M. 2003. Composition of the essential oil of *Medicago marina* L. from the coastal dunes of Tuscany, Italy. *Flavour and Fragrance Journal* 18: 460-462.

Fleisher A, Fleisher Z. 1994. The fragrance of biblical Mandrake. *Economic Botany* 48: 243-251.

Fleisher Z, Fleisher A. 1992. Volatiles of the Mastic tree – *Pistacia lentiscus* L. Aromatic plants of the holy land and the Sinai. Part X. *Journal of Essential Oil Research* 4: 663-665.

Fletcher BS, Bateman MA, Hart NK, Lamberton JA. 1975. Identification of a fruit fly attractant in an Australian plant, *Zieria smithii* as O-methyl eugenol. *Journal of Economic Entomology* 68: 815-816.

Fokialakis N, Magiatis P, Mitaku S. 2002. Essential oil constituents of *Valeriana italica* and *Valeriana tuberosa*. Stereochemical and conformational study of 15-acetoxyvaleranone. *Zeitschrift für Naturforschung* 57c: 791-796.

Fournier G, Hadjiakhoondi A, Leboeuf M, Cave A, Charles B. 1997. Essential oils of Annonaceae. Part VIII. Volatile constituents of the essential oils from three *Guatteria* species. *Journal of Essential Oil Research* 9: 275-278.

Franceschi VR, Krokene P, Christiansen E, Krekling T. 2005. Anatomical and chemical defenses of conifer bark against bark beetles and other pests. *New Phytology* 167: 353-376.

Franchomme P, Peneol D. 1995. *L'Aromatherapie Exactement*. Jollois R. (in French).

Fujita H, Yamashita M. 1973. Constituents of the essential oil from *Alpinia speciosa*. *Yakugaku Zasshi* 93: 1635-1638. (in Japanese).

Fujita S, Fujita Y. 1973. Essential oils of the plants from various territories. XXXIII. Essential oil of *Agastache rugosa*. *Yakugaku Zasshi* 93: 1679-1681.(in Japanese).

Fujita Y, Fujita S, Yoshikawa H. 1974. Biogenesis of essential oils in camphor trees. XXXIII. Components of essential oils of *Cinnamomum doederleinii*. I. *Nippon Nogei Kagaku Kaishi* 48: 633-636. (1n Japanese).

Fun CE, Svendsen AB. 1990. The essential oil of *Lippia alba* (Mill.) N.E. Br. *Journal of Essential Oil Research* 2: 265-267.

Fun CE, Svendsen AB. 1990. The essential oil of *Hyptis suaveolens* grown in Aruba. *Flavour and Fragrance Journal* 5: 161-163.

Găinar MZI, Bala D. 2006. Influence of the process parameters on supercritical CO_2 extraction of fennel essential oil. *Analele Universității din Bucureşti – Chimie, Anul XV* 1: 107-111.

Garcia-Fajardo J, Martinez-Sosa M, Estarron-Espinosa M, Vilarem G, Gaset A, De Santos JM. 1997. Comparative study of the oil and supercritical CO_2 extract of Mexican pimento (*Pimenta dioica* Merrill). *Journal of Essential Oil Research* 9: 181-185.

Georgiou C, Koutsaviti A, Bazos I, Tzakou O. 2010. Chemical composition of *Echinophora tenuifolia* subsp. *sibthorpiana* essential oil from Greece. *Records of Natural Products* 4: 167-170.

Ghani A, Saharkhiz MJ, Hassanzadch M, Msaada K. 2009. Changes in the essential oil content and chemical compositions of *Echinophora platyloba* DC. during three different growth and developmental stages. *Journal of Essential Oil Bearing Plants* 12: 162-171.

Gnavi G, Bertea CM, Usai M, Maffei ME. 2010. Comparative characterization of *Santolina insularis* chemotypes by essential oil composition, 5S-rRNA-NTS sequencing and EcoRV RFLP-PCR. *Phytochemistry* 71: 930-936.

Goel D, Mallavarupu GR, Kumar S, Singh V, Ali M. 2008. Volatile metabolite compositions of the essential oil from aerial parts of ornamental and artemisinin rich cultivars of *Artemisis annua*. *Journal of Essential Oil Research* 20: 147-152.

Gogus, F, Mustafa ZO, Lewis AC. 2006. Extraction of essential oils of leaves and flowers of *Achillea monocephala* by superheated water. *Flavour and Fragrance Journal* 21: 122-128.

Gottlieb OR, Da Rocha AI. 1972. Chemistry of Brazilian Lauraceae. XIX. Constituents of *Aniba hostmanniana*. *Phytochemistry* 11: 1861-1863.

Gracza L, 1980. HPLC determination of phenylpropane derivatives in drugs and drug preparations. Part 3. Analysis of phenylpropane derivatives. *Deutsche Apotheker Zeitung* 120: 1859-1863.

Gregonis DE, Portwood RD, Davidson WH, Durfee DA, Levinson AS. 1968. Volatile oils from foliage of coast redwood and big tree. *Phytochemistry* 7: 975-981.

Griffiths DW, Robertson GW, Shepherd T, Ramsay G. 1999. Epicuticular waxes and volatiles from faba bean (*Vicia faba*) flowers. *Phytochemistry* 52: 607-612.

Grosso C, Teixeira G, Gomes I, Martins ES, Barroso JG, Pedro LG, Figueiredo AC. 2009. Assessment of the essential oil composition of *Tornabenea annua*, *Tornabenea insularis* and *Tornabenea tenuissima* fruits from Cape Verde Islands. *Biochemical Systematics and Ecology* 37: 474-478.

Gu J, Liu L, Zhang Y. 1990. Study on the essential oil from the fruits of *Cinnamomum camphora* (L.) Presl var. *linaloolifera* Fujita. *Linchan Huaxue Yu Gongye* 10: 77-82. (Chinese with English summary).

Guchu E, Diaz-Maroto MC, Diaz-Maroto IJ, Vila-Lameiro P, Perez-Coello MS. 2006. Influence of the species and geographical location on volatile composition of spanish oak wood (*Quercus petraea* Lieb. and *Quercus robur* L.). *Journal of Agricultural and Food Chemistry* 54: 3062-3066.

Gudaityte O, Venskutonis PR. 2007. Chemotypes of *Achillea millefolium* transferred from 14 different locations in Lithuania to the controlled environment. *Biochemical Systematics and Ecology* 35: 582-592.

Guerrini A, Sacchetti G, Muzzoli M, Rueda GM, Medici A, Besco E, Bruni R. 2006. Composition of the volatile fraction of *Ocotea bofo* Kunth (Lauraceae) calyces by GC-MS and NMR fingerprinting and its antimicrobial and antioxidant activity. *Journal of Agricultural and Food Chemistry* 54: 7778-7788.

Gulati BC, Khan MN. 1979. Essential oil of *Artemesia pallens* Wall (Davana) - as study of minor constituents. *7th International Congress of Essential Oils* 7: 357-359.

Gutirrez, RMP, Luna HH, Garrido SH. 2010. Antioxidant activity of *Tagetes erecta* essential oil. *Journal of the Chilean Chemical Society* 51: 882-886.

Hadad M, Zygadlo JA, Lima B, Derita M, Feresin GE, Zacchino SA, Tapia A. 2007. Chemical composition and antimicrobial activity of essential oil from *Baccharis grisebachii* Heiron (Asteraceae). *Journal of Chilean Chemical Soceity* 52: 1186-1189.

Halabi S, Battah AA, Aburjai T, Hudaib M. 2005. Phytochemical and platelet investigation of *Gundelia tournifortil. Pharmaceutical Biology* 43: 496-500.

Hamm S, Bleton J, Connan J, Tchapla A. 2005. A chemical investigation by headspace of SPME and GC-MS of volatile and semi-volatile terpenes in various olibanum samples. *Phytochemistry* 66: 1499-1514.

Hammami S, Khoja I, Jannet HB, Halima MB, Highri Z. 2007. Flowers essential oil composition of Tunisian *Matthiola longipetala* and its bioactivity against *Tribolium confusum* insect. *Journal of Essential Oil Bearing Plants* 10: 162-167.

Han A-R, Kim HJ, Shin M, Hong M, Kim YS, Bae H. 2008. Constituents of *Asarum sieboldii* with inhibitory activity on lipopolysaccharide (LPS)-induced NO production in BV-2 microglial cells. *Chemical Biodiversity* 5: 346-351.

Hassanpouraghdam MB, Shalamzari MS, Sepehri N. 2009. GC/MS analysis of *Echinophora platyloba* DC. Essential oil from Northwest Iran: a potential source of (Z)-β-ocimene and α-phellandrene. *Chemija* 20: 120-123.

Hayashi N, Maeshima K, Komae H. Phenol ethers of three north american *Hexastylis* species. *Phytochemistry* 22: 299.

Hazzit M, Baaliouiamer Z, Faleiro ML, Miquel MG. 2006. Composition of the essential oils of *Thymus* and *Origanum* species from Algeria and their antioxidant and antimicrobial activities. *Journal of Agricultural and Food Chemistry* 54: 6314-6321.

Hee AKW, Tan KH. 2004. Male sex pheromonal components derived from methyl eugenol in the haemolymph of fruit fly *Bactrocera papayae*. *Journal of Chemical Ecology* 30: 2127-2138.

Herrmann KM, Weaver LM. 1999. The shikimate pathway. *Annual Review of Plant Physiology and Plant Molecular Biology* 50: 473-503.

Hethelyi E, Danos B, Tetnyl P, Juhasz G. 1987. Phytochemical studies on *Tagetes* species; infraspecific differences of the essential oil in *T. minuta* and *T. tenuifolia*. *Herba Hungarica* 26: 145-158.

Ho C, Wang EIC, Wei X, Lu S, Su Y. 2008. Composition and bioactivities of the leaf essential oils of *Cinnamomum subavenium* Miq. from Taiwan. *Journal of Essential Oil Research* 20: 328-334.

Horvat RJ, Senter SD. 1984. Identification of the volatile constituents from scuppernong berries (*Vitis rotundifolia*). *Journal of Food Science* 49: 64-66.

Horvat RJ, Chapman GW, Robertson JA, Meredith FI, Scorza R, Callihan AM, Morgan P. 1990. Comparison of the volatile compounds from several commercial peach cultivars. *Journal of Agricultural and Food Chemistry* 38: 234-237.

Hosni K, Msaada K, Taarit MB, Ouchikh O, Kallel M, Marzouk B. 2008. Essential oil composition of *Hypericum perfoliatum* L. and *Hypericum tomentosum* L. growing wild in Tunisia. *Industrial Crops and Products* 27: 308-314.

Howes M-JR, Kite GC, Simmonds MSJ. 2009. Distinguishing Chinese star anise from Japanese star anise using thermal desorption-gas chromatography-mass spectrometry. *Journal of Agricultural and Food Chemistry* 57: 5783-5789.

Howlett FM. 1912. VII. The effect of oil of *Citronella* on two species of *Dacus*. *Transactions of the Entomological Society of London* 60: 412-418.

Howlett FM. 1915. Chemical reactions of fruit flies. *Bulletin of Entomological Research* 6: 297-305.

Hsiao Y-Y, Tsai W-C, Kuoh C-S, Huang T-H, Wang H-C, Wu T-S, Leu Y-L, Chen W-H, Chen H-H. 2006. Comparison of transcripts in *Phalaenopsis bellina* and *Phalaenopsis equestris* (Orchidaceae) flowers to deduce monoterpene biosynthesis pathway. *BMC Plant Biology* 6: 1-14.

Huber FK, Kaiser R, Sauter W, Schiestl FP. 2005. Floral Scent Emission and Pollinator Attraction in two species of *Gymnadenia* (Orchidaceae). *Oecologia* 142: 564-575.

Hudaib MM, Aburjai TA. 2006. Composition of the essential oil from *Artemisis herba-alba* grown in Jordan. *Journal of Essential Oil Research* 18: 301-304.

Hussain RA, Poveda LJ, Pezzuta JM, Soejarto DD, Kinghorn AD. 1990. Sweetening agents of plant origin: Phenylpropanoid constituents of seven sweet-tasting plants. *Economic Botany* 44: 174-182.

Hussein MS, El-Sherbeny SE, Khalil MY, Naguib NY, Aly SM. 2006. Growth characters and chemical constituents of *Dracocephalum moldavica* L. plants in relation to compost fertilizer and planting distance. *Scientia Horticultae* 108: 322-331.

IAEA. 2003. *Trapping guidelines for area-wide fruit fly programmes*. Joint FAO/IAEA Division of Nuclear Techniques in Food and Agriculture, International Atomic Energy Agency.

Ibanez E, de Murga AOG, Lopez-Sebastian S, Tabera J, Reglero G. 1999. Supercritical fluid extraction and fractionation of different preprocessed Rosemary plants. *Journal of Agricultural and Food Chemistry* 47: 1400-1404.

Iscan G, Kirimer N, Kurkuoglu M, Arabach T, Kupeli E, Baser KHC. 2006. Biological activity and composition of the essential oils of *Achillea schischkinii* Sosn. and *Achillea aleppica* Dc. Subsp. *aleppica*. *Journal of Agricultural and Food Chemistry* 54: 170-173.

Ishikawa M, Tani K. 2007. Odor of flower of Koufuku-no-Ki (*Dracaena fragrans* 'Massangeana'). *Koryo* 236: 89-98. (Japanese with English Abstract).

Jakobson HB, Olsen CE. 1994. Influence of climatic factors on emission of flower volatiles in situ. *Planta* 192: 365-371.

Jantan I, Ayop N, Au BH, Ahmad AS. 2002. Chemical composition of the essential oils of *Cinnamomum cordatum* Kosterm. *Flavour and Fragrance Journal* 17: 212-214.

Jantan I, Ayob N, Ali NAM, Ahmad AS, Yalvema MF, Muhammad K, Azizi AR. 2004. The essential oils of *Cinnamom rhycophyllum* Miq. as natural sources of benzyl benzoate, safrole and methyl (E)-cinnamate. *Flavour and Fragrance Journal* 19: 260-262.

Jarikassem S, Brophy JJ, Rerk-am U, Supattanakul W. 2006. Essential oil constituents from two uncommon Zingiber rhizomes. In: *47th Annual Meeting of Society for Economic Botany - Folk Botanical Wisdom: Towards Global Markets*.

Javidnia K, Banani A, Miri R, Kamalinejad M, Javidnia A. 2006. Constituents of the volatile oil of *Inula oculus-christl* L. from

Iran. *Journal Essential Oil Research* 18: 676-678.

Jean F-I, Deslauriers H, Collin GJ, Gagnon M, Hachey J-M, Pare JR, Belanger A. 1990. The essential oil of *Ligusticum scoticum* L. *Journal of Essential Oil Research* 2: 37-44.

Jerkovic I, Mastelic J, Milos M, Juteau F, Masotti V, Viano J. 2003. Chemical variability of *Artemisia vulgaris* L. essential oils originated from the Mediterranean area of France and Croatia. *Flavour and Fragrance Journal* 18: 436-440.

Jeong, ES, Choi KY, Kim SC, Son IS, Cho HC, Ahn SY, Woo MH, Hong JT, Moon DC. 2009. Pattern recognition of the herbal drug, Magnoliae flos according to their essential oil components. *Bulletin of Korean Chemical Society* 30: 1211-1126.

Jerkovic I, Mastelic J. 2003. Volatile compounds from leaf-buds of *Populus nigra* L. (Salicaceae) *Phytochemistry* 63: 109-113.

Jeya Johti G, Benniamin A, Maridass M, Raju G. 2009. Identification of essential oils composition and antifungal activity of *Eugenia singampattiana* fruits. *Pharmacology online* 2: 727-733.

Jirovetz L, Smith D, Buchbauer G. 2002a. Aroma compound analysis *of Eruca sativa* (Brassicaceae) SPME headspace leaf samples using GC, GC-MS, and olfactometry. *Journal of Agricultural and Food Chemistry* 50: 4643-4646.

Jirovetz L, Buchbauer G, Ngassoum MB, Geissler M. 2002b. Aroma compound analysis of *Piper nigrum* and *Piper guineense* essential oils from Cameroon using solid-phase microextraction–gas chromatography, solid-phase microextraction–gas chromatography–mass spectrometry and olfactometry. *Journal of Chromatography A* 976: 265-275.

Jirovetz L, Buchbauer G, Stoyanova AS, Georgiev EV, Damianova ST. 2003. Composition, quality control, and antimicrobial activity of the essential oil of long-time stored dill (*Anethum graveolens* L.) seeds from Bulgaria. *Journal of Agricultural and Food Chemistry* 51: 3854-3857.

Jirovetz L, Buchbauer G, Stoyanova A, Balinova A, Guangjiun Z, Xihan M. 2004. Solid phase microextraction/gas chromatogaphic and olfactory analysis of the scent and fixative properties of the essential oil of *Rosa damascena* L. from China. *Flavour and Fragrance Journal* 20: 7-12.

Jirovetz L, Buchbauer G, Ngassoum MB, Parmentier M. 2005. Chemical composition and olfactory characterization of essential oils of fruits and seeds of African pear (*Dacryodes edulis* (G. Don) H.J. Lam) from Cameroon. *Flavour and Fragrance Journal* 20: 215-218.

Jirovetz, L., Buchbauer G, Stoilova I, Stoyanova A, Krastanov A, Schmidt E. 2006. Chemical composition and antioxidant properties of clove leaf essential oil. *Journal of Agricultural and Food Chemistry* 54: 6303-6307.

Johnson SD, Ellis A, Dotterl S. 2007. Specialization for pollination by beetles and wasps: the role of lollipop hairs and fragrance in *Satyrium microrrhynchum* (Orchidaceae). *American Journal of Botany* 94: 47-55.

Johnson SD, Griffiths ME, Peter CI, Lawes MJ. 2009. Pollinators, “mustard oil” volatiles, and fruit production in flowers if the diecious tree *Drypetes natalensis* (Putranjivaceae). *American Journal of Botany* 96: 2080-2086.

Joichi A, Yomogida K, Awano K, Ueda Y. 2005. Volatile components of tea-scented modern roses and ancient Chinese roses. *Flavour and Fragrance Journal* 20: 152-157.

Jordan MJ, Martnez RM, Goodner KL, Baldwin EA, Sotomayor JA. 2006. Seasonal variation of *Thymus hyemalis* Lange and Spanish *Thymus vulgaris* L. essential oils composition. *Industrial Crops and Products* 24: 253-263.

Joy B, Rao JM. 1997. Essential oil of the leaves of *Annona squamosa* L. *Journal of Essential Oil Research* 9: 349-350.

Jurgens A, Dotterl S. 2004. Chemical composition of anther volatiles in Ranunculaceae: Genera-specific profiles in *Anemone*, *Aquilegia*, *Caltha*, *Pulsatilla*, *Ranunculus*, and *Trollius* species. *Journal of Botany* 91(12): 1969-1980.

Jürgens A, Witt T, Gottsberger G. 2003. Flower scent composition in *Dianthus* and *Saponaria* species (Caryophyllaceae) and its relevance for pollination biology and taxonomy. *Biochemical Systematics and Ecology* 31: 345-357.

Juteau F, Masotti V, Bessière JM, Viano J. 2002. Compositional characteristics of the essential oil of *Artemisia campestris* var. *glutinosa*. *Biochemical Systematics and Ecology* 30: 1065-1070.

Kainulainen P, Tarhanen J, Tiilikkala K, Holopainen JK. 1998. Foliar and emission composition of essential oil in two carrot varieties. *Journal of Agricultural and Food Chemistry* 46: 3780-3784.

Kaiser R. 1991. New volatile constituents of the flower concrete of *Michelia champaca* L. *Journal of Essential Oil Research* 3: 129-146.

Kaiser R. 1993. *The Scent of Orchids - Olfactory and Chemical Investigations*. Elsevier.

Kaluzna-Czaolinska J. 2007. GC-MS analysis of biologically active compounds in cosmopolitan grasses. *ACTA Chromographica* 19: 279-282.

Kamdem DP, Gage DA. 1995. Chemical composition of essential oil from the root bark of *Sassafras albidum*. *Planta Medica* 61: 574-575.

Kameoka H, 1993. The Essential Oil Constituents of Some Useful Plants from China. In: *Recent Developments in Flavour and Fragrance Chemistry – Proceedings of the 3rd International Haarman and Reimer Symposium Pub*. VCH NY.

Kameoka H, Wang CP. 1980. The constituents of the essential oils from *Trachycarpus excelsa* Wendl and *T. fortunei* W. *Nippon Nogei Kagaku Kaishi* 54: 111-115. (in Japanese).

Kameoka H, Sagara K, Miyazawa M. 1989. Components of essential oils of Kakushitsu (*Daucus carota* L. and *Carpesium abrotanoides* L.) *Nippon Nogei Kagaku Kaishi* 63: 185-188. (in Japanese).

Kapetamos C, Karrioti A, Bovic S, Marin P, Vejic M, Skaltsa H. 2008. Chemical and principal-component analyses of the essential oils of Apiodeae taxa (Apiaceae) from Ventral Balkan. *Chemical Biodiversity* 5: 101-118.

Kapteyn J, Qualley AV, Xie ZZ, Fridman E, Dudareva N, Gang DR. 2007. Evolution of cinnamate/p-coumarate carboxyl methyltransferases and their role in the biosynthesis of methylcinnamate. *The Plant Cell* 19: 3212-3229.

Karamenderes C, Demirci, Baser KHC. 2008. Composition of essential oils of ten *Centaurea* L. taxa from Turkey. *Journal of Essential Oil Research* 20: 342-349.

Katsouri E, Demetzos C, Perdetzoglou D, Loukis A. 2001. An interpopulation study of the essential oils of various parts of *Crithmum maritimum* L. growing in Amorgos Island, Greece. *Journal of Essential Oil Research* 13: 303-308.

Katsumi Y. 1987. Minor components from growing buds of *Artemisia capillaris* that act as insect antifeedants. *Journal of Agricultural and Food Chemistry* 35(6): 889-891.

Kawano T, Saito T. 1968. Study on attractant of the rice stem borer, *Chilo suppressalis* Walker. *Botyu-Kagaku* 33: 122-130. (in Japanese with English summary).

Kawano Y, Mitchell WC, Matshmoto H. 1968. Identification of the male oriental fruit fly attractant in the golden shower blossom. *Journal of Economic Entomology* 61: 986-988.

Kawata J, Kameda M, Miyazawa M. 2007. Constituents of essential oil from the dried fruits and stems of *Akebia quinata* (Thunb.) Decne. *Journal of Oleo Science* 56: 59-63.

Kaya A, Demirci B, Baser KHC. 2007. Study of the essential oils from the flowers and fruits of *Scandix iberica* Bieb. growing in Turkey. *Journal of Essential Oil Research* 19: 155-156.

Kayser O, Lattè K, Kolodziej H, Hammerschmidt F-J. 1998. Composition of the essential oils of *Pelargonium sidoides* DC. and *Pelargonium reniforme* Curt. *Flavour and Fragrance Journal* 13: 209-212.

Kelm MA, Nair MG, Schutzki RA. 1997. Mosquitocidal compounds from *Magnolia salicifolia*. *International Journal of Pharmacognosy* 35: 84-90.

Kessler A, Baldwin IT. 2001. Defensive function of herbivore-induced plant volatile emissions in nature. *Science* 291: 2141-2144.

Khan VA, Dubovenko ZV, Pentegova VA. 1983. Oxygen-containing mono- and sesquiterpenoids of the oleoresin of *Picea koraiensis*. *Kihmiya Prirodnykh Soedinenii* 1: 109-110. (in Russian).

Khan VA, Bol'hakova VL, Grigorovich ML, Shmidt EN, Dubovenko ZV, Pentegova VA. 1984. Terpenoids of *Pinus funebris*. *Kihmiya Prirodnykh Soedinenii* 4: 444-448. (in Russian).

Khodakov GV, Kotikov IV, Pankovetskii VN. 2009. Component composition of essential oil from *Artemisia abrotanum* and *A. dracunculus*. *Chemistry of Natural Compounds* 45: 905-908.

Khosla MK, Pushpangadan P, Thappa RK, Sobti SN. 1980. Search for new aroma chemicals from *Ocimum* species. III. Studies on genetic variability for essential oil and other allied characters of South American species *O. micranthum* Willd. *Indian Perfumer* 24: 148-152.

Khosla MK, Bradu BL, Thapa RK. 1989. Biogenetic studies on the inheritance of different essential oil constituents of *Ocimum* species, their F1 hybrids and synthesized allopolyploids. *Herba Hungaria* 28: 13-19.

Kilic A, Hafizoglu H, Kollmannsberger H, Nitz S. 2004. Volatile constituents and key odorants in leaves, buds, flowers, and fruits of *Laurus nobilis* L. *Journal of Agricultural and Food Chemistry* 52: 1601-1606.

Kim H-J, Kim K, Kim N-S, Lee D-S. 2000. Determination of floral fragrances of *Rosa hybrida* using solid-phase trapping-solvent extraction and gas chromatography-mass spectrometry. *Journal of Chromatography A* 902: 389-404.

Kim J-Y, Kim S-S, Oh T-H, Baik JS, Song G, Lee NH, Hyun C-G. 2009. Chemical composition, antioxidant, anti-elastase, and anti-inflammatory activities of *Illicium anisatum* esstential oil. *ACTA Pharmaceutica* 59: 289-300.

Kiran SR, Devi PS, Reddy KJ. 2007. Bioactivity of essential oils and sesquiterpenes of *Chloroxylon swietenia* DC against *Helicoverpa armigera*. *Current Science* 93: 544-548.

Kittibarmruangsook P. 1980. *Effects of volatile oils extracted from some plants to the Oriental fruit fly (Dacus dorsalis Hendel).* M.Sc. Thesis in Agriculture, Kasetsart University, Bangkok, Thailand.

Kivanc M. 1988. Antimicrobial activity of "Cortuk" (*Echinophora sibthorpiana* Guss.) spice, its essential oil and methyleugenol. *Nahrung* 332: 635-637.

Kivanc M, Akgul A. 1990. Mould growth on black table olives and prevention by sorbic acid, methyl-eugenol and spice essential oil. *Nahrung* 34: 369-373.

Klischies M, Stockigt j, Zenk MH. 1975. Biosynthesis of the allylphenols eugenol and methyleugenol in *Ocimum basilicum* L. *Journal of the Chemical Society: Chemical Communications* 1975: 879-880.

Knudsen JT, Mori SA. 1996. Floral scents and pollination in neotropical Lecythidaceae. *Biotropica* 28: 42-60.

Knudsen JT, Tollsten T, Bergstrom LG. 1993. Floral scents – a checklist of volatile compounds isolated by head-space techniques. *Phytochemistry* 33: 253-280.

Knudsen JT, Andersson S, Bergman P. 1999. Flroal scent attraction in *Geonoma macrostachys*, an understorey palm of the Amazonian rain forest. *Oikos* 85: 409-418.

Knudsen JT, Tollsten L, Ervik F. 2001. Flower scent and pollination in selected neotropical palms. *Plant Biology* 3: 642-653.

Knudsen JT, Eriksson R, Stahl B. 2006. Diversity and distribution of floral scent. *Botanical Review* 72: 1-120.

Knudsen JT, Tollsten L, Grothe I, Bergstrom G, Raguso RA. 2004. Trends in floral scent chemistry in pollination syndromes: floral scent composition in hummingbird-pollinated taxa. *Botanical Journal of the Linnean Society* 146: 191-199.

Koezuka Y, Honda G, Tabata M. 1986. Genetic control of phenylpropanoids in *Perilla frutescens*. *Phytochemistry* 25: 2085-2087.

Koo BS, Park KS, Ha JH, Park JH, Lim JC, Lee DU. 2003. Inhibitory effects of the fragrance inhalation of essential oil from *Acorus gramineus* on central nervous system. *Biological and Pharmaceutical Bulletin* 26: 978-982.

Kordali S, Kotan R, Mavi A, Cakir A, Ala A, Yilsdrim A. 2005. Determination of the chemical composition and antioxidant activity of the essential oil of *Artemisia dracunculus* and of the antifungal and antibacterial activities of Turkish *Artemisia abshinthium*, *A. dracunculus*, *Artemisia santonicum* and *Artemisia spicigera* essential oils. *Journal of Agricultural and Food Chemistry* 53: 9452-9458.

Kosuge T, Yokota M, Nukaya H, Gotoh Y, Nagasawa M. 1978. Studies on antitussive principles of *Asiasari radix*. *Chemical and Pharmaceutical Bulletin* 26: 2284-2285. (inJapanese).

Kothari SK, Bhattacharya AK, Ramesh S, Garg SN, Khanuja SPS. 2005. Volatile constituents in oil from different plant parts of methyl eugenol-rich *Ocimum tenuiflorum* L.f. (syn. *O. sanctum* L.) grown in South India. *Journal of Essential Oil Research* 17: 656-658.

Kovacevic NN, Simic MD, Ristic MS. 2007. Essential oil of *Laurus nobilis* from Montenegro. *Chemistry of Natural Compounds* 43: 408-411.

Krauze-Baranowska M, Mardarowicz M, Wiwart M, Poblocka L, Dynowska M. 2002. Antifungal activity of the essential oils from some species of the genus *Pinus*. *Zeitschrift für Naturforschung* 57c: 478-482.

Kristiawan M, Sobolik V, Allaf K. 2008. Isolation of Indonesian cananga oil using multi-cycle pressure drop process. *Journal of Chromatography A* 1192: 306-318.

Krüger H, Hammer K, Hammerschmidt F-J, Hennig L. 2005. Methyl Eugenol and g-asarone two new main components in fennel. Abstract (unpublished).

Kubo I, Himejima M, Muroi H. 1991. Antimicrobial activity of flavor components of cardamom *Elattaria cardamomum* (Zingiberaceae) seed. *Journal of Agricultural and Food Chemistry* 39: 1984-1986.

Kumar N, Motto MG. 1986. Volatile constituents of Peony flowers. *Phytochemistry* 25: 250-253.

Kundakovic T, Fokialakis N, Kovacevic N, Chinou I. 2007. Essential oil composition of *Achillea lingulata* and *A. umbellata*. *Flavour and Fragrance Journal* 22: 184-187.

Kurita N, Miyaji M, Kurane R, Takahara Y. 1981. Antifungal activity of components of essential oils. *Agricultural Biology and Chemistry* 45: 945-952.

Kuo YH, Lin YT, Lin YT. 1983. Studies on the extractive constituents of the nutmeg of *Myristica fragrans* Houtt. *Journal of Chinese Chemical Society* 30: 63-67.

Kurkcuoglu M, Baser KHC. 2003. Studies on Turkish rose concrete, absolute and hydrosol. *Chemistry of Natural Compounds* 39: 457-464.

Lamarque AL, Maestri DM, Zygadlo JA, Grosso NR. 1998. Volatile constituents from flowers of *Acacia caven* (Mol.) Mol. var. *caven*, *Acacia aroma* Gill. ex Hook., *Erythrina crista-galli* L. and *Calliandra tweedii* Benth. *Flavour and Fragrance Journal* 13: 266-268.

Lane AL, Kubanek J. 2006. Structure–activity relationship of chemical defenses from the freshwater plant *Micranthemum umbrosum*. *Phytochemistry* 67: 1224-1231.

Lassaak EV, Pinhey JT. 1969. Constituents of *Eriostemom trachyphyllus*. Structure of trachtyphyllin, a new couomarin. *Australian Journal of Chemistry* 22: 2175-2185.

Lavid N, Wang J, Shalit M, Guterman I, Bar E, Beuerle T, Menda N, Shafir S, Zamir D, Adam Z, Vainstein A, Weiss D, Pichersky E, Lewinsohn E. 2002. O-Methyltransferases involved in the biosynthesis of volatile phenolic derivatives in rose petals. *Plant Physiology* 129: 1899-1907.

Lechat-Vahirua I, Francois P, Menut C, Lamaty G, Bessiere JM. 1993. Aromatic plants of French Polynesia. I. Constituents of the essential oils of rhizomes of three Zingiberaceae: *Zingiber zerumbet* Smith, *Hedychium coronariium* Koenig and Etlingera cevuga Smith. *Journal of Essential Oil Research* 5: 55-59.

Lee S-E, Lee B-H, Choi W-S, Park B-S, Kim J-G, Campbell BC. 2001. Fumigant toxicity of volatile natural products from Korean spices and medicinal plants towards the rice weevil, *Sitophilus oryzae* (L). *Pest Management Science* 57: 548-553.

Lewinsohn E, Ziv-Raz I, Dudai N, Tadmor Y, Lastochkin E, Larkov O, Chaimovitsh D, Ravid U, Putievsky E, Pichersky E, Shoham Y. 2000. Biosynthesis of estragole and methyl-eugenol in sweet basil (*Ocimum basilicium* L). Development and chemotypic association of allylphenol O-methyltransferase activities. *Plant Science* 160: 27-35.

Lewis JA, Moore CJ, Fletcher MT, Drew RAI, Kitching W. 1988. Volatile compounds from the flowers of *Spathiphyllum cannaefolium*. *Phytochemistry* 27: 2755-2757.

Lim GK. 2005. Chemical constituents and biological activity of *Clausena excavata* (Rutaceae). M.Sc. Thesis, School of Graduate Studies, Universiti Putra Malaysia.

Limberger RP, Scopel M, Sobral M, Henriques AT. 2007. Comparative analysis of volatiles from *Drimys brasiliensis* Miers and *D. angustifolia* Miers (Winteraceae) from Southern Brazil. *Biochemical Systematics and Ecology* 35: 130-137.

Lin Z, Hua Y. 1989. Chemical constituents of the essential oil from *Mosla scabra* (Thunb.) C.Y. Wu et H.W. Li. *Zhiwu Xuebao* 31: 320-322. (in Chinese).

Lis-Balchin M. 1993. The essential oils of *Pelargonium grossularioides* and *Erodium cicutarium* (Geraniaceae). *Journal of Essential Oil Research* 5: 317-318.

Lis-Balchin M, Roth G. 2000. Composition of the essential oils of P. odoratissimum, *P. exstipulatum* and *P. fragrans* (Geraniaceae). *Flavour and Fragrance Journal* 15: 391.

Liu X, Zhao M, Luo W, Yang B, Jiang Y. 2009. Identification of volatile components in *Phyllanthus emblica* L. and their antimicrobial activity. *Journal of Medicinal Food* 12: 423-428.

Liu C-T, Zhang J-X, Yiao R-R, Gan L-X. 1981. Chemical studies on the essential oils of

Cymbopogon genus. *Acta Chimica Sinica* 39: 241-247.

Lopes NF, Kato MJ, de Aguiar FH, Andrade JG, Maia S, Yoshida M. 1997. Circadian and seasonal variation in the essential oil from *Virola surinamensis* leaves. *Phytochemistry* 46: 689-693.

Lopes-Lutz D, Alviano DS, Alviano CS, Kolodziejczky PP. 2008. Screening of chemical composition, antimicrobial and antioxidant activities of *Artemisia* essential oils. *Phytochemistry* 69: 1732-1738.

Lu B, Li Y, Mai L, Sun B, Zhu L. 1986. Chemical constituents of essential oil from *Cinamomum rigidissimum*, a new natural resource of safrole. *Linchan Juaxue Yu Gongye* 6: 39-44. (in Chinese).

Macini B. 1980. Pharmacognostic study of leaves and stems of *Wedelia paludosa* DC var. *vialis* DC., Compositae. Analysis of the essential oil. *Revista de Ciencias Farmaceuticas* 2: 61-76. (in Portugese).

MacLeod AJ, de Troconis NG. 1982. Volatile flavor components of Sapodilla fruit (*Achras sapota* L.). *Journal of Agricultural and Food Chemistry* 30: 515-517.

Magalhães PJC, Criddle DN, Tavares RA, Melo EM, Mota TL, Leal-Cardoso JH. 1998. Intestinal myorelaxant and antispasmodic effects of the essential oil of *Croton nepetaefolius* and its constituents cineole, methyl-eugenol and terpineol. *Phytotherapy Research* 12: 172-177.

Mhamdi B, Wannes WA, Dhiffi W, Marzouk B. 2009. Volatiles from leaves and flowers of Borage (*Borgo officinalis* L.). *Journal of Essential Oil Research* 21: 504-507.

Maia JGS, Andrade EHA. 2009. Database of the Amazon aromatic plants and their essential oils. *Quimica Nova* 32: 595-622.

Maia JGS, Ramos LS, Luz AIR. 1985. Studies on the essential oil from *Licaria puchury-major* by gas chromatography/mass spectrometry (GC/MS). *ACTA Amazonica* 15: 179-183. (in Portugese).

Maia JGS, da Silva MHL, Andrade EHA, Carreira LMM. 2005. Essential oil variation in *Lippia glandulosa* Schauer. *Journal of Essential Oil Research* 17: 676-680.

Malagon O, Vila R, Iglesias J, Zaragoza T, Canigueral S. 2003. Composition of the essential oils of four medicinal plants from Ecuador. *Flavour and Fragrance Journal* 18: 527-531.

Mansour ES, Maatooq GT, Khalil AT, Marwan EM, Sallam AA. 2004. Essential oil of *Daucus glaber* Forssk. *Zeitschrift für Naturforschung* 59c: 373-378.

Manzoor-i-Khuda A, Rahman M, Yusuf M, Chaowdhury J. 1986. Studies on essential oil bearing plants of Bangladesh. Part II. Five species of *Cymbopogon* from Bangladesh and the chemical constituents of their essential oils. *Bangladesh Journal of Scientific and Industrial Research* 21: 70-82.

Marotti M, Piccaglia R, Biavati B, Marotti I. 2004. Characterization and yield evaluation of essential oils from different *Tagetes* species. *Journal of Essential Oil Research* 16: 440-444.

Martins ER, Casali VWD, Barbosa LCA, Carazza F. 1997. Essential oil in the taxonomy of *Ocimum selloi* Benth. *Journal of Brazilian Chemical Society* 8: 29-32.

Martins AP, Salgueiro L, Vila R, Tomi F, Canigural S, Casanova J, Da Cunha AP, Adzet T. 1998. Essential oils from four *Piper* species. *Phytochemistry* 49: 2019-2023.

Marzouki H, Piras A, Marongiu B, Rosa A, Dessì MA. 2008. Extraction and separation of volatile and fixed oils from berries of *Laurus nobilis* L. by supercritical CO_2. *Molecules* 13: 1702-1711.

Marzouki H, Piras A, Haj Salah KB, Medini H, Pivetta T, Bouzid S, Marongiu B, Falconieri D. 2009. Essential oil composition and variability of *Laurus nobilis* L. growing in Tunisia, comparison and chemometri investigation of different plant organs. *Natural Product Research* 23: 343-354.

Masoudi S, Rustaiyan A, Ameri N, Monfared A, Komeilizadeh H, Kamalinejad M, Jami-Roodi J. 2002. Volatile oils of *Carum copticum* (L.) C.B. Clarke in Benth. et Hook. and *Semenovia tragioides* (Boiss.) Manden. from Iran. *Journal of Essential Oil Research* 14: 288-289.

Massumi MA, Fazeli MR, Alavi SHR, Ajani Y. 2007. Chemical constituents and antibacterial activity of essential oil of Prangos ferulacea (L.) Lindl. fruits. *Iranian Journal of Pharmaceutical Sciences* 3: 171-176.

Matasyoh LG, Matasyoh JC, Wachira FN, Kinyua MG, Muigai AWT, Mukiama TK. 2007. Chemical composition and antimicrobial activity of the essential oil of *Ocimum gratissimum* L. growing in Eastern Kenya. *African Journal of Biotechnology* 6: 760-765.

Mathela CS, Pande C, Pant AK, Singh AK. 1990. Phenylpropanoids constituents of *Cymbopogon microstachys*. *Journal of Indian Chemical Society* 67: 526-528.

Matsuda H, Morikawa T, Ishiwada T, Managi H, Kagawa M, Higashi Y, Yoshikawa M. 2003. Medicinal Flowers. VIII. Radical scavenging constituents from the flowers of *Prunus mume*: Structure of prunose III. *Chemical and Pharmaceutical Bulletin* 51: 440-443.

Matsumoto F, Idtsuki H, Harada K. 1993. Volatile components of *Hedychium coronarium* Koenig flowers. *Journal of Essential Oil Research* 5: 123-133.

Mazza G. 1983. GCMS investigation of volatile components of myrtle berries. *Journal of Chromatography* 264: 304-311.

Medina AL, Lucero ME, Holguin FO, Estell RE, Posakony JJ, Simon J, O'Connell MA. 2005. Composition and antimicrobial activity of *Anemopsis californica* leaf oil. *Journal of Agricultural and Food Chemistry* 53: 8694-8698.

Medina AL, Holguin FO, Micheletto S, Goehle S, Simon JA, O'Connell MA. 2008. Chemotypic variation of essential oils in the medicinal plant, *Anemopsis californica*. *Phytochemistry* 69: 919-927.

Merle H, Ferriol M, Boira H, Blazquez A. 2006. Composition of the essential oil of *Dictamnus hispanicus* from Spain. *Journal of Essential Oil Research* 18: 483-485.

Metcalf RL. 1990. Chemical ecology of Dacinae fruit flies (Diptera: Tephritidae).

Annals of Entomological Society of America 83: 1017-1030.

Metcalf RL, Mitchell WC, Fukuto TR, Metcalf ER. 1975. Attraction of the oriental fruit fly, *Dacus dorsalis*, by methyl eugenol and related olfactory stimulants. *Proceedings of the National Academy of Sciences USA* 72: 2501-2505.

Metcalf RL, Metcalf ER. 1992. Fruit flies of the family Tephritidae. In: Metcalf RL, Metcalf ER, Editors. *Plant Kairomones in Insect Ecology and Control*. pp. 109-152. Chapman Hall.

Mhamdi B, Wannes WA, Dhiffi W, Marzouk B. 2009. Volatiles from leaves and flowers of Borage (*Borago officinalis* L.). *Journal of Essential Oil Research* 21: 504-506.

Mihara S, Tateba H, Nishimura O, Machii Y, Kishino K. 1987. Volatile components of Chinese quince (*Pseudocydonia sinensis* Schneid). *Journal of Agricultural and Food Chemistry* 35: 532-537.

Miles DH, Kokpol U, Mody NV, Hedin PA. 1975. Volatiles in *Sarracenia flava*. *Phytochemistry* 14: 845-846.

Minott DA, Brown HA. 2007. Differentiation of fruiting and non-fruiting *Pimenta dioica* (L.) Merr. trees based on composition of leaf volatiles. *Journal of Essential Oil Research* 19: 354-357.

Mishra RK, Chaudhary, Pandey R, Gupta S, Mallavarpu GR, Kumar S. 2010. Analysis of linalool content in the inflorescence (flower) essential oil and leaf oil of *Lippia alba* cultivar 'kavach'. *Journal of Essential Oil Research* 22: 3-7.

Mitić V, Đorđević S. 2000. Essential oil composition of *Hyssopus officinalis* L. cultivated in Serbia. *Facta Universitatis Series: Physics, Chemistry and Technology* 2: 105-108.

Miyazawa M, Kameoka H. 1989. Volatile flavor components of crude drugs. Part VII. Volatile flavor components of corni fructus (*Cornus officinalis* Sieb. et Zuec.). *Agricultural and Biological Chemistry* 53: 3337-3340.

Miyazawa M, Kawata J. 2006. Identification of the key aroma compounds in dried roots of *Rubia cordifolia*. *Journal of Oleo Science* 55: 37-39.

Miyazawa M, Minamino Y, Kameoka H. 1996. Volatile components of the rhizomes of *Rheum palmatum* L. *Flavour and Fragrance Journal* 11: 57-60.

Miyazawa M, Kurose K, Itoh A, Hiraoka N. 2001. Comparison of the essential oils of *Glehnia littoralis* from northern and southern Japan. *Journal of Agricultural and Food Chemistry* 49: 5433-5436.

Miyazawa M, Fujita T, Yamafuji C, Matsui M, Kasahara N, Takagi Y, Ishikawa Y. 2004. Chemical composition of volatile oil from the roots of *Periploca sepium*. *Journal of Oleo Science* 53: 511-513.

Moraes LAS, Facanall R, Marques MOM, Ming LC, Meireles MAA. 2002. Phytochemical characterization of essential oil from *Ocimum selloi*. *Anais da Academia Brasileira de Ciências* 74: 183-186.

Moreira DL, Souza PO, Kaplan MAC, Pereira NA, Cardoso GL, Guimaraes EF. 2001. Effect of leaf essential oil from Piper solmsianum C.

Dc. in mice behaviour. *Anais da Academia Brasileira de Ciencias* 73: 33-37.

Moshonas MG, Shaw PE. 1978. Compounds new to essential orange oil from fruit treated with abscission chemicals. *Journal of Agricultural and Food Chemistry* 26: 1288-1290.

Mostafavi A, Afzali D. 2009. Chemical composition of the essential oils of *Rosa damascena* from two different locations in Iran. *Chemistry of Natural Compounds* 45: 110-113.

Moraes LAS, Facanall R, Marques MOM, Ming LC, Meireles MAA. 2002. Phytochemical characterization of essential oil from *Ocimum selloi*. *Anais da Academia Brasileira de Ciências* 74(1): 183-186.

Moreira DL, Souza PO, Kaplan MAC, Pereira NA, Cardoso GL, Guimaraes EF. 2001. Effect of leaf essential oil from *Piper solmsianum* C. Dc. In mice behaviour. *Anais da Academia Brasileira de Ciências* 73: 33-37.

Mostafavi A, Afzali D. 2009. Chemical composition of thate essential oils of *Rosa damascena* from two different locations in Iran. *Chemistry of Natural Compounds* 45: 110-113.

Muckensturm B, Duplay D, Muhammadi F, Moradi A, Robert PC, Simonis MT, Kienlen JC. 1982. Role of natural phenylpropanoids as antifeeding agents for insects. *Colloques de l'INRA* 7: 131-135. (in French).

Naeole CKM, Haymer DS 2003. Use of oligonucleotide arrays for molecular taxonomic studies of closely related species in the oriental fruit fly (*Bactrocera dorsalis*) complex. *Molecular Ecology Notes* 3: 662-665.

Nagasawa M, Murakami T, Ikada K, Hisada Y. 1969. Geographical variation of essential oils of Flos magnoliae. *Yakugaku Zasshi* 89: 454-459.

Najjaa H, Neffati M, Zouari S, Ammar E. 2007. Essential oil composition and antibacterial activity of different extracts of *Allium roseum* L., a North African endemic species. *Comptes Rendus Chimie* 10: 820-826.

Nath SC, Sarma KK, Vajezikova I, Leclercq PA. 2002. Comparison of volatile infrorescence oils and taxonomy of certain *Cymbopogon* taxa described as *Cymbopogon flexuosus* (Nees ex Steud.) Wats. *Biochemical Systematics and Ecology* 30: 151-162.

Newell IM, Haramoto FH. 1968. Biotic factors influencing populations of *Dacus dorsalis* in Hawaii. *Proceedings of the Hawaiian Entomological Society* 20: 81-139.

Ngamo TSL, Noudjou WF, Ngassoum MB, Mapongmestsem PM, Aminatou Boubakaary AB, Malaisse F, Haubruge E, Lognsy G, Hance T. 2007. Investigations on both chemical composition and insecticidal activities of essential oils of *Vepris heterophylla* (Rutaceae) from two localities of northern Cameroon towards *Tribolium castaneum* (Heerbst) (Coleoptera: Tenebrionidae). *Research Journal of Biological Sciences* 2: 57-61.

Ngassoum MB, Ngamo LT, Maponmetsem PM, Jirovetz L, Buchbaluer G. 2003. Investigations of medicinal aromatic plants from Cameroon: GD/Fid, GC/MS and olfactoric analyses of essential oils of *Ocimum* *suave* Willd. (Lamiaceae). *ACTA Pharmaceutica Turica* 45: 69-75.

Ngoh SP, Choo LEW, Pang FY, Huang Y, Kini MR, Ho SH. 1998. Insecticidal and repellent properties of nine volatile constituents of essential oils against the American cockroach, *Periplaneta americana* (L.). *Pesticide Science* 54: 261-268.

Niemeyer HM, 2009. Composition of essential oils from five aromatic species of Asteraceae. *Journal of Essential Oil Research* 21: 350-353.

Nishda R, Tan KH, Serit M, Lajis NH, Sukari AM, Takahashi S, Fukami H. 1988. Accumulation of phenylpropanoids in the rectal glands of male Oriental fruit fly, *Dacus dorsalis*. *Experientia* 44: 534-536.

Nishida R, Tan KH, Takahashi S, Fukami H. 1990. Volatile components of male rectal glands of the melon fly, *Dacus cucurbitae* Coquillett (Diptera: Tephritidae). *Applied Entomology and Zoology* 25: 105-112.

Nishida R, Iwahashi I, Tan KH, 1993. Accumulation of *Dendrobium* (Orchidaceae) flower fragrance in the rectal glands by males of the melon fly, *Dacus cucurbitae* (Tephritidae). *Journal of Chemical Ecology* 19: 713-722.

Nishida R, Tan KH, Wee SL, Hee AKW, Toong YC. 2004. Phenylpropanoids in the fragrance of the fruit fly orchid, *Bulbophyllum cheiri*, and their relationship to the pollinator, *Bactrocera papayae*. *Biochemical Systematics and Ecology* 32: 245-252.

Nivinskienė O, Butkienė R, Gudalevič A, Mockutė D, Meškauskienė V, Grigaliūnaitė B. 2007. Influence of urban environment on chemical composition of *Tilia cordata* essential oil. *Chemija* 18: 44-49.

Nogueira, PCL, Bittrich V, Shepherd GJ, Lopes AV, Marsaiolia AJ. 2001. The ecological and taxonomic importance of flower volatiles of *Clusia species* (Guttiferae). *Phytochemistry* 56: 443-452.

Nor Azah MA, Zaridah MZ, Majid JA, Said AA, Faridz ZM, Rohani A. 2006. Chemical composition of essential oils and their related biological activities. In: Highlights of FRIM's IRPA Projects 2005: 156-160.

Ntezurubanza L, Scheffer JJC, Svendsen AB. 1988. Composition of the essential oils of *Ocimum urticifolium* (Lamiaceae) chemotypes grown in Rwanda. *Botanical Journal of the Linnean Society* 96: 97-104.

Nurdijati S, Tan KH, Toong YC. 1996. Basil plants (*Ocimum* spp.) and their prospects in the management of fruit flies. In: Chua TH, Khoo SG, Editors. *Problems and Management of Tropical Fruit Flies*. pp. 47-51. Kai Wah Press.

Oger JM, Rucginne P, Guinaudeau H. 1994. *Aniba canelilla* (H.B.K.) Mez essential oil: Analysis of chemical constituents, fungistatic properties. *Journal of Essential Oil Research* 6: 493-497.

Ohloff G. 1978. Importance of minor components in flavors and fragrances. *Perfume Flavor* 3: 10-22.

Orankanok W, Chinvinijkul S, Sawatwangkhoungm A, Pinkaew S, Orankanok S. 2009. Application of chemical supplements to enhance *Bactrocera dorsalis* and *B. correcta* sterile males performance in Thailand. Fourth FAO/IAEA Research Co-ordination meetings on “Improving Sterile Male Performance in Fruit Fly SIT Programmes”.

Ozcan MM, Chalchat J-C. 2007. The flavor profile of young shoots, flowerbuds, and unripe fruits of capers growing wild in Turkey. *Chemistry of Natural Compounds* 43: 336-338.

Ozcan M, Bagci Y, Akgul A, Dural H, Novak J. 2000. Chemical composition of the essential oil of *Prangos uechtritzii* Boiss. et Hausskn. fruits from Turkey. *Journal of Essential Oil Research* 12: 183-185.

Ozcan M, Bagci Y, Ertugrul K, Novak J. 2004. Comparison of the leaf, root and fruit oils of *Diplotaenia cachrydifolia* from Turkey. *Journal of Essential Oil Research* 16: 211-213.

Ozek G, Ozek T, Baser KHC, Hamzaoglu E, Duran A. 2007. Composition of the essential oil of *Hippomarathrum cristatum* (DC.) Boiss. *Journal of Essential Oil Research* 19: 540-542.

Ozman M, Chalchar J-C. 2004. Aroma profile of *Thymus vulgaris* L. growing wild in Turkey. *Bulgarian Journal of Plant Physiology* 30: 68-73.

Pai KF, Chen CC, Yang JT, Chen CJ 2004. Green lacewing *Ankylopteryx exquisite* attracted to methyl eugenol. *Plant Protection Bulletin* 46: 93-97.

Paniandy JC, Chane-Ming J, Pieribattesti JC. 2000. Chemical composition of the essential oil and headspace solid-phase microextraction of the guava fruit (*Psidium guajava* L.). *Journal of Essential Oil Research* 12: 153-158.

Paramonov EA, Khalilova AZ, Odinokov VN, Khalilov LM. 2000. Identification and biological activity of volatile organic compounds isolated from plants and insects. III. Chromatography-mass spectrometry of volatile compounds of *Aegopodium podagraria*. *Chemistry of Natural Compounds* 36: 584-586.

Park BS, Lee KG, Shibamoto T, Lee SE, Takeoka GR. 2003. Antioxidant activity and characterization of volatile constituents of taheebo (*Tabebuia impetiginosa* Martius ex DC). *Journal of Agricultural and Food Chemistry* 51: 295-300.

Park I-K, Kim J, Lee S-G, Shin S-C. 2007. Nematicidal activity of plant essential oils and components from ajowan (*Trachyspermum ammi*), allspice (*Pimenta dioica*) and litsea (*Litsea cubeba*) essential oils against pine wood nematode (*Bursaphelenchus xylophilus*). *Journal of Nematology* 39: 275-279.

Pavela R, Sajfrtova M, Sovova H, Barnet M, Karban J. 2010. The insecticidal activity of *Tanacetum parthenium* (l.) Schultz Bip. extracts obtained by supercritical fluid extraction and hydrodistillation. *Industrial Crops and Products* 31: 449-454.

Pedro LG, Santos AG, Da Silva JA, Figueiredo AC, Barroso JG, Deans SG, Looman A, Scheffer JJC. 2001. Essential oils from Azorean *Laurus azorica*. *Phytochemistry* 57: 245-250.

Perez AG, Cert A, Rios JJ, Olias JM. 1997. Free and glycosidically bound volatile compounds from two banana cultivars: Valery and Pequena Enana. *Journal of Agricultural and Food Chemistry* 45: 4393-4397.

Perfumi M, Valentini G, Bellomaria B. 1999. Chemical constituents and spasmolytic activity in guinea-pig ileum of essential oil of *Artemisia alba* from two geographically and ecologically different localities. *Journal of Essential Oil Research* 11: 223-228.

Piccaglla R, Pace P, Tammaro F. 1999. Characterization of essential oils from three Italian ecotypes of Hyssop [*Hyssopus officinalis* L. subsp. *aristatus* (Gordon) Briq.]. *Journal of Essential Oil Research* 11: 693-699.

Pichersky E, Gang DR. 2000. Genetics and biochemistry of secondary metabolites in plants: an evolutionary perspective. *Trends in Plant Science* 5: 439-445.

Picone JM, Clery RA, Watanabe N, MacTavish HS, Turnbull CGN. 2004. Rhythmic emission of floral volatiles from *Rosa damascena* semperflorens cv. 'Quatre Saisons'. *Planta* 219: 468-478.

Pino JA, Quijano CE. 2008. Volatile compounds of *Pourouma cecropiifolia* Mart. fruits from Colombia. *Journal of Essential Oil Research* 20: 242-244.

Pino JA, Marbot R, Aguero J. 2002. Volatile components of baga (*Annona glabra* L.) fruit. *Journal of Essential Oil Research* 14: 252-253.

Pina JA, Mesa J, Munoz Y, Marti MP, Marbot R. 2005. Volatile components from Mango (*Mangifera indica* L.) cultivars. *Journal of Agricultural and Food Chemistry* 53: 2213-2223.

Pripdeevech P, Machan T. 2010. Fingerprint of volatile flavor constituents andantioxidant activities of teas from Thailand. *Food Chemistry* 125: 797-802. DOI: 10.1016/j.foodchem.2010.09.074

Prudent D, Perineau F, Bessiere JM, Michel G, Bravo R. 1993. Chemical analysis, bacteriostatic and fungistatic properties of the essential oil of the Atoumau from Martinique (*Alpinia speciosa* K. Schum.). *Journal of Essential Oil Research* 5: 255-264.

Quilici S, Duyck PF, Franck A. 2004. Preliminary experiments on the influence of exposure to methyleugenol on mating success of males in the peach fruit fly, *Bactrocera zonata*. 1st RCM on improving sterile male performance in fruit fly SIT, Antigua, Guatemala.

Rabha LC, Hazarika AK, Bordoloi DN. 1986. *Cymbogon khasianus* a new rich source of methyl eugenol. *Indian Perfumer* 30: 339-344.

Radriamiharisoa R, Gaydou EM, Bianchini JP, Ravelojaonha G, Vernin G. 1986. Study of the variation in the chemical composition and classification of basil essential oils from Madagascar. *Sciences des Aliments* 6: 221-231. (in French).

Radulescu V, Oprea E. 2008. Analysis of volatile compounds of officinal *Tiliae flos* by gas-chromatography coupled with mass spectrometry. *Farmacia* 56: 129-138.

Radulovic N, Dekic M, Stojanovic-Radic Z, Palic R. 2009.Volatile constituents of *Erodium cicutarium* (L.) L'Herit. (Geraniaceae). *Central European Journal of Biology* 4: 404-410.

Raguso RA, Pichersky E. 1995. Floral volatiles from *Clarkia breweri* and *C. concinna* (Onagraceae): recent evolution of floral scent and moth pollination. *Plant Systematics and Evolution* 194: 55-57.

Raina VK, Kumar A, Srivastava SK, Syamsundar KV, Kahol AP. 2004. Essential oil composition of 'kewda' (*Pandanus odoratissimus*) from India. *Flavour and Fragrance Journal* 19: 434–436.

Raina VK, Verma SC, Dhawan S, Khan M, Ramesh S, Singh SC, Yadav A, Srivastava SK. 2006. Essential oil composition of *Murraya exotica* from the plains of northern India. *Flavour and Fragrance Journal* 21: 140-142.

Rajeswara Rao BT, Kaul PN, Bhattacharya AK, Rajput DK. 2006. Comparative chemical composition of stearm-distilled and water-soluble essential oils of South American marigold (*Tagetes minuta* L.). *Journal of Essential Oil Research* 18: 622-626.

Ramanoelina PA, Viano J, Bianchini J-P, Gaydou EM. 1994. Occurrence of various chemotypes in Niaouli (*Melaleuca quinquenervia*) essential oils from Madagascar using multivariate statistical analysis. *Journal of Agricultural and Food Chemistry* 42: 1177.

Ramanoelina PAJ, Rasoarahona JRE, Gaydou EM. 2006. Chemical composition of *Ravensara aromatica* Soon, leaf essential oils from Madagascar. *Journal of Essential Oil Research* 18: 215-217.

Rao JT, Nigam SS. 1973. Chemical investigation of essential oil recovered from *Ageratum conyzoides*. *Koerperpflegem* 23: 209-210. (in German).

Ravindran PN, Shulaja M, Babu KN, Krishnamoorthy B. 2003. Botany and crop improvement of cinnamon and cassia. In: Ravindran PN, Babu KN, Shylaja M, Editors. *Cinnamomum and Cassia: The genus Cinnamomum*. pp. 80-120. CRC Press.

Reinaldo S, Chavez K, Mateu E, Orsini G, Arvelo F, Suarez AI. 2010. Composition and cytotoxic activity of essential oils from *Croton matourensis* and *Croton micans* from Venezuela. *Records of Natural Products* 4: 101-108.

Reish JD, Bergenthal SK, Adesina D, Akinwusi D, Olatunji AO. 1986. Consitutents of *Fagara macrophylla* and *Zanthoxylum rigidifollum pericarps*. *Journal of Natural Products* 49: 1169-1171.

Ribnicky DM, Poulev A, O'Neal J, Wnorowski G, Malek DE, Jager D, Raskin I. 2004. Toxicological evaluation of the ethanolic extract of *Artemisia dracunculus* L. for use as a dietary supplement and in functional foods. *Food and Chemical Technology* 42: 585-598.

Robison SH, Barr DB. 2006. Use of biomonitoring data to evaluate methyl eugenol exposure. *Environmental Health Perspectives* 114: 1797-1801.

Rodilla JM, Tinoco MT, Morais JC, Gimenez C, Cabrera R, Martın-Benito D, Castillo L, Gonzalez-Coloma A. 2008. *Laurus novocanariensis* essential oil: Seasonal variation and valorization. *Biochemical Systematics and Ecology* 36: 167-176.

Rossi P, Bao L, Luciani A, Panighi J, Desjobert J, Costa J, Casanova J, Bolla J, Berti L. 2007. (E)methylisoeugenol and elemicin: Antibaterial components of *Daucus carota* L. essential oil against *Campylobacter* *jujuni*. *Journal of Agricultural and Food Chemistry* 55: 7332-7336.

Ruff C, Hor K, Weckerle B, Konig T, Schreier P. 2002. Authencity assessment of estragole and methyl eugenol by on-line gas chromtography-isotope ratio mass spectrometry. *Journal of Agricultural and Food Chemistry* 50: 1028-1031.

Russell GF, Jennings WG. 1969. Constituents of Black Pepper – Some oxygenated compounds. *Journal of Agricultural and Food Chemistry* 17: 1107-1112.

Ryan D. 1991. *Aromatherapy - the Encyclopedia of Plants and Oils and How They Help You*. Judy Piatkus Ltd.

Saad H-EA, El-Sharkawy SH, Halim AF. 1995. Essential oils of *Daucus carota* ssp. *maximus*. *Pharmaceutics Acta Helvetiae* 70: 79-84.

Sadeghpour O, Asghari G, Ardekani MR. 2004. Composition of essential oil of *Artemisia persica* Boiss. from Iran. *Iran Journal of Pharmaceutical Research* 3: 65-67.

Saeidnia S, Gohari AR, Yassa N, Shafiee A. 2005. Composition of the volatile oil of *Achillea conferta* DC. from Iran. *DARU Journal of Pharmaceutical Science* 13: 34-36.

Safaei-Ghomi J, Bamoniri A, Hafami A, Batooli H. 2007. Determination of volatile components in Iranian *Rosa hemisphaerica*. *Chemistry of Natural Compounds* 43: 738-740.

Saglam H, Gozler T, Kivcak B, Demirci B, Baser KHC. 2001. Composition of the essential oil of *Haplophyllum myrtifolium*. *Chemistry of Natural Compounds* 37: 439-441.

Sagrero Nieves L, Bartley JP. 1995. Volatile components of avocado leaves (*Persea americana* Mill) from the Mexican race. *Journal of the Science of Food and Agriculture* 67: 49-51.

Saidana D, Mahjoub S, Boussaada O, Chriaa J, Mahjoub MA, Cheraif I, Daami M, Mighri Z, Helal AN. 2008a. Antibacterial and antifungal activities of the essential oils of two Saltcedar species from Tunisia. *Journal of American Oil Chemical Society* 85: 817-826.

Saidana D, Mahjoub MA, Boussaada O, Chriaa J, Cheraif I, Daami M, Mighri Z, Helal AN. 2008b. Chemical composition and antimivrobial activity of volatile compounds of *Tamarix boveana* (Tamaricaceae). *Microbiological Research* 63: 445-455.

Saiki Y, Saito T, Sasaki H, Fukushima S. 1967a. Gas chromatography of natural volatile oils. I. On the volatile oil of Chinese drup "Xixin". *Yakugaku Zasshi* 87: 1524-1528.

Saiki Y, Akakori Y, Noro T, Morinaga K, Taira T, Fukushima S, Harada T. 1967b. Gas chromatography of natural volatile oils. II. *Asiasarum* and *Asarum* genera. *Yakugaku Zasshi* 87: 1529-1534.

Saiki Y, Akakori Y, Morinaga K, Taira T, Noro T, Fudushima S, Harada T. 1967c. Gas chromatography of natural volatile oils. III. Gas chromatograpy of the volatile oils of plants belonging to the *Heteroptera* genus. 1. *Yakugaku Zasshi* 87: 1535-1538.

Saiki Y, Akakori Y, Morinaga K, Taira T, Noro T, Fudushima S, Harada T. 1967d. Gas chromatography of natural volatile oils. IV.

Gas chromatograpy of the volatile oils of plants belonging to the *Heteroptera* genus. 2. *Yakugaku Zasshi* 87: 1539-1543.

Saiki Y, Akakori Y, Morinaga K, Taira T, Noro T, Fudushima S, Harada T. 1967e. Gas chromatography of natural volatile oils. V. Gas chromatograpy of the volatile oils of plants belnging to the *Heteroptera* genus. 3. *Yakugaku Zasshi* 87: 1544-1547.

Sainsbury M, Sofowora EA. 1971. Essential oil from the leaves and inflorescence of *Ocimum gratissimum*. *Phytochemistry* 10: 3309-3310.

Sajjadi SE, Ghannadi A. 2005. Essential oil of the Persian sage, *Salvia rhytidea* Benth. *ACTA Pharmaceutica* 55: 321-326.

Sajjadi SE, Mehregan I. 2003. Chemical composition of the essential oil of *Prangos asperula* Boiss. subsp. *haussknechtii* (Boiss.) Herrnst et Heyn fruits. *DARU Journal of Pharmaceutical Science* 11: 79-81.

Sammy GM, Nawar WW. 1968. Identification of the major components of nutmeg oil by gas chromatography and mass spectrometry. *Chemistry and Industry* 38: 1279-1280.

Sanford KJ, Heinz DE. 1971. Effects of storage on the volatile composition of nutmeg. *Phytochemistry* 10: 1245-1250.

Sangun MK, Aydin F, Timur M, Karadeniz H, Caliskan M, Ozkan A. 2007. Comparison of chemical composition of the essential oil of *Laurus nobilis* L. leaves and fruits from different regions of Hatay, Turkey. *Journal of Environmental Biology* 28: 731-733.

Sarker SD, Armstrong JA, Waterman PG. 1995. (-)-1,12-oxaguai-10(15)-ene: A sesquiterpene from *Eriostemon fitzgeraldii*. *Phytochemistry* 40: 1159-1162.

Saroglou V, Dorizas N, Kypriotakis Z, Skaltsa HD. 2006. Analysis of the essential oil composition of eight *Anthemis* species from Greece. *Journal of Chromatography* 1104: 313-322.

Saxena BP, Koul O, Tikku K, Atal CK. 1977. A new insect chemosterilant isolated from *Acorus calamus* L. *Nature* 270: 512-513.

Scheuer PJ. 1955. The constituents of mokihana (*Pelea anisata* Mann). *Chemistry and Industry* 33: 1257-1258.

Schecter A, Lucier GW, Cunningham ML, Abdo KM, Blumenthal G, Silver AG, Melnick R, Portier C, Barr DB, Barr JR, Stanfill SB, Patterson Jr. DG, Needham LL, Stopford W, Masten S, Mignogna J, Tung KC. 2004. Human consumption of methyleugenol and its elimination from serum. *Environmental Health Perspectives* 112: 678-683.

Schiestl FP. 2010. The evolution of floral scent and insect chemical communication. Ecology Letters 13: 643-656.

Schwerdtfeger M, Gerlach G, Kaiser R. 2002. Anthecology in the Neotropical genus *Anthurium* (Araceae): A preliminary report. *Selbyana* 23: 258-267.

Scrivanti LR, Anton AM, Zygadlo JA. 2009. Essential oil composition of *Bothriochloa* Kuntze (Poaceae) from South America and their chemotaxonomy. *Biochemical Systematics and Ecology* 37: 206-213.

Sellami IH, Maamouri E, Chahed T, Wannes WA, Kchouk ME, Marzouk B. 2009. Effect of growth stage on the content and composition of the essential oil and phenolic fraction of sweet marjoram (*Origanum majorana* L.). *Industrial Crops and Products* 30: 395-402.

Senanayake UM, Lee TH, Wills RBH. 1978. Volatile constituents of Cinnamon (*Cinnamomum zeylanicum*) oils. *Journal of Agricultural and Food Chemistry* 26: 822-824.

Senatore F, Sorta EU, Soria RU, Della Porta G, Taddeo R, De Feo V. 1997. Essential oil of *Eremocharis triradiata* (Wolff.) Johnston (Apiaceae) growing wild in Peru. *Flavour and Fragrance Journal* 12: 257-259.

Senatore F, De Feo V. 1999. Chemical composition of the essential oil from *Tagetes mandonii* Sch. Bip. (Asteraceae). *Flavour and Fragrance Journal* 14: 32-34.

Sezik E, Basaran A. 1985. Phytochemical investigations on the plants used as folk medicine and herval tea in Turkey. II. Essential oil of *Stachys lavandulfolia* Vahl var. lavandulifolia. *Istanbul Universitesi Eczacilik Fakültesi Mecmuasi* 21: 98-107.

Sezik E, Usun O, Demirci B, Baser KHC. 2010. Composition of the oils of *Pinus nigra* Arnold from Turkey. *Turkey Journal of Chemistry* 34: 313-325.

Shatar S, Altantsetseq S, Dung NX, Ngoc PH, Klinkby N, Leclercq PA. 2002. The essential oil of *Artemisia subdigitata* Mattf. from Mongolian the desrt-Gobi. *Journal of Essential Oil Research* 14: 99-100.

Sharma ML, Rawat AKS, Blalasubrhmanyam VR, Singh A. 1983. Studies on essential oil of betel vine leaf (*Piper betle* Linn.). *Indian Perfumer* 27: 91-93.

Shatar S, Altantsetseg S. 2000. Essential oil composition of some plants cultivated in Mongolian climate. *Journal of Essential Oil Research* 12: 745-750.

Shaver TN, Bull DL. 1980. Environmental fate of methyl eugenol. *Bulletin of Environmental Contamination and Toxicology* 24: 619-626.

Shelly TE. 2010. Effects of methyl eugenol and raspberry ketone/cue lure on the sexual behavior of *Bactrocera* species (Diptera: Tephritidae). *Applied Entomology and Zoology* 45: 349-361.

Shelly TE, Dewire A-LM. 1994. Chemically mediated mating success in male Oriental fruit flies (Diptera: Tephritidae). *Annals of the Entomological Society of America* 87: 375-382.

Shelly TE, Dewire A-LM. 2000. Flower-feeding affects mating performance in male Oriental fruit flies (Diptera: Tephritidae). *Ecological Entomology* 25: 109-114.

Shelly TE, Edu J, McInnis D. 2010. Pre-release consumption of methyl eugenol increases the mating competitiveness of sterile males of the oriental fruit fly, *Bactrocera dorsalis*, in large field enclosures. *Journal of Insect Science* 10: 8. Available online, insectscience.org/10.8

Shum ACS, Smadja J. 1992. Volatile constituents of Faham (*Jumellea fragrans* (Thou.) Schltr.). *Journal of Agricultural and Food Chemistry* 40: 642-646.

Siderhurst MS, Jang EB. 2006. Female-biased attraction of Oriental fruit fly, *Bactrocera dorsalis* (Hendel), to a blend of host fruit volatiles from *Terminalia catappa* L. *Journal of Chemical Ecology* 32: 2513-2524.

Silou T, Loubak L, Figueredo G, Chalchat J-C. 2006. Study of essential oil composition of *Elyonurus hensii* Schum from Congo. *Journal of Essential Oil Research* 18: 518-520.

Silva CGV, Zago HB, Junior HJGS, Da Camara CAG, De Oliverira JV, Barros R, Schwartz MOE, Lucena MFA. 2008. Composition and insecticidal activity of the essential oil of *Croton grewloides* Baill. against Mexican bean weevil (*Zabrotes subfasciatus* Boheman). *Journal of Essential Oil Research* 20: 179-182.

Simon JE, Morales MR, Phippen WB, Vieira RF, Hao Z. 1999. Basil: A source of aroma compounds and a popular culinary and ornamental herb. In: Janick J, Editor. *Perspectives on New Crops and New Uses*. pp. 499–505. ASHS Press.

Simonsen HT, Adsersen A, Bremner P, Heinrich M, Wagner SU, Jaroszewski JW. 2004. Antifungal constituents of *Melicope borbonica*. *Phytotherapy Research* 18: 542-545.

Sinchaisri P, Areekul S. 1985. Natural attractants in *Colocasia exculenta* blossom for the Oriental fruit fly, *Dacus dorsalis* Hendel. *Thai Agricultural Research Journal* 3: 182-190.
(in Thai with English Abstract).

Singh AK, Yadaw A. 2005. Composition of essential oils from different parts of *Thuja orientalis* (L.) syn. *Biota orientalis* Endl. *Indian Perfumer* 49: 173-177.

Singh G, Kapoor IPS, Singh P, de Heluani CS, de Lampasona MP, Catalan DAN. 2008. Chemistry, antioxidant and antimicrobial investigations on essential oil and oleoresins of *Zingiber officinale*. *Food Chemistry and Toxicology* 46: 3295-3302.

Smith RL, Adamsb TB, Doullc J, Ferond VJ, Goodmane JJ, Marnettf LJ, Portogheseg PS, Waddellh WJ, Wagneri BM, Rogers AE, Caldwellk J, Sipesl IG. 2002. Safety assessment of allylalkoxybenzene derivatives used as flavouring substances - methyl eugenol and estragole. *Food and Chemical Toxicology* 40: 851-870.

Smitt UW. 1995. A chemotaxonomic investigation of *Thapsia villosa* L., Apiaceae (Umbelliferae). *Botanical Journal of the Linnean Society* 119: 367-377.

Sobti SN, Khosla MK, Pushpangadan P, Thapa RK. 1981. Search for new aroma chemicals from *Ocimum* species. II. Essential oil of American species of *O. carnosum* Lk. et Otto. *Herba Hungaria* 20: 49-56.

Sookar P, Alleck M, Ahseek N, Khayrattee FB, Permalloo S. 2009. Improving male reproductive performance of *Bactrocera zonata* and *Bactrocera cucurbitae*. Fourth FAO/IAEA Research Co-ordination meetings on "Improving Sterile Male Performance in Fruit Fly SIT Programmes".

Srivastava AK, Srivastava SK, Syamsundar KV. 2006. Volatile composition of *Curcuma angustifolia* Roxb. Rhizome from central and southern India. *Flavour and Fragrance Journal* 21: 423-426.

Staniszewska M, Kula J. 2001. Composition of the essential oil from wild carrot umbels (*Daucus carota* L. ssp. Carota) growing in Poland. *Journal of Essential Oil Research* 13: 439-441.

Stashenko EE, Martınez JR, Ruız CA, Arias G, Duran C, Salgar W, Cala M. 2010. *Lippia origanoides* chemotype differentiation based on essential oil GC-MS and principal component analysis. *Journal of Separation Science* 33: 93-103.

Steiner LF. 1969. A method of estimating the size of native populations of Oriental, Melon and Mediterranean fruit flies, to establish the overflooding ratios required for sterile-male releases. *Journal of Economic Entomology* 62: 4-7.

Steiner LF, Mitchell WC, Harris EJ, Kozuma TT, Fujimoto MS. 1965. Oriental fruit fly eradication by male annihilation. *Journal of Economic Entomology* 58: 961-964.

Suanarunsawat T, Ayutthaya WDN, Songsak T, Thirawarapan S, Poungshompoo S. 2010. Antioxidant activity and lipid-lowering effect of essential oils extracted from *Ocimum sanctum* Linn. leaves in rats fed with a high cholesterol diet. *Journal of Clincal Biochemistry and Nutrition* 46: 52-59.

Suarez C, Enrique L. 1980. Hydrosyotobain and reticuline from *Ocotea caparrapi*. *Revista Latinoamericana de Quimica* 11: 110-111. (in Spanish).

Suarez M, Bonilla J, De Diaz AMP, Achenbach H. 1983. Studies of Colobian Lauraceae. Dehydrodieugenols from *Nectandra polita*. *Phytochemistry* 22: 609-610.

Suárez AI, Vásquez LJ, Manzano MA, Compagnone RS. 2005. Essential oil composition of *Croton cuneatus* and *Croton malambo* growing in Venezuela. *Flavour and Fragrance Journal* 20: 607-610.

Suarez AI, Vasquez LJ, Taddei A, Arvelo F, Compagnone RS. 2008. Antibacterial and cytoxic activity of leaf essential oil of *Croton malambo*. *Journal of Essential Oil-Bearing Plants* 11: 208-213.

Suda DY, Cunningham RT. 1970. *Chrysopa basalis* captured in plastic traps containing methyl eugenol. *Journal of Economic Entomology* 63: 1706.

Sudhakar P, Latha P, Sreenivasulu Y, Reddy BV, Hemalaatha TM, Balakrishna M, Reddy KR. 2009. Inhibition of *Aspergillus flavus* colonization and aflatoxin (AfB1) in peanut by methyleugenol. *Indian Journal of Experimental Biology* 47: 63-67.

Sukari MA, Takahashi S. 1988. Biological activity of some Malaysian plant extracts. *Pertanika* 11: 249-253.

Suliman FEO, Fatope MO, Al-Saidi SH, Al-Kindy SMZ. 2006. Composition and antimicrobial activity of he essential oil of *Pluchea arabica* from Oman. *Flavour and Fragrance Journal* 21: 469-471.

Svendsen CE, Baerheim A. 1990. The essential oil of *Lippia alba* (Mill.) N.E. Br. *Journal of Essential Oil Research* 2: 265-267.

Taarit MB, Msaada K, Hosni K, Hammanmi M, Kchouk ME, Marzouk B. 2009. Plant growth, essential oil yield and composition of sage (*Salvia officinalis* L.) fruits cultivated under salt stress conditions. *Industrial Crops and Products* 30: 333-337.

Taarit MB, Msaada K, Hosni K, Chahed T, Marzouk B. 2010. Essential oil composition of *Salvia verbenaca* L. growing wild in Tunisia. *Journal of Food Biochemistry* 34: 142-151.

Tabanca N, Kirimer N, Demira B, Demirci F, Baser KHC. 2001. Composition and antimicrobial activity of the essential oils of *Micromeria cristata* subsp. *phrygia* and the enantiomeric distribution of borneol. *Journal of Agricultural and Food Chemistry* 49: 4300-4303.

Tabanca N, Demirci B, Kirimer N, Baser KHC, Bedir E, Khan IA, Wedge DE. 2005a. Gas chromatographic-mass spectrometric analysis of essential oils from *Pimpinella aurea*, *Pimpinella corymbosa*, *Pimpinella peregina* and *Pimpinella puberula* gathered from eastern and southern Turkey. *Journal of Chromatography A* 109: 192-198.

Tabanca N, Douglas AW, Bedir E, Dayan FE, Kirimer N, Baser KHC, Aytac Z, Khan IA, Scheffler BE, 2005b. Patterns of essential oil relationships in *Pimpinella* (Umbelliferae) based on phylogenetic relationships using nuclear and chloroplast sequences. *Plant Genetic Resources* 3: 149–169.

Tabanca N, Demirci B, Baser KHC, Aytac Z, Ekici M, Khan SI, Jacob MR, Wedge DE. 2006. Chemical composition and antifungal activity of *Salvia macrochlamys* and *Salvia recognita* essential oils. *Journal of Agricultural and Food Chemistry* 54: 6593-6597.

Talenti ECJ. 1982. Study of the essential oil of *Pluchea sagittalis* (Lamarck) Cabrera. 9. *Essenze Derivati Agrumari* 52: 21-51. (in Spanish).

Talenti ECJ, Mancini PME, Retamar JA. 1981. Study of the essential oil of *Acacia caven*. *Essenze Derivati Agrumari* 51: 98-100. (in Spanish).

Tan KH. 1985. Estimation of native populations of male *Dacus* spp. by Jolly's stochastic method using a new designed attractant trap in a village ecosystem. *Journal of Plant Protection in the Tropics* 2: 87-95.

Tan KH. 2003. Interbreeding and DNA analysis of *Bactrocera dorsalis* sibling species. In: *Recent Trends on Sterile Insect Technique and Area-Wide Integrated Pest Management - Economic Feasibility, Control Projects, Farmer Organization and Bactrocera dorsalis Complex Control Study*. pp. 113-122. Research Institute for the Subtropics.

Tan KH. 2009. Fruit fly pests as pollinators of wild orchids. *Orchid Digest* 73: 180-187.

Tan KH, Jaal Z. 1986. Comparison of male adult population densities of the Oriental and *Artocarpus* fruit flies, *Dacus* spp. (Diptera: Tephritidae), in two nearby villages in Penang, Malaysia. *Researches on Population Ecology* 25: 85-89.

Tan KH, Lee SL. 1982. Species diversity and abundance of *Dacus* (Diptera: Tephritidae) in five ecosystems of Penang, Malaysia. *Bulletin of Entomological Research* 72: 709-716.

Tan KH, Nishida R. 1996. Sex pheromone and mating competition after methyl eugenol consumption in *Bactrocera dorsalis* complex. In: McPheron BA, Steck GJ, Editors. *Fruit Fly Pests – A World Assessment of their Biology and Management*. pp. 147-153. St. Lucie Press.

Tan KH, Nishida R. 1998. Ecological significance of a male attractant in the defence and mating strategies of the fruit fly pest, *Bactrocera papayae*. *Entomologia Experimentalis et Applicata* 89: 155-158.

Tan KH, Nishida R. 2000. Mutual reproductive benefits between a wild orchid, *Bulbophyllum patens*, and *Bactrocera* fruit flies via a floral synomone. *Journal of Chemical Ecology* 26: 533-546.

Tan KH, Nishida R. 2005. Synomone or Kairomone? - *Bulbophyllum apertum* (Orchidaceae) flower releases raspberry ketone to attract *Bactrocera* fruit flies. *Journal of Chemical Ecology* 31: 509-519.

Tan KH, Nishida R. 2007. Zingerone in the floral synomone of *Bulbophyllum baileyi* (Orchidaceae) attracts *Bactrocera* fruit flies during pollination. *Biochemical Systmatics and Ecology* 35: 334-341.

Tan KH, Serit M. 1988. Movements and population density comparisons of native male adult *Dacus dorsalis* and *Dacus umbrosus* (Diptera: Tephritidae) between three ecosystems in Tanjong Bungah, Penang. *Journal of Plant Protection in the Tropics* 5: 17-21.

Tan KH, Serit M. 1994. Adult population dynamics of *Bactrocera dorsalis* (Diptera: Tephritidae) in relation to host phenology and weather in two villages of Penang Island, Malaysia. *Environmental Entomology* 23: 267-275.

Tan KH, Nishida R, Toong YC. 2002. *Bulbophyllum cheiri*'s floral synomone lures fruit flies to perform pollination. *Journal of Chemical Ecology* 28: 1161-1172.

Tan KH, Tan LT, Nishida R. 2006. Floral phenylpropanoid cocktail and architecture of *Bulbophyllum vinaceum* orchid in attracting fruit flies for pollination. *Journal of Chemical Ecology* 32: 2429-2441.

Tan KH, Tokushima I, Ono H, Nishida R. 2011a. Comparison of phenylpropanoid volatiles in male rectal pheromone gland after methyl eugenol consumption, and molecular phylogenetic relationship of four global pest fruit fly species - *Bactrocera invadens*, *B. dorsalis*, *B. correcta* and *B. zonata*. *Chemoecology* 21: 25-33.

Tan, K.H., Wee, S.L., Hee, A.K.W., Ono, H., Tokushima, I., Nishida, R. 2011b. Comparison of male sex pheromonal components after methyl eugenol consumption in seven highly invasive *Bactrocera* species. 6th Asia-Pacific Conference on Chemical Ecology, October 11-15, 2011, Beijing, China. Available online, http://apace-news.org/archives/APACE2011_program_and_abstracts.pdf

Tanker N, Tanker M, Sener B, Svendsen AB. 1976. Gas-liquid chromatographic research on the volatile oil of *Echinophora tenuifolia* subsp. *sibthorpiana* (Umbelliferae). *Ankara Universitesi Eczacilik Fakültesi Mecmuasi* 6: 161-180. (in Turkish).

Tellez MR, Estell RE, Fredrickson EL, Havstad KM. 1997. Essential oil of *Dyssodia acerosa* DC. *Journal of Agricultural and Food Chemistry* 45: 3276-3278.

Thongdon-A J, Inprakhon P. 2009. Composition and biological activities of essential oils from *Limnophila geoffrayi* Bonati. *World Journal of Microbiology and Biotechnology* 25: 1313-1320.

Thoppil JE. 1997. Essential oil compositon of *Moschosma polystachya* (L). Benth. *Indian Journal of Pharmceutical Sciences* 59: 191-192.

Tian Z, Dong SN, Wang BR, Lou ZC. 1981a. Identification of the constituents of volatile oils from Chinese *Asarum* species. I. Volatile oil from Liao xixin, *Asarum hertropoides* var. *mandshuricum*. *Pei-ching I Hsueh Yuan Hsueh Pao* 13: 179-182. (in Chinese).

Tian Z, Dong SN, Wang BR, Lou ZC. 1981b. Identification of the constituents of volatile oils from Chinese *Asarum* species. II. Volatile oil from huaxixin, *Asarum sieboldii*. *Beijing Yixueyuan Xuebao* 13: 282-284. (in Chinese).

Torrado A, Saurez M, Duque C, Krajewski D, Neugebauer W, Schreier P. 1995. Volatile constituents from Tamarillo (*Cyphomandra betacea* Sendtn.) fruit. *Flavour and Fragrance Journal* 10: 349-354.

Tram Ngoc LY, Yamauchi R. Kato K. 2001. Volatile components of the essential oils in Galanga (*Alpinia officinarum* Hance) from Vietnam. *Food Science and Technology Research* 7: 303-306.

Treutter D. 2005. Significance of flavonoids in plant resistance and enhancement of their biosynthesis. *Plant Biology* 7: 581-591.

Trusheva B, Popova M, Bankova V, Simova S, Marcucci MC, Miorin PL, Pasin FR, Tsvetkova I. 2006. Bioactive constituents of Brazilian red propolis. *Evidence-based Complementary and Alternative Medicine* 3: 249-254.

Tucker AO, Maciarello MJ. 1997. Volatile oils of *Illicium floridanum* and *I. parviflorum* (Illiciaceae) of the southeastern United States and their potential economic utilization. *Economic Botany* 53: 435-436.

Tucker AO, Maciarello MJ, Clancy K. 1999. Sweet goldenros (*Solidago odora*, Asteraceae): A medicine, tea and state herb. *Economic Botany* 53: 281-284.

Tucker AO, Maciarello MJ, Adams RP, Landrynm LR, Zanoni TA. 1991. Volatile leaf oils of Caribbean Myrtaceae. I. Three varities of *Pimenta racemosa* (Miller) J. Moore of the Dominican Republic and the commercial bay oil. *Journal of Essential Oil Research* 3: 323-329.

Tutupalli LV, Brown JK, Chaubal MG. 1975. Essential oil of *Saururus cernuus*. *Phytochemistry* 14: 595-596.

Tutupalli LV, Chaubal MG, Malone MH. 1975. Saururaceae. VI. Hippocratic screening of *Anemopsis californica*. *Lloydia* 38: 352-354.

Tzakou O, Loukis A, Argyriadou N. 1993. Volatile constituents of *Achillea crithmifolia* flowers from Greece. *Journal of Essential Oil Research* 5: 345-346.

Tzakou O, Loukis A, Said A. 2007. Essential oil from the flowers and leaves of *Cassia fistula* L. *Journal of Essential Oil Research* 19: 360-361.

Ueyama Y, Hashimoto S, Nii H. 1990. The chemical composition of the essential oil of *Daphne genkwa* Sieb. et Zucc. *Journal of Essential Oil Research* 2: 247-250.

Vagionas K, Ngassaoa O, Runyoro D, Graikou K, Gortzi O, Chinou I. 2007. Chemical analysis of edible aromatic plants growing in Tanzania. *Food Chemistry* 105: 1711-1717.

van Dort HM, Jiigers PP, ter Heide R, van der Weerdt AJA. 1993. *Narcissus trevithian* and *Narcissus geranium*. Analysis and synthesis of compounds. *Journal of Agricultural and Food Chemistry* 41: 2063-2075.

Vanhaelen M, Vanhaelen-Fastre R. 1980. Constituents of essential oil of *Myrtus communis*. *Planta Medica* 39: 164-167.

Vargas RI, Shelly TE, Leblanc L, Pinero JC. 2010. Recent advances in methyl eugenol and cue-lure technologies for fruit fly detection, monitoring, and control in Hawaii. Vitamins and Hormones: 83: 575-596.

Verghese A. 1998. Methyl eugenol attracts female mango fruit fly, *Bactrocera dorsalis* Hendel. *Insect Environment* 4: 101.

Verite P, Nacer A, Kabouche Z, Seguin E. 2004. Composition of seeds and stems essential oils of *Pituranthos scoparius* (Cross. & Dur.) Schinz. *Flavour and Fragrance Journal* 19: 562-564.

Vernin G, Vernin C, Pieribattesti JC, Roque C. 1998. Analysis of the volatile compounds of *Psidium cattleianum* Sabine fruit from Reunion Island. *Journal of Essential Oil Research* 10: 353-362.

Vilegas JHY, Lancas FM, Vilegas W. 1998. Composition of the volatile compounds from *Aniba canelilla* (H.B.K.) Mez. Extracted by CO_2 in the supercritical state. *Revista Brasileira de Farmacognosia* 7-8: 13-19.

Viljoen AM, Moolla AF, van Vuuren SL, van Zyl R, Baser KHC, Demici B, Ozek T, Trinder-Smith T. 2006. The biological activity and essential oil composition of 17 Agathosma (Rutaceae) species. *Journal of Essential Oil Research* 18: 2-16.

Viña A, Murillo E. 2003. Essential oil composition from twelve varieties of basil (*Ocimum* spp) grown in Colombia. *Journal of Brazilian Chemical Society* 14: 744-774.

Vinutha AR, Von Rudloff E. 1968. Gas-liquid chromatography of terpenes. XVII. Volatile oil of the leaves of *Juniperus virginiana*. *Canadian Journal of Chemistry* 46: 3743-3750.

Viswanathan MB, Maridass M, Thangadurai D, Ramesh N. 2002. Chemical constituents of the fruit essential oil of *Diospyros malabarica* (Desr.) Kostel (Ebenaceae). *ACTA Pharmaceutica* 52: 207-211.

Von Bulow MV, Franca NC, Gottlieb OR, Suarez AMP. 1973. Guianan: A neolignan from *Aniba guianensis*. *Phytochemistry* 12: 1805-1808.

Von Guelow MV, Franca NC, Gottlieb OR, Saurez AMP. 1973. Chemistry of Brazilian Lauraceae. XXIV. Guianin. Neolignan from *Aniba guinensis*. *Phytochemistry* 12: 1805-1808.

Vuts J, Imrei Z, Toth M. 2010. New co-attractants synergizing attraction of *Cetonia aurata aurata* and *Potosia cuprea* to the known floral attractant. *Journal of Applied Entomology* 134: 9-15.

Wakayama S, Namba S, Ohno M. 1970. Odorous constituents of lilac flower oil. *Nippon Kagaku Zasshi* 92: 256-259. (in Japanese).

Wang DJ, 1979. Studies on the constituents of the essential oils of four aromatic flowers. *K'o Hsssueh Fa Chan Yueh K'an* 7: 1036-1048. (in Chinese).

Wang J, Dudareva N, Bhakta S, Raguso RA, Pichersky E. 1997. Floral scent production in *Clarkia breweri* (Onagraceae). II. Localization and developmental modulation of the enzyme SAM: (Iso)Eugenol O-methyltransferase and phenylpropanoid emission. *Plant Physiology* 114: 213-221.

Wang D, Wang X, Xia X. 1997. Analysis of season variation of methyleugenol and safrole in *Asarum heterotropoides* by gas chromatography. *Chinese Journal of Chromatography* 15: 85-86. (in Chinese with English summary).

Wannes WA, Mhamdi B, Marzouk B. 2009. Variations in essential oil and fatty acid composition during *Myrtus communis* var. *italica* fruit maturation. *Food Chemistry* 112: 621-626.

Wannes WA, Mhamdi B, Sriti J, Marzouk B. 2010. Changes in essential oil composition of Tunisian *Myrtus communis* var. *italica* L. during its vegetative cycle. *Journal of Essential Oil Research* 22: 13-18.

Wannes WA, Mhamdi B, Sriti J, Jemia MB, Ouchikh O, Hamdaoui G, Kchouk ME, Marzouk B. 2010. Antioxidant activities of the essential oils and methanol extracts from myrtle (*Myrtus communis* var. *italica* L.) leaf, stem and flower. *Food and Chemical Toxicology* 48: 1362-1370.

Weyerstahl P, Marschall H. 1992. Constituents of the leaf extract of *Amomyrtus meli* (R. A. Philippi) Legrand et Kausel, *Amomyrtus luma* (Molina) Legrand et Kausel and of *Amomyrtella guili* (Speg.) Kausel. *Flavour and Fragrance Journal* 7: 247-251.

Weyerstahl P, Marschall-Weyerstahl H, Manteuffel E, Kaul VK. 1992. Constituents of the essential oil of *Strobilanthes callosus* Nees. *Journal of Essential Oil Research* 4: 281-285.

Wee SL, Tan KH, Nishida R. 2007. Pharmacophagy of methyl eugenol by males enhances sexual selection of *Bactrocera carambolae* (Diptera: Tephritidae). *Journal of Chemical Ecology* 33: 1272-1282.

Williams NH, Whitten WM. 1983. Orchid floral fragrances and male euglossine bees: methods and advances in the sesquidecade. *Biological Bulletin* 164: 355-395.

Wilson LA, Senechal NP, Widrlechner MP. 1992. Headspace analysis of the volatile oils of *Agastache*. *Journal of Agricultural and Food Chemistry* 40: 1362-1366.

Wu CS, Wang Y, Zhan DW, Sun SW, Ma YP, Chen J. 1985. The main components of the essential oil from *Rosa rugosa* Thunb. *Zhiwu Xuebao* 27: 510-515. (in Chinese).

Wu SJ, Kao YH, Li TY, Yang CC. 1981. Study on the chemical constituents in the volatile oil of *Michelia hedyosperma* Law. *Chung Ts'ao Yao* 12: 8-10.

Wu S, Watanabe N, Mita S, Ueda Y, Shibuya M, Ebizuka Y. 2003. Two O-methyltransferases isolated from flower petals of *Rosa chinensis* var. *spontanea* involved in scent biosynthesis. *Journal of Bioscience and Bioengineering* 96: 119-128.

Yaacob KB, Zakaria Z, Ramli Z. 1990. Major constituents of *Cinnamomum parthenoxylon* wood oil. *Journal of Essential Oil Research* 2: 51.

Yano K. 1987. Minor components from growing buds of *Artemisia capillaris* that act as insect antifeedants. *Journal of Agricultural and Food Chemistry* 35: 889-891.

Yassa N, Akhani H, Aqaahmadi M, Salimian M. 2003. Essential oils from two endemic species of Apiaceae from Iran. *Zeitschrift Naturforschung* 58: 459-463.

Yomogida K. 1992. Scent of modern roses. *Koryo* 175: 65-89. (in Japanese).

Yu J, Lei J, Yu H, Cai X, Zou G. 2004. Chemical composition and antimicrobial activity of the essential oil of *Scutellaria barbata*. *Phytochemistry* 65: 881-884.

Zabaras D, Wyllie SG. 2001. The effect of mechanical wounding on the composition of essential oil from *Ocimum minimum* L. leaves. *Molecules* 6: 79-86.

Zabka M, Pavela R, Slezakova L. 2009. Antifungal effect of *Pimenta dioica* essential oil against dangerous pathogenic and toxinogenic fungi. *Industrial Crops and Products* 30: 250-253.

Zanoni TA, Adams RP. 1991. Essential oils of plants from Hispaniola: 5. The volatile leaf oil of *Lepechinia urbanii* (Briq.) Epling (Lamiaceae). *Flavour and Fragrance Journal* 6: 75-77.

Zhang F, Xu Q, Fu S, Ma X, Xiao H, Liang X. 2005. Chemical constituents of the essential oil of *Asarum forbesii* Maxim (Aristolochiaceae). *Flavour and Fragrance Journal* 20: 318-320.

Zhao C-X, Li X-N, Liang Y-Z, Fang H-Z, Huang L-F, Guo F-Q. 2006. Comparative analysis of chemical components of essential oils from different samples of *Rhododendron* with the help of chemometrics methods. *Chemometrics and Intelligent Laboratory Systems* 82: 218-228.

Zhao C, Zeng Y, Wen M, Li R, Liang Y, Li C, Zeng Z, Chau F-T. 2009. Comparative analysis of essential oils from eight herbal medicines with pungent flavor and cool nature by GC-MS and chemometric resolution methods. *Journal of Separation Science* 32: 660-670.

Zhao M-M, Liu XL, Cul C, Luo W. 2007. Composition and antimicrobial activity of essential oil from *Phyllanthus emblica* L., by supercritical CO_2 extraction. *Journal of South China University of Technology* 35: 116-120.

Zhou G-D, Moorthy B, Bi J, Donnelly KC, Randerath K. 2007. DNA adducts from alkoxyallybenzene herb and spice constituents in cultured human (HepG2) cells. *Environmental and Molecular Mutagenesis* 48: 715-712.

Zhou H, Huang K, Pan Z, Huang G, Guan S, Su T, Lin C. 2008. Analysis of essential oil from the fruit peel of *Clausena indica* (Datz.) Oliv by gas chromatography-mass spectrometry. *Jingxi Huagong* 25: 65-67. (in Chinese with English summary).

Zhu L, Lu B, Xu D. 1982. Preliminary study on the chemical constituents of the essential oil of *Michelia alba* DC. *Zhiwu Xuebao* 24: 355-359. (in Chinese).

Zimowska GJ, Handler AM. 2005. PiggyBac transposons in *Bactrocera dorsalis* and their use for species identification. Abstract in 8th Exotic Fruit Fly Symposium.

Zoghbi MDGB, Andrade EHA. 2006. Essential oil composition of *Bacopa axillaris* (Benth.) Standl. *Journal of Essential Oil Research* 18: 142-143.

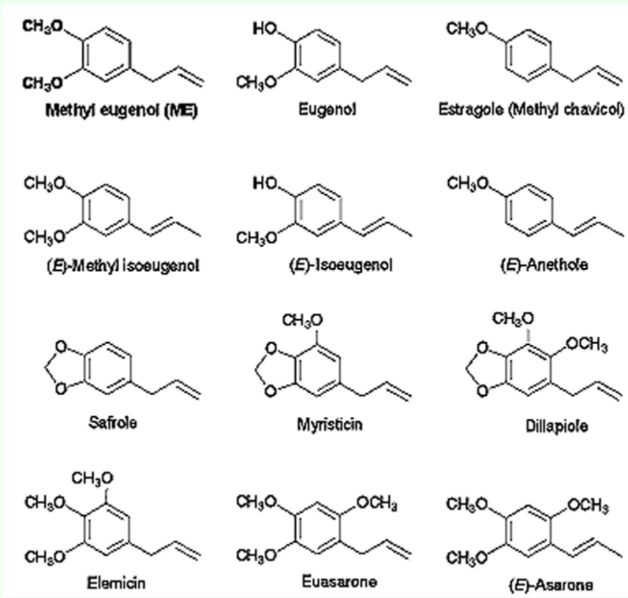

Figure 1. Chemical structures of methyl eugenol (ME) and its analogs. High quality figures are available online.

Figure 3. A male *Bactrocera* umbrosa feeding on *Spathiphyllum cannaefolium spadix*. High quality figures are available online.

Figure 2. Male fruit flies (*Bactrocera dorsalis* and *Bactrocera umbrosa*) feeding along yellow–brown border of an infected leaf of *Proiphys amboinensis*. High quality figures are available online.

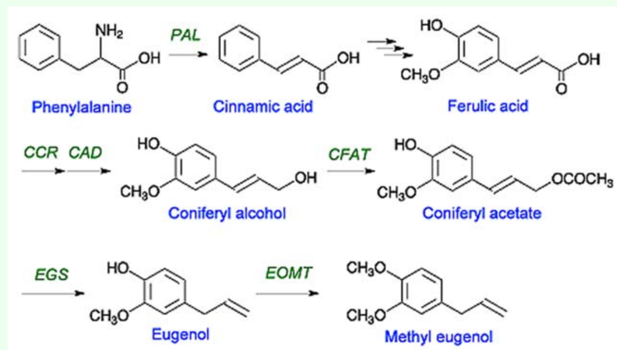

Figure 4. A possible biosynthetic pathway of methyl eugenol in an orchid flower of a bactrocerophilous *Bulbophyllum* species. **PAL**, phenylalanine ammonia lyase; **CCR**, cinnamoyl-CoA reductase; **CAD**, cinnamyl alcohol dehydrogenase; **CFAT**, coniferyl alcohol acyltransferase; **EGS**, eugenol synthase; **EOMT**, eugenol O-methyltransferase. High quality figures are available online.

Figure 5. A male *Bactrocera dorsalis* bearing pollinia on see–saw lip of *Bulbophyllum* patens. High quality figures are available online.

Figure 6. Male fruit flies, *Bactrocera dorsalis*, congregating and licking on a fully bloomed *Bulbophyllum cheiri* flower. High quality figures are available online.

Figure 8. Flower of *Bulbophyllum vinaceum* with its spring–loaded lip in a closed position and a pollinarium–bearing fruit fly, *Bactrocera dorsalis*. High quality figures are available online.

Figure 7. Male *Bactrocera dorsalis* bearing pollinia of *Bulbophyllum cheiri*. High quality figures are available online.

Figure 9. A male *Bactrocera dorsalis* bearing a pollinarium just removed from the *Bulbophyllum elevatopuntatum* flower (P.T. Ong). High quality figures are available online.

Table 1. Plant family (order) and species containing methyl eugenol (ME)*.

Species (Synonym) [Common name]	Remark**	Reference
Acanthaceae - Acanthus family (Lamiales)		
Justicia ventricosa	Plant attracted the oriental fruit fly and volatile oil contained 8.0% ME.	Kittibamruangsook 1980
Strobilanthes callosus (*Carvia callosa*)	Combined leaf & stem at pre- and post-flowering stages had ME 0.04 and 0.16% of EO, resp.	Weyerstahl et al. 1992.
Acoraceae - Calamus family (Acorales)		
Acorus calamus [Sweet flag]	ME present (1.0%); plant EO had 1.0% ME; root EO of up to 80% ME in European & Japanese samples.	Saxena et al. 1977; De Vincenzi et al. 2000; Duke 1985
Acorus gramineus [Japanese sweet flag]	ME (0.64 %) in EO from rhizomes.	Koo et al. 2003
Amaryllidaceae -Amaryllis/ Daffodil family (Asparagales)		
Proiphys amboinensis (*Eurycles amboinensis*) [Cardwell/Christmas Lily]	Green leaf had ME in tr, but during leaf browning, yellow and brown parts had 0.1 and 0.2-0.3 µg/mg.	Chuah et al. 1997
Anacardiaceae – Sumac family (Sapindales)		
Mangifera indica [Mango]	Leaf EO contained ME; Fruit EO of 10 from 20 CVs had ME in tr.	Craveiro et al. 1980; Pino et al. 2005
Pistacia lentiscus [Mastic tree]	ME of aerial parts EO from 4 areas tr and 0.18% in another area in Sardinia, Italy; leaves and fruits had ME at 1.97 & 0.79% of EO, resp.	Barra et al. 2007; Fleisher & Fleisher 1992
Spondias mombin (S. lutea) [Hog plum]	Fruit EO contained 2 ppm of ME and 3 ppm of α-copaene.	Adedeji et al. 1991
Annonaceae – Custard-apple family (Magnoliales)		
Annona glabra [Pond apple]	ME tr amount in fruit volatiles.	Pino et al. 2002
Annona squamosa [Sugar apple; Sweetsop]	ME 2.3% of leaf EO.	Joy & Rao 1997
Guatteria wachenheimi (*Guatteria microsperma*)	ME 1.4% & 0.4% in bark and leaf EOs, resp.	Fournier et al. 1997
Pseuduvaria mulgraveana var glabrescens [Mulgrave's Yellowwood]	Leaf EO with ME (61%) as major component.	Brophy et al. 2004
Apiaceae - Carrot family (Apiales)		
Anthriscus cerefolium [Garden cheroil, Chervil]	ME detected.	Degen 1998
Bupleurum chinense [Chai hu, Thorowax, Saiko]	EO of dried root contained ME (0.1%) and eugenol (0.9%).	Zhao et al. 2009
Crithmum maritimum [Sea fennel, rock samphire]	ME (0.3% of EO) only in leaves of 1 of 4 populations of Amorgos Island, Greece.	Katsouri et al. 2001
Cuminum cyminum [Cumin]	Root EO 1.52% ME, and leaf & stem EO had 1.22% ME.	Bettaieb et al. 2010
Daucus carota [Wild carrot]	ME (1.23%) in plant EO; 0.2% ME in leaf EO that had antibacterial activity due to (*E*)-methyl isoeugenol; subsp. *sativus* var Flakker had ME (1.2 - 2.1%) in leaflet EO but tr in var Nantes; subsp. *maximus* fruit EO had 1.97 & 37.2% of ME & *E*-methyl isoeugenol, resp.	Kameoka et al. 1989; Rossi et al. 2007; Kainulalnen et al. 1998; Saad et al. 1995
Daucus glaber (*D. litoralis*) [Coastal carrot]	ME 1.55% and 2.51% in leaf and fruit EO, resp.	Mansour et al. 2004
Diplotaenia cachrydifolia	ME & *E*-methyl isoeugenol detected only in root EO at 0.8 & 1.1% , resp.	Ozcan et al. 2004
Echinophora platyloba	ME (0.02%) in EO of aerial parts; aerial parts at rosette, budding & flowering stages had ME at 2.2, 0.9 & 0.6% of EO, resp.	Hassapouraghdam et al. 2009; Ghani et al. 2009
Echinophora sibthorpiana [Tarhana herb, Cortuk spice]	ME major component in aerial parts EO, & 0.05-0.1% ME inhibited yeast & moulds growth; ME (50.4%) the major component in EO from Iran.	Kivanc 1988; Ahmad et al. 1999
*Echinophora tenuifolia*subsp. *Sibthorpiana* [Turkish hyssop]	ME 49.86%. (EO 1.3%); Fruit EO (1.0-2.2%) contained ME (18-59%), as one of three main components; ME (24.7%) in EO of fully bloom aerial parts; ME (28.6 % of EO) 2nd major component.	Tanker et al. 1976; Baser 2002; Akgul & Chialva 1989; Georgiou et al. 2010
Eremocharis triradiata	ME (69.8%) main constituent of EO of aerial parts with 58 compounds.	Senatore et al. 1997
Foeniculum vulgare	ME and methyl isoeugenol 0.07% and 0.12% in leaf EO, resp; fruits had ME and eugenol 0.18% and 0.52% of EO, resp; ME in aerial parts at 0.9% of EO.	Chowdhury et al. 2009; Găinar & Bala 2006; Shatar & Altantsetseg 2000
Foeniculum vulgare subsp. *piperitum* [Sweet Fennel]	One form contained 15 % ME and 41 % g-asarone.	Krüger et al. 2005 (unpublished)
Glehnia littoralis [Beach/ American silvertop]	ME (0.09 – 3.19%) in four out of eight plant parts EO.	Miyazawa et al. 2001
Heracleum transcaucasicum [Common hogweed]	ME (0.3%) in EO of aerial parts.	Firuzi et al. 2010
Hippomarathrum cristatum [Wild marathon]	Phenylpropanoids (4.9% of EO) with myristicin 4.4% & ME in tr.	Ozek et al. 2007
Levisticum officinale [Lovage]	Seed EO contained 0.1-0.2 % ME.	Bylaite et al. 1998
Libanotis montana	ME (0.6%) of EO.	Kapetanos et al. 2008
Ligusticum mutellina (*Mutellina purpurea*) [Alpine Lovage]	Myristicin (27-39%) main component of fruit, herb & root EOs with 0.12% ME in fruit EO & tr in latter two EOs.	Brandt & Schultze 1995
Ligusticum scoticum [Scotch lovage/ parsley]	Aerial parts EO contained ME 0.043%	Jean et al. 1990
Lomatium graveolens [King desertparsley]	ME 0.2% of aerial parts EO.	Beauchamp et al. 2009
Lomatium junceum [Rush biscuitroot]	ME 0.1% of aerial parts EO.	Beauchamp et al. 2009
Myrrhis odorata [Cicely or Sweet Cicely]	Plant EO contained *E*-anethole (85.48%) and ME (9.08%).	Hussain et al. 1990
Osmorhiza longistylis [Aniseroot, licorice root, or wild anise]	Plant EO contained *E*-anethole (95.43%) and ME (0.04%).	Hussain et al. 1990
Petroselinum crispum (*Apium petroselinum*) [Garden parsley, Parsley]	Aerial parts (leaves and fruits) contained ME and eugenol 3.8% & 0.7% of EO, resp.	Shatar & Altantsetseg 2000
Pimpinella affinis	ME 2.3 & 9.7% in seed EO from two populations in Iran.	Askari & Sefidkon 2006
Pimpinella anisum (*Anisum vulgare*) [Anise]	14 sampleof seed EOs varied in ME (0 - 1.18%) and methyl chavicol (0 -2.67%).	Arslan et al. 2004

Pimpinella barbata	Aerial parts contained ME & elemicin at 34% & 6.9% of EO, resp.	Fakhari & Sonboli 2006
Pimpinella corymbosa	Stem and leaf EO contained 0.1% ME.	Tabanca et al. 2005a
Pimpinella olivieroides	Leaves contained ME at 70.6% of EO.	Tabanca et al. 2005b
Pimpinella puberula	Fruit and leaf & stem EOs had 23.1% and 29.6% ME, resp; Leaf EO has ME 23.1 % of oil.	Tabanca et al. 2005a;b
Pimpinella rhodantha	Leaves had <5.0% ME of EO.	Tabanca et al. 2005b
Pituranthos scoparius	Stem EO had ME (5.6%) as 1 of 4 major components; seed & stem EOs had 1.6 & 5.9% ME, resp..	Verite et al. 2004; Boutaghane et al. 2004
Portenschlagiella ramosissima (*Athamanta ramosissima*)	Seed EO (15%) - with ME; Root, aerial parts and seeds had 0.4, 0.3-0.7 and 1.0% of EO, resp.	Bohannon & Kleiman 1977; Sokovic et al. 2008
Prangos asperula subsp. *haussknechtii*	ME (0.6%) of fruit EO.	Sajjdai & Mehregan 2003
Prangos ferulacea	Fruit EO contained ME (0.07%).	Massumi et al. 2007
Prangos heyniae	Fruit EOs from two localities - one had 0.1% ME but none in the other.	Baser et al. 2000
Prangos uechtritzii	ME at 2.2% of fruit EO.	Ozcan et al. 2000
Scandix iberica	Fruits contained estragole (90.5% of EO) with 0.2% ME.	Kaya et al. 2007
Semenovia tragioides	ME (5%) of aerial parts EO.	Masoudi et al. 2002
Thapsia maxima	ME (59-63%) major component in fruit EO of two plant types; ME 6.8% in type II & none in type I plants.	Avato et al. 1992; Avato & Smitt 2000
Thapsia villosa	Polyploid plants of Type 4 & 5 with 2n = 44 & 66, resp, had ME and limonene as major components via TLC; ME varied from 0.03 to 0.4% in fruit EO, whereas type 5 had 33-66% ME; ME in 5 tetraploid & 4 hexaploid specimens at 33.3 – 66.1% & 45.7 – 62.5%, resp.	Smitt 1995; Avato et al. 1996a; Avato et al. 1996b.
Tornabenea annua (*Melanoselinum annuum*)	Trace quantities of ME in fruit EO from some specimens in Cape Verde Islands.	Grosso et al. 2009
Tornabenea insularis	Trace quantities of ME in fruit EO from some specimens in Cape Verde Islands.	Grosso et al. 2009
Trachyspermum copticum	ME tr quantity in dried fruit EO.	Chialva et al. 1993
Zeravschania pastinacifolia	ME (0.1%) in EO of dried aerial parts.	Yassa et al. 2003
Apocynaceae - Dogbane family (Gentianales)		
Periploca sepium	ME (0.05%), eugenol (0.39%) & (*Z*)-methyl isooeugenol (0.02%) in root EO.	Miyazawa et al. 2004
Aquifoliaceae – Holly family (Aquifoliales)		
Illicium anisatum (*I. religiosum, I. japonicum ,I. shikimmi and I. skimmi*)	ME (9.8%) 1 of 5 main components of leaf EO; ME not detected, instead methyloxyeugenol (0.5%).	Cook & Howard 1966; Kim et al. 2009
Illicium brevistylum	Tr ME detected in fruit EO.	Howes et al. 2009
Illicium lanceolatum	Fruit EO contained ME (< 0.1 to 2.1%).	Howes et al. 2009
Illicium parviflorum [Swarm star anise, Yellow anise tree]	Leaf and branch EO dominated by 68.14 ± 0.88% safrole, 13.18 ± 1.01% linalool, and 11.89 ± 0.87% ME.	Tucker and Maciarello 1997
Illicium simonsii	8.9% ME & 1.8% elemicin in fruit EO.	Chu et al. 2010
Illicium verum [Star anise]	Fruit EO contained trans-anethole (90.11%) and ME (0.43%).	Hussain et al. 1990
Aristolochiaceae – Birthwort family (Piperales)		
Asarum canadense [Snake root]	ME 11% in volatile oil.	Saiki et al. 1967b
Asarum caulescens	ME 15% in volatile oil.	Saiki et al. 1967b
Asarum forbesii	ME (10.3%) and a-asaone (58.8%) major components in root EO; methyl isoeugenol (33.3%) in leaf oil.	Zhang et al. 2005
Asarum heterotropoides [Xi xin]	ME (47%) in root extract; ME in EO of subterranean and upterranean parts 21-39% &1.4-9.6%, resp, and ME highest during sprouting & after-fruiting.	Kosuge et al. 1978; Wang et al. 1997
Asarum heterotropoides var seoulensis	ME a major component in volatile oil of the Korean 'Xixin'.	Saiki et al. 1967a
Asarum leptophyllum	ME 8% and safrole 36% of EO.	Saiki et al. 1967b
Asarum sieboldii [Chinese wild ginger]	EO contained ME; ME (0.47% in root EO).	Tian et al.1981b; Han et al. 2008
Asarum sieboldii var cincoliferum	ME 78% of EO.	Saiki et al. 1967b
Asiasarum dimidiatum Maekawa	ME 26% of EO.	Saiki et al. 1967b
Asiasarum heteropoides var *mandshuricum* [Liao Xixin]	ME 59% of EO.	Saiki et al. 1967B ; Tian et al. 1981a
Heterotropa albivenium	ME 1% of volatile oil.	Saiki et al. 1967d
Heterotropa asaroides	ME 2%, elemicin 0.3 % and safrole 94% of volatile oil.	Saiki et al. 1967e
Heterotropa aspera	ME 0.1% of volatile oil.	Saiki et al. 1967c
Heterotropa constricta	ME 4% of volatile oil.	Saiki et al. 1967c
Heterotropa controversa	ME 0.2% of volatile oil.	Saiki et al. 1967b .
Heterotropa costata	ME 0.1% of volatile oil.	Saiki et al. 1967c
Heterotropa crassa	ME 1% of volatile oil.	Saiki et al. 1967c
Heterotropa curvistigma	ME 0.3% of volatile oil.	Saiki et al. 1967e
Heterotropa faurie	ME 2% of volatile oil.	Saiki et al. 1967d
Heterotropa fudzinoi	ME 11% of volatile oil.	Saiki et al. 1967e
Heterotropa hayatana	ME 1% of volatile oil.	Saiki et al. 1967c

Heterotropa hexaloba	ME 3% of volatile oil.	Saiki et al. 1967c
Heterotropa hexaloba var perfecta	ME 41% of volatile oil.	Saiki et al. 1967c
Heterotropa kiusiana	ME 1% of volatile oil.	Saiki et al. 1967e
Heterotropa kurosawae	ME 0.1% of volatile oil.	Saiki et al. 1967d
Heterotropa megacalyx	ME 50% of volatile oil.	Saiki et al. 1967d
Heterotropa muramatsui	ME 20% of volatile oil.	Saiki et al. 1967e
Heterotropa nankaiensis	ME 0.3% of volatile oil.	Saiki et al. 1967d
Heterotropa nipponica	ME 3% of volatile oil.	Saiki et al. 1967d
Heterotropa nipponica var kaoyana	ME 0.5% of volatile oil.	Saiki et al. 1967d
Heterotropa nipponica var rachypodion	ME 4% of volatile oil.	Saiki et al. 1967d
Heterotropa oblonga	ME 2% of volatile oil.	Saiki et al. 1967c
Heterotropa rigescens	ME 0.2% of volatile oil.	Saiki et al. 1967d
Heterotropa sakawana	ME 3% of EO.	Saiki et al. 1967c
Heterotropa satsumensis	Me 1% of volatile oil.	Saiki et al. 1967e
Heterotropa savatieri	ME 2% of volatile oil.	Saiki et al. 1967d
Heterotropa takaoi	ME 21% of volatile oil.	Saiki et al. 1967d
Heterotropa takaoi var dilatata	ME 1% of volatile oil	Saiki et al. 1967d
Heterotropa tamaensis	ME 2% of volatile oil.	Saiki et al. 1967e
Heterotropa unzen	ME 1% of volatile oil.	Saiki et al. 1967e
Heterotropa yakusimensis	ME 1% of volatile oil.	Saiki et al. 1967e
Hexastylis arifolia	Root & leaf EOs contained safrole & ME at ratios of 58.2% : 19.9% and 69.9% : 5.4%, resp.	Hayashi et al. 1983
Hexastylis minus	Root EO contained safrole and ME in traces, and no ME in leaf EO.	Hayashi et al. 1983
Asteraceae - Aster family (Asterales)		
Achillea conferta	Among 48 volatile components - ME (2.7%) of aerial parts EO.	Saeidnia et al. 2005
Achillea goiocephala	Dried flowering herbal parts EO had tr quantity of ME.	Baser et al. 2001b
Achillea ketenoglui	ME (0.6-0.7%) and eugenol (0.4-0.6% TIC of EO of aerial parts.	Baser et al. 2001a
Achillea lycaonica	ME (0.3%) and eugenol (0.8%) TIC in EO of aerial parts.	Baser et al. 2001a
Achillea millefolium [Common yarrow]	Plants from 2 of 14 different locations in Lithuania contained ME (0.07-0.14%) in leaf EO.	Gudaityte & Venskutonis 2007
Achillea monocephala	ME in leaf EO decreased from 0.6% to zero with temperature (100-175 °C) during water extraction.	Gogus et al. 2006
Achillea oxyodonta	Aerial parts contained 0.2% ME of EO.	Esmaeili et al. 2006
Ageratum conyzoides [Whiteweed; Goat weed]	ME 1.8% of plant (without roots) EO.	Rao & Nigam 1973
Anthemis melanolepis	Air-dried plant EO had 0.4% ME.	Saroglou et al. 2006
Anthemis tinctoria var *parnassica*	ME (1.2%) in EO of air-dried plant materials..	Saroglou et al. 2006
Anthemis werneri ssp. *werneri*	Air-dried plant EO contained 0.1% ME.	Saroglou et al. 2006
Arctium lapp [Greater Burdock]	EO of dried ripe fruits contained 0.1% of ME.	Zhao et al. 2009
Artemisia annua [Annual or sweet wormwood]	2 CVs - 1 has ME & eugenol at 0.2 & 0.3% of EO, resp, and tr in the other.	Goel et al. 2008
Artemisia abrotanum	2 of 4 vegetative phases – emergence of runner and mass flowering phases ME was 1.58 & 0.30 % in weight of EO.	Khodakov et al. 2009
Artemisia capillaris [Yin Chen Hao; Chinese moxa]	Growing buds contained ME.	Yano 1987
Artemisia campestris var glutinosa [Western Sagewort]	ME in tr amount in EO of aerial parts.	Juteau et al. 2002
Artemisia demissa	ME (8.5%) in oil.	http://www.ema.europa.eu
Artemisia dranunculus [Tarragon]	ME 280.1± 95.8 ppm in EO of field grown plants; EO of aerial parts had ME (35.8%) and methyl chavicol (16.2%); aerial parts EO had ME (1.8%).	Ribnicky et al. 2004; Lopes-Lutz et al. 2008; Kordali et al. 2005
Artemisia filatovae [Filatov wormwood]	ME - 0.2% in weight of aerial parts EO.	Atazhanova et al. 1999
Artemisia glabella	4.6% ME and 0.2% eugenol in dried plant EO.	Bicchi et al. 1985
Artemisia herba-alba (A. inculta) [Desert wormwood]	Combined flowers, leaves, and stems contained ME and estragole at 0.7 and 0.5% of EO, resp.	Hudaib & Aburjai 2006
Artemisia pallens [Davana]	ME and eugenol detected.	Gulati & Khan 1979
Artemisia persica [Davana]	ME (0.46%) in EO (0.40%) of the dried plant.	Sadeghpour et al. 2004
Artemisia scoparia [Red-stem wormwood]	EO of aerial parts contained ME (27.5%).	Basher et al. 1997
Artemisia subdigitata	Leaf EO dominated by 11.2% eugenol , 9.4% ME and 9.0% camphor.	Shatar et al. 2002
Artemisia vulgaris [mugwort or common wormwood]	Plants from France had ME at 5.4, 6.8 and 1.0% of EO in vegetative, flower-buds & flowering stages, resp.	Jerkovic et al. 2003
Baccharis grisebachii	ME (0.5%) in EO of aerial parts.	Hadad et al. 2007

Bubonium imbricatum	ME 0.02% of aerial parts EO.	Alilou et al. 2008
Centaurea calcitrapa	One of ten *Centaurea* spp. that had ME - 0.5% of aerial parts EO.	Karamenderes et al. 2008
Dyssodia acerosa (*Thymophylla acerosa*) [Prickleleaf dogweed]	ME (0.1%), eugenol (0.3%), β-carphyllene (0.1%) and a-humulene (tr) in plant EO.	Tellez et al. 1997
Felicia muricata [White Felicia]	ME (0.4%) of leaf EO.	Ashafa et al. 2008
Gundelia tournifortil [Galgal, Tumbleweed, Tumble thistle]	EO of aerial parts contained ME (12.57%), eugenol (6.7%), & β-caryophyllene (5.94%).	Halabi et al. 2005
Inula oculus-christi [Christ's eye]	ME (9.6%) one of five major components of EO.	Javidnia et al. 2006
Ophryosporus pinifolius	EO of aerial parts from Andes, Chile, contained 1% ME.	Niemeyer 2009
Pluchea arabica (*P. laxa*, *P. multiflora*)	ME (9.15%) in fresh twigs EO.	Suliman et al. 2006
Pluchea sagittalis [Wingstem camphorweed, lucera, madrecravo]	Leaf and stem EOs contained 23 terpenoids - including ME.	Talenti 1982
Rhaponticum acaule (*Leuzea acaulis* or *Centaurea chamaer-haponicum*)	EOs of capitula and aerial parts contained 11.4 and 10.6% of ME, resp.	Boussaada et al. 2007
Santolina insularis [Crespolina maggiore]	4 chemotypes - two had ME 50.78 (±0.35) and 121.05 (±94.03) μg/g dry wt in EO, and two with no ME.	Gnavi et al. 2010
Solidago odora [Sweet Golderod, Texas Goldenrod]	Varieties *f inodora* and *f odora* contained 4.37±3.20 and 5.77±2.61%, resp; and the former also contained *E*-ethyl isoeugenol (12.89%) and *E*-isoeugenol (3.08%).	Tucker et al. 1999
Tagetes lucida	Major components - estragole and ME at 45 and 20% in plant EO, resp,	Hethelyi et al. 1987
Tagetes filicifolia (*T. minuta*)	Plant EO had estragole (61.3%) and E-anethole (36.6%) with 0.01% ME.	Hussain et al. 1990
Tagetes lucida [Mexican/Spanish/Texas tarragon, sweet mace]	Plant EO contained 3.9% ME.	Ruff et al. 2002
Tagetes mandonii ["chick chimpa"]	ME 0.2% in EO of aerial parts.	Senatore & De Feo 1999
Tagetes terniflora	ME (2.2%) in EO of aerial parts.	De Feo et al. 2005
Tanacetum parthenium [Feverfew]	Flowering aerial parts EO contained camphor (46.2%) with 0.1% ME; leaves and inflorescences emitted 9.9 ± 3.3 ng/24h.	Pavela et al. 2010; Christensen et al. 1999
Vanillosmopsis arborea [Candeia]	ME 5.9% of bark oil and 36% of wood bark EO.	http://www.ema.europa.eu
Vernonia smithiana (*Hilliardiella smithiana*) ["Umwanzuranya"]	Dried plant EO contained 5.41% β-elemicin and 3.12% ME.	Vagionas et al. 2007
Wedelia paludosa var vialis	ME among 28 compounds detected in leaf and stem oils.	Mancini 1980
Bignoniaceae -Bignonia/Trumpet-creeper family (Lamiales)		
Tabebuia impetiginosa [Pink Trumpet tree]	ME (0.24%) and eugenol (0.96) of inner bark EO.	Park et al. 2003
Boraginaceae – Borage or Forget-me-not family (order= unplaced asterid I)		
Borago officinalis [Borage, Starflower]	Leaves ME content at 1.5% of EO or 4.5 μg/g fresh weight.	Mhamdi et al. 2009
Brassicaceae – Mustard family (Brassicales)		
Eruca sativa (*Eruca vesicaria subsp. sativa, Brassica eruca*) [Rocket/Rucola salad]	ME (0.9%) in headspace sample of fresh leaf volatiles.	Jirovetz et al. 2002a
Burseraceae –Torchwood/ Frankincense family (Sapindales)		
Boswellia serrata [Indian frankincense]	Gum resin contained ME (3.7%) and methylchavicol (8.9%), which were absent in other *Boswellia* species.	Hamm et al. 2005
Canarium indicum [Blume galip]	ME (300-700 ppm) in oil.	http://www.ema.europa.eu
Dacryodes edulis [Safou, African pear]	Fruit EO contained traces of ME which was not detectable in seeds.	Jirovetz et al. 2005
Canellaceae – Canella family (Canellales)		
Canella winterana (*Canella alba*) [Wild cinnamon]	Bark yielded eugenol, ME, asarone etc.	Gracza 1980
Capparaceae – Caper family (Brassicales)		
Capparis spinosa var *spinosa*	ME 0.3% of shoot EO and not detected in fruits.	Ozcan & Chalchat 2007
Cistaceae – Rock-rose family (Malvales)		
Cistus salviifolius [Rock rose]	6 of 15 populations in Greece had ME (0.1-0.9%) in EO of aerial parts during fruiting.	Demetzos et al. 2002
Clusiaceae – Mangosteen family (Malpighiales)		
Clusia scrobiculata [Brazilian Red Propolis]	*E*-anethol (13%), methyl eugenol (14%), *E*-methyl isoeugenol (18%), elemicin (26%) and *E*-isoelemicin (11%) in non-polar fraction.	Trusheva et al. 2006
Hypericum aegypticum	Dried plants had ME at 0.5 and 0.6% of EO in ssp. *aegypticum* and ssp. *marrocanum*, resp.	Crockett et al. 2007
Hypericum tomentosum	ME (1.92%) in EO of aerial parts.	Hosni et al. 2008
Combretaceae – Indian Almond family (Myrtales)		
Terminalia catappa [Tropical almond fruit; Sea almond]	Headspace extraction using SPME and Porapak Q showed fruit volatiles contained 31±1 and 6±2 % ME, resp.	Siderhurst & Jang 2006
Cornaceae – Dogwood family (Cornales)		
Cornus officinalis [Japanese cornel, Japanese cornelian cherry]	Fruit EO contained ME (7.4%), isoasarone (7.1%), β-phenylethyl alcohol (4.1%) & elemicin (3.2%).	Miyazawa & Kameoka 1989
Cupressaceae – Cypress family (Pinales)		
Juniperus angosturana	Leaf EO contained tr quantity of ME	Adams et al. 2007
Juniperus chinensis var kaizuca [Chinese Juniper]	ME (4.4-5.3%) in plant EO.	Adams et al. 1994
Juniperus flaccida [Drooping Juniper]	Trace amount of ME in two varieties - *flaccida* & *poblana*.	Adams et al. 1984

Juniperus gracilior var *urbaniana* [Graceful Juniper]	ME (0.9%) in leaf EO.	Adams 1997
Juniperus lucayana [Lucayan juniper, Barbados-cedar]	Leaf EO ME (8.2%) from Bahama Islands, but tr amount of ME from Cuba.	Adams et al. 1987
Juniperus scopulorum Sarg.	ME (15.5%) in leaf EO.	Adams et al. 1981
Juniperus virginiana [Red juniper, Eastern red cedar]	Leaf oil - mainly sabiene with ME (tr–12.1%), safrole (tr–18.9%), and elemicin (1-12.3%); in var silicicola & virginiana – 8.2 & 2.9% ME in leaf EO, resp.	Vinutha & Von Rudloff 1968; Adams 1994
Picea koraiensis [Korean spruce]	Oleoresin contained moderate amounts of ME.	Khan et al. 1983
Pinus funebris (*P. densiflora* [Japanese red pine]	ME one of four main monoterpenes.	Khan et al. 1984
Pinus nigra Arnold	ME 0.05% - 0.17% in pine needle EO varied according to season.	Sezik et al. 2010
Sequoiadendron giganteum [Giant sequoia, Sierra/Sierran redwood]	ME 2.1% and 0.9% in distilled residue and total leaf EO; new foliage had no safrole, eugenol, ME and elemicin which constituted ca. 10% of the oil from the mature foliage.	Gregonis et al. 1968; Levinson et al., 1971
T*huja orientalis* (*Biota orientalis*)	Root and stem wood oils contained 2.1 & 1.3%, resp.	Singh & Yadaw 2005
Ebenaceae – Ebony family (Ericales)		
Diospyros malabarica (*Diospyros embryopteris* [Thimbiri]	Fruit EO contained 1.3% ME among several phenylpropanoids (36.7%).	Viswanathan et al. 2002
Doryphora sassafras [Sassafras]	Leaf and bark EO contained ME (27-47%), safrole (15-30%) and camphor (15-19%).	Brophy et al. 1993
Equisetaceae - Horsetail family (Equisetales)		
Equisetum hiemale/ hyemale (*E. prealtum*) [Horsetail, Scouring rush]	EO from dried aerial parts contained ME (0.1%).	Zhao et al. 2009
Ericaceae – Heath family (Ericales)		
Rhododendron simii	Leaves contained ME at 0.1% of EO, and no detectable ME in flowers.	Zhao et al. 2006
Euphorbiaceae - Spurge family (Malpighiales)		
Croton aff. zehntneri	EO contained ME.	Craveiro et al.1978
Croton cuneatus	ME (25.9%) and methyl isoeugenol (1.2%) of aerial parts EO.	Suárez et al. 2005
Croton grewloides	ME (10.6%) and (*E*)-methyl isoeugenol (4.7%) in leaf EO, the latter (30.0%) and ME (4.6%) in stem EO.	Silva et al. 2008
Croton jimenezil	Leaf EO of plants from a location had ME (29.5%), while ME was absent from another location in Costa Rica.	Ciccio and Segnini 2002
Croton malambo [Malambo/Matias bark]	ME 65.4% of bark EO; 94.2% in leaf EO; 420g heartwood oil yielded 166g ME (i.e. ca 40% EO).	Suárez et al. 2005 & 2008; Bracho & Crowley 1966
Croton matourensis	EO contained ME (14.2%), elemicine (7.6%). & isoelemicine (11.3%).	Reinaldo et al. 2010
Croton nepetaefolius	Main components in EO were cineole, ME and terpineol; ME 6.6% of leaf EO.	Magalhães et al. 1998; Abdon et al. 2002
Croton palanostigma	17.2, 16.3, 24.1, and 25.6% ME in EOs of leaves, fruits, branches and bark, resp, *E*-methyl isoeugenol found in EO of branches (15.3%) and bark (25.6%).	c/f Maia & Andrade 2009
Croton parvifolius	EO contained small amounts of ME.	De Etcheves et al. 1981
Phyllanthus emblica (*Emblica officinalis*) [Indian gooseberry]	Fruit EO ME (1.25 %), β-caryophyllene, β-bourbonene and thymol - four components with antimicrobial activity; 1.80% and 3.34% ME in fruit EO, resp.	Zhao et al. 2007; Liu et al. 2009
Fabaceae – Pea family (Fabales)		
Acacia caven. [Molina]	ME and eugenol found in oil.	Talenti et al. 1981
Hedysarum polybotrys [Milk-vetch Root]	ME (9.6%) of EO.	Chen et al. 1987b
Medicago marina [Coastal/sea medick]	ME content of aerial parts EO in vegetative and reproductive phases was 1.7% and 20.4%, resp.	Flamini et al. 2003
Monopteryx uqudu	Major components of EO - ME (39.0%), elemicin (29.6%) and methyl chavicol (13.7%).	c/f Maia & Andrade 2009
Fagaceae – Beech family (Fagales)		
Quercus petrea [Sessile oak]	Wood EO contained ME, eugenol and isoeugenol with mean values of 0.21, 0.75 and 0.25 μg/g, resp.	Guchu et al. 2006
Quercus robur [Pedunclate oak]	Wood EO contained ME, eugenol and isoeugenol with mean values of 0.52, 1.14 and 0.15 μg/g, resp.	Guchu et al. 2006
Geraniaceae Geranium family (Geraniales)		
Erodium cicutarium (*Geranium cicutarium*) [Redstem filaree, Common Stork's-bill]	ME (10.6%) one of four major components in EO.	Lis-Balchin 1993
Pelargonium grossularioides [gooseberry]	ME (11.2%) one of four major components in EO.	Lis-Balchin 1993
Pelargonium odoratissimum [Apple geranium]	ME (31.7-79.8%) in leaf EO.	Lis-Balchin & Roth 2000
Pelargonium sidoides [Kalwerbossie; Rabassam]	Leaf oil contained 4.3% ME and 3.6% elemicin.	Kayser et al. 1998
Pelargonium x fragrans (*Geranium fragrans*) [Mabel grey]	ME (10.2%) in EO.	Lis-Balchin & Roth 2000
Lamiaceae -Mint family (Lamiales)		
Agastache foeniculum [Anise hyssop / Lavender hyssop]	ME in leaf and inflorescence increased from 28.6 to 41% of EO during 17 day storage; ME 0.5 - 1.48% of total leaf oil.	Dimitriev et al. 1981; Charles et al. 1991
Agastache rugosa [Korean mint]	ME 0.09-9.08% of total leaf oil; ME (83.5-92.2 %) in EO.	Charles et al. 1991; Fujita & Fujita 1973
Agastache rugosa x *A. Nepetoides*	0.09 -1.74% of ME in total leaf oil, but absent in *A. nepetoides*.	Charles et al. 1991;
Coleus aromaticus [Amboinese coleus]	ME minor component.	Baslas & Kumar 1981
Collinsonia anisata. [horse balm]	EO contained 80% ME.	http://www.ema.europa.eu
Dracocephalum moldavica [Dragonhead]	Plant EO contained ME (0.3 -2.0%) and methyl isoeugenol (1.2 – 3.0%); aerial parts EO contained 0.1% of ME in oil.	Hussein et al. 2006; Shatar & Altantsetseg 2000
Hyptis sauveolens	Weed attracted the oriental fruit fly and volatile oil contained 1.2% ME.	Kittibarmruangsook 1980
Hyssopus officinalis [Hyssop]	ME 38.3% & 0.4% in Montenegro and Serbia plants, resp; ME (0.54%) in EO; plant ME in 3 forms, 4 genotypes each, in Yugoslavia with blue, pink & white flowers had 0.1 -.3, 0.2 -.3 & 0.2-.4% of plant EO, resp.	Mitić & Đorđević 2000; De Vincenzi *et al*., 2000; Chalchat et al. 2001

Hyssopus officinalis subsp. *aristatus*	One of three strains grown in Italy had ME (43.9%) as main component.	Piccaglla et al. 1999
Lepechinia urbanii	Leaf EO had ME (1.26%) and α-copaene (13.82%).	Zanoni & Adams 1991
Mentha piperita (*M. balsamea*) [Peppermint]	Aerial parts contained 0.1% ME of EO.	Shatar & Altantsetseg 2000
Micromeria cristata subsp. *phrygia* P. H. Davis	ME (0.1%) with borneol (27-39%) and camphor (9-15%) as main components in EO of herbal parts.	Tabanca et al. 2001
Moschosma (Ocimum) polystachya [Musk basil; Swamp basil]	Oil rich (0.6 %) with ME (39.3 %) and methyl isoeugenol (8.4%).	Thoppil 1997
Mosla scabra	45 volatiles in EO with ME as one of five major components.	Lin & Hua 1989
Ocimum americanum [American basil; Hoary basil; Lime basil]	ME from less than 1 to more than 25 % peak area of EO.	Viña & Murillo 2003
Ocimum basillicum [sweet basil]	ME (0.9 - 4.2 %) in EO;ME (24.7%) in EO (Fijian variety).	Randriamiharisoa et al. 1986; Brophy & Jogia 1986
Ocimum campechianum (*O. micranthum*) [Least basil; Mosquito bush]	Eugenol & ME major components; ME (2.91%) in plant EO; ME (12.0%) and eugenol (9.0%) as major components in leaf EO.	Khosla et al. 1980; Carovic-Stanko et al. 2010; Benitez et al. 2009
Ocimum canum [Schrubby basil]	ME (1.14%), in aerial parts EO.	Burralhep et al. 2007
Ocimum carnosum (*O. selloi*) [Fertility-control herb; Uruguayan basil]	Elemicin (38.5-59.2%) and ME (29.2%) major constituents.	Sobti et al. 1981
Ocimum citriodorum (O. basilicum x *O. americanum)* [Lemon basil]	Leaf EO contained *E*- & *Z*-citral (79.2%), linalool (4.7%), geraniol (2.1%) and ME (2.0%).	Nor Azah et al. 2006
Ocimum gratissimum [Africain basil; Clove basil; East Indian basil; Tree basil]	Leaf EO dominated by monoterpenes, eugenol (68.8%) & ME (13.21%); Leaf and floral EOs contained ME (1.7%); 1 of 3 types in Brazil had ME (46.8%).	Matasyoh et al. 2007; Sainsbury & Sofowora 1971 c/f Maia & Andrade 2009
Ocimum minimum [Bush basil; Greek basil; Fine-leaved basil]	ME ca 1% of peak area of EO; ME increased from 1.59 to 1.95% in 24 hour after mechanical wounding.	Viña & Murillo 2003; Zabaras & Wyllie 2001
Ocimum sanctum (*O. tenuiflorum*) [Holy basil; red basil]	ME & eugenol varied with growth & development; ME 78-81% of leaf EO; \ME 72.5%, 75.3%, 83.7% and 65.2% in oils from whole herb, leaf, stem and inflorescence, resp.	Dey & Choudhuri 1985; Nudijati et al. 1996; Kothari et al. 2005
Ocimum selloi	Leaf EO 0.10-0.12 % ME; two accessions in Brazil, one with estragole and ME at 80.7 and 1.13%, resp, & the other ME at 63.08% with no estragole.	Moraes et al. 2002; Martins et al. 1997
Ocimum suave (*O. gratissimum* var *gratissimum*) [Vietnamese basil]	EO of aerial parts contained mainly elemicine (9.8-38.5%), eugenol (1-33.1%), & cis-methyl isoeugenol (6.8-19.3%) with tr amount of ME.	Ngassoum et al. 2003
Ocimum urticifolium (*O. suave*)	ME (tr - 87.0%) and eugenol (0.1-93.0%) in EO of leaves plus flowers. 12 chemotypes – 3 dominated by one component only – ME, eugenol and trans-methyl isoeugenol.	Ntezurubanza et al. 1988
Origanum majorana (*Majorana hortensis*) [Sweet majoram]	Aerial parts EOs during early growth and budding stages contained 0.37 & 0.04% of ME, resp, but not during late growth and fully flowering stages.	Sellami et al. 2009
Orthosiophon stamineus [Misai Kucing]	ME (3%) and eugenol (8.3%) in dried leaf EO.	Sukari & Takahashi 1988
Platostoma africanum	Plants divided into ME and eugenol chemotypes.	Chalmont et al. 2001
Rosemarinus officinalis [Rosemary]	Leaf EO has ME (0.12 – 1.46%); leaf and twig had tr ME and eugenol 0.1-0.2% of EO.	Ibanez et al. 1999; Elamrani et al. 2000
Salvia macrochlamys	EO of aerial parts contained ME (0.1 %) among >100 compounds.	Tabanca et al. 2006
Salvia officinalis [C*ommon sage]*	In vitro shoot EO contained 19.8% ME; fruits contained ME and eugenol at 1.45 and 1.01 % of EO, resp.	Avato et al. 2005; Taarit et al. 2009
Salvia recognita .	EO of aerial parts had ME (0.4%) of >100 compounds.	Tabanca et al. 2006
Salvia rhytidea [Persian sage]	Aerial parts EO contained ME (0.8%) and α-copaene (5.3%).	Sajjadi & Ghannadi 2005
Salvia verbenaca	ME 7.7-9.4% in EO of aerial parts collected in 2 Tunisia sites.	Taarit et al. 2010
Satureja Montana [Winter savory]	ME 25-415 ppm of plant.	http://www.emea.eu.int
Scutellariaa barbata [Ban-Zhi-Lian]	ME (5.6%) in aerial parts EO.	Yu et al. 2004
Thymus guyonii	ME (0.1%) in EO of fresh aerial parts.	Hazzit et al. 2006
Thymus hyemalis	Aerial parts EO had ME at 0.01% and tr at vegetative and flowering stages, resp.	Jordan et al. 2006
Thymus serpylloides subsp. *serpylloides* [thyme of the Sierra]	ME in tr quantity for individual plant EO during flowering but for fruiting plant 0.62% and 0.69% in 1989 & 1990, resp.	Arrebola et al. 1994
Thymus vulgaris [Thyme]	ME (0.21%) of aerial parts EO; ME (0.1%) of aerial parts EO.	Ozcan & Chalchar 2004; Shatar & Altantsetseg 2000
Vernonia smithiana ["umhlonyana"]	Aerial parts EO contained 3.12% ME.	Vagionas et al. 2007
Lardizabalaceae - Lardizabala family (Ranunculales)		
Akebia quinata [Chocolate vine]	Fruit and stem EOs contained ME at 1.1% and 0.3%, resp.	Kawata et al. 2007
Lauraceae – Laurel family (Laurales)		
Aniba canelilla [Cascalpreciosa]	EO of stem bark contained 2.9% ME; ME in EO of bark 21.3–34.7% and of wood 10.5–23.0%; ME (9.26%) and eugenol (3.97%) in trunk bark EO.	Oger et al. 1994; c/f Maia & Andrade 2009; Vilegas et al. 1998
Aniba guianensis [Chachajo]	Wood contained ME; ME and methyl isoeugenol among 6 major components of trunk wood EO.	Von Guelow et al. 1973;Von Bulow et al. 1973
Aniba hostmanniana.	Bark EO - 0.3% ME & 94.5% asarone.	Gottlieb & DaRocha 1972
Aniba pseudocoto	EO contained ME.	c/f Maia & Andrade 2009
Aniba puchury-minor	Bark EO contained ME (43.1 %), ME not detected in leaves.	c/f Maia & Andrade 2009
Cinnamomum camphora var linaloolifera	Fruit EO contained ME (40.9-51.2%), safrole (23.9-53.2%).	Gu et al. 1990
Cinnamomum cecidodphne (*C. glaucescens*) [Sugandha kokila]	Chemotypes A, B and C with ME, ME(45%)+safrole(20%), & safrole as major constituents, resp; fruits contained 0.6% ME of total EO.	Birch, 1963 c/f Ravindran et al. 2003;Adhikary et al. 1992
Cinnamomum cordatum	ME - 4.4% and 92.1% in leaf and bark EOs, resp.	Jantan et al. 2002
Cinnamomum culitlawan [Cinnamon kulit lawan]	Chemotypes A, B and C with safrole, safrole (35-53%) + ME (41-50%), and eugenol as major constituents, resp.	Spoon-Spruit, 1956 c/f Ravindran et al. 2003
Cinnamomum doederleinii	Shoot EO (0.08%) - contained eugenol (2.3%) and ME (0.7%).	Fujita et al. 1974
Cinnamomum glanduliferum [Nepal camphor tree]	Chemotypes A, B and C with safrole, ME, and ME (45%) + safrole (25%) as major constituents, resp.	Ravindran et al. 2003
Cinnamomum loureiri [Vietnamese cinnamon]	ME detected from root, bark, and heart wood oils.	Asakawa et al. 1971
Cinnamomum pedunculatum (*C. japonicum*) [Japanese Cinnamon]	Chemotypes A and B with Safrole (60%) + eugenol, and eugenol + ME as major constituents, resp.	Birch. 1963 c/f Ravindran et al. 2003

Cinnamomum parthenoxylon [Yellow cinnamon]	Wood oil (1.0% yield) - ME (45%) and safrole (20%).	Yaacob et al. 1990
Cinnamomum rhyncophyllum	EO of leaf, bark and wood contained 0.2, 1.6 and 4.4% ME, resp.	Jantan et al. 2004
Cinnamomum rigidissimum	Stump EO contained 61.7% safrole and 28.6% ME.	Lu et al. 1986
Cinnamomum sintok	Chemotypes A, B, C, and D with eugenol, eugenol + ME, ME + safrole and safrole as major components, resp.	c/f Ravindran et al. 2003
Cinnamomum subavenium	ME (75.9%) in leaf EO.	Ho et al. 2008
Cinnamomum tahijanum	Stem bark oil contained 7.4% ME.	Ali & Jantan 1999
Cinnamomum tamala	ME and eugenol detected in leaf EO.	Dighe et al. 2005
Cinnamomum tenuipilum	Leaf EO showed 9 chemical types – ME type contained 69 - 89% ME.	Cheng et al. 1993
Cinnamomum zeylanicum (*Cinnamomum verum*)	ME in leaf and stem bark EO 0.1% and tr amount, resp.	Senanayake et al.1978
Laurus azorica (L. canariensis) [Loireiro, Louro]	ME tr quantity in leaf EO.	Pedro et al.2001
Laurus nobilis [Bay; Bay laurel; Laurel tree]	Plant contained ME with antifeeding activity; ME (8.1%); EO of berries contained 1.0-1.4% ME; Leaf EO of 3 regions of Turkey had ME at 1.96, 3.39 & 0.41%.	Muckensturm et al. 1982; Caredda et al. 2002; Marzouki et al. 2008; Sangun et al. 2007
Laurus novocanariensis [Madeira /Canary Laurel]	Spring & fall leaves contained ME at 0.8% & 0.2 % of EOs, resp, & only unripe fruits had ME - 0.4%.	Rodilla et al. 2008
Licaria puchury - major [Pichury/Pichurim bean; Sassafras nuts]	Seed oil contained safrole (36.1-51.3%); eugenol (3.3 - 4.1%) and ME (2.9 – 3.60%).	Carlini et al. 1983; Maia et al. 1985
Lindera neesiana ["Siltimur"]	Fruits contained myristicin and ME at 4.41% and 1.94% of EO, resp.	Comai et al. 2010
Nectandra polita	54 g of solvent wood extract yielded 0.06g eugenol, 0.04g ME.	Suarez et al. 1983
Ocotea caparrapi [Caparrapi Olive tree]	ME & myristicin (major components).	Suarez & Enrique 1980
Ocotea pretiosa [Sassafras tree]	ME (0.1-78%) in wood oil.	http://www.ema.europa.eu
Persea americana [Avocado]	Leaf EO contained estragole (78.12%) and ME (3.37 %).	Sagrero Nieves & Bartley 1995
Ravensara aromatica (*Ravensara anisata*) [Clove nutmeg, ravensara]	EO contained 0.10% ME; leaf EO from Madagascar contained methyl chavicol (79.7%) & ME (8.5%); high variation in ME (tr to 81.6%) and methyl chavicol (1.4 – 94.5%) contents in leaf EO between and within forest localities in Madagascar.	Franchomme & Peneol 1995; Ramanoelina et al. 2006; Andrianoelisoa et al. 2006
Sassafras albidum [Sassafras]	ME (1.10%) of root bark oil.	Kamdem & Gage 1995
Umbellularia californica [California bay/Laurel]	Leaf EO contained ME (5.4%) and isoeugenol (0.1%).	Buttery et al. 1974
Magnoliaceae – Magnolia family (Magnoliales)		
Magnolia denudata (M. heptapeta) [Lily tree, Yulan magnolia, Tulip tree]	EO of magnoliae flos (dried buds) contained 0.01-0.10% ME.	Jeong et al. 2009
Magnolia lilifora [Lily magnolia]	EO of magnoliae flos contained 0.00-0.22% ME.	Jeong et al. 2009
Magnolia salicifolia [Willow-leaved Magnolia]	EO contained large amounts of ME and safrole; leaf ME induced 100% mortality of 4th instar larvae of *Aedes aegypti* at 60 ppm.	Nagasawa et al. 1969; Kelm et al. 1997
Michelia alba [White Champaca; White Sandalwood]	EO contained ME and eugenol;leaf EO contained 0.22% ME & 0.1% estragole among >100 components.	Wang 1979; Ueyama et al. 1992
Michelia hedyosperma	Safrole 95% and ME, linalool & (+)-limonene.	Wu et al. 1981
Talauma gioi	Major constituents of the fruit pulp and kernel oils were safrole (70.2% & 72.9%) and ME (24.2% & 18.5%).	Dung et al. 1997
Malvaceae – Mallow family (Mavales)		
Tilia argentea (*T. tomentosa*)	ME 0.2% and 0.1% of bract and leaf EOs, resp, but no ME in flowers.	Toker et al. 1999
Monimiaceae – Monimia family (Laurales)		
Antherosperma moschatum	Two subspecies, *moschatum & integrifolium*, had ME (55 – 87%) as the major component.	Brophy et al. 2009
Doryphora sassafras [Sassafras]	ME (27-47%), safrole (15-30%) and camphor (15-19%) in leaf & bark EOs.	Brophy et al. 1993
Peumus boldus [Boldo; Boldina]	ME (4.3%) of leaf EO.	http://www.emea.eu.int
Moraceae – Fig/Mulberry family (Rosales)		
Pourouma cecropiifolia (*P. multifida*) [Amazon Grape]	Peeled fruits contained ME and eugenol each at 0.2% of EO with 0.23% of a-copaene.	Pino & Quijano 2008
Musaceae – Banana family (Zingiberales)		
Musa acuminate [Banana]	ugenol, 5-methoxyeugenol, elemicin & ME contributed to the mellow aroma of ripe bananas. ME-glycoside (0.66-1.07 %) in glycosidic extracts.	Engle et al. 1990
Myristicaceae – Nutmeg family (Magnoliales)		
Myristica fragrans [Nutmeg]	Many volatiles among them were safrole, ME, and eugenol;ME 0.1-17.9% in nutmeg EO; ME (0.3-17.9%) & it increased with time from 7.8 to 15% when whole nutmegs were ground and stored up to 48h.	Sammy & Nawar 1968; De Vincenzi et al. 2000; Kuo et al. 1983; Sanford & Heinz, 1971
Virola surinamensis	ME in leaf EO, circadian variation 0 - 0.43% of total peak area, and seasonal variation - ME (0.43%) in February and in June 0.12-0.2% .	Lopes et al. 1997
Myrtaceae – Myrtle family (Myrtales)		
Amomyrtella guili	ME (48.5%) and (*E*)-methyl isoeugenol (6.7%) in leaf EO.	Weyerstahl & Marschall 1992
Backhousia myrtifolia [Cinnamon mytrle, Grey myrtle, Ironwood]	Three chemotypes: a) ME (86.4%) with 1% *E*-methyl isoeugenol, & 4.1% elemicin, b) *E*-methyl isoeugenol (74%) with 4.9% ME & 4.6% elemicin, and c) elemicin (91.5%) with ME 4.0% & 0.4% *E*-methyl isoeugenol	Brophy et al. 1995
Choricarpla leptopetala	Leaf EO contained small amounts (< 3%) of ME, methyl isoeugenol and elemicin; leaf EO contained ME (0.07%), methyl isoeugenol (0.36%), elemicin (1.35%).	Brophy et al. 1994; Brophy & Goldsack 1994
Eucalyptus globulus (*E. glauca*)	Leaves had ME at 0.15-0.51% of EO, but no ME in bud, fruit & stem.	Chalchat et al. 1995
Eugenia singampattiana	Fruit EO contained ME (11.52%).	Johti et al. 2009
Melaleuca alternifolia [Narrow-leaved paperbark/ Tea-tree]	ME tr amount in EO.	Brophy et al. 1989
Melaleuca bracteata [Black T-tree, River tea-tree]	ME 97.7% of leaf EO.	Aboutabl et al. 1991
Melaleuca ericifolia [Swamp paperbark]	ME 96.84% of EO.	Farag et al. 2004

Melaleuca leucadendra [Cajeput tree]	One of three chemotypes had ca 99% ME in leaf EO; EO of aerial parts contained ME (96.6 ± 0.7%).	Brophy & Lassak 1988;Silva et al. 2008
Melaleuca quinquenervia [Melaleuca trees, paperbark tea trees]	Two chemotypes rich in ME (up to 99 percent).	Ramanoelina et al. 1994
Myrcianthes rhopaloides [Arrayan]	ME (0.2%) a minor component in leaf EO.	Malagon et al. 2003
Myrtus communis [Myrtl]	Myrtle berry oil 2.3% ME; leaf & unripe fruit ME 2.3% & 0.04% of EO, while ripe fruit had no detectable ME; ME content 2.3% in Myrtl EO; fruits & leaves from 1st station had ME at 0.6 & 0.8% of EOs, resp, in 2nd- ME 1.1% of leaf EO and none in fruits.	Mazza 1983; Boelens & Jimenez 1992; De Vincenzi et al. 2000; Flamini et al. 2004
Pimenta acris [Wild cinnamon, Bay-rum tree, Bayberry or Jamaica bayberry;]	Chavicol, eugenol, and ME form 65-70% of leaf and berry EO.	Ryan 1991
Pimenta dioica (*P. officialis*) [Allspice, Pimento, Jamaica pepper]	ME (48.3-67.9%) main component of Mexican pimento berries EO; EO high in eugenol (64.29%) and ME (20.55%) contents; fruiting & non-fruiting trees contained ME (0.08 & 0.13%) & eugenol (79.8 & 83.7%) of leaf EO, resp.	Garcia-Fajardo et al. 1997;Zabka et al. 2009; Minott & Brown 2007
Pimenta officialis [Pimento]	ME (5.0-8.8%) of EO.	De Vincenzi et al. 2000
Pimenta racemosa [Bay rum tree]	ME in leaf EO for var grisea (0.30 - 92.60%) and var hispaniolensis (0 – 63.88%); ME 8.9% of fruit EO.	Tucker et al. 1991; Ruff et al. 2002
Pseudo-caryophyllus guili	ME and eugenol were major volatile components; ME (5%) in leaf oil and fruits.	De Fenik et al. 1972; http://www.ema.europa.eu
Psidium cattleianum [Strawberry guava]	Red variety of fruit contained ME and eugenol among >154 volatiles.	Vernin et al. 1998
Psidium guajava [Guava]	ME (0.2%) of fruit EO.	Paniandy et al. 2000
Syzgium aromaticum (*Eugenia caryophyllu*, *E. caryophyllata*) [Clove]	Leaf EO had eugenol (76.8%) and β-caryophyllene (17.4%) as major components with tr ME; ME (0.12%) of EO with eugenol (78.6%).	Jirovetz et al. 2006; Dzamic et al. 2009
Orchidaceae – Orchid family (Asparagales)		
Brassla chkirikeyca	EO contained ME (8.8%),	c/f Maia & Andrade 2009
Jumellea fragrans [False rein orchid]	ME in minute quantity of leaf EO.	Shum & Smadja 1992
Papaveraceae – Poppy family (Ranunculales)		
Escholtzia flava	EO had 40.5% ME.	http://www.ema.europa.eu
Pinaceae – Pine family (Pinales)		
Pinus ponderosa [North American pine]	ME (0.6%) in needle (leaf) EO.	Krauze-Baranowska et al. 2002
Piperaceae – Pepper family (Piperales)		
Piper auritum [Root beer plant, Vera cruz pepper]	ME (0.8%), safrole (91.3%) and myristicin (4.8%) in leaf EO.	Bueno-Sanchez et al. 2009
Piper betle [Betel; Betel pepper; Sireh]	Two CVs gave 0.15-0.2% EO - ME (4.1-6.9%) and eugenol (82.2-90.55%).	Sharma et al. 1983
Piper capense	Aerial parts EO contained 0.2% ME.	Martins et al. 1998
Piper divaricatum (*Piper columbrinum*)	ME (17-93%) and eugenol (2.0-46.0%) main constituents in EO.	c/f Maia & Andrade 2009
Piper guineense [West African black pepper]	Berry EO rich in phenylpropanoids – ME (1.53%) & eugenol (0.07%); white and black berries EOs contained 0.11 & 0.22%, resp.	Ekundaya et al. 1988; Jirovetz et al. 2002b
Piper lenticellosum	Leaf EO contained limacine, isosafrole, ME and sarisan.	Diaz et al. 1986
Piper nigrum [Black pepper]	ME – one of twelve identified polar compounds in oil of black pepper; berries contained 0.92% ME.	Russell & Jennings 1969; Jirovetz et al. 2002b
Piper solmsianum	Leaf EO had ME (1.10%).	Moreira et al. 2001
Piper xylosteoides	ME 0.08% of aerial parts EO.	Ferraz et al. 2010
Plumbaginaceae - Leadwort family (Caryophyllales)		
Limonium echioides	Aerial parts EO had ME & eugenol at 0.01% and 0.75% of volatiles.	Saidana et al. 2008a
Poaceae – Grass family (Poales)		
Bothriochloa perforata	One of 16 *Bothriochloa* sibling species contained ME (1.8%) in whole plant EO.	Scrivanti et al. 2009
Bromus hordeaceus [Soft brome]	Trans methyl cinnamate (31.2%), ME (30.3%) & eugenol (19.1%) of plant EO.	Kaluzina-Czaplinska 2007
Cymbopogon distans	ME (13%) and limonene (29%) as major component in EO.	Singh & Sinha 1976 c/f Akhila 2009
Cymbopogon flexuosus ([Lemongrass]	ME (20%) in EO.	Atal & Bradu 1976
C. flexosus var Skimensis	ME (23%) in EO.	Manzoor-i-Khuda et al. 1986
Cymbopogon jwarancusa [Iwarancusa grass]	Khawi grass - ME one of major components.	Ansari & Qadry 1987
Cymbopogon khasianus	0.6-0.85% oil yield - contained ME (75-85%).	Rabha et al. 1986
Cymbopogon microstachys	EO had ca 60% phenyl propanoids with ME (19.5%), elemicin (25.3%) & methyl isoeugenol (4.2%).	Mathela et al. 1990
Cymbopogon nardus [Citronella grass]	ME major component; ME (4.1%) with traces of eugenol and ethyl iso-eugenol.	Howlett 1915; Akhila 2009
Cymbopogon tortilis [Ogarukaya, Okarukaya]	ME (55%) in EO.	Liu et al. 1981
Cymbopogon winterianus [Java citronella]	ME (20-60 ppm) of whole plant (1%) EO; EO contained tr quantities of ME and eugenol.	http://www.ema.europa.eu; Akhila 2009
Elyonurus hensii	ME (0.6% of EO) in roots and not detected in other aerial parts.	Silou et al. 2006
Lolium perenne	ME (16.6%), eugenol (24.1%) & trans methyl cinnamate as major components in plan EO.	Kaluzina-Czaplinska 2007
Podocarpaceae – Podocarpus family (Pinales)		
Dacrydium franklinii (*Lagarostrobos franklinii)* [Huon pine heartwood]	Wax contained eugenol, ME ether, elemicine, and coniferyl alcohol.	Baggaley et al. 1967
Lagarostrobos franklinii [Huon pine]	Wood EO had 57-74% ME, 2-18% *E*-methyl isoeugenol & 22-24% elemicin.	Brophy et al. 2003
Lolium perenne [Perennial ryegrass]	Eugenol (24.1%), *E*-methyl cinnamate (18.5%) & ME (16.6%) in plant EO.	Kaluzina-Czaplinska 2007

Polygonaceae – Buckwheat family (Caryophyllales)		
Rheum palmatum [Chinese rhubarb]	Rhizome EO contained 5.4% ME.	Miyazawa et al. 1996
Rheum rhabarbarum [Rhubarb]	Mean values of ME in stalk EO varied from 2-7%.	Dregus & Engel 2003
Rosaceae – Rose family (Rosales)		
Pseudocydonia sinensis [Chinese quince]	0.4% & 0.1% ME in fruit peel and fresh EO, resp.	Mihara et al. 1987
Prunus persica [Peach]	ME (<1%) found in fruits of four ripe peach CVs and two breeding lines.	Horvat et al. 1990
Rosa damascena. (*Hybrid of Rosa gallica* and *Rosa moschata*) [Damask rose]	Rose oil contained 0.1- 1.9 % ME and 0.2 – 1.8 % eugenol; ME (3.56%) in Chinese rose oil using SPME technique.	Mostafavi & Afzali 2009; Jirovetz et al. 2004
Rosa hemisphaerica [Sulphur rose]	ME 0.3% of EO.	Safaei-Ghomi et al. 2007
Rosa hybrida CV Mi-hyang	ME (0.79 %) and eugenol (0.84 %) in Korean rose oil.	Cho et al. 2006
Rubiaceae – Madder family (Gentianales)		
Rubia cordifolia [Common/Indian Madde]	ME (1.2% of peak area) in root EO.	Miyazawa & Kawata 2006
Rutaceae – Rue family – (Sapindales)		
Agathosma pungens [Bookoo, Buchu]	Plant EO contained 1.4% ME.	Viljoen et al. 2006
Chloroxylon swietenia [Ceylon/East Indian Satinwood or Buruta]	3.15 and 12.12 % ME in leaf and stem EO, resp.	Kiran et al. 2007
Citrus aurantium var *myrtifolia* [Chinotto]	Fresh fruits were air dried to yield dried peel which possessed tr ME in EO.	Chialva & Doglia 1990
Citrus paradise [Grapefruit]	Grapefruit juice contained 0.02 ppm of ME.	http://www.lal.ufl.edu/rouseff/Website2002/Subpages/flavor_phenolics.htm
Clausena anisata .	Leaf EO contained 92.7% ME.	http://www.ema.europa.eu
Clausena excavata [Pink Wampee]	Elemicin (65.02 %) and ME (12.95%) as major components of leaf EO.	Lim, 2005
Clausena indica	Fruit peel EO contained 0.43% ME.	Zhou et al. 2008
Coleonema album [Breath of heaven]	Shoot oil contained ME.	Berger et al. 1990
Dictamnus hispanicus	ME (3.7%) in EO of aerial parts.	Merle et al. 2006
Dinosperma melanophloia (*Melicope melanophloia*) [Hard aspen]	One of three chemotypes had ME (51-67%) and methyl chavicol (5-13%).	Brophy et al. 1997
Eriostemon fitzgeraldii	234 mg of ME from 10.2 g n-hexane extract concentrate of aerial plant parts.	Sarker et al. 1995
Eriostemon trachyphyllus [Rock Wax-flower]	ME and eugenol in tree.	Lassaak & Pinhey 1969
Fagara macrophylla [East African satinwood]	ME (4.68 %) in pericarp EO.	Reish et al. 1986
Haplophyllum myrtifolium	Plant EO had 10.8% ME and 19.1% eugenol.	Saglam et al. 2001
Helietta parvifolia [Barreta]	EO of leaves and branches - eugenol & ME.	Dominguez et al. 1971
Leionema ambiens (*Eriostemon ambiens*)	ME - 1.1% of leaf EO.	Brophy et al. 2006
Lovunga scandens	Berries contained ME among other monoterpenes.	Aggarwal et al. 1983
Melicope anisata (*Pelea anisata*) [Mokihana]	Leaf steam distillate contained p-methoxypropenylbenzene (ca 40%) with lesser quantities of ME, limonene, methyl isoeugenol and estragole.	Scheuer 1955
Melicope borbonica	Leaf EO of this medicinal plant with antifungal activity contained ME (209 mg of 430 g powdered leaves).	Simonsen et al. 2004
Murraya exotica [Orange jasmine]	ME 0.1% of leaf EO, ME absent in flower EO.	Raina et al. 2006
Pseudocydonia sinensis [Chinese Quince]	0.4% and 0.1% of ME in fruit peel and fresh fruit EO, resp.	Mihara et al. 1987
Vepris heterophylla	ME at 0.3% of leaf EO from 1 of 2 localities in northern Cameroon.	Ngamo et al. 2007
Vepris madagascarica	ME - 1 of 5 main components in leaf and stem oils.	Billet & Favre-Bonvin 1973
Zieria smithii [Sandfly Zieria]	85% ME in leaf EO.	Fletcher et al. 1975
Salicaceae – Willow family (Malpighiales)		
Populus nigra [Black poplar]	ME in fresh and dried buds 0.3 and 0.5%, and eugenol - 1.1 & 3.9%, resp.	Jerkovic & Mastelic 2003
Sapotaceae - Sapodilla family (Ericales)		
Manilkara zapota (*Achras sapota)* [Sapodilla, Ciku]	ME (0.5 %) in fruit EO which had 61 volatiles – 0.03 pg/kg of fruits.	MacLeod & de Troconis 1982
Sarraceniaceae – Pitcher family (Ericales)		
Sarracenia flava [Yellow pitcherplant]	ME (0.3%) in EO of aerial parts.	Miles et al. 1975
Saururaceae – Lizard-tail family (Piperales)		
Anemopsis californica [Yerba mansa]	ME (ca 6.9%) in rhizomes & dried roots; leaf EO contained 6.5-7.3 % ME; ME (59%) in New Mexico root EO; ME (55%) of rhizome & root EO.	Tutpalli et al. 1975; Medina et al. 2005 & 2008; Acharya & Chaubal 1968
Saururus cernuus	ME (< 2%) in EO of dried aerial parts.	Tutupalli et al. 1975
Scrophulariaceae – Figwort /Snapdragon family (Lamiales)		
Bacopa axillaris	Whole plant EO had camphor (30.6%) and ME (28.3%) as major components; ME (35.9%) and camphor (28.1%).	Zoghbi & Andrade 2006; Maia & Andrade 2009
Limnophila geoffrayi (*Limnophila racemosa*)	Aerial parts (flowers not included) contained ME at 0.33% (v/v) of EO.	Thongdon-A & Inprakhon 2009
Solanaceae – Nightshade/Potato family (Solanales)		
Cyphomandra betacea (*Solanum betaceum*) [Tamarillo, Tree tomato]	Fruit pulp volatiles contained <100 g/kg of ME.	Torrado et al. 1995

Mandragora officinarum [Mandrake, Hog apple Ground lemon]	ME (0.40%), eugenol (2.37%) and *E*-isoeugenol (1.63%) in fruit EO.	Fleisher & Fleisher 1994
Tamaricaceae – Tamarix family (Caryophyllales)		
Tamarix boveana	Aerial parts, leaf and stem EOs had 0.89%, 0.22% & tr ME, resp.	Saidana et al. 2008b
Theaceae – **Tea family**(Ericales)		
Camellia sinensis [Chinese tea]	ME (0.053 - 0.814 as ratio of peak area to that of internal standard) in 5 samples of tea EO.	Pripdeevech & Machan 2010
Thymelaeaceae – Mezereum family (Malvales)		
Daphne genkwa	ME (4.5%) in aerial parts EO.	Ueyama et al. 1990
Verbenaceae – Verbena family (Lamiales)		
Aloysia triphylla [Lemon verbena]	Dried leaves contained eugenol & ME at 0.5-0.6% & 0.3-1.2% of EO, resp.	Crabas et al. 2003
Lippia alba [Bushy lippia; Anise verbena]	ME small amounts.	Svendsen & Baerheim 1990
Lippia glandulosa	14 plant samples had eugenol 0.1-0.6% of EO but only 2 with tr ME.	Maia et al. 2005
Vitaceae – Grape family (Vitales)		
Vitis rotundifolia [Muscadines, Scuppernong berries]	ME in ripe berries from three CVs - Fry, Jumbo and Watergate.	Horvat & Senter 1984
Winteraceae - Winter's Bark Family (Canellales)		
Drimys brasiliensis	Fresh leaves collected in Dec., May and Oct. contained 0.5, 0.2 and 0% of ME, resp, and no ME in dried leaf stem, bark and unripe fruit.	Limberger et al. 2007
Zingiberaceae – Ginger family (Zingiberales)		
Alpinia galanga (Languas galang) [Greater galanga]	ME and a-copaene appeared as single peak (3.6%) of EO of fresh rhizomes; ME 0.9% of rhizome EO.	De Pooter et al. 1985; Pripdeevech et al. 2009
Alpinia officinarum [Galanga, galangal, galangale]	1.0% and 3.3% ME in EO of fresh and dried rhizome, resp; ME 3.0% and eugenol 0.5% of rhizome EO.	Tram Ngoc et al. 2001; Pripdeevech et al. 2009
Alpinia speciosa [Chinese Beauty, Atoumau, Variegated Dwarf]	ME in stem & leaves; only leaves from Japan, among 6 countries of origins, had ME, estragole & methyl cinnamate at 2.9, 4.6 &24.1% of EO, resp.	Fujita & Yamashita 1973; Prudent et al. 1993
Boesenbergia sp. (species unknown)	Plant attracted the oriental fruit fly and volatile oil contained 17% ME.	Kittibarmruangsook 1980
Curcuma angustifolia (*Maranta arundinaceae*) [The narrow leaved Turmeric]	Rhizome EO from Central India had ME (10.5%).	Srivastava et al. 2006
Elattaria cadamomum [Cadamom]	ME and eugenol among the ten most abundant volatile components in seed EO; plant EO contained 0.1% ME.	Abo-Khatwa & Kubo 1987 c/f Kubo et al. 1991; De Vincenzi et al. 2000
Etlingera cevuga [Wax flower]	ME (47.4%) and *Z*- & *E*-methyl isoeugenol (18.8%) in rhizome EO	Lechat-Vahirua et al. 1993
Etlingera linguiformis	Rhizome oil contained methyl chavicol (49.9%) and ME (32.3%).	Bhuiyan et al. 2010
Zingiber junceum	ME (54.73%), α-pinene (10.49%) & *E*-methyl isoeugenol (8.68 %) found in rhizome oil.	Jarikassem et al. 2006 (poster)
Zingiber officinale [Ginger]	Rhizome EO from alcoholic extract contained tr to 0.5% ME.	Singh et al. 2008

* excluding flower/floral fragrance, and quantitative data given if available;
** % = percentage of peak areas (if not stated), cv = cultivar, EO = essential oil, resp = respectively, SPME= Solid phase micro extraction, TLC = Thin layer chromatography, tr = trace, v. = variety, wt = weight.

Table 2. Plant family (order) and species containing methyl eugenol [ME] in flowers*.

Species (Synonym) [Common name]	Remark on ME presence**	Reference
Amaryllidaceae -Amaryllis/ Daffodil family (Asparagales)		
Narcissus bugei	*E*-β-Ocimene (54.7 - 64.4%) plus ME (0.2%) in floral EO.	Dobson et al. 1997
Narcissus geranium – a variety of *N. tazetta x N. poeticus* hybrid	Flower EO contains ME as a minor component.	van Dort et al. 1993
Narcissus jonquilla var *trevithian* (*N. trevithian*) [Trevithian narcissus]	Flowers contained ME as a minor component.	van Dort et al. 1993
Narcissus poeticus [Poet's Daffodil/Nargis]	ME a minor component of flower EO.	Ehret et al. 1989 c/f van Dort et al. 1993
Annonaceae – Custard apple family (Magnoliales)		
Cananga odorata forma macrophylla [Cananga]	Dried flower oil via controlled pressure drop method contained 0.4% ME & 0.5% eugenol, while via steam distillation contained 0.1% ME & 0.18% eugenol of EO (% = mass%).	Kristiawan et al. 2008
Apiaceae – Carrot family (Araliales)		
Aegopodium podagraria [Bishops Goutweed]	ME 0.22% of volatiles collected during flowering via Tenax GC sorbent.	Paramonov et al. 2000
Cuminum cyminum [Cumin]	ME (0.08%) & eugenol (0.79%) in floral EO.	Bettaieb et al. 2010
Daucus carota ssp. carota [Wild carrot]	Blooming umbels have tr quantities of ME and eugenol in EO	Staniszewska & Kula 2001
Eryngium amethystinum [calcatreppola ametistina]	ME (2.3%) and *E*-methyl isoeugenol (0.7%) in inflorescences and undetected in other plant parts.	Flamini et al. 2008
Levisticum officinale	Floral EO contains 0.1 - 0.2 % ME among 58 volatiles.	Bylaite et al. 1998
Pimpinella affinis	Inflorescence and seed EO contain 2.2% and 2.3% ME, resp, while seeds from 2nd locality contain ME (9.7%).	Askari & Sefidkon 2006
Portenschlagiella ramosissima	ME at 0.3% of EO in flowering aerial parts	Sokovic et al. 2008
Scandix iberica	Flowers contain estragole (95.8% of EO) with 0.3% ME.	Kaya et al. 2007
Seseli buchtormense	ME in whole flowering tops EOs varied with altitude - 0.1 % at 300 m but in tr at 400 to 2030 m in Russian Altai (Siberia)	Tkachev et al. 2006
Araceae – Arum family (Arales)		
Anthurium apaporanum.	ME (0.1 %) in floral fragrance.	Schwerdtfeger et al. 2002
Colocasia esculenta [Elephant Ears]	Flowers contain ME and eugenol, in floral spadix and bract. Photo showed >30 oriental fruit flies on visible side of a flower.	Sinchaisri & Areekul 1985
Spathiphyllum cannaefolium [Fruit fly lily]	Flower spike contains ME (20%), methyl chavicol, *p*-methoxybenzyl acetate, & benzyl acetate as major components.	Lewis et al. 1988
Arecaceae – Palm family (Arecales)		
Geonoma macrostachys var macrostachys	ME varied 0.11-0.16% and 0.09-0.25% during staminate & pistillate phases, resp, & emitted ME & eugenol peaked at 11:15 - 13:00 hour.	Knudsen et al. 1999
Geonoma polyandra	ME detected in tr amount from two staminate inflorescences.	Knudsen et al. 2001
Trachycarpus excelsa	ME (tr amount) and eugenol (8.2%) in floral EO.	Kameoka & Wang 1980
Trachycarpus fortunei (*T. wagnerianus*) [Chusan/Windmill Palm]	Eugenol (32.2%) and ME (tr quantity) in flower EO.	Kameoka & Wang 1980
Asparagaceae - Agave-Century-plant family (Asparagales)		
Dracaena fragrans [Corn plant, Chinese money tree, or Cornstalk Dracaena]	Head-space analysis of flowers using two adsorbents, twister and tenax-TA showed ME at 0.015 and 0.002 %, resp.	Ishikawa & Tani 2007
Polianthes tuberose	Floral absolute oil contained ca 20% *E*-isomethyleugenol, and ca 1.5% of ME and eugenol.	
Asteraceae - Aster family (Asterales)		
Achillea conferta	Top flowering aerial parts contained ME at 2.7% of EO.	Saeidnia et al. 2005
Achillea crithmifolia	Flower EO contained ME (0.08%).	Tzakou et al. 1993
Achillea millefolium [Yarrow, Common]	Flowers (white linguiform) from one of 14 different locations in Lithuania contained ME (0.15%) in floral EO.	Gudaityte & Venskutonis 2007
Achillea umbellata	Flower head ME 0.09% & eugenol 0.07% of EO; the chemicals not present in *A. lingulata*.	Kundakovic et al. 2007
Artemisia alba (*A. camphorata*.)	Inflorescences from northern Italy – ME (tr – 1.3%) & central Italy ME (0.2%), and those from central Italy a year later no ME.	Perfumi et al. 1999
Solidago odora [Sweet goldenrod]	Flowering tops EO of *f. odora* and *f. inodor* contained 5.8 and 4.4% ME, resp.	Tucker et al. 1999
Tagetes erecta [Aztec marigold]	ME (12.3%) and β-caryophyllene (15.2%) of flower EO; ME 0.7% of EO.	Gutierrez et al. 2010; Marotti et al. 2004
Tagetes lucida [Mexican tarragon]	Flowers and leaves contained ME at 0.1 & 3.6% of EO.	Marotti et al. 2004
Tagetes minuta [Wild marigold, South American Marigold]	ME in flowering shoots via hydrodistilled, steam-distilled and water-soluble oils was 0.6, 0.1 and 0.5-0.6 % of EO, resp.	Rajeswara Rao et al. 2006
Tagetes patula [French Marigold]	Flowers contained ME at 0.2% of EO but not detected in leaf EO.	Marotti et al. 2004
Tanacetum chiliophyllum var. *chiliophyllum*	Flowers contained ME at 0.2% of EO.	Baser et al. 2001c
Boraginaceae – Borage or Forget-me-not family (order = unplaced asterid I)		
Borago officinalis [Borage, Starflower]	Flower ME 2.9% of EO or 34.2 µg/g fresh wt.	Mhamdi et al. 2009
Brassicaceae – Cabbage/Mustard family (Brassicales)		
Matthiola longipetala subspecies *livida*	Flowers contained ME and eugenol at 0.7% & 19.9% wt/wt of EO among 49 components.	Hammami et al. 2007
Campanulaceae - Bellflower family (Campanulales)		
Siphocampylus giganteus	ME second highest component in volatiles of two hummingbird-pollinated flowers, having relative amounts of 24% & 12%.	Knudsen et al. 2004

Caryophyllaceae – Pink family (Caryphyllales)		
Dianthus arenarius	Floral volatiles emitted were eugenol (4.2%), ME (2.0%), elemicin (1.3%) & methyl isoeugenol (0.1%) besides methyl benzoate (42.1%).	Jürgens et al. 2003
Dianthus monspessulanus	ME (1.4%), elemicin (1.5%) emitted as part of floral volatiles.	Jürgens et al. 2003
Dianthus superbus.	Emitted floral volatiles contain cis-β-ocimene (49.8%), ME (0.2%) and elemicin (0.2%).	Jürgens et al. 2003
Dianthus sylvestris	Floral volatiles emitted contain methyl benzoate (85.7%), eugenol (0.3%) and tr of ME.	Jürgens et al. 2003
Silene latifolia [White champion]	ME (0 - 0.9%) in single flower volatiles from a North American population but not detected in European populations.	Dotterl et al. 2005
Clusiaceae – Mangosteen family (Euphorbiales)		
Clusia parviflora	ME (3.5%) and 1,3,5-trimethoxy-benzene (0.5%) in fresh petal EO.	Nogueira et al. 2001
Clusia renggerioides	ME (2.0%), vanillin (1.1%) and eugenol (tr) in fresh petal EO.	Nogueira et al. 2001
Kielmeyera rugosa	ME (0.2%) found in bee pollinated flower EO but not in leaf and fruit EOs.	Andrade et al. 2007
Cycadaceae – Cycad family (Cycadales)		
Cycas revolute	Estragole (67.0 - 92.7%) with small amounts of anethole, methyl salicylate, ME & ethyl benzoate released from male & female cones.	Azuma & Kono 2006
Euphorbiaceae - Spurge family (Euphorbiales)		
Croton micans	ME (0.1%) in floral EO but not detected in leaf EO.	Compagnone et al. 2010
Fabaceae – Pea family (Fabales)		
Acacia aroma [Aromita]	Flowers contained ME and eugenol at 0.3 and 15.5% of EO.	Lamarque et al. 1998
Acacia caven var. caven [Roman Cassie]	Flowers contained traces of ME and eugenol at 11.2% of EO.	Lamarque et al. 1998
Calliandra tweedii	Flowers contain traces of ME and eugenol at 9.3% of EO.	Lamarque et al. 1998
Cassia fistula [Golden shower, Indian Labernum]	An attractant of *Bactrocera dorsalis* in the blossom was identified as ME; flower EO contained 7.3% ME and tr of eugenol.	Kawano et al. 1968; Tzakou et al. 2007
Ceratonia siliqua [Carob tree]	Male whole flowers contained ME (2.8%) and female whole flowers 3.2 and 1.5 % in Galhosa and Mulata CVs.	Custodio et al. 2006
Medicago marina [Coastal medick, Sea medick]	EO of reproductive parts contained ME (20.4%) & eugenol (1.8%), and vegetative parts contained eugenol (4.9%) & ME (1.7%).	Flamini et al. 2003
Trifolium repens [White clover, Creeping clover]	Flower volatiles contained 8-11% ME, day emission 3 folds of night, and higher with increase temperature (10 - 20° C).	Jakobsen & Olsen 1994
Vachellia farnesiana (*Acacia farnesiana* [Needle bush]	Cassie (floral distillate) contained ME.	Duke 1981
Vicia faba (*Faba sativa*) [Broad bean, Faba bean, Fava bean]	Headspace volatiles of cultivar Maris Bead flowers contained ME (0.29%), eugenol (0.66%), cinnamyl alcohol (0.77%), and methyl isoeugenol (0.02%).	Griffiths et al. 1999
Lamiaceae – Mint family (Lamiales)		
Agastache foeniculum [Anise hyssop]	ME in inflorescences & leaves increased from 28.6 to 41% in EO during 17 day storage; A putative hybrid of *A. rugosa* and *A. foeniculum* possessed ME (2.4%) in inflorescence EO.	Dimitriev et al. 1981; Wilson et al. 1992
Ocimum basilicum.	ME 3-11% of inflorescence EO in two var.	Nudijati et al. 1996
Ocimum gratissimum.	Floral EO contained ME (1.7%).	Sainsbury & Sofowora 1971
O.gratissimum x O.viride	Flower of this cross showed higher ME (3.16%) than that of parental species.	Khosla et al. 1989
Ocimum sanctum. (Ocimum tenuiflorum [Holy basil; red basil]	ME contents in 5 var high in ME 64-77% and 2 var high in eugenol 1.7 – 2.3 % of inflorescence EO; ME in EO of leaf, stem and inflorescence 72.5%, 75.3%, 83.7%, resp.	Nudijati et al. 1996; Kothari et al. 2005
Ocimum selloi [Pepper basil]	Leaf and flower EOs in accession A had ME at 0.79 and 1.13%, resp, and in accession B, 65.5% and 66.2%, resp.	Martins et al. 1997
Ocimum suave.	ME (66.18%) in flower oil.	http://www.emea.eu.int
Rosemarinus officionalis	Rosemary oil obtained from pale blue flowers contained < 0.01% ME.	
Stachys lavandulifolia	EO of flowering aerial parts contained 3.61% ME.	Sezik & Basaran 1985
Lauraceae – Laurel family (Laurales)		
Laurus nobilis	ME in headspace analyses of female flowers, flowering tops of female and male plants were 0.2, 1.6 & 3.6%, resp; ME(3.9%) in floral oil.	Flamini et al. 2002; Kovacevic et al. 2007
Ocotea bofo	EO of floral calyxes contained ME (0.08%) of 46 compounds.	Guerrini et al. 2006
Lecythidaceae – Lecythis family (Lecythidales)		
Couroupita guianensis [Cannon ball tree]	Floral EO contains eugenol (2.9%) with traces of ME and *E*-methyl isoeugenol.	Knudsen & Mori 1996
Gustavia longifolia	Floral EO contains ME (7.9%), eugenol (0.1%), *E*-methyl isoeugenol (0.1%) & elemicin (1.3%).	Knudsen & Mori 1996
Liliaceae – Lily family (Lilliales)		
Allium roseum var. odoratissimum [Rosy garlic]	Fresh flowers contain ME and eugenol at 1.4 and 12.7 % of EO, resp.	Najjaa et al. 2007
Hyacinthus orientalis.	Headspace volatiles of white flowers had ME (0.34 – 0.49%) among >70 constituents.	Brunke et al. 1994
Magnoliaceae – Magnolia family (Magnoliales)		
Magnolia kobus.	Flowers from 1 of 32 localities studied emitted ME at 0.03 μg/flower/hour.	Azuma et al. 2001
Magnolia salisifolia [Willow-leafed/ Anise magnolia]	1.8 kg of flower buds yielded 498 mg of ME.	Li et al. 2007
Michelia alba	Floral and leaf EO possessed 0.38% & 0.22% ME, resp.	Kameoka 1993
Michelia chempaka	ME & methyl isoeugenol detected among many EO volatile components; champaca concrete contained 0.1% ME.	Zhu et al. 1982; Kaiser 1991
Michelia longiflora	Floral volatile oil contained linalool, ME, methyl- ethyl- acetic ester, & acetic acid.	

Malvaceae – Mallow family (Mavales)		
Ochroma pyramidalis [Balsa]	Bat-pollinated flowers contained 0.8% ME in floral volatiles.	Knudsen & Tollsten 1996
Tilia cordata [Linden]	Blossoms from 2 of 6 trees contained 0.6 and 0.1 % of EO, resp.	Nivinskienė et al. 2007
Tilia platyphyllos [Largeleaf Linden]	Inflorescences contained 2.43% eugenol and 1.27% ME.	Radulescu & Oprea 2008
Meliaceae – Mahogany family (Sapindales)		
Carapa guianensis [Caropa]	Flowers in one campus of Para, Brazil had eugenol (2.4%) & no ME, while flowers in another campus 2.9% eugenol and 0.1% ME.	Andrade et al. 2001
Morinaceae - Morinaceae family (Dipsacales)		
Morina persica [Prickly Whorlflower]	Fresh flowers had 32 components with ME and eugenol 0.36% and 0.27% of EO, resp.	Baser & Kurkcuoglu 1998
Myrtaceae – Myrtale family (Myrtales)		
Myrtus communis [Myrtle]	Flowers from Western and Central Albania had ME at 0.76 and 1.68% of EO, resp; ME (4.02% of EO) 1 of 7 major floral components in var *italica*.	Asllani 2000; Wannes et al. 2010
Syzygium aromaticum (*Eugenia caryophyllus*)	310 - 340 ppm of ME in flowers.	http://www.emea.eu.int
Oleaceae – Olive family (Lamiales)		
Syringa vulgaris [Lilac or Common lilac]	ME (tr) in floral EO; ME present in floral volatiles.	Wakayama et al. 1970; Lamparsky 1985 c/f Knudsen et al. 2006
Onagraceae – Evening Primrose family (Myrtales)		
Clarkia breweri [Fairy fans]	ME and isoME derived from eugenol and isoeugenol via the action of (*iso*)*eugenol O-methyltransferase* (*IEMT*); inbred line II contained vertraldehyde (1.54 %), methyl isoeugenol (0.66%), ME (0.59%), & iso-eugenol (0.16 %), but absent in inbred line I.	Wang et al. 1997; Raghuso & Pichersky 1995
Orchidaceae – Orchid family (Orchidales)		
Angraecum bosseri (Angraecum sesquipedale var. angustifolium)	Traces of ME in orchid flower (Madagascar).	Kaiser 1993
Bulbophyllum cheiri [Fruit fly orchid]	ME (594 ppm) major component and four other phenylpropanoids (in much smaller quantities) in floral volatiles.	Tan et al. 2002; Nishida et al. 2004
Bulbophyllum elevatopunctatum [Raised dot Bulbophyllum]	ME 78.5 + 21.6 µg (mean + SD; n=10) per flower as major component in floral EO.	Tan & Nishida (unpublished)
Bulbophyllum patens [Ginger orchid]	ME - ca. 40 ng /flower, corresponding to a thousandth of zingerone (main floral volatile).	Tan & Nishida 2000
Bulbophyllum vinaceum [Wine red orchid]	ME – the 2nd main component of eight floral phenylpropanoids detected.	Tan et al. 2006
Cattleya araguaiensis	Amazon region - ME and eugenol in tr amount.	Kaiser 1993
Cattleya leopoldii.	ME (3%) in floral EO.	Kaiser 1993
Epidendrum nocturnum	Night-scented orchid, ME in minute quantity.	Kaiser 1993
Gymnadenia conopsea	Floral scent varied greatly, ME – 5.7%; Floral day and night emissions for ME 9.83% & 3.91% of volatiles and for eugenol 8.91% & 6.12%, resp.	Kaiser 1993; Huber et al. 2005
Gymnadenia odoratissima.	Relative quantity of volatiles emitted during day and night for ME 0.07 & 0.18 and for eugenol 4.65 & 3.11, resp.	Huber et al. 2005
Odontoglossum pulchellum.	'Rosy-floral' scent varied with volatiles - ME (1 - 20%) and hydroquinone dimethyl ether (10 – 60%).	Kaiser 1993
Oncidium sarcodes	Neo-tropics orchid – ME tr amount.	Kaiser 1993
Pescatorea dayana	ME (1.4% of peak area) and elemicin in tr.	Kaiser 1993
Phalaenopsis violacea	Eugenol and ME in tr amounts, and elemicin (26.7%) in the Malayan type. No ME detected in the Borneo type (currently *P. belina* Christenson).	Kaiser 1993
Rangaeris amaniensis.	Highland orchid with tr quantity of ME.	Kaiser 1993
Satyrium microrrhynchum	Floral scent in 1 (Tam Cave) of 3 populations in South Africa, contained eugenol (0.14 - 0.55 %), ME (1.83 – 4.51%) & elemicin (2.01 - 8.53%).	Johnson et al. 2007
Zygopetalum crinitum [Hairy Zygopetalum]	Eugenol (2.6%), ME (3.1%) and chavicol (3.9%) of EO.	Kiaser 1993
Zygopetalum mackayi (*Z. mackaii*) [Caper bean]	ME a minor component in floral volatiles.	Williams & Whitten 1983
Paeoniaceae - Peony family (Saxifragales)		
Paeonia lactiflora (*P. albiflora*) [Chinese peony]	ME and eugenol present in low concentration (0.1-0.5%) of flower EO.	Kumar & Motto 1986
Pandanaceae – Screw-pine family (Pandanales)		
Pandanus odoratissimus	ME (0.1%) in volatile oil of fresh flowers.	Raina et al. 2004
Piperaceae – Pepper family (Piperales)		
Piper betel [Betel]	Flower EO had safrole as a major phenol, followed by hydroxychavicol, eugenol, ME, isoeugenol, flavone, and quercetin.	Chin & Sun 1990
Poaceae – Grass family (Poales)		
Cymbopogon flexuosus	ME and elemicin chemotypes had ME 32.6 –34.2% and 0.2-0.4 % of EO in inflorescence, resp, and no ME in citral and citronellol chemotypes	Nath et al. 2002
Putranjivaceae - Rosid family (Malpighiales)		
Drypetes natalensis [Natal drypetes]	Few minor phenylpropanoids and pollinated by cetoniid beetles – ME in male (tr - 2.2%) & female flowers 0.3-0.9% .	Johnson et al. 2009
Ranunculaceae - Buttercup or crowfoot family (Ranunculales)		
Pulsatilla rubra [Pasque Flower]	Violet-purple flowers with traces of ME in anther volatiles, 1 of 2 among 12 spp.	Jurgens & Dotterl 2004
Ranunculus platanifolius [Large white buttercup]	White open flowers with tr quantity of ME in anther volatiles, 1 of 2 among 12 spp in 6 genera in this family.	Jurgens & Dotterl 2004
Rhamnaceae – Buckhorn family (Elaeagnales)		
Zizyphus mauritiana [Indian jujube]	ME (0.4%) in floral faecal-like odor that attracted green dung beetles and many flies.	Alves et al. 2005

Rhizophoraceae – Mangrove family (Malpighiales)		
Rhizophora stylosa	Floral ME & eugenol at 6.8 & 27.2% of volatiles, resp, and floral scent had ME in traces – flowers visited by bees and others.	Azuma et al. 2002
Rosaceae – Rose family (Rosales)		
Prunus mume [Japanese apricot]	ME present as minor component among 22 non-polar constituents of flowers.	Matsuda et al. 2003
Rosa centifolia	ME (1.4%) in EO.	Ohloff 1978
Rosa chinensis [China rose]	ME and isomethyl eugenol as minor floral components in var spontanea; ME at 0.65, 0.04 & 0.9 % of volatiles in CVs Diorama, Grand Mogul & Lady Hillingdon, resp, only 'Diorama' emitted ME (0.34% of volatiles).	Wu et al. 2003; Joichi et al. 2005
Rosa damascena [Damask Rose]	ME (1.4%) in EO; ME increased with time of fermentation (0-36 min.) 0 – 4.34% of EO.	Ohloff 1978; Baydar et al. 2008
Rosa damascena semperflorens cv.'Quatre Saisons'	Free ME detected in petal volatiles, and detected volatiles emitted rhythmically, with maximum peaks coincided at 8–10 hour.	Picone et al. 2004
Rosa hybrida	Petals contained ME; ME (0.2%) detected only in floral EO of "Sandra" using C 18 (octadecyl silane) cartridge.	Lavid et al. 2002; Kim et al. 2000;
Rosa Phoenicia	Tr of ME and eugenol in petals fragrance.	Yomogida 1992
Rosa rugosa	Floral EO contained ME (6.88%); Volatiles from flower and pollen contain >20%ME and eugenol >4% - <20% of highest peak; ME and eugenol among 12 major components in pollen & pollenkitt volatiles.	Wu et al. 1985; Dobson et al. 1987; Dobson & Bergstrom 2000
Rosa setate X Rosa rugosa	Floral fragrance contained 0.30% eugenol and 0.68% ME.	Chen et al. 1987a
Solanaceae - Nightshade/Potato family (Solanales)		
Brunfelsia australis[Paraguay jasmine]	ME tr and 0.1% in young deep purple and mature white flowers, resp, with linalool and (E)-ocimene as major components.	Bertrand et al. 2006
Tamaricaceae – Tamarix family (Tamaricales)		
Tamarix boveana	ME (tr) and eugenol (0.83%) in floral EO.	Saidana et al. 2008b
Thymelaeaceae – Mezereum family (Malvales)		
Daphne genkwa	Flower EO contained 121 compounds - ME (4.55%) and eugenol (tr).	Ueyama et al. 1990
Valerianaceae - Valerian family (Dipsacales)		
Valeriana tuberose	Inflorescence contained 0,47% and 0.45% of EO for eugenol and ME, resp, which were not found in other plant parts.	Fokialakis et al. 2002
Verbenaceae - Verbena/Vervain family (Lamiales)		
Lippia alba cv kavach [Bushy Matgrass/ Lippia]	Linalool in leaf (67.7%) & inflorescences (79.9%) with 0.1% ME & 0.5% eugenol of inflorescence EO, but absent in leaf EO.	Mishra et al. 2010
Lippia origanoides (*Lippia schomburgkiana*) [Origanum dictamnus]	Three chemotypes – only type A collected from 3 different sites in Columbia had ME 0.01- 0.19% in aerial parts EO.	Stashenko et al. 2010
Zingiberaceae – Ginger family (Zingiberales)		
Hedychium coronarium [White ginger lily]	ME tr amount in flower EO with *E*- & *Z*-methyl isoeugenol 0.45 & 0.06% of peak area.	Matsumoto et al. 1993

* quantitative data given if available.
** symbols and abbreviations as in Table 1.