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Melliferous Aromatic Plants

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Abstract: Important reference source show that more than eight hundred species of medicinal plants grow on the Romanian's territory, of which only a small proportion are cultivated. Part of the spontaneous and cultivated medicinal plants, native or introduced in Romania, are aromatic plants, which are rich in essential volatile oils. Essential oils have important biological properties and are increasingly used in various industries such as pharmaceutical, food and cosmetics to name a few. Many plants secreting aromatic essential oils are also plants with a high melliferous potential. Studies carried out over several years, on aromatic plants in spontaneous flora and in integrated crops have demonstrated important melliferous potential for representatives of several botanic families such as: *Lamiaceae, Apiaceae, Asteraceae, Brassicaceae* and *Amaryllidaceae*. The *Lamiaceae* family is best represented, species such as: *Melissa officinalis, Salvia officinalis, Lavandula angustifolia, Mentha piperita, Hyssopus officinalis, Dracocephalum moldavica, Satureja hortensis* and *Thymus vulgaris* being extremely valuable both for the quality and multiple uses of their essential oils, for the honey base they provide to beekeepers as well as the particular quality of the honey. Medicinal and aromatic plants greatly contribute to the beneficial properties of bee keeping products (honey, pollen, royal jelly and propolis) and have the potential to deliver more bioactive bee products.

Keywords: essential oil, flowers, bees, honey, Lamiaceae, nectar.

Introduction

Natural flora potential of Romania is huge. By more than 4000 spontaneous or cultivated species, around 800 represent medicinal plants, from which 283 representatives have proven therapeutical

properties (Muntean et al., 2016).

Conventionally, aromatic plants have been classified together with medicinal plants as one category, namely: Aromatic and Medicinal Plants (MAPs). The reason being their use as raw material in the pharmaceutical industry. Some authors consider that this classification should be extended to aromatic, medicinal and cosmetic plants, given their intensive use in perfumery (Slikkerveer, 2006).

Aromatic plants are in general those containing aromatic compounds, mainly essential oils, which are complex mixtures of lipophilic and highly volatile secondary plant metabolites (phenylpropenes and/or terpenes), with low boiling point, strong aroma and highly concentrated (Ríos, 2016).

Through their properties, volatile oils seem to meet the current requirements in terms of benefits for human and animal nutrition and health (Brenes and Roura, 2010; Anuradha and Bharadvaja, 2023). The wide uses of these substances have led to an intensive development of scientific research in various fields: pharmaceutical industry, food industry, agriculture, cosmetics industry and animal husbandry (Bakkali et al., 2008).

The study of aromatic plants from the perspective of their honey potential also has increasing practical implications nowadays. Cultivation of aromatic plants in the vicinity of bee colonies has been shown to provide increased yields of volatile oils (Radev, 2022), and at the same time, the health of bee colonies can increase significantly (Chagnon and Lebeau, 2013), particularly, their infestation with the parasite *Varroa destructor* is significantly reduced (Chagnon and Lebeau, 2013; Conti et al., 2020; Bava et al., 2023). Also, the intercropping of melliferous aromatic plants in plots of intensive agricultural crops, can increase biodiversity, resource use efficiency and productivity (Fallah et al., 2018). This can be a strategy for increased production of secondary metabolites (Gharakhani-Beni et al., 2023).

Honey obtained from aromatic and medicinal plant crops has particular valuable properties, specific to them. Generally speaking, most types of honey share only about 80% of their physical and chemical composition (Young and Blundell, 2023), but the medicinal properties and organoleptic characteristics of each, depend on the floral source, the botanical and environmental origin of the nectar (Al-Ghamdi and Ansari, 2021).

The honey potential of aromatic plants is: very high for the *Lamiaceae* family, intermediate for representatives of the *Apiaceae* and *Asteraceae* families and low for the *Brassicaceae* (Ion et al., 2018). Also, the most suitable plants for cultivation (by the same category) are species of the families *Apiaceae, Lamiaceae* and *Brassicaceae* (Stana et al., 2007).

In the following, reference will be made to aromatic and medicinal plant species of the family *Lamiaceae*.

Plant species of the family *Lamiaceae*

Lamiaceae is a plant family with a cosmopolitan distribution, and a great diversity containing about 236 genera which are estimated to comprise 6900-7200 species. The largest genera are *Salvia, Scutellaria, Stachys, Plectranthus, Hyptis, Teucrium, Vitex, Thymus* and *Nepeta* (Martínez-Gordillo et al., 2013). The vast majority of species are concentrated in the Mediterranean region, with smaller groups of this family also found in Australia, Southwest Asia and South America (Kokkini et al., 2003). The family contains mainly medicinal plants with aromatic and culinary properties, used since ancient times, many of them being important sources for essential oils extraction (Vârban et al., 2022).

Representatives of *Lamiaceae* family are annual or perennial herbaceous plants, or shrubs, often more or less densely covered with trichomes and packed with volatile aromatics. In addition to non-glandular trichomes, the aerial parts of plants present various densities of glandular trichomes, depending on species. Two main types of these secretory structures occur in this family: glandular peristomes (capitate) and glandular scales (peltate). Most of the essential oil is produced and accumulated in the glandular scales (Kokkini et al., 2003). The essential oil secretions protect the plants against pathogens and play an important role in attracting pollinators (Werker, 1993).

The attraction of pollinators is a consequence of the rich terpenoid composition (especially monoterpenes) of the volatile oils produced by the plants. Commonly, the plants of the *Lamiaceae* family have nectariferous glands at the base of the ovary, and the nectar itself most likely does not attract the pollinating bee. Therefore, it seems that the attractant factor is the chemical scent of the volatile compounds (Cseke et al., 2007).

Although, *Lamiaceae* family is considered to be the most important category of aromatic plants with melliferous potential, it contains representatives that produce only small amounts of volatile compounds, which are almost odourless, and whose honey potential is therefore low. For example, some representatives of the species *Phlomis* and *Sideritis*. Also, some species of *Lycopus* and *Micromeria* are very low in volatile compounds (Kokkini et al., 2003).

In the table below are presented the most important *Lamiaceae* family species as sources of essential oils (Table 1).

Table 1

Plants of the family *Lamiaceae* - representatives in the spontaneous flora of Romania and non-native cultivated plants as essential oil source

Aromatic plant/Species	**Major components Essential oil***	**Biologic activity Essential oil****	**References**
Acinos suaveolens	pulegone, menthone, limonene, germacrene D	bacteriostatic, antioxidant, food preservative	Stojanović et al., 2009
Ballota nigra	β-caryophyllene, germacrene D	bacteriostatic activity; active on 3 *Candida* species	Morteza-Semnani and Saeedi, 2007
Dracocephalum moldavica	geranyl acetate geraniol, geranial, neral, nerol, citral	antioxidant, antibacterial, immunostimulant	Aćimović et al., 2022
Hyssopus officinalis	β-pinene, limonene, β-phellandrene, 1,8-cineole, pinocamphone, isopinocamphone, pinocarvone, germacrene D methyleugenol, aliphatic fatty acids	medium *in vitro* antibacterial activity, insecticidal, antiviral antifungal; excellent antioxidant and anticancer activities	Sharifi-Rad et al., 2022
Lamium album	geranial, neral germacrene D, caryophyllene, E-β-caryophyllene, terpineol, linalool, spatulenol, bisabolol	antimicrobial, antioxidant, anti-tumor action, antifungal, insecticide, anti-inflammatory	Konarska et al., 2021
Lamium purpureum	germacrene D, α-pinene, β-pinene, β-	Antimicrobial, cytotoxic activity	Jones et al., 2012;

	elemene		Akkoyunlu and Dulger, 2019
Lavandula angustifolia, Lavandula latifolia	linalool, linalyl acetate, geraniol, lavandulol, β-caryophyllene, lavandulyl acetate, α- and β-pinene, myrcene, limonene, camphor, borneol	antibacterial, antifungal, carminative (smooth muscle relaxant), sedative, antidepressant	Cavanagh and Wilkinson, 2002; Crişan et. al., 2023
Leonurus cardiaca	epi-cedrol, α-humulene, dehydro 1,8-cineole, germacrene D, spathulenol	-	Morteza-Semnani et al., 2008
Lophanthus anisatus	limonene, β-caryophyllene, methyl chavicol, germacrene B	bactericidal, immune-stimulatry, tonic and sedative	Nykänen et al., 1989; Chisnicean and Colţun, 2014
Marrubium vulgare	E-caryophyllene, germacrene D, α-humulene, α-copaene	antioxidant, antifungal on dermatophyte strains	Aćimović et al., 2021; Rezgui et al., 2020
Melissa officinalis	trans-carveol, citronellol, δ-3-carene, citronellal, geraniol, spathulenol	anti-tumor, antibacterial, antimicrobial, antispasmodic, antioxidant, antiviral, antiulcerogenic,	Jafer et al., 2008
Melittis melissophyllum	1-octen-3-ol, germacrene D, β-caryophyllene, (E)-3-hexen-1-ol	narcotic, antifungal, antibacterial, muscle relaxant, anticonvulsant	Baldini et al., 2009
Mentha aquatica	limonene, caryophyllene, germacren D, menthofuran, bicyclogermacrene	antioxidant, antibacterial	Malingré and Maarse, 1974 Mogosan et al., 2017
Mentha piperita	menthol, menthofuran, menthol acetate, 1,8 Cineol	carminative, cholagogue, antibacterial, secretolytic and choleretic, anti-inflammatory, antinociceptive,	Mogosan et al., 2017; Kokkini et al., 2003

		antifungal, antioxidant,	
Mentha crispata	carvone, menthol, menthone, pulegone, limonene, menthol acetate	anti-inflammatory, antinociceptive, pulegone as a pesticide	Fatiha et al., 2017 Mogosan et al., 2017; Kokkini et al., 2003
Nepeta pannonica	germacrene D, β-caryophyllene, germacreneD-4-ol, spathulenol, 1,8-cineol	phytotoxic, antibacterial activity	Kobaisy et al., 2005 Malenčić et al., 2008
Nepeta cataria	4a-α, 7-α, 7a-β-nepetalactone, 4a-α, 7-β, 7a-α-nepetalactone	antimicrobial, insecticide, mosquito repellent, antioxidant, antispasmodic, carminative, mild sedative, beneficial for bronchitis, cough, asthma	Zomorodian et al., 2013
Ocimum basilicum	linalool, elemene, farnesen, guaien	antioxidant, antiviral, antimicrobial, anti-inflammatory, analgesic, diuretic, food additive	Benedec et al., 2009; Zagoto et al., 2021
Phlomis tuberosa	Phytol, linalool, eugenol, caryophyllene oxide, terpineol, geraniol	antimicrobial	Olennikov et al., 2010
Prunella vulgaris	1,8-eucalyptol, β-pinene, myrcene, Linalyl acetate, α-phellandene, linalool, 1,6-cyclononone	antiviral, astringent, antibacterial, antiseptic, antihemorrhagic	Wang et al., 2019
Salvia nemorosa	sabinene, β-caryophyllene, germacrene D	antibacterian, antioxidant	Coisin et al., 2012
Salvia officinalis	1,8-cineol, camphor, α- and β-thujone, borneol, sabinene, camphene, caryophyllene	antibacterial, tonic, sleep disorders, anti-depressive, immunostimulant, possible anesthetic effects	Mot et al., 2022
Salvia	linalyl acetate, linalool,	antibacterial,	Cui et al., 2015

sclarea	germacren D	antioxidant and preservative in the food industry	
Salvia verticillata	camphene, β-pinene, sabinene	antibacterial, antioxidant	Mot et al., 2022
Stachys officinalis	germacrene D, isocaryophyllene	antioxidant and antimicrobial, treatment of: headache, anxiety, depression, neuralgia, chronic fatigue syndrome	Tobyn et al., 2011
Teucrium montanum	δ-cadinene, β-selinene	antibacterial, antifungal, anti-inflammatory antioxidant	Vukovic et al., 2007
Thymus vulgaris	thymol, carvacrol, p-cymene, γ-terpene, linalool, β-myrcene, terpinen-4-ol	antibacterial, antifungal, spasmolytic, antioxidant, anti-inflammatory, topical for would healing, anthelmintic, antiparasitic, antiviral, insecticidal, repellent against mosquitoes	European Union herbal monograph on *Thymus* spp.

Note: *chemical composition of the volatile oil may vary depending on geographical area, method of extraction of the plant, parts of the plant used to extract the essential oil, external factors, ** refers strictly to the biological and therapeutic action of the essential oil.

Honey potential of aromatic plants from *Lamiaceae* family

Medicinal plants contribute greatly to the beneficial properties of bee keeping products (honey, pollen, royal jelly and propolis) and have the potential to deliver more bioactive bee products. The value of bee products is closely linked to the properties of the plants which are visited by the bees (Durazzo et al., 2021). From this point of view, *Lamiaceae* family representatives can be categorized as one of the most important melliferous plant family.

Honey potential is defined as the theoretical amount of honey

(in kilograms/ha) that could be obtained during a season from a hectare of land covered with the focal plant. It is calculated for each plant species based on the amount of sugar secreted by individual flowers, the length of the flowering period and the number of flowers per hectare. Three conditions are considered: optimal growing conditions for the plants, adequate population of worker bees to collect the total amount of nectar secreted, and suitable climatic conditions for foraging by honey bees. Although in practice these conditions are seldom met, honey bee potential provides a useful basis for comparison (Crane, 1975).

To help beekeepers and farmers, lists have been drawn up with a hierarchy of honey plants for several decades. These references can be useful as a global review and checklists for the honeybee potential of many species (Crane, 1990). As a guiding tool for beekeepers, some data on honeybee potential are available in beekeeping manuals, but the source of reported values is generally not provided. In addition, honey potential should not be understood by beekeepers as the actual honey harvest because of the presence of other pollinator communities of which the honey bee is a part, and which also collect and consume nectar from the flowers.

According to the European red list of medicinal plants, representatives of *Lamiaceae* are highlighted as one of the most important categories as a food source (both nectar and pollen) for wild pollinators and honey bees. More than 34 species are included, from some genera such as: *Hyssopus, Lavandula, Thymus, Glechoma, Nepeta, Origanum, Prunella, Rosmarinus, Salvia, Teucrium, Galeopsis, Lamium, Leonurus, Melissa, Satureja, Stachys* and *Mentha* (Durazzo et al., 2021; Allen et al., 2014).

Besides species mentioned in the checklist of European medicinal plants, also some cultivated medicinal plant species from this botanic family are also indicated as relevant nectar and pollen source for bees (Durazzo et al., 2021; MAA-Ministère de l'Agriculture et de l'Alimentation-Liste de plantes attractives pour les abeilles, 2017).

The beekeeping potential determined on the basis of an extensive data set collected in Romania, on 153 herbaceous plants from several herb families, showed that the beekeeping potential was considerable and high for the *Lamiaceae* family. The data collected for 40 representatives of *Lamiaceae* placed these herbs in the top of melliferous plants included in the analysis (Ion et al., 2018).

Below is a general nomination of some important *Lamiaceae* family representatives and their melliferous potential (Table 2).

Table 2

Plants of the family *Lamiaceae* - melliferous potential of representatives in the spontaneous flora of Romania and non-native/ cultivated plants

Species	**Flowering period**	**Melliferous potential* (kg/ha**)**
Acinos suaveolens	Jun-Aug	n/a
Ballota nigra	Jul-Aug	100
Dracocephalum moldavica	Jul-Aug	300-400
Hyssopus officinalis	Jun-Sep	50-120
Lamium album	May-Jun	50-150
Lamium purpureum	Mar-Oct	50-200
Lavandula angustifolia	Jun-Sep	150-200
Lavandula latifolia	Jun-Sep	150-200
Leonurus cardiaca	Jun-Aug	200-400
Lophanthus anisatus	Jul-Oct	94-245
Marrubium vulgare	Jun-Aug	50-60
Melissa officinalis	Jun-Aug	150
Melittis melissophyllum	May-Jun	n/a
Mentha aquatica	Jun-Oct	220
Mentha piperita	Jul-Aug	100-200
Mentha crispata	Jul-Sep	100
Nepeta pannonica	Jul-Aug	130-240
Nepeta cataria	Jul-Aug	400
Ocimum basilicum	Jun-Oct	100-120
Phlomis tuberosa	Jun-Aug	n/a
Prunella vulgaris	Jul-Aug	50-120
Salvia nemorosa	Jul-Aug	300
Salvia officinalis	Jul-Aug	300
Salvia sclarea	Jun-Jul	250-300
Salvia verticillata	Jun-Aug	400-600
Stachys officinalis	May-Jul	100-200
Teucrium montanum	Jun-Aug	n/a
Thymus vulgaris	Jun-Aug	80

Note: * melliferous potential represents the theoretical amount of honey (in kilograms/ha) that might be obtained during a season; ** the interval was determined based on harmonizing autochthonous sources: Mârza and Nicolaide (1990), Cîrnu (1980), Chisnicean and Colţun (2014); n/a – no data available.

Conclusions

This work provides a general overview on main species from the *Lamiaceae* family which have a documented aromatic and melliferous potential. Based on literature review was determined that several native as well as non-native species of this botanic family have good prospects to be cultivated in Romania for complementary use: as melliferous plants and for essential oil extraction.

Following the literature research, it was determined that many practical implications can be highlighted, based on the highly complex mutual relationship existing between aromatic medicinal plants and bees. Firstly, several sources report a considerable improvement of the health status of bee populations (mainly attributed to the biological action of volatile oils), enhanced quality properties of bee products, as well as increasing of crop yield.

Besides the many direct benefits reported, some authors have also proposed the intercropping of melliferous aromatic plants with intensive crop fields, because increased qualitative component of pollination was associated with an increase of crop yields.

The *Lamiaceae* family is well known, intensively studied and economically important. Due to the biological activity of essential oil and other active metabolites these plants represent important raw materials for pharmaceutical industry, but it's also used as flavouring or preservative in the food industry. These plants have also found applications in the control of crop diseases and pests.

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