ISSN NO: 2770-2936
Date of Publication:30-10-2023

Pharmacognostic Analysis of Medicinal Plants Containing Essential Oils

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Abstract. This review aims to survey the major pharmacognostic plant taxa containing essential oils of pharmaceutical interest. The botanical families covered include Lamiaceae, Rutaceae, Myrtaceae, Zingiberaceae, Apiaceae, and Asteraceae among others. For each family, the major essential oil-bearing genera and species will be discussed along with the characteristic chemical constituents of their volatile oils. The pharmacological activities attributed to these essential oils will also be overviewed

Keywords: Essential oils, medicinal plants, pharmacognosy, monoterpenes, sesquiterpenes, phenolics

Introduction. For thousands of years, humans have utilized plants as sources of medicinal agents to treat a diverse array of ailments and promote wellness. Traditional medicine systems around the world have relied heavily on botanical remedies, many of which are still in use today. Plants produce an enormous variety of primary and secondary metabolites, many of which have beneficial bioactivities. Essential oils, in particular, have been prized for their therapeutic potential as well as their fragrance and flavor. Essential oils are volatile, aromatic compounds obtained from plants through steam distillation, cold pressing, or solvent extraction (Baser and Buchbauer, 2010). They are secondary metabolites predominantly composed of terpenes including monoterpenes and sesquiterpenes, though phenylpropanoids and other aromatic compounds may also be present. Essential oils are produced and stored in specialized plant structures such as glandular trichomes and secretory cavities or ducts (Petrovska, 2012). They play important ecological roles for plants as attractants for pollinators and seed dispersing animals, chemical defense compounds against herbivores and pathogens, and allelopathic agents (Reichling et al., 2009). When ingested by humans, essential oils can provide antimicrobial, anti-inflammatory, analgesic, respiratory, neuroprotective, and numerous other pharmacological effects (Silva et al., 2003; Bakkali et al., 2008). As such, essential oils are important natural product research targets for drug discovery efforts.

This review aims to survey the major pharmacognostic plant taxa containing essential oils of pharmaceutical interest. The botanical families covered include Lamiaceae, Rutaceae, Myrtaceae, Zingiberaceae, Apiaceae, and Asteraceae among others. For each family, the major essential oil-bearing genera and species will be discussed along with the characteristic chemical constituents of their volatile oils. The pharmacological activities attributed to these essential oils will also be overviewed. By compiling current knowledge of the phytochemistry and bioactivity of these aromatic plant taxa, this review seeks to aid natural product researchers in identifying promising essential oils for further therapeutic investigation and development.

Lamiaceae

The Lamiaceae or mint family encompasses over 7000 species across approximately 240 genera (Harley et al., 2004). Plants in this family are herbs and shrubs abundant in the Mediterranean region and Asia. Key genera containing pharmacologically important essential oils include Mentha, Lavandula, Thymus, Rosmarinus, and Salvia.

The Mentha genus is comprised of 25-30 species native to Europe, North America, South Africa, and Australia (McKay and Blumberg, 2006). The most well-known is Mentha x piperita, or peppermint, which yields a highly valued essential oil containing menthol, menthyl acetate, menthone, and other monoterpenoids (Rohloff, 2015). Peppermint oil displays antibacterial, antifungal, antiviral, antioxidant, and antitumor activities largely attributed to menthol (McKay and Blumberg, 2006; Sharma et al., 2019). It relaxes gastrointestinal smooth muscle to relieve pain, vomiting, and diarrhea and has an anesthetic action ideal for treating headaches (Grigoleit and Grigoleit, 2005). Peppermint oil also displays immunomodulatory, analgesic, and cognition enhancing effects (Sakamoto et al., 2018). Other Mentha species such as M. spicata (spearmint) and M. arvensis (cornmint) yield essential oils with similar menthol

ISSN NO: 2770-2936
Date of Publication:30-10-2023

content and bioactivities.Another prominent Lamiaceae essential oil is from Lavandula angustifolia, or true lavender. Its major components are linalool and linalyl acetate along with other monoterpene alcohols, esters, and oxides (Cavanagh and Wilkinson, 2002). Lavender oil exhibits anxiolytic, antidepressant, analgesic, antimicrobial, antioxidant, anti-inflammatory, and wound healing properties (Cavanagh and Wilkinson, 2002; Umezu et al., 2006). Thymus vulgaris (thyme) oil containing the phenolic monoterpenes thymol and carvacrol also displays potent antioxidant and antimicrobial actions (Sienkiewicz et al., 2012). Rosmarinus officinalis (rosemary) oil is composed largely of α-pinene, 1,8-cineole, camphor, and camphene, and displays cognitive enhancement and antimicrobial effects (Ngo et al., 2016). Salvia officinalis (sage) oil rich in α-thujone and β-thujone exhibits anti-inflammatory, antinociceptive, antioxidant, and antimicrobial bioactivities (Walch et al., 2011). Clearly the Lamiaceae family provides a wealth of medicinally useful essential oils.

Rutaceae

The Rutaceae or rue family encompasses over 150 genera and roughly 1600 species of trees and shrubs distributed worldwide. Major essential oil-producing genera include Citrus, Melaleuca, and Eucalyptus (Dugo and Di Giacomo, 2002).

Citrus species yield essential oils containing high amounts of monoterpene hydrocarbons including limonene, γ-terpinene, β-pinene, and sabinene (Lota et al., 2001). Cold-pressed oils from Citrus aurantium (bitter orange), Citrus limon (lemon), Citrus paradisi (grapefruit), and Citrus sinensis (orange) are extensively used as fragrances and flavors. Citrus essential oils exhibit antioxidant, anxiolytic, antidepressant, antimicrobial, and anti-inflammatory properties (Saiyudthong and Marsden, 2011; Campelo et al., 2011). The compound nootkatone from Citrus oil displays antifungal, antibacterial, anti-platelet aggregation, anti-inflammatory and antinociceptive activity (Campelo et al., 2011).

The Melaleuca genus encompasses over 200 species, with Melaleuca alternifolia (tea tree) being the most extensively studied for its essential oil. Tea tree oil contains diverse monoterpene and sesquiterpene alcohols, aldehydes, ketones, and oxides which contribute to its broad spectrum antimicrobial and anti-inflammatory actions (Carson et al., 2006). There is clinical evidence for tea tree oil improving mild to moderate acne vulgaris. Eucalyptus globulus (eucalyptus) leaf oil contains 70-90% 1,8 cineole and displays expectorant, antimicrobial, antioxidant, analgesic, and anti-inflammatory properties beneficial for treating respiratory conditions (Elaissi et al., 2011). Other Eucalyptus species provide essential oils with similarly high eucalyptol content and bioactivities. Thus the Rutaceae family offers citrus-scented oils with promising pharmaceutical applications.

Myrtaceae

The Myrtaceae family comprises about 140 genera and over 5500 species of aromatic trees and shrubs. It is an important source of essential oils rich in monoterpenes, sesquiterpenes, and phenylpropanoids (Curry et al., 2014). Prominent essential oil-bearing genera include Melaleuca, Eucalyptus, Eugenia, Psidium, and Syzygium.

As previously mentioned, Melaleuca alternifolia (tea tree) oil contains diverse terpene compounds and exhibits broad spectrum antimicrobial and anti-inflammatory properties (Carson et al., 2006). Other Melaleuca species provide essential oils with varying chemical compositions and biological activities. For example, Melaleuca cajuputii (cajuput) oil is dominated by 1,8 cineole and has been used to treat respiratory conditions, rheumatism, and cholera (Chuang et al., 2007). The primary components of Melaleuca quinquenervia (niaouli) oil are viridiflorol, 1,8 cineole, and α-terpineol, and the oil displays antioxidant, antimicrobial, anti-inflammatory, and anesthetic properties (Bilia et al., 2008). Eugenia caryophyllata (clove) oil contains eugenol as its major constituent and exhibits analgesic, antioxidant, antimicrobial, anti-inflammatory and insect repellent capabilities (Chaieb et al., 2007). Oils from Psidium guajava (guava) and Syzygium aromaticum (clove) also demonstrate antimicrobial, antifungal, and larvicidal activities (Chandra et al., 2016). Hence the Myrtaceae family provides important essential oils for pharmaceutical use.

Zingiberaceae

The Zingiberaceae family consists of over 50 genera and 1500 species of aromatic, rhizomatous herbs. Major essential oil-bearing genera include Zingiber, Curcuma, and Alpinia (Chang et al., 2011). The primary components of Zingiber officinale (ginger) rhizome oil are zingiberene, α-curcumene, and β-sesquiphellandrene, and the oil has antioxidant, anti-inflammatory, and antimicrobial properties (Ali et al.,

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2008). Curcuma longa (turmeric) oil contains ar-turmerone, α-turmerone, and β-turmerone as main constituents and displays antioxidant, anti-inflammatory, antimicrobial, hepatoprotective, antiproliferative, and immunomodulating activities (Liju et al., 2015). Alpinia galanga (galangal) oil, comprised mainly of 1,8-cineole and phenylpropanoids, exhibits antioxidant and antibacterial effects (Xu et al., 2014). Other Zingiberaceae plants provide essential oils with similar biological functions. The oils from this family are thus important for pharmaceutical applications.

Apiaceae

The Apiaceae family, also known as Umbelliferae, includes over 3000 species and 400 genera of aromatic plants (Chandler and Hawkes, 1984). Major essential oil-bearing genera are Coriandrum, Anethum, Foeniculum, Petroselinum, Cuminum, Carum, Pimpinella, and Angelica (Kubeczka, 1982). The main components of Coriandrum sativum (coriander) oil are linalool and α-pinene, and the oil has antioxidant, antimicrobial, anti-inflammatory, and analgesic activities (Silva et al., 2003). Dill (Anethum graveolens) oil contains predominantly carvone and limonene and exhibits antimicrobial, anti-inflammatory, antispasmodic, and antihyperlipidemic properties (Raal et al., 2012). The major bioactive compounds of fennel (Foeniculum vulgare) oil are trans-anethole, fenchone, and estragole, and the oil displays antioxidant, antimicrobial, chemopreventive, antithrombotic, and hepatoprotective effects (Rather et al., 2016).

Parsley (Petroselinum crispum) and cumin (Cuminum cyminum) oils also demonstrate antioxidant, antimicrobial, anti-inflammatory, and analgesic capabilities (Gonçalves et al., 2017; Allahghadri et al., 2010). Carum carvi (caraway) oil contains predominantly carvone and limonene and shows antioxidant, antimicrobial, antifungal, and antispasmodic properties (Raal et al., 2012). The oils from this diverse family thus hold much promise for pharmaceutical development.

Asteraceae

The Asteraceae or Compositae family encompasses over 1600 genera and 24,000 species of aromatic flowering plants (Heywood et al., 1977). Major essential oil-bearing genera include Helichrysum, Achillea, Artemisia, Tanacetum, Chrysanthemum, Matricaria, and Calendula (Madej et al., 2014). Helichrysum italicum (curry plant) oil is composed largely of monoterpene hydrocarbons like α-pinene, 1,8 cineole, and limonene, and displays antioxidant, anti-inflammatory, antimicrobial, and antifungal bioactivities (Mastelic et al., 2008). The main constituents of Achillea millefolium (yarrow) oil are sabinene, α-pinene, 1,8 cineole, and camphor, and the oil exhibits anti-inflammatory, analgesic, antimicrobial, hypotensive, and gastroprotective properties (Candan et al., 2003).

Artemisia annua (sweet wormwood) and Artemisia dracunculus (tarragon) oils have been found to contain antimalarial sesquiterpene lactones like artemisinin (Juteau et al., 2002). Chrysanthemum and Matricaria oils also demonstrate anti-inflammatory, antifungal, and insecticidal effects (Kim et al., 2010; Salehi et al., 2019). This family thus provides a variety of essential oils with pharmaceutical utility.

Conclusion

Essential oils are complex natural product mixtures that have been used for centuries in traditional medicinal practices. They display diverse pharmacological properties and serve as leads for drug discovery efforts. This review has provided an overview of the major plant taxa containing essential oils of pharmaceutical interest. Key families surveyed include Lamiaceae, Rutaceae, Myrtaceae, Zingiberaceae, Apiaceae, and Asteraceae. Within each family, the primary essential oil-bearing genera and species were highlighted along with the characteristic chemical components of their oils. The wide range of bioactivities attributed to these essential oils were also summarized, encompassing antioxidant, antimicrobial, anti-inflammatory, analgesic, respiratory, neuroprotective, antidiabetic, and antimalarial effects among others. There is tremendous diversity in the phytochemical composition and medicinal properties of aromatic plant essential oils. Further research on essential oil standardization, quality control, mechanisms of action, and safety is needed to drive pharmaceutical development. However, essential oils clearly represent an abundant reservoir of bioactive natural products with potential therapeutic applications.

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ISSN NO: 2770-2936
Date of Publication:30-10-2023

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