Antimicrobial Activity of Essential Oils Extracted From Lamiaceae Family (Basil, Mint and Thyme)

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Abstract: Extraction of essential oils from medicinal plants is as old as human history. Moreover, more than 500 plants are used to extract essential oils however; their composition and percentage yield depends on various factors mainly type of plant, type of organ (leaf, fruit, flowers, stem, roots, and seeds), geographical distribution of specie, weather conditions and methods used for their extraction. Different conventional methods such as super critical fluid extraction, hydro distillation, steam distillation, Soxhlet extraction and advance method such as solvent free microwave extraction are in practice for extraction of essential oils. To find the constituent composition varied chromatographic techniques are in practice that reports presence of phenols, flavonoids, aldehydes, terpenes, phenolics, esters, ketones, alcohols and various other antimicrobial compounds in them. The essential oils showed wide range of antimicrobial activities against bacterial, fungal, viral and parasitic strains. Furthermore, extracted oils are used as food additives, in cosmetics and for different pharmaceutical/medicinal purposes such as minor burns, skin cuts, acne, to resolve respiratory problems, skin allergies, promote relaxation and sleep. The main advantage of essential oils is the susceptibility of MRS (Multiple Resistant Strains) to these oils due to the presence of phenolic compounds in them. S. aureus, E. coli, Salmonella, candida albicans and many other food borne pathogens are found to be inhibited by activity of essential oils. In this paper composition, uses and antimicrobial activities of Basil (tulsi), Peppermint (podina) Callistemons (bottle brushes) and various other plant species are reviewed.

Keywords: Essential oil, medicinal plants, basil, mint, thyme, antimicrobial activity, distillation; Chromatographic technique.
INTRODUCTION

The use of essential oils in medicine and cosmetics and as antibacterial, antifungal, anti parasitic, antiviral, anti insecticide, is popular from the ancient times/middle ages and trend to use these still increasing due to their anticancer and capability to change tumour behavior (Edris, 2007; Bakkali et al., 2008; Kaefer and Milner, 2008). On the other hand excessive uses of antibiotics against pathogens results in more and more resistance in them thus more multi resistant pathogens are seen now than before (Davies and Davies, 2010; Lopez-Romero et al., 2015). Moreover, gram negative bacteria are showing more resistance than gram positive bacteria (Sakkas and Papadopoulou, 2017). The activity can be enhanced by adding terpenes extracted from plants with antibiotics (Fournomiti et al., 2015). Recent researches on different plant extracts mainly essential oil extracted from different parts of plants, revealed the extracts exhibit strong antimicrobial activities against bacteria, viruses, parasites (Cimanga et al., 2002; Rasooli et al., 2003; Baydar et al., 2004; Bozin et al., 2006; Saei-Dehkordi et al., 2010). The essential oil are present in leaves, stems, roots and even fruits of different plant species (Swammy et al., 2016). The bio-extracts can be separated by different conventional and advanced methods (Guan, 2007) and extraction using advanced methods such as solvent free microwave extraction is better technique than conventional hydro- distillation method (Lucchesi et al., 2004)

 Chemical Composition of Essential Oil

More than 15 chemicals such as 1,8-cineole, α and β-pinene, p-cymene, myrcene, γ-terpinene, α-terpineol and limonene are separated from six ecucalyptus spp. and four others (Cimanga et al., 2002). Similarly (Hussain et al., 2008) reported linalool, epi-α-cadinol, α-bergamotene and γ-cadinene from aerial parts of basil. Many plants produce essential oil as secondary metabolites (Bryan et al., 2015). They are aromatic and volatile compounds with the composition of more than 500 different compounds that mainly include terpenes (monoterpenes and sesquiterpenes), terpenoids (isoprenoids), and aliphatic and aromatic compounds such as aldehydes and phenols (Sakkas and Papadopoulou 2017). These compounds come from different precursors of primary metabolism and are synthesized through different pathways conferring antimicrobial and antifungal properties. The diverse composition is mainly due to two different compounds (terpenoids, phenyl propanoids) and their derivatives. They are produced in different chemical reactions of primary metabolism exhibiting antimicrobial activities against an extensive range of bacteria and fungi. Therefore medicinal plants are of great interest (Bersan et al., 2014).

An extensive range of essential oils are present and chemical composition of essential oil of different plant species varies, depending on different factors such as environmental conditions, soil composition and cultivation method. Due to this chemical composition difference, their antimicrobial activity also varies against different pathogens (Cimanga et al., 2002).

Plant Species Having Essential Oil

Basil: (Ocimum basilicum)

Basil is the common name for the culinary herb Ocimum basilicum of the family Lamiaceae (Labiateae). It contains 45-48 compounds (monoterpenoids, sesqui terpenoids and phenyl propanoids) and only
basil leaves contain 0.21% of essential oils (Lopez et al., 2008; Sakkas and Papadopouloou, 2017). The essential oil extracted from aerial parts of basil showed varied composition in winter and summer season and showed different antioxidant and antimicrobial activity (Hussain et al., 2008).

Anti-inflammatory and analgesic activities of basil essential oils are in use for the treatments of cephalalgia, diarrhea, constipation, indigestion and cough (Kathirvel and Ravi, 2012). It is also used in food products such as pastry items, tinned meat sausages as spices, as an additive and as contamination inhibitor for acid-resistant bacteria. It also shows antiseptic effects therefore use in oral solutions like mouthwash and in dental preparations for surgical uses. However, its use is limited due to its cytotoxic and carcinogenic activities, caused by eugenol and estragole present in it (Bakkali et al., 2008; Li et al., 2016). However, Villarini et al. (2014) revealed estragole was not able to induce DNA damage or apoptosis. According to the Council of Europe eugenol is not detectable and the amount of estragole should not be more than 0.05%mg/kg in food products. Inhibitory effect of basil essential oils against Shigella spp. and anti microbial activity against various microbial and fungal strains (S. aureus, E. coli, B. subtilis, P. multocida and pathogenic fungi A. niger, Mucormucedo, F. solani, B. theobromae, R. solani) was reported (Bagamboula et al., 2004; Hussain et al., 2008; Sakkas and Papadopouloou, 2017). The basil essential oils are also effective for different strains of Salmonella enteritidis particularly against S. enteritidis SE3 at minimum inhibitory concentration (Rattanachaikunsopon and Phumkhachorn, 2010).

**Mentha piperita**

Peppermint is the common name of Mentha piperita. It belongs to the family Lamiaceae. Its essential oil is extracted from the aerial parts of the flowering plant, dried leaves and the whole plant. The branched stems are mostly purple or violet (Singh et al., 2011). It is used for flavors, fragrances and also in pharmaceutical companies as digestant, stimulant and tonic (Iscan et al., 2002; Singh et al., 2011).

The chemical analysis of peppermint oil reveals its complexity and variability. The main component of Mentha piperita L. were menthol (40.7%) and menthone (23.4%) however, (+/-)-menthyl acetate, 1,8-cineole, limonene, beta-pinene and beta-caryophyllene are also present in small amounts (Schmidt et al., 2009). It shows antimicrobial activity against gram negative (Escherchia and Klebsiella) as well as gram positive bacteria (Staphylococcus and Streptococcus). However, Singh et al., (2015) reported mint oils are more effective against Gram +ve organisms when compared to Gram –ve organisms. Besides antimicrobial activity peppermint oil also works as antioxidant and anticancer (Singh et al., 2011; Arias, and Ramón-Laca, 2005; Schmidt et al., 2009). It also showed antibacterial activity against respiratory tract pathogens caught via breathing (Inouye et al., 2001).

**Thymus vulgaris**

Thymus vulgaris is also a flowering medicinal plant that belongs to family Lamiaceae. It is an ever green shrub but shows better growth in moderate to heat or sunny climate, specifically when not shaded (Hosseinzadeh et al., 2015). The genus thyme has almost 928 species that have been reported in Europe, Nortehrn Africa, Asia,
Southern America and Australia. It is a medicinal plant and belongs to family Lamiaceae. Two species *T. serpyllum* and *T. vulgaris* are commercially important. Many other species are also found in Mediterranean region. The plant is highly aromatic and good for yield of essential oils. It is also reported the essential oil composition of *T. vulgaris* is very complex containing up to 30 monoterpenes exhibiting different chemotypes. Comparing the different chemotypes, *T. vulgaris* has geraniol, alpha-terpineol, thuyaol-4, linalool, carvacol and thymol in species found in Southern France and 1,8-cineol is the only main chemotype in species found in Spain (Sakkas and Papadopoulou, 2017). A good percentage yield of 1.25%, extracted using steam distillation and GC-MS analysis reveals that the major component was thymol contributing (47.59%), following γ-terpinene (30.90%) and p-cymene (8.41%) (Boruga et al., 2014). The essential oils extracted from *T. vulgaris* showed great antimicrobial activity against bacterial as well as fungal strains. The high activity of thymus oils recorded against *Streptococcus pyogenes* and *Streptococcus mutans* at minimum inhibitory concentrations of 1.9 and 3.6μg/mL, respectively. Similarly, the susceptible fungal strains were *Candida albicans*, *Porphyromonas gingivalis*, and *Aggregatibacter actinomycetemcomitans* with minimum inhibitory concentrations of 16.3, 32 and 32μg/ml. The oils are also very active against *E.coli* (Fani and Kohanteb, 2017).

**Antimicrobial Action**

The mechanism of action of essential oil components is almost same as of artificially synthesized antibiotics (Fournomiti et al., 2015). Several components of medicinal and aromatic plants (MAPs) have different antimicrobial activity. They can cause cell death in different ways, compromising cell permeability, creating hypertonic environment for the cell that cause cell lysis or by influencing the normal mechanisms necessary for the cell stability. These essential oils are synthesized to protect the plants from microbial pathogens. The antimicrobial property of essential oil varies according to their chemical components (aldehydes, terpenes, phenolics, esters, ketones, alcohols and various other antimicrobial compounds) and the amount of major effective component (Degenhardt et al., 2009; Swamy et al., 2016). These chemical compounds are secreted through a series of molecular interactions under specific biotic/abiotic stress conditions. Each compound may exhibit a different mechanism of action against microbes. The

**Antimicrobial Effects of Essential Oil Extracted From Various Other Plants Species**

Essential oils derived from different medicinal plants have numerous applications in medicine, cosmetic, scent, agronomy and sanitary industries and are of great economic importance (Chouhan et al., 2017). Antimicrobial activity against psychotropic bacteria were assessed using oils extracted from nine plants chilli, cinnamon, cloves, ginger, nutmeg, oregano, rosemary, sage, thyme and highest inhibition zone was observed for cloves and cinnamon (Fabio et al., 2003). The appreciating aspect of these natural compounds is that microbes could not enhance their resistance against them, even if they are used for a long term as in case of synthetic antibiotics. It is also the point to be considering that if these compounds are added in food products to avoid microbial contamination, they will not compromise the nutritional values of food (Rojus et al., 2007).
chemical compositions of essential oil influence the biochemical reactions taking place in bacterial cell. Moreover, the antibacterial activity of essential oils also differs because of different bacterial architecture, such as Gram-positive and Gram-negative bacteria, which differ in their cell membrane compositions (Holley, and Patel, 2005; Sharifi-Rad et al., 2017).

Antimicrobial activities of essential oils depend on their hydrophobic nature. The major component of bacterial cell wall is peptidoglycan linked with some protein and teichoic acid molecules, while there is an extra outer layer of hydrophilic lipopolysaccharides only in gram negative bacteria which do not interact with the hydrophobic compounds like the essential oil components. This is the reason gram positive bacteria are more likely to be susceptible than gram negative bacteria. But essential oil components also show antibacterial activity against gram negative bacteria because they travel through the porin proteins present in bacterial cell wall and slowly gain access to periplasm (Lodhia et al., 2009; Silhavy et al., 2010; Nazzaro et al., 2013; Bryan et al., 2015; Lopez-Romero et al., 2015; Stojiljkovic et al., 2018).

CONCLUSION

More than 500 plant species are important source for essential oils and are used to treat a number of diseases like skin allergies, cephalalgia, diarrhea, constipation, indigestion and cough. Several plants derived essential oils such as basil, peppermint and thyme oils are effective as alternative to synthetic additives in food, cosmetic and pharmaceutical industries because of their antimicrobial activities. The composition of essential oils varies due to various factors that effects mechanism of action.

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