Essential Oils: Potential Application in Disease Management

Swapnil Pandey, Sankalp Misra, Vijay Kant Dixit, Shashank Kumar Mishra, Ritu Dixit, and Puneet Singh Chauhan

Abstract

Natural essential oils extracted from dietary plants and their constituents which include monoterpenes, sesquiterpenes, and phenolics play crucial role in different disease management. Several mechanisms such as antioxidant, enhancement of immune function, enzyme induction, and enhancing detoxification are responsible for different disease management. Essential oils are representing a promising source of active elements and an array of pharmacological properties, including antibacterial, antifungal, antiaging, etc. This study presents the overview of different action exerted by essential oils and discusses active constituents and their effect on disease control.

Keywords

Essential oils · Disease management · Ayurveda · Phytomolecules · Antibacterial

1 Introduction

Essential oils (EOs) are aromatic oily liquids extracted from plant material (flowers, buds, seeds, leaves, etc.) possessing antibacterial, antifungal, and antiviral properties which have been considered worldwide as an alternative source to treat

S. Pandey · S. Misra · S. K. Mishra · P. S. Chauhan (✉)
Microbial Technologies Division, CSIR-National Botanical Research Institute (CSIR-NBRI), Lucknow, Uttar Pradesh, India

Academy of Scientific and Innovative Research (AcSIR), Ghaziabad, Uttar Pradesh, India
e-mail: puneet@nbri.res.in

V. K. Dixit · R. Dixit
Microbial Technologies Division, CSIR-National Botanical Research Institute (CSIR-NBRI), Lucknow, Uttar Pradesh, India

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infectious diseases and agents promoting food preservation (Belletti et al. 2008; Alviano and Alviano 2009; Safaei-Ghomi and Ahd 2010; Astani et al. 2010). EOs or their components have also been shown to exhibit antiviral (Bishop 1995), antitoxigenic (Juglal et al. 2002), and antiparasitic (Pandey et al. 2000) properties. The quantity of active components present in essentials oils differs among species and plant parts. These types of components have chemical origin from terpenes and their oxygenated derivatives, which are aromatic and phenolic compounds.

1.1 Use and Role of Essential Oils

The modern lifestyle could be stressful at some point of time which quickly becomes overwhelming. The wealth of natural products that we inherited from our ancestors in the form of plants and minerals might be utilized in medicines. Apart from medicinal use, natural extracts are predominantly used in essential oils and aromatherapy. Other important roles of essential oils include fragrance, bathing products, incense, perfumes, and cosmetics. Aromatherapy in the form of alternative medicine could be used, as well as further research to evaluate how plant extracts can help patients are still being carried out by the scientific community. Some essential oils like eucalyptus, peppermint, and tea tree oil are well known for their role in treating minor ailments. EOs have a broad-spectrum use such as in food, perfumes, and pharmaceuticals (Van Welie 1997; Van de Braak and Leijten 1999). The antibacterial properties of essential oils could be employed for manufacturing many products like dental root canal sealers (Manabe et al. 1987) and antiseptics (Cox et al. 2000). According to these reports, essential oils are rich sources of natural antioxidants and used in the treatment of many diseases.

1.2 Antibacterial Essential Oils

Essential oils consist of an odoriferous mixture of monoterpenes, sesquiterpenes, and aromatic compounds. Bacterial infections are caused by some agents such as *Staphylococcus aureus*, *Escherichia coli*, etc. leading cause of health hazard in the developing world. It is generally due to the partial admittance of the poorer economy population to integrated health care and treatments. To overcome this type of problem, there is a serious need to explore and develop natural and cheap agents which could be used as powerful substitutes to the current synthetic drugs. Essential oils are a very good alternative for this type of infections.

1.3 Antifungal Activity of Essential Oils

Synthetic drugs are of crucial concern due to the emergence of drug-resistant microbes, raising the reluctance toward the use of chemical-based products. In this context, natural products such as extracts or essential oils can play a fundamental role. EOs mainly consist of active molecules, well known for their medicinal properties such as anti-inflammatory, analgesic, and sedative (Masango 2005; Macwan et al. 2016).

Chemical treatments are most efficient, but strains develop resistance against it. EOs can be used as one of the most capable natural products for different types of infections (Kalemba and Kunicka 2003). Natural extracts obtained from different plants or herbs exhibited strong antifungal properties (Prakash et al. 2012; Lang and Buchbauer 2012; Ghalem 2016). Like other phytochemicals, EOs could mitigate microbial growth and development of biofilms through specific mechanisms (Hyldgaard et al. 2012).

1.4 Nematicidal Activity of Essential Oils

The parasitic nematode is one of the plant pest leading to an extensive monetary loss in the form of reduced crop yield and production. About (Masango 2005; Macwan et al. 2016) earlier, a report on eucalyptus essential oil demonstrated inhibition of root-knot nematode *Meloidogyne incognita* by *E. citriodora* and *E. hybrids* (Pandey et al. 2000). Ibrahim et al. (2006) reported that *Eucalyptus camaldulensis*-, *E. saligma*, *E. urophylla*-extracted essential oil caused mortality of *Meloidogyne exigua* and *M. incognita*.

1.5 Anticancer Activity of Essential Oils

Cancer is the world's second-largest cause of death. There is no active drug available in the market to treat most diseases like cancer. Natural products deal opportunities for drug discovery and play an essential role in cancer treatment. A large number of antitumor drugs are currently used worldwide from natural origin, isolated from medicinal plants, for the prevention of cancer. For pharmaceutical purposes, traditional medicinal herbs have been used, and dietary therapy is currently used in cancer treatment (Cai et al. 2004).

1.6 Antiaging Activity of Essential Oils

Aging is a natural sensation experienced by most species. Many of the research conducted over the past few decades have suggested that aging is not entirely an arbitrary deterioration of cells and tissues and is influenced by genetic pathways (Lithgow 2006; Kenyon 2010). Nowadays, many essential oils extracted from plants have increased responsiveness for various types of bioactivity, such as antibacterial, antiviral, and antifungal. The Juniper berry (*Juniperus communis* L.) essential oils (JBEOs) extracted from juniper berries have a lot of components, i.e., α-pinene, limonene β-caryophyllene, δ-cadinene, etc. reported as an in vivo antioxidant and antiaging agent (Pandey et al. 2018). *Trachyspermum ammi* L., traditionally known as carom seed, is used in India to cure severe human and animal disorders. This medicinal plant is used as a standard spice and is used as a stimulant and tonic, and its essential oil is also used to treat age-related disorders (Rathor et al. 2017).

1.7 Anti-Alzheimer's Activity of Essential Oils

Cholinergic dysfunction is primarily associated with diseases such as Alzheimer's and Parkinson's and neurodegenerative and psychiatric disorders. The extent of cholinergic affliction is maximum in Alzheimer's disease which is a progressive neurodegenerative disorder involving the death of cholinergic neurons. To date, only the use of acetylcholinesterase (Ache) inhibitors limits the therapeutic management of cholinergic dysfunction to provide symptomatic relief. Essential thyme oil increases neurotransmission through the modulation of levels of synaptic acetylcholine (Ach) and receptor activity of nicotinic acetylcholine (Sammi et al. 2017). Similarly, essential oils from *Hedychium gardnerianum* had shown acetylcholinesterase inhibition properties and radical scavenging properties (Arruda et al. 2012). The essential oil of *S. lavandulifolia* reported having acetylcholinesterase-inhibiting properties in striatum and hippocampus of the brain (Table 1).

1.8 Role of Essential Oils Against Human Pathogenic Bacteria

Some medicinal agents have been isolated from natural sources, along with an impressive number of new drugs. The presence of various life-sustaining components in plants has led scientists to investigate these plants for their potential uses in the treatment of certain infectious diseases. Natural medicine has long been accepted in many countries as an alternative to Western medicine practices. Infections caused by infectious microorganisms such as bacteria, fungi, viruses, or parasites are a vital pathological condition and one of the world's top ten causes of morbidity and mortality. Essential plant-isolated oils were studied for their antimicrobial activity against microorganisms, including many pathogens (Dorman and Deans 2000; Delaquis et al. 2002). The essential oils can be a powerful tool for reducing the development and spread of various microorganisms that are resistant to antimicrobials. Hence, the activity of various essential oils against the different pathogenic bacteria is listed in Table 2.

1.9 Multidrug-Resistant Bacteria

Antibiotics are used in large numbers for human treatment, as well as in animals and even fish in aquaculture, resulting in the selection of multiple drug-resistant pathogenic bacteria. Two mechanisms in bacteria can generate the resistance of many drugs. First, these bacteria can accumulate different genes for resistance to a single drug within a unique cell coding. Unusual gene accumulation occurs naturally on plasmids with resistance (R). Second, the increased expression of genes that code for multidrug efflux pumps, extruding a wide range of drugs, may also result in multiple drug resistance. The treatments are very complicated when infections are caused by multidrug-resistant bacteria; sometimes, few or no treatment options

Table 1 List of essential oils with different disease control properties

Plants	Essential oils	Different properties	References
Thymus vulgaris	Thyme oil	Antimicrobial, antioxidant cholinergic dysfunction	Sammi et al. (2017), Rota et al. (2008), and Zheng and Wang (2001)
Hedychium gardnerianum	Hedychium gardnerianum oil	Antithrombin, antibacterial, anti-acetylcholinesterase, and antioxidant activity	Medeiros et al. (2003) and Arruda et al. (2012)
Eucalyptus globulus	Eucalyptus oil	Antimicrobial, nematicidal, acaricidal	Fiori et al. (2000) and Pandey et al. (2000)
Lavandula angustifolia	Lavender oil	Antibacterial, antifungal, astringent, anti-inflammatory	Cavanagh and Wilkinson (2005) and Hammer et al. (1999)
Matricaria recutita L.	Chamomile oil	Antidiarrheal and antioxidant, neuroprotective, anti-allergic, anti-inflammatory, antimicrobial, anticancer	Ranpariya et al. (2011), Chandrashekhar et al. (2011), Bulgari et al. (2012), Silva et al. (2012), and Matić et al. (2013)
Melaleuca alternifolia	Tea tree oil	Antioxidant, anti-skin cancer, antibacterial, antiviral, antifungal, antiprotozoal, antitumor	Mantle et al. (2001), Greay et al. (2010), Mondello et al. (2006), and Carson et al. (2006)
Rosa damascena	Rose oil	Antidepressant, analgesic, hypnotic, antispasmodic, anti-inflammatory, anticonvulsant	Boskabady et al. (2006), Rakhshandah and Hosseini (2006), and Kheirabadi et al. (2008)
Juniperus communis L.	Juniper berry oil	Antioxidant, antiaging, antistress	Pandey et al. (2018) and Emami et al. (2007)
Anthemis Palestina	Anthemis oil	Antioxidant, antispasmodic, antihelicobacter, antimicrobial, antiproliferative	Bardaweel et al. (2014), Konstantopoulou et al. (1992), and Teixeira (2004)
Cinnamomum zeylanicum	Cinnamon oil	Antioxidant, anti-inflammatory, antidiabetic, antimicrobial, anticancer, neurological disorders	Mancini-Filho et al. (1998), Tung et al. (2010), Park et al. (2005), Jana et al. (2013), Marom et al. (2011), Hili et al. (1997), and Chou et al. (2013)
Trachyspermum ammi L.	Ajwain oil	Antiaging, antistress, antioxidants, antimicrobial, nematicidal, antihelminthic, antifilarial, antifungal, antibacterial, and antiviral agent	Rathor et al. (2017) and Chatterjee et al. (2013)

Table 2 In vitro and in vivo activities of essential oils against human bacterial pathogens

Name of essential oils	Bacterial pathogens	References
Sesame oil (*Sesamum indicum*)	*Escherichia coli, Staphylococcus aureus, Klebsiella pneumonia, Bacillus cereus, Salmonella typhi, Shigella flexneri, Acinetobacter baumannii*	
Santhanathi oil (*Santalum album*)	*Escherichia coli, Staphylococcus aureus, Klebsiella pneumonia, Bacillus cereus, Salmonella typhi, Shigella flexneri, Acinetobacter baumannii*	
Mustard oil (*Brassica nigra*)	*Escherichia coli, Staphylococcus aureus, Klebsiella pneumonia, Bacillus cereus, Salmonella typhi, Shigella flexneri, Acinetobacter baumannii*	
Punga oil (*Pongamia pinnata)*	*Escherichia coli, Staphylococcus aureus, Klebsiella pneumonia, Bacillus cereus, Salmonella typhi, Shigella flexneri, Acinetobacter baumannii*	
Tea tree oil *(Melaleuca alternifolia)*	*Alternaria* spp. *A. flavus*, *A. fumigates*, *A. niger*, *Blastoschizomyces capitatus*, *C. albicans*, *C. glabrata*, *C. parapsilosis*, *C. tropicalis*, *Cladosporium* spp., *C. neoformans*, *Epidermophyton floccosum*, *Fusarium* spp., *Malassezia furfur*, *Microsporum canis*, *M. sympodialis*, *M. gypseum*, *Penicillium* spp.	Carson and Riley (1993) and Hammer et al. (2012)
Euphrasia rostkoviana	*C. albicans*	Novy et al. (2015)
Thuja sp. *(Thuja plicata*, *Thuja occidentalis)*	*P. aeruginosa*, *K. pneumoniae*, *S. aureus*, *E. coli*	Jirovetz et al. (2006)
Thymus zygis	*S. choleraesuis*, *S. typhimurium*, *E. coli*	Peñalver et al. (2005)
Salvia lavandulifolia	*P. vulgaris*, *P. aeruginosa*, *K. pneumonia*, *E. faecalis*	Jirovetz et al. (2006)

persist. In many cases, health-care workers have to use antibiotics that are more toxic to the patient. Many bacteria are multidrug-resistant, viz. *Staphylococcus aureus*, *Salmonella paratyphi*, *Shigella dysenteriae*, *Escherichia coli*, *Bacillus subtilis*, and *Candida albicans.*

1.10 Essential Oils Synergy with Antibiotics

Antibiotic therapy is one of the most critical treatments used in the fight against infectious diseases and since its introduction has greatly enhanced the health aspects of human life. In nature, the role of antibiotics remains unproven due to bacteria's responses by demonstrating different forms of resistance after new antibiotics for clinical use have been initiated. Antibiotic resistance can lead to failure of treatment, increased cost of treatment, as well as death rates and create even wider problem-controlled infection-controlled resistant bacteria from hospital to the community. Essential oils are produced from the secondary metabolism of aromatic plants, also known as volatile oils. The term is "essential" because it represents the

very essence of the plant and its essential part. Synergy occurs when combined therapy is used because the combined effect is greater than the sum of the individual outcomes. In past studies, when resistance to β-lactam antibiotics occurred, pharmaceutical scientists modified the β-lactam warhead periphery to obtain a more useful variant, and the penicillin and cephalosporin, second- and third-generation β-lactams, emerged. Occasionally, essential oils are synergistic enhancers because they are not capable of producing any significant inhibitory effects when used alone, but when used in combination with standard drugs, the combination impact surpasses their performance and improves antimicrobial activity (Gibbons et al. 2003). It has been found that synergistic action using essential oils reduces the minimum effective dose of antibiotics in infection treatment and reduces the adverse effects of antibiotics. Most importantly, a combination of antibiotics with essential oils targeting resistant bacteria may have a distinct mechanism of action, leading to new choices to overcome the microbial resistance attack. Because essential oils are multicomponent compared to many conventional antimicrobials that have only one target site, the exploitation of essential oils to prevent bacterial resistance is considered more promising. A new concept is the combination of traditional antimicrobial agents and essential oils (Table 3).

Table 3 The synergistic effect of essential oils and antibiotics in human pathogenic bacteria

Pair combinations	Pathogens	Methods	Interaction	References
Oregano/fluoroquinolones	*E. coli*	Broth microdilution	Synergistic	Si et al. (2008)
Oregano/doxycycline		Checkerboard assay		
Oregano/lincomycin				
Oregano/maquindox				
Pelargonium graveolens/norfloxacin	*S. aureus, B. cereus*	Agar dilution checkerboard assay	Synergistic	Rosato et al. (2007)
Lantana montevidensis/aminoglycosides	*E. coli*	Broth microdilution	Synergistic	
		Checkerboard assay		
Eugenol/vancomycin	*E. coli, E. aerogenes, P. vulgaris, P. aeruginosa, S. typhimurium*	Broth microdilution checkerboard assay	Synergistic	Hemaiswarya and Doble (2009)
Eugenol/β-lactams				
Rosmarinus officinalis/ciprofloxacin	*K. pneumoniae*	Broth microdilution	Synergistic	Van Vuuren et al. (2009)
		Checkerboard assay		
Eucalyptus/chlorhexidine digluconate	*Staphylococcus epidermidis*	Broth microdilution	Synergistic	Karpanen et al. (2008)
		Checkerboard assay		

(continued)

Table 3 (continued)

Pair combinations	Pathogens	Methods	Interaction	References
Zataria multiflora/vancomycin	*S. aureus* (MRSA and MSSA)	Broth microdilution	Synergistic	Mahboubi and Ghazian Bidgoli (2010)
		Checkerboard assay		
Aniba rosaeodora/gentamicin	*Bacillus cereus, Bacillus subtilis, S. aureus, E. coli, Acinetobacter baumannii, Serratia marcescens, Yersinia enterocolitica*	Broth microdilution	Synergistic	Rosato et al. (2007)
Pelargonium graveolens/gentamicin		Checkerboard assay		
Citrus limon/amikacin	*Acinetobacter* spp	Broth microdilution	Synergistic	Guerra et al. (2012)
Cinnamomum zeylanicum/amikacin		Checkerboard assay		
Coriander/chloramphenicol	*A. baumannii*	Broth microdilution	Synergistic	Duarte et al. (2012)
Coriander/ciprofloxacin		Checkerboard assay		
Coriander/gentamicin				
Coriander/tetracycline				

2 Conclusion

Essential oils play a vital role in traditional medicine for treating different types of infection worldwide for centuries and are important and alternative medicine for many diseases. Many studies focused on revealing the specific action mechanisms of essential oils and their active ingredients. In the current scenario, essential oils against bacterial, fungal, nematicidal, aging, Alzheimer's, etc. have been used effectively. This review emphasizes to make way for a new route of phytomolecules-based drugs for several disease management from the diverse pool of natural compounds.

3 Future Prospective

Essential oils, phytoconstituents, and herbal medicine are also necessary to manage the pathological conditions of several diseases. The active constituents from natural resources are presenting enormous scope for improved therapeutic application for the treatment of human disease. Therefore, it is time to decipher and identify our traditional knowledge regarding plant products and understand its recent advancements to fight against different disease management, to give it a worthy place.

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