Chapter 1

Potential of Medicinal Use of Essential Oils from Aromatic Plants

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http://dx.doi.org/10.5772/intechopen.78002

Abstract

The use of medicinal plants rich in essential oils can represent a viable source for the control of some diseases, being able to constitute a possible therapeutic alternative due to its effectiveness. Essential oils are natural volatile fractions extracted from aromatic plants and formed by classes of substances such as esters of fatty acids, mono and sesquiterpenes, phenylpropanoids, aldehyde alcohols and, in some cases, aliphatic hydrocarbons, among others. Essential oils have been used by mankind for medicinal purposes for several centuries, with reports coming from Ancient Egypt. In this sense, the present work aims to approach the biological activities of essential oils such as antioxidant, anticancer, antiprotozoal, antifungal, antibacterial and anti-inflammatory activities of different plant matrices rich in essential oils.

Keywords: natural products, essential oils, medicinal application, biological activity

1. Introduction

The essential oils are formed by volatile substances and generally have low molecular weight, these substances are formed in the secondary metabolism of aromatic plants [1, 2]. However, some natural factors such as physiological variations, environmental conditions, geographic variations, genetic factors and plant evolution can alter the chemical composition of these oils as well as their yield [3].

The extraction of essential oils usually occurs with the use of conventional techniques such as hydrodistillation using a Clevenger type extractor, which is the most widespread technique for the isolation of volatile plant oils [4, 5], however, other extraction techniques are also efficient such as extraction with supercritical CO_2 [6, 7], this type of extraction is a technique considered clean and does not cause change in the chemical structures of the molecules, since it usually works at low operating temperatures [8].

In nature, essential oils play an important role in plants as protection and communication, chemical protections that these secondary metabolites present, also is decisive in plant resistance against pathogens and herbivores [9]. In the communication the plant can use a chemical agent that travels through the atmosphere and activate defensive genes of other plants, such as the methyl jasmonate of *Solanaceae* and *Fabaceae* [10].

In the industry these oils are widely studied, mainly for their potential applications as agents promoting biological activities. The volatile compounds have presented over the years several pharmacological applications, such as antioxidant, anticancer, antiprotozoal, antimicrobial and anti-inflammatory activities [11–15]. In recent work [16] demonstrated that species like *Ocimum basilicum* and *Thymbra spicata* have good antioxidant and antimicrobial activity against *Staphylococcus aureus*, *Streptomyces murinus*, *Micrococcus luteus*, *Bacillus subtilis*, *Klebsiella pneumoniae*, *Pseudomonas aeruginosa*, *Yersinia enterocolitica*, *Proteus vulgaris*, *Candida albicans* and *Aspergillus niger*. Jeena et al. [17] revealed that ginger oil has significant antioxidant, anti-inflammatory and antinociceptive activities and Xiang et al. [18] evidenced that the essential oils of *Curcuma herbs* have anticarcinogenic actions against LNCaP and HepG2 cells. In this sense, this work aims to approach different biological activities of essential oils that may be important for the maintenance of human health.

2. Biological activities of essential oils

2.1. Antibacterial and antifungal activity of essential oils (EO)

The antimicrobial action of essential oils is not yet fully understood, but can be attributed to their permeability to the cell wall of microorganisms due to their diverse chemical and synergistic composition. The hydrophobic characteristic of the essential oils acts in the partition of the lipids of the cellular membrane and the mitochondria, making them more permeable, in this way, the critical ions and molecules (lipids, proteins and nucleic acids) are extravasated, leading them to death. EOs generally have less action on gram-positive bacteria than on gram-negative bacteria due to the interaction of the hydrophobic components of the essential oils and the cell membrane [19–21].

http://dx.doi.org/10.5772/intechopen.78002

Different methods are used to evaluate the antibacterial and antifungal properties. The most used are: the method of disc diffusion of Agar, Minimal Inhibition Concentration (MIC), Minimum Bacteria Concentration (MBC) and Minimum Fungicide Concentration (MFC). Since the use of the disc diffusion method in agar is limited by the hydrophobic nature of essential oils and plant extracts that prevents its uniform diffusion through the agar medium, most authors report the results obtained with MIC and MBC [22].

In recent years, different microbial species of medical interest have been tested, from which encouraging results have emerged. **Table 1** shows data on the antimicrobial activity of essential oils on fungi and bacteria, also showing the main components of essential oil.

The potential antimicrobial activity of essential oils of the *Hedychium coronarium* Koen rhizome from different locations in Eastern India was studied in gram-positive, gram-negative bacteria and fungal strains. The study revealed that the essential oils presented more satisfactory effects to the antifungal action than to the antibacterial activity. In addition, the gram-positive bacteria are more sensitive to oil than gram-negative due to the peptidoglycan layer did not selectively act on essential oil compounds. The antimicrobial action of the essential oils was attributed to its constituents in an isolated way, as well as synergistically, additive or antagonistic to each other [23].

Essential oils isolated from *Nepeta leucophylla*, *Nepeta ciliaris*, *Nepeta clarkei* and *Calamintha umbrosa* showed significant antifungal activity *in vitro* against phytopathogenic fungi responsible for plant diseases. Essential oils have the potential to be used as a possible biofungicide (as an alternative to synthetic products) that may contribute to an increase in the pre and post harvest storage life of food crops [25].

The good results obtained encourage future research aimed at a possible application of these substances in food, pharmaceutical and cosmetology fields. **Table 1** presents the main chemical components of essential oils of several plants with antimicrobial potential.

2.2. Antioxidant activity

The interest in the study of the antioxidant substances of essential oils has become more and more intensified and is now indispensable for the prevention of diverse pathologies [27]. In the literature, it is reported the presence of antioxidant activity in several essential oils [28–30].

This property acts at different levels in the microorganism protection and plays a key role in some of the biological activities of essential oils, being able to combat the development of oxidative stress that causes damage to health, increasing the risk of diseases such as Alzheimer's, Parkinson's and inflammation associated with atherosclerosis and rheumatoid arthritis. Some studies point out that these diseases may be consequences of damages caused by free radicals, besides oxygen and reactive nitrogen species that act as mediators of inflammation as messenger molecules. This shows that essential oils can also act as an anti-inflammatory agent [31–33].

Essential oils have great potential in the nutrition industry in view of their antioxidant properties, they are use as feed additives for farm animals, for example, and that may be fundamental to the quality of food products from these animals, since essential oils can improve nutritional value, oxidative stability and increase the shelf life of these products such as meats

Plant source	Main components	Microorganism	*MIC	Reference
Hedychium coronarium Koen.	β-Pinene; eucalyptol; linalool; coronarin-E; α-pinene; p-cymene; γ-terpinene and 10-*epi*-γ-eudesmol	*Candida albicans* and *Fusarium oxysporum*	3.12–400 μg/ml	[23]
Laportea aestuans (Gaud)	Methyl salicylate; fenchol; 1,2-cyclohexanedione dioxime; 1,4-octadiene and linalool	*E. coli*; *S. aureus*, *B. subtilis*; *P. aeruginosa*; *K. pneumoniae*; *S. typhi*; *C. albicans*; *R. stolon*; *A. niger* and *P. notatum*	50–200 mg/ml	[24]
C. umbrosa	β-caryophyllene	*F. oxysporum*	1500–3000 μg/ml	[25]
	Germacrene D	*H. maydis*		
	Spathulenol	*A. solani*		
N. leucophylla	Caryophyllene oxide	*F. oxysporum*	1000–3000 μg/ml	
	Iridodial β-monoenol	*H. maydis*		
	Acetate	*A. solani*		
N. ciliaris	β-Caryophyllene	*F. oxysporum*	1000–3000 μg/ml	
	β-Sesquiphellandrene	*H. maydis*		
	Caryophyllene oxide	*A. solani*		
N. clarkei	β-Sesquiphellandrene	*F. oxysporum*	1000–3000 μg/ml	
	Actinidine	*H. maydis*		
	Germacrene D	*A. solani*		
Juglans regia L.	α-Pinene	*S. aureus*	15.62–62.50 μg/ml	[26]
	β-Pinene	*E. coli*		
	β-Caryophyllene germacrene D limonene	*S. typhi*		
		S. dysenteriae		
		K. pneumonia		
		B. subtilis		
		S. epidermidis		
		P. vulgaris		
		P. aeruginosa		

*Minimum Inhibitory Concentrations.

Table 1. Main components of essential oils with antimicrobial potential.

and eggs. In addition, they are often treated as foods to enhance the taste and organoleptic properties, and even has the function of decreasing the process of deterioration of food. The latter is mainly due to its antimicrobial and antioxidants activities [31, 34, 35].

The interest in extracts rich in natural antioxidants has recently increased, especially the antioxidant activity of essential oils. Most of them confirm the assumption that essential oils are promising as natural antioxidants, which can replace synthetic additives such as butylated hydroxyanisole (BHA) and butylated hydroxytoluene (BHT) that are potentially harmful to human health [36–38]. In this context, **Table 2** presents some more recent studies found in the literature based on the antioxidant activity of essential oils, highlighting its main constituents and antioxidant performance evaluation methods.

2.3. Anticancer activity

Essential oils from aromatic plants have been treated as a product containing anticancer properties because they have the ability to inhibit cell proliferation and decrease the spread of cancer, improving the quality of life of cancer patients and reducing the level of their agony. Mediated therapy with essential oils can be used in combination with conventional therapies in the treatment of cancer (quimioterapia e radioterapia) [44–46].

According to the World Health Organization [47] cancer is a generic term used for a large group of diseases that can affect any part of the body, is characterized by the growth of abnormal cells beyond their usual limits in the body. Other common terms used are malignant tumors and neoplasms, the latter process or stage of the disease is called metastasis. Cancer is a major public health problem and is considered the second leading cause of death worldwide, accounting for 8.8 million deaths by 2015, where nearly 1 in 6 deaths is caused by cancer. Ref. [48] reported that the American Cancer Society reported in the year 2017 approximately 1,688,780 new cases of cancer and 600,920 deaths from cancer in the United States. According to [49–51] the most common causes of cancer death are melanoma, leukemia, followed by lung, liver, prostate, breast, cervical, colorectal, and endometrial cancers.

Plant source	Main constituents	Biological activity	Reference
Pinus (*P. tabulaeformis*, *P. tabulaeformis* f. *shekanensis*, *P. tabulaeformis* var. *mukdensis*, *P. tabulaeformis* var. *umbraculifera*, *P. henryi* and *P. massoniana*)	α-Pinene, bornyl acetate, β-caryophyllene, α-guaiene, germacrene D	*Pinus* were evaluated for antioxidant potential by three methods (DPPH, FRAP and ABTS)	[39]
Ocimum basilicum L.	Linalool, methyl chavicol, 1,8-cineole	The free radical scavenging activity of the oil was measured by the DPPH method	[40]
Ocimum basilicum, *Mentha spicata*, *Pimpinella anisum* and *Fortunella margarita*	Carvone, methyl chavicol, trans-anethole, limonene	The evaluation of the ability to eliminate the free radicals of the oils was by the DPPH and ABTS methods	[41]
Salvia lavandulifolia	Camphor, 1,8-cineole, camphene, α-pinene	The *S. lavandulifolia* were evaluated for antioxidant potential by three methods (DPPH, FRAP and ABTS)	[42]
Rosmarinus officinalis	α-Pinene, 1,8-cineole, Camphor	The antioxidant activity was evaluated in 7 samples of rosemary oil based on the measurement of the antioxidant reduction capacity in relation to the DPPH radical	[43]

Table 2. Antioxidant activity of essential oils.

The sharp increase in the number of cancer cases can be attributed to eating habits, since foods contain many chemicals such as preservatives and dyes, making people more susceptible to cancer, which can also be accentuated with the use of tobacco and alcohol, chronic infections, exposure to harmful radiation, or due to change in lifestyle and environmental pollution [45, 52]. Previous studies have reported that oxidative stress increases the onset of different chronic diseases, including cancer. Reactive oxygen species (ROS) are highly unstable compounds that have the ability to attack cells and tissues in the human body, followed by destructive effects that lead to the beginning of cancer [46, 53].

Therefore, there has been a recent increase in the use of natural products such as spices and plants to replace or accompany common treatments for cancer because of their high costs, side effects and the development of resistance of patients against anticancer drugs [44, 52].

Thus, essential oils from different aromatic plants have anticancer potential against mouth, breast, lung, prostate, liver, kidney, colon, bone, ovary, pancreas, uterus and brain cancer and even in leukemia, glioblastoma, melanoma [45, 54]. Thus [52] have shown that essential oil extracted from cloves (*Syzygium aromaticum* L.) is an ideal natural source as a chemopreventive agent against breast cancerbetulinic acid and other triterpenes, can be indicated as constituents responsible for anticancer properties [55] which determined that the essential oil of eucalyptus (*Pulicaria inuloides*) presented anticancer activity against breast, liver and colorectal/colon cancer due to the abundant presence of citronellol, pulegol and citronelil acetate.

The myrtle essential oil (*Myrtus communis* L.) shows anticancer activity against blood cancer (leukemia) due to the presence of 1,8-cineole, linalool, myrtenyl acetate, and myrtenol [56]. However, [46] have shown that orange peel oil (*Citrus sinensis*) has anticancer properties against colorectal/colon, prostate and lung cancer, with D-limonene being the predominant chemical constituent. Therefore, the results of studies justify the use of essential oils, as a possible alternative medicine in the treatment of cancer.

Essential oils act in the chemoprevention and suppression of cancer, which involve apoptosis, cell cycle retention, antimetastatic and antiangiogenic, increased levels of reactive oxygen and nitrogen species (ROS/RNS), modulation of DNA repair and others that demonstrate their antiproliferative cancer cell activity [53, 57]. In addition, the lipophilic nature of the EOs allows them to cross cell membranes and enter easily within the cell [45, 54], in **Table 3** we can observe the anticancer activities of different aromatic plants.

2.4. Antiparasitic activity

Current treatment media control most diseases of protozoan origin mainly through chemotherapy, where synthetic drugs are generally used, but they show several side effects of cytotoxicity in humans. Due to the hydrophobic and bioactivities nature of its components, essential oils (EO) can be considered important sources of development of agents against intracellular pathogens such as protozoa, which cause parasitic diseases [64].

The EO of leaves of *Artemisia indica* showed antimalarial activity in vitro, being a prophylactic potential of malaria, which is a disease caused by the protozoan of the genus *Plasmodium*. The oil inhibited at least two recombinant enzymes from the biosynthesis of plasmid fatty acids and showed low cytotoxicity in mammals [65].

http://dx.doi.org/10.5772/intechopen.78002

Plant source	Main constituents	Biological activity	Reference
Rosa damascena	Nerol, kaempferol and geraniol	Liver cancer, human breast cancer, prostate cancer	[58]
Pulicaria inuloides	4,5-dimetiltiazol-2-il and 2,5-difeniltetrazólio	Breast cancer	[55]
Citrus sinensis	D-Limonene and alcohol perylic (oxygenated monoterpene)	Colorectal/colon cancer, prostate cancer, lung cancer	[46]
Aquilaria crassna	β-Caryophyllene, 1-phenanthrenecarboxylic acid, α-caryophyllene and azulene benzenedicarboxylic acid	Colorectal/colon carcinoma, pancreatic cancer	[59]
Myrtus communis L.	1,8-cineole, linalool, myrtenyl acetate and myrtenol	Blood cancer (leukemia)	[56]
Eucalyptus citriodora Hook	Pulegol, citronellol and citronellil acetate	Breast cancer, liver cancer, colorectal/colon cancer	[53]
Cinnamon cassia spp.	Cinnamic aldehyde, cinnamyl aldehyde and tannins	Head and neck cancer	[57]
Syzygium aromaticum L.	Betulinic acid and triterpenes	Human breast cancer	[52]
Trachyspermum ammi L.	γ-Terpinene, timol and P-cymene	Liver cancer	[60]
Commiphora myrrha	2-cyclohexen-1-one and 4-ethynyl-4-hydroxy-3,5,5-trimethyl	Liver cancer, cervical cancer	[61]
Salvia officinalis	Hydrocarbons, monoterpene, oxygenated monoterpenes sesquiterpene and diterpenes	Human breast cancer, prostate cancer, kidney cancer	[62]
Tagetes minuta L.	cis-β-ocimene, cis-tagetone and trans-tagetenone	Breast cancer, blood cancer (leukemia)	[63]

Table 3. Anticancer activity of essential oils.

Another EO that presents the antimalarial effect is that obtained from *Piper aduncum* leaves, with camphor (17.1%), viridiflorol (14.5%) and piperitone (23.7%) being the main components found in this oil [66]. The EO of the leaves of *Aniba canelilla* (HBK) Mez presented a trypanocidal effect, being considered a potential for the natural treatment to trypanosomosis, which is caused by the protozoan *Trypanosoma evansi*, since it proved its action *in vivo*. Its antiprotozoal activity is related to the compounds 1-nitro-2-phenylethane (83.68%) and methyleugenol (14.83%), the latter being slightly more active than the first in the treatment of the disease [67].

The EO of the leaves of *Tetradenia riparia* presented antileishmanial effect *in vivo* and *in vitro*, being effective in the fight against the protozoan of the species *Leishmania (Leishmania) amazonenses*, without showing toxicity to human erythrocytes. The main compound responsible for this therapeutic effect is the 6,7-dehydroroyleanone, which was also tested in isolation and showed a similar effect to the EO [68]. EO from *Lippia alba*, was investigated *in vitro* and *in vivo* assays to evaluate antiparasitic effects and histopathological changes of tambaqui (*Colossoma macropomum*). Concentrations of 1280 and 2560 mg/L showed 100% efficacy after 20 min of oil exposure in (*Anacanthorus spathulatus*, *Notozothecium janauachensis* and *Mymarothecium boegeri*) [69].

The antiparasitic activity of *Lavandula stoechas* oil was investigated in *Leishmania major*, *Leishmania tropica* and *Leishmania infantum*. The evaluation of the antileishmanial activity of *Lavandula stoechas* EO presented a greater effect in comparison to the drug Glucantime. The bioactive compounds present in this oil are: fenchone (31.81%), camphor (29.60%), terpineol (13.14%), menthone (8.96%) and eucalyptol [70].

The anthelmintic activity of *Thymus vulgaris* L. EO was investigated in *in vitro* and *in vivo* tests to evaluate the effect on *Haemonchus contortus* parasites present in the gastrointestinal system of sheep. Thymol is the major compound corresponding to 50.22% of the oil from the *Thymus vulgaris* species. Results showed that EO inhibited 96.4% of egg incubation, 90.8% of larval development and 97% of larval mobility [71]. Other essential oils, their chemical constituents and biological antiparasitic activities are shown in **Table 4**.

2.5. Anti-inflammatory activity

Essential oils have complex mixtures of chemicals that are present in different concentrations, these oils are used in medicine to treat a myriad of diseases because they present potential for anti-inflammatory activity [78, 79].

Inflammation is typically a protective mechanism that can be stimulated by a variety of harmful agents, which may be chemical, physical or biological. Living and vascular tissues respond to stimuli that are considered irritating to the body. These irritations can usually be linked to pain, redness (erythema), heat, tumor (edema), tissue loss or organic function [80, 81].

In recent years the anti-inflammatory potential of essential oils and their chemical position has become the object of study of several researchers in the search for new drugs of natural origin [82–84], as well as a study of the synergistic anti-inflammatory effect of the chemical constituents of essential oils and synthetic drugs, showing a possible association between

Plant source	Main constituents	Biological activity	Reference
Chenopodium ambrosioides	Ascaridole, carvacrol and caryophyllene oxide	Antileshmanial, antimalarial and antitrypanosoma	[72]
Cinnamomum verum	(E)-cinnamaldehyde and eugenol	Antitrypanosoma	[73]
Eugenia uniflora L.	Sesquiterpenes, curzerene, γ-elemene and trans-β-elemenone	Antileshmanial	[74]
Lavandula angustifolia	Borneol, epi-ᴅ-muurolol, ᴅ-bisabolol, precocene I and eucalyptol	Antischistosomatic	[75]
Piper hispidinervum (Piperaceae)	Safrole	Antiamoebicidal	[76]
Teucrium ramosissimum	δ-Cadinene, δ-cadinol, β-eudesmol, γ-gurjunene and cedrene	Antiamoebicidal	[77]

Table 4. Anti-parasitic activity of essential oils.

Plant source	Main constituents	Biological activity	Reference
Globba sessiliflora Sims.	β-Eudesmol, (E)-β-caryophyllene, caryophyllene oxide, T-muurolol	Anti-inflammatory	[91]
Piper glabratum	β-Pinene, longiborneol, α-pinene, (E)-caryophyllene	Anti-inflammatory	[84]
Phyllanthus muellerianus	Isoelemicinb, caryophyllene oxide, α-Cadinol, 2-isopropyl benzoic acid	Anti-inflammatory	[92]
Salvia officinalis	1,8-Cineole, camphor, β-pinene, E-β-caryophyllene	Anti-inflammatory	[93]
Lippia gracilis Schauer	Thymol, carvacrol, p-cymene, α-pinene	Anti-inflammatory and healing activity	[94]
Citrus limon	Limonene, β-pinene, γ-terpinene, sabinene	Anti-inflammatory	[95]
Cymbopogon citratus	Geranial, neral, β-myrcene, geranyl acetate	Anti-inflammatory	[96].
Anethum graveolens L.	α-Phellandrene, limonene, dill ether, α-pinene	Anti-inflammatory	[97]
Citrus aurantium L.	Linalool, linalylacetate, nerolidol, Z,E-farnesol	Anti-inflammatory	[98]
Blumea balsamifera (L.) DC.	Borneol, caryophyllene, ledol, caryophyllene oxide	Anti-inflammatory	[99]

Table 5. Anti-inflammatory activity of essential oils.

clinical remedies with natural products as a pharmacological alternative and avoiding adverse reactions caused by synthetic products [85]. In vivo tests performed on rats confirm the potential of these essential oils as natural products, helping to advance research [86, 87].

The knowledge of the chemical composition and the chemootype of the aromatic plants are important factors in studies of the anti-inflammatory activity, since the concentration of the compounds diverge due to this biological variation, in this way researchers have evaluated both aspects [88, 89]. Evaluating the specific constituents of a particular essential oil may help in understanding the performance of these compounds in the anti-inflammatory action [90]. **Table 5** shows the anti-inflammatory potential of different essential oils.

3. Conclusion

Essential oils may play an important role in the maintenance of human health, since they have several biological properties, and may become a natural alternative for the control of several diseases, however, the great majority of published works present the results of these oils based on its chemical composition complex and not only based on a substance, because the biological effects of these oils can be related to a synergism and/or an antagonism between the chemically active substances that are part of its composition.

Acknowledgements

Oliveira M. S (Process Number: 1662230) thank CAPES for the doctorate scholarship.

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