Medicinal & Aromatic Plants

Properzi et al., Med Aromat Plants 2013, 2:5
DOI: 10.4172/2167-0412.1000136

Review Article Open Access

Some Biological Activities of Essential Oils

Alessandro Properzi[1]*, Paola Angelini[1], Gianluigi Bertuzzi[2] and Roberto Venanzoni[1]

[1]*Department of Applied Biology, University of Perugia, Borgo XX giugno 74-06121 Perugia (PG), Italy*
[2]*Master Medicina Estetica. Dip.to di Medicina dei sistemi, Università di Roma "Tor Vergata", Via Montpellier, 1-00133 Roma (RM), Italy*

Abstract

Presentation of case: Essential oils and their volatile constituents have been widely used since the middle ages, to prevent and treat human disease. They have been widely used for bactericidal, fungicidal, antioxidant, allelochemical, medicinal, cosmetic applications, pharmaceutical, sanitary, cosmetic, agricultural and food industries. They contain some volatile constituents, such as phenol-derived aromatic components, aliphatic components, terpenes and terpenoids. *In vitro* evidence shows that essential oils can act as antibacterial agents against pathogenic fungi and bacterial strains.

Aim: The finality of this review is to aim of attracting the attention of scientific community seeking new drugs from plant and fungi, as well as to study the pharmaceutical diversity of essential oils.

Conclusion: The data presented show how the old art of "essential oil therapy" is revitalized due to the progress of scientific knowledge on their mode of action.

Keywords: Essential oil; Antibacterial agents; Antifungal agents; Antioxidant agents; Allelochemical agents

Introduction

The aromatic plants had been used since ancient times for a large number of purpuse, for example, they are used for their preservative and medicinal properties or to impart flavor and aroma to food. In the past, 'the father of modern medicine', Hippocrates, already prescribed perfume fumigations. The presence of essential oils is one of the main causes of the pharmaceutical properties of plants. The term 'essential oil' was used for the first time in the 16th century by the founder of the discipline of toxicology, Paracelsus von Hohenheim. Paracelsus named the active component of a drug, 'Quinta essential' [1]. Essential oils are natural multi-component systems, they consist largely in small molecole, such as terpenes, usually formed from only carbon and hydrogen, but often also oxygen containing. Essential oils are used in perfumes and make-up products, as food preservers and additives, in sanitary products, in agriculture, and as natural remedies. Moreover, essential oils are used in massages as mixtures with vegetal oil or in baths, but most frequently in aromatherapy. There are several techniques that can be used to extract essential oils: water distillation, steam distillation, solvent extraction, expression under pressure, supercritical fluid extractions and subcritical water extractions. Pharmaceutical and food uses of natural extracts are more widespread as alternatives to synthetic chemical products to protect the ecological equilibrium. The type of extraction is chosen according to the purpose of the use. For pharmaceutical and food uses extraction by steam distillation or by expression, for example for *Citrus*, is preferred. For perfume uses, extraction with lipophilic solvents and sometimes with supercritical carbon dioxide is favoured. Thus, the chemical profile of the essential oil products differs not only in the number of molecules, but also in the stereochemical types of molecules extracted, according to the type of extraction. The extraction product can vary in quality, quantity and in composition, according to climate, soil composition, plant organ, age and vegetative cycle stage [2,3]. So, in order to obtain essential oils of constant composition, they have to be extracted under the same conditions from the same organ of the plant, which has been growing on the same soil, under the same climate, and has been picked in the same season. Most of the commercialized essential oils are chemotyped by gas chromatography and mass spectrometry analysis. Analytical monographs have been published [4-7], to ensure good quality of essential oils. Do to their antibacterial, antifungal and insecticidal activities, essential oils have been largely employed for their properties already observed in natural environment. Nowdays more than 3000 essential oils are known, 300 of which are commercially important, especially for industries. Some essential oils have particular medicinal properties that have been praised to cure certain organ dysfunction or systemic disorder [8-10]. Owing to the new attraction for natural products like essential oils, despite their wide use and being familiar to us as fragrances. Improve knowledge on their mode of biological action will allow to develop new applications in human health, agriculture and the environment. Some of them constitute effective alternatives or complements to synthetic compounds of the chemical industry, without showing the same secondary effects [11].

Essential Oils

Essential oils as antibacterial agents

The Ancient Egyptians used aromatic plants (and the essential oils content in them) in embalming, in that manner, bacteria stop to growth and decay was prevent. This was confirmed from strong *in vitro* evidence. In fact, essential oils can act as antibacterial agents against a wide spectrum of pathogenic bacterial strains, including: *Listeria monocytogenes, L. innocua, Salmonella typhimurium, Escherichia coli* O157:H7, *Shigella dysenteria, Bacillus cereus, Staphylococcus aureus* and *Salmonella typhimurium* [8,12-14], and many more [15]. Also, *Commiphora africana* (A.Rich.) Endl. essential oil can inhibit some pathogenic bacterial strains, such as *Staphylococcus aureus*, *Escherichia coli*, *Candida albicans* [16] and *Helicobacter pylori* [17]. *Helicobacter*

***Corresponding author:** Alessandro Properzi, Department of Applied Biology, University of Perugia, Borgo XX giugno 74-06121 Perugia (PG), Italy, E-mail: properzialessandro@gmail.com

Received September 19, 2013; **Accepted** September 30, 2013; **Published** October 04, 2013

Citation: Properzi A, Angelini P, Bertuzzi G, Venanzoni R (2013) Some Biological Activities of Essential Oils. Med Aromat Plants 2: 136. doi: 10.4172/2167-0412.1000136

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pylori is a Gram-negative microaerophilic bacterium. It is a highly motile and thought to be an infective agent widely spread on the world population (more than 50%), this makes it the most common chronic infection for humans. *H. pylori* is widely recongnized as a gastrointestinal pathogen. It is the causative of chronic superficial gastritis, and is major factor contributing to the pathogenesis of duodenal ulcer disease.The medical treatment for *H. pylori* include a combinations of different active substances: antibiotics, H^{2-}blockers, bismuth subsalicylate, proton pump inhibitors, is well known that multi-drug therapy is associated with considerable side effects, but there is an alternative. Few studies have been shown that some traditional herbal medicines can act against *H. pylori*; one of this (*C. africana*) was tested by Epifano et al. [17]. Antibacterical activity against *H. pylori*, Gram-positive (*S. aureus*, *S. epidermis*, *E. faecalis*) and Gram-negative (*E. coli*, *P. aeruginosa*) bacteria was tested *in vitro* by Epifano et al. [17]. In this study *in vitro* agar dilution method was employed for the assessment, as reccomended by the National Committee for Clinical Laboratory Standard (2002/2003). The results pointed out that *C. africana* essential oil has shown a potent anti-*H. pylori* activity with MIC values of 1 µl/ml (much lower than those of the reference compound metronidazole), while little or no activity against different species of Gram-positive and Gram-negative bacteria has been showed. The results show a selective antibacterical activity of *C. africana* essential oil against *H. pylori*. The activity of *C. africana* essential oil against *H. Pylori*, is comparable to the one of known antimicrobial agents, but the latter may favour the emergence of resistant colonies and also present a potential for the disruption of intestinal microbial flora, which is responsible for side effects [17].

Essential oils as antifungal agents

Despite of modern knowledge on slaughter hygiene and food, production techniques show an increasing during the last years, food safety remaining an increasingly important public health issue [4]. It has been estimated that as many as 30% of people in industrialised countries suffer from a food borne disease each year, and in 2000, at least two million people died from diarrhoeal disease worldwide [5]. There is, therefore, still a need for new methods of reducing or eliminating foodborne pathogens, possibly in combination with existing methods [14]. At the same time, Western society appears to be experiencing a trend of 'green' consumerism [18,19], desiring fewer synthetic food additives and products with a smaller impact on the environment. Moreover, the World Health Organization has recently asked for a worldwide reduction in the consumption of salt that is correlated to the incidence of cardio-vascular disease [5]. If the level of salt in processed foods is reduced how reccomend WHO, it is necessary that other additives will be develop to maintain the safety of foods. There is, hence, scope for new methods of making food safe, which have a natural or 'green' image. One such possibility is the use of essential oils as food additives that can act as antibacterial and antifungal additives.

Angelini et al. [20] pointed out the use of essential oils in the food industry, as natural sanitizing agents; in this study, Angelini et al. [20] evaluate some antimicrobial activity parameters as mycelial growth inhibition, minimum inhibitory concentration (MIC) and minimum fungicidal concentration (MFC) of six essential oils against *Aspergillus niger*, *Aspergillus terreus*, *Chaetomium globosum*, *Penicillium chrysogenum*, *Penicillium pinophilum*, *Trichoderma harzianum* and *Trichoderma viride*. The antimicrobial activity of essential oils was monitored by the macrodiluition technique. The mycelial growth inhibition, fungistatic and fungicidal concentrations were recorded for each strain that showed sensitivity to the essential oils. The essential oils of catnip, cinnamon, tea tree and thyme essential oils exhibited a large spectrum antimicrobial activities; those of clary sage and laurel inhibited the mycelial growth in a few fungal strains. The essential oils of cinnamon and thyme had the lowest MIC and MFC values against all the fungi assayed, followed by catnip, tea tree, clary sage and laurel [20].

In the last two decades, there has been a considerable increase in the incidence of life-threatening systemic fungal infections. The challenge has been to develop strong strategies for treating fungal diseases, to treat opportunistic fungal infections in human immunodeficiency virus-positive patients, and others who are immunocompromised due to cancer chemotherapy or the indiscriminate use of antibiotics [21,22]. Most clinically-used antifungal drugs have various drawbacks. They are pretty toxic, they have a low efficacy and high cost, furthermore, their frequent use has produced resistant strains [23]; therefore, there is a great need for new antifungals that concern to a wide range of structural classes, that can selectively work on new targets with fewer side effects [24,25].

Strong *in vitro* evidence indicates that some essential oils like *Thymus schimperi* Ronniger essential oil, can act as antibacterial agents against a wide spectrumof pathogenic fungal isolates including (*Penicillium chrysogenum*, *Verticillium* sp., *Aspergillus tubingensis*, *Aspergillus minutus*, *Beauveria bassiana* and *Microsporum gypseum)* [26]. *In vitro* susceptibility testing of the isolates to conventional antifungal agents and to two chemically well-defined chemotypes of *T. schimperi* essential oil was performed. Most of the isolated fungi were resistant to amphotericin B (except *A. minutus*), and itraconazole, while terbinafine was quite active on these fungi. *T. schimperi* essential oil showed antifungal activity against all of the tested fungal isolates. The minimal inhibitory concentration values was similar or lower than those of terbinafine. Considerable morphological and cytological changes revealed by transmission electron microscopy analyses, occur when essential oil inhibit fungal growth [26].

Also, Tirillini et al. [27] focused our investigation on the antifungal activities of *Laserpitium garganicum* subsp. *garganicum* (Ten.) Bertol essential oil. *L. garganicum* subsp. *garganicum* (Ten.) Bertol. (=*Laserpitium siler* L. subsp. *garganicum* (Ten.) Arcangeli) is a perennial herb belonging to the *Apiaceae* family. The distribution is limited to the southern area of the Balkan peninsula and Italy. In Italy, this plant is found in the central Apennines, Sicily and Sardinia. This plant is described as a subspecies of *L. siler* or a species of *Laserpitium* in the Flora Europaea and the Flora d'Italia, respectively. Tirillini et al. [27] tested *L. garganicum* subsp. *garganicum* essential oil against some phytopathogens and opportunistic human fungi. A few studies have reported the biologically active components isolated from *L. siler*, mainly sesquiterpene lactones, and one refers to sesquiterpene lactones from the roots of *L. garganicum*. Tirillini et al. [27] identified fifty-six compounds in *L. garganicum* essential oil, representing 92.3% of the total oil.

Table 1 shows the anfungal activity of the essential oil of *L. garganicum* [27].

Essential oils as antioxidant agents

Free radicals and other reactive oxygen species produce oxidation of proteins, amino acids, unsaturated lipids and DNA. Reactive oxygen species produce molecular alterations related to aging, arteriosclerosis and cancer [28], Alzheimer's disease [29], Parkinson's disease, diabetes and asthma [30]. The human body has defense mechanisms against free radicals present in almost all cells [31]. Is possible that occur an

Microorganism	% Inhibition*			
	0.125 µL/mL**	0.250 µL/mL**	0.5 µL/mL**	1 µL/mL**
A. niger	21 ± 7	31 ± 6	32 ± 4	28 ± 4
A. terreus	n.i.	14 ± 5	17 ± 5	22 ± 6
C. globosum	n.i	22 ± 3	22 ± 4	20 ± 4
P. chrisogenum	n.i.	10 ± 4	15 ± 5	47 ± 5
P. pinophilum	23 ± 6	28 ± 5	34 ± 5	54 ± 4
T. viride	13 ± 4	33 ± 3	42 ± 4	67 ± 2

*The data are the mean of triplicate values ± SD.
**Essential oil content (µL/mL cultured medium)
n.i.: no inhibition.

Table 1: Antimicrobic activity of the essential oil of *L. garganicum*

imbalance between free radical production and their removal by the body's antioxidant system; this imbalance bring to a phenomena known as 'oxidative stress' [32,33]. Balance between free radicals and antioxidants can be recovered from an external supply of antioxidants. Essential oils are rich in phenolic compounds, and for this reason, attract investigators to evaluate their activity as antioxidants or free radical scavengers. The essential oils of basil, cinnamon, clove, nutmeg, oregano and thyme have proven radical-scavenging and antioxidant properties in the DPPH radical assay at room temperature [34]. The order of effectiveness was found to be: clove>>cinnamon>nutmeg>basil ≥ oregano>>thyme. The essential oil of *Thymus serpyllum* L. showed a free radical scavenging activity close to that of the synthetic butylated hydroxytoluene (BHT) in a β-carotene/linoleic acid system [35]. The antioxidant activity was attributed to the high content of the phenolics thymol and carvacrol (20.5% and 58.1%, respectively).

Bertuzzi et al. [36] investigates the action of *Citrus×limonum* Risso essential oil to control free radical-induced lipid peroxidation and preventing tissue damage in skin. In this study, the essential oil was analized by GC-MS technics. The superoxide anion scavenging activity of *C. limonum* essential oil was evaluated by the enzymatic hypoxanthine/xanthine oxidase system. The antiradical activity was tested on human volunteers after UV ray ex position. The essential oil was diluted in DMSO or grape-seed oil, then it was spread on the face of human volunteers. The presence of peroxyl radicals was detected on a sample skin lipids that has been previously collected. The detection of peroxyl radicals based on the measurement of light emitted (chemiluminescence), when the excited carbonyl and singlet oxygen decay to ground state. Bertuzzi et al. [36] demonstrate that the lemon essential oil is more active than a-tocopherol against O^{2-} and peroxide free radical inhibition at 1: 100 dilution, therefore, protocol for controlling free radical-induced lipid peroxidation in human skin was thus proposed. The results of the study by Bertuzzi et al. [36] suggest that lemon essential oil has properties that could benefit human skin, as it undergoes environmental and chronological ageing, therefore, the scavenging action of lemon essential oil could have a practical application for treating human skin against oxidative damage [36]. The scavenging action of lemon essential oil solubilized in grape-seed oil could have a practical application in aesthetic medicine for treating human skin against oxidative damage. Therefore, continuous application of lemon essential oil solubilized in grape-seed oil might contribute to the prevention of lifestyle-related skin diseases by regulating the balance of oxidative stress [36].

Essential oil as allelochemical agents

Although oleogumresins/essential oils are well known antimicrobial agents, they stimulates some microorganisms and use them as carbon energy sources [37,38]. Angelini et al. [39] suggest that the weak parasitism of *P. eryngii* spp.-complex on roots and stems of umbellifers (family *Apiaceae*, genera *Eryngium*, *Ferula*, *Ferulago*, *Cachrys*, *Laserpitium*, *Diplotaenia* and *Elaeoselinum*) is mediated by allelopathic interactions. The oleogum-resin/essential oils (or their components) shifts the microrganism balance in favour of those microrganisms (e.g. *Pleurotus* spp.) that can tolerate them. Some even use them as a carbon and energy source [39,40].

The term "Allelopathy" has undergone several changes over time [41,42]. The definition adopted by the International Allelopathy Society (IAS) in 1996 is "The science that studies any process involving secondary metabolites produced by plants, algae, bacteria and fungi that influences the growth and development of agricultural and biological systems". Allelopathic interactions derive from the production of secondary metabolites. The secondary metabolites are synthesized for a wide range defense by plant and microorganisms. The secondary metabolites involved are called allelochemicals [43].

Trichoderma harzianum is a fungal contaminant that causes extensive losses in the cultivation of *Pleurotus* species. *Melaleuca alternifolia* (Maiden and Betche) Cheel (tea tree) essential oil was investigated by Angelini et al. [39]. This essential oil have "*in vitro*" allelopathic ability to control *Trichoderma harzianum*. The antifungal activity of *M. alternifolia* essential oil and antagonist activities between *Pleurotus* species against three *T. harzianum* strains were studied in dual-culture experiments. The dual-culture was realized on an agar-based medium, in which different concentrations of essential oil were incorporated. *M. alternifolia* essential oil at a concentration of 0.625 l L/mL, inhibited *T. harzianum* mycelial growth by 5.9-9.0%, depending on the strain. At the same concentrations *P. ferulae* and *P. nebrodensis* stimulated mycelial growth by 5.2-8.1%. All strains of *T. harzianum* were antagonistic to the *Pleurotus* species in the control. When essential oil was added to the substrate cultural, the antagonistic activity of *T. harzianum* against the *Pleurotus* species was weak (0.0625 l L of essential oil) or non-existent (0.125 l L of essential oil). Currently, synthetic chemicals are currently used to prevent and control *T. harzianum* in mushroom cultivation; *M. alternifolia* essential oil could be an alternative to the synthetic [44].

Essential oils, aromatherapy: From at least 4000 years, essential oils are used by man to for prevention and treatment of many disorders. Due to the balancing properties of essential oils, a type of "alternative medicine" called aromatherapy has been developed. Aromatherapy is defined as the treatment or disorders prevention by the use of essential oils. Aromatherapy is a complementary medicine that can be considered a branch of phytotherapy; it combines two words: aroma (a fragrance) and therapy (a treatment). Our sense of smell access to the brain's limbic system, which is an anatomical structure that is our emotional "part", to spread the 'essential oil in the environment is used burners, nebulizers and diffusers. A source of heat to evaporate the essential oil previously diluted in water. The heat is used to dissolve the oil in the water, which otherwise would not be water-soluble, only aroma delivery through inhalation, to induce psychological or physical effects, can be defined as aromatherapy [45]. Nevertheless, the clinical use of essential oils and their volatile constituents *via* inhalation or massage has expanded worldwide.

Conclusion

The studies reviewed in this article are intended for retrieving the attention of scientific community on the wide range of application of essential oils. They can provide to develop new drugs from natural products. Thus, essential oils and their constituents can hopefully be considered in the future for more clinical evaluations and possible applications, and as adjuvants to current medications. The data presented provide a basis for reviving investigation on the pharmaceutical diversity of essential oils.

Our topical modern scientific knowledge can help to reinterpret old art of 'essential oil therapy', how described here.

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