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RESEARCH ARTICLE

ESSENTIAL OILS: EXTRACTION TECHNOLOGY, BIOACTIVITY AND USE IN FOOD PRESERVATION

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ABSTRACT

Essential oils (EOs) have received increasing attention as the natural additives for the shelf-life extension of food products, due to the risk in using synthetic preservatives. These are concentrated liquids of complex mixtures of volatile compounds. Essential oils, also called volatile odoriferous oil extracted from different parts of plants, for example, leaves, peels, barks, flowers, buds, seeds, and so on. They can be extracted from plant materials by several methods like steam distillation, solvent extraction, and so on. Essential oils are a good source of several bioactive compounds, which possess antioxidative and antimicrobial properties. In addition, some essential oils are being used as medicine. Furthermore, essential oils can be incorporated into packaging, in which they can provide multifunction termed as "active or smart packaging." New technology for lowering the unique and undesirable smell of essential oil, which can limit their use in foods by encapsulation technology, can be utilized to counter their negative effect on sensory perception. As a consequence, essential oil can be widely used without any negative effect on sensory property of foods. Novel technologies such as encapsulation of EOs into Nano emulsions and the use of EOs as part of hurdle technology to improve the microbial stability and the sensory quality of meat and meat products are being used in the meat industry; traditional methods of adding EOs directly into meat batter during manufacturing of meat products are also used. The development of release system for essential oil from packaging or fuming system inside packaging is conducted to maximize the activity of active compounds in essential oils. Therefore, it can serve as the convenient packaging, which can effectively extend the shelf life of foods.

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INTRODUCTION

Essential oils, also called volatile odoriferous oil, are aromatic oily liquids extracted from different parts of plants, for example, leaves, peels, barks, flowers, buds, seeds, and so on. They can be extracted from plant materials by several methods which mainly include steam distillation and expression. Among all methods, steam distillation has been widely used, especially for commercial scale production (Cassel and Vargas 2006; Di Leo Lira *et al.*, 2009). Most of the commercialized essential oils are chemo typed by gas chromatography and mass spectrometry analysis. Analytical monographs have been published (European pharmacopoeia, ISO, WHO, Council of Europe; Smith *et al.*, 2005) to ensure good quality of essential oils. Essential oils have been widely used as food flavors (Burt 2004). This can affect the applications as the ingredient in some particular foods. Essential oils have been known to possess antioxidant and antimicrobial activities, thereby serving as natural additives under concept of "hurdle technology." Thus, essential oils can serve as the alternative additives or processing aid as green technology.

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Sources, Chemical Composition, Classification and Extraction methods

Several plants contain essential oils, however, parts of plants, which serve as the major source of essential oil can be different, which include roots, peels, leaves, seeds, fruits, barks, and so on. Plant essential oils are usually the complex mixture of natural compounds, both polar and nonpolar compounds (Masango, 2005). Dominant compounds in various essential oils are presented in Table 1 Classification in Table 2 and Extraction methods in Table 3.

Mode of action

The antimicrobial effects of EOs have been screened against a wide range of microorganisms over the years, but their mechanism(s) of action are still not completely understood. Several mechanisms have been proposed to explain the actions of the chemical compounds contained in the EOs (Cox *et al.*, 2000; Burt, 2004). Essential oils are composed of several components and their antimicrobial activity cannot be confirmed based only on the action of one compound (Bajpai *et al.*, 2012). Several researchers have proposed that the antimicrobial action of EOs may be attributed to their ability to penetrate through bacterial membranes to the interior of the cell and exhibit inhibitory activity on the functional properties of the cell, and to their lipophilic properties (Smith-Palmer *et al*., 1998; Fisher & Phillips, 2009; Guinoiseau *et al*., 2010; Bajpai *et al*., 2012). The phenolic nature of EOs also elicits an antimicrobial response against food borne pathogen bacteria (Shapira and Mimran, 2007; Bajpai *et al*., 2012). Phenolic compounds disrupt the cell membrane resulting in the inhibition of the functional properties of the cell, and eventually cause leakage of the internal contents of the cell (Bajpai *et al*., 2012). The mechanisms of action may relate to the ability of phenolic compounds to alter microbial cell permeability, damage cytoplasmic membranes, interfere with cellular energy (ATP) generation system, and disrupt the proton motive force (Burt, 2004; Friedly *et al*., 2009; Li *et al*., 2011; Bajpai *et al*., 2012). The disrupted permeability of the cytoplasmicmembrane can result in cell death (Li *et al*., 2011). The cytoplasmic membrane of bacteria generally has 2 principal functions: (i) barrier function and energy transduction, which allow the membrane to form ion gradients that can be used to drive various processes, and (ii) formation of a matrix for membrane-embedded proteins (such as the membrane-integrated F_0 complex of ATP synthase) (Sikkema *et al.,* 1995; Hensel *et al*., 1996). Antimicrobial mechanism of essential oil is proposed as shown in Figure 1.

Applications

A) In Active packaging

Nowadays, smart packaging has gained increasing attention, for example, antimicrobial packaging, which can be applied to extend the shelf life of food and products (Appendini and Hotchkiss, 2002; Quintavalla and Vicini, 2002). To enhance the property of those packaging, antimicrobial compounds or extracts with the selected bioactivity are incorporated. Moradi *et al*., 2011 studied the antioxidant effects of chitosan film containing *Zatariamultiflora boiss* essential oil (ZEO) wrapped on mortadella sausage during 21 d of refrigeration storage (4 °C). Lipid oxidation of samples decreased markedly at first 6 d when compared to samples wrapped with control film (without ZEO incorporated) and unwrapped samples up to the end of storage. The most effectiveness was observed when samples packed with film containing 10 g/kg ZEO and combination with 10 g/kg grape seed extract. Tongnuanchan *et al*., 2012 reported that water vapor permeability (WVP) of fish skin gelatin film decreased markedly from 3.11 to 1.88, 1.89, and 2.45 × 10−11 gm−1s−1Pa−1, when films were incorporated with ginger, turmeric, andplai essential oils, respectively, at a level of 100% based on protein. The incorporation of ginger, turmeric, and plai essential oils at the highest level (100% based on protein) reduced WVP of film by 39.54%, 39.22%, and 21.22%, respectively. The result suggested different hydrophobicity of compounds present in different essentialoils used.

Salgado *et al*. 2013 tested the antioxidant activity of sunflower protein films enriched with clove essential oil in preserving fish patties during 13 d of storage at 2°C. The rate of malonaldehyde production was lower in patties wrapped with clove containing films during the first 3 d of storage, indicating a noticeable delay in hydroperoxide (primary lipid oxidation products) degradation exerted by the clove essential oil components. This allowed thiobarbituric acid-reactive substances (TBARS) remaining at the lowest values during storage.

B) In Cyclodextrins (CDs)

Miriana *et al*., 2015 investigated six CDs. The ability of CDs to retain EOs and reduce their volatility was demonstrated. The results suggested that CD inclusion complexes could overcome limitations of EOs application in food by reducing their volatility and lost during storage or food process and enhancing their radical scavenging ability. Thus, they could generate controlled release systems for food packaging use as well as for improved aroma differentiation and aroma burst.

C) In leafy vegetables

Isbella *et al*., 2015 tested Oregano and rosemary EOs as sanitizers in fresh vegetables in mixtures of sub inhibitory amounts. EOs found to have a synergistic interaction, reduced pathogenic bacteria and native spoilage flora in leafy vegetables

Table 1. Major compounds in different plant essential oils

Essential oils	Monoterpene hydrocarbon	Seisqoterpene hydrocarbons	Esters	References
Basil	*β-Pinene, β-Limonene*	*β-Elemene,*	-	Teixeira *et al*., 2013
Citronella	S-3-Carene,	*β-Elemene, β-Selinene,*	Cinnamic acid methyl ester	Teixeira *et al*., 2013
Clove	-	*trans-Caryophyllene*	Aceteugenol	Teixeira *et al*., 2013
Garlic	1(7),5,8-*o-Menthatriene*	-	-	Teixeira *et al*., 2013
Lemon	*α-Pinene, β-Pinene,*	*trans-Caryophyllene*	-	Teixeira *et al.,* 2013
Mandarin	*α-Pinene, di-Limonene,*	Farnesene, *α-Farnesene*	-	Mohamad *et al*., 2010
Mint	*α-Pinene, Myrcene,*	*β-Bourbonene,*	-	Bezic *et al*., 2006
Rose mary	*α-Pinene, Camphene,*	*trans-Caryophyllene*	Bornylacetate	Teixeira *et al*., 2013
Sage	*β-Pinene, Cymene,*	*trans-Caryophyllene*	Bornylacetate	Teixeira *et al*., 2013
Thyme	Camphene, *β-Pinene,*	*trans-Caryophyllene*	-	Teixeira *et al*., 2013

Table 2. Classification of Compounds and aroma of essential oils

Terpene hydrocarbons	Oxygenated compounds
Terpenes are the most common class of chemical compounds found in essential oils.	These compounds are the combination of C, H, and O and there are a variety of compounds found in essential oils.
Terpenes are made from isoprene units (several 5 carbon base units, C5), which are the combinations of 2 isoprene units, called a "terpene unit."	Oxygenated compounds can be derived from the terpenes, inwhich they are termed "terpenoids.
Essential oils consist of mainly monoterpenes (C10) and sesquiterpenes (C15).	Thymol, eugenol, carvacrol, chavicol are the examples of oxygenated compounds.

Table 3. Extraction of essential oils from various sources using several methods

Extraction method	Plants	References
Solvent extraction	Sage (*Salvia officinalis*)	Durling *et al*., 2007
Super critical CO_2	Rosemary(*Rosmarinusofficinalis*)	Pereira and Meireles (2007)
Subcritical water	Marjoram (*Origanum majorana*)	Deng *et al*., 2005
Distillation steam	Rose scented geranium (*pelargonium sp.)*	Babu and Kaul (2005)
Hydro distillation	Rose scented geranium (*pelargonium sp*.)	Babu and Kaul (2005)
Hydro diffusion	Orange (*Citrus sinensis*)	Farhat *et al*., 2011
Combination methods	Cumin (*Cuminumcyminum*) Tobacco (*Nicotianatabacum*)	Li *et al*., 2009; Zhang *et al*., 2012

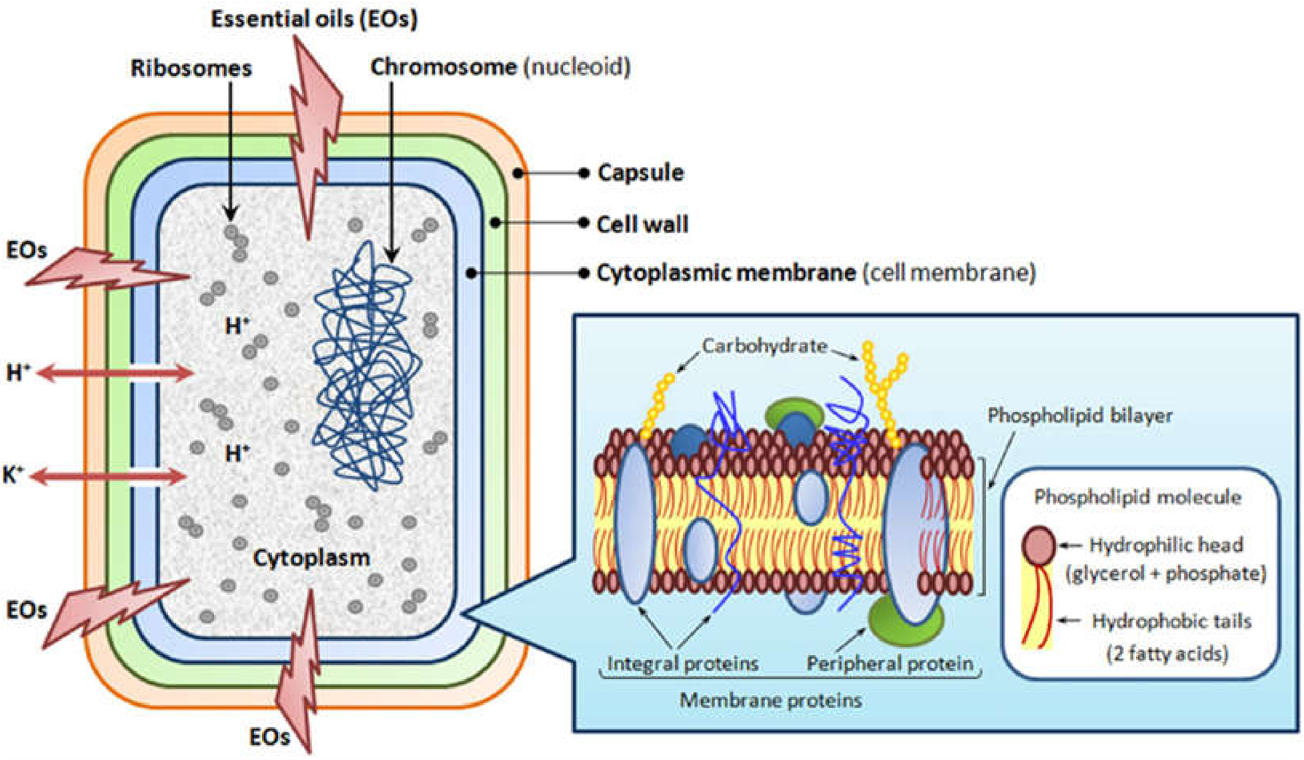

Figure 1. Schematic illustration for the effect of essential oils on bacteria cell

D) In Nano Emulsions

Maria *et al*., 2016 accessed long term stability (56 days) of nano emulsions containing EOs (oregano, thyme, lemongrass or mandarin) stabilized by high methoxyl pectin and a non-ionic surfactant. It was reported that nano emulsions containing lemongrass or mandarin EO present a high stability during storage, with a constant droplet size below 100 nm during 56 days as well as absence of creaming. The results showed valuable information for the optimal design of long-term stable nano emulsions to be used as delivery systems in food products. However, information about the antimicrobial activity of nanoemulsions during storage needed in order to design long-term stable effective antimicrobial delivery systems for food products.

E) Other medicinal and future medical applications

Yoo *et al*., 2005 demonstrated that eugenol from Eugenia caryophyllata (=Syzygiumaromaticum) inhibits the proliferation of cancerous cells. Geraniol inhibits also colon cancer cell proliferation by inducing membrane depolarisation and interfering with ionic canals and signalling pathways. Zaida *et al*., 2015 reported that essential oils isolated from *A. mexicana* and *P. linaria* show a strong antifungal activity against a panel of eleven fun-gal strains isolated from wheat grains during storage. These oils show no toxicity when exposed to neither human-derived macrophages nor brine shrimp. In addition, an increase of pro-inflammatory cytokines was not observed when exposed to the human macrophages aforementioned. EOs protects grains from fungal infection during storage, thus providing a viable alternative to the use of synthetic chemical fungicides.

Conclusion

Food products are highly subjected to deterioration, which leads to safety and quality issue. Several plant-derived EOs can be effectively used as natural alternative to synthetic additives. These EOS are responsible for anti-microbial activity to increase permeability of cell membrane and leading to loss of cellular constituents. The development of release system for EOs from packaging can effectively extend shelf life of foods without any negative on quality and sensory property of foods.

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