Scientific Bulletin. Series F. Biotechnologies, Vol. XVII, 2013
ISSN 2285-1364, CD-ROM ISSN 2285-5521, ISSN Online 2285-1372, ISSN-L 2285-1364

ESSENTIAL OILS UTILIZATION IN FOOD INDUSTRY - A LITERATURE REVIEW

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Abstract:

Nowadays, essential oils are used in pharmaceutical, sanitary, cosmetics, agriculture and food industry because of the biological activity, notably antibacterial, antifungal and antioxidant properties.
Essential oils, or (EOs) for short, are natural compounds with a complex composition that contains volatile principles present in plants such as terpenes, terpenoids, phenol-derived aromatic components and aliphatic components.
In food industry, it is crucial that the products to be supplied without any microbial contamination, but the biological efficacy of EOs to be used as antimicrobial agents in food system, depends on some factors as temperature, pH, appearance, load of microbial flora and the favorable environment.
Studies demonstrated that the antimicrobial effects of EOs confirm structural and functional damages of membrane of bacterial pathogenic, resulting the leaking of the inner cell components, and eventually leading to the cell death (Cox et al., 2000). Usually, Gram-negative bacteria are less susceptible to antimicrobials, but this doesn't mean that Gram-positive bacteria are always more sensitive.
Due to the fact that essential oils present compounds with antioxidant activity (phenolic compounds) it can be used in food industry as preservatives to prevent the spoilage of the products and to increase the shelf life.

Keywords: *antimicrobial activity, essential oils, food products.*

INTRODUCTION

Lately, the consumers demand for safe and natural food products, free from synthetic chemical preservatives and minimally processed, with a longer shelf life. It's a challenge to obtain these products, and in the same time the products to be safety and healthy. Because of this situation, natural compounds with antimicrobial activity found in herbs and plants are recommended to be added, either alone or in combination.
In recent years, several researches have shown that many species and herbs which exert antimicrobial activity due to their essential oil fractions can be used in food system like antifungal, antibacterial and antioxidant agents by inhibiting the growth of pathogenic microorganisms, this way ensuring the microbiological safety of food products (Benkeblia et al., 2004; Burt, 2007, Ye Chun-Lin et al., 2013).
According to the 8th Edition of the French Pharmacopeia (1965), essential oils (EOs for short) are products of complex general composition that contain volatile principles present in plants, more or less modified during their preparation. EOs are obtained from different plant parts, such as flowers, leaves, seeds, bark, fruits and roots and are stored in secretory cells, cavities, canals, epidermic cells or glandular trichomes. The composition of EOs from a particular species of plant can differ between harvesting seasons and between geographical sources (Burt, 2004).
EOs are liquid, volatile, limpid and rarely colored, lipid soluble and soluble in organic solvents with a generally lower density than the density of water.
The composition of EOs includes a complex mixture of several compounds. The main group is composed of terpenes and terpenoids and the other of aromatic and aliphatic constituents, all

characterized by low molecular weight (Bakkali et al., 2008).
Volatile oils contain two or three major components at high concentrations (20-70%) compared to the other components which are found in trace amounts. Mono- and sesquiterpenoids are the major components of essential oils, which are phenolic in nature. Aromatic compounds occurs less frequency than the terpenes, but the antimicrobial effect of essential oils depends on the content of phenolic components (Cakir et al., 2004).
There are as well various chemical components present in plant-origin antimicrobials including, saponins and flavonoids, thiosulfinates, glucosinolates and saponins (Tajkarimi et al., 2010).
The most studied compounds of EOs are carvacrol, thymol (one of the major components of *Origanum compactum* essential oil and thyme oils) and eugenol (found in *Eugenia caryophylata*).
Essential oils are efficient against some varieties of organisms, such as bacteria, virus, fungi, protozoa, parasites, acarids, larvae and mollusks.
For the extraction of essential oils there are known several methods, such as liquid carbon dioxide or microwave, and the most commonly methods for obtaining antimicrobials from plants are SD (steam distillation) and HD (hydro distillation) methods, and alternative methods such as SFE (supercritical fluid extraction) provide higher solubility and improved mass transfer rates (Bakkali et al., 2004; Tajkarimi et al., 2010).

MECHANISM OF ACTION

The exact mechanism of action of many natural extracts is not well known, but it has been demonstrated by studies that essential oils have bacteriostatic or bactericide activity and that the antimicrobial effects of EOs exhibit structural and functional damages of membrane of bacterial pathogenic by various antimicrobial mechanisms (Cox et al., 2000; Burt, 2007). The quantity of spices and herbs mostly used in food products is between the ranges of 0.05–0.1% (500–1000 ppm). Some spices have stronger antimicrobial activity than others and can be effective at 1000 ppm.

Most of the studies on the mechanism of action of phenolic compounds have focused on their effects on cellular membranes. It has been shown that EOs pass through the cell wall and cytoplasmic membrane, attack the different layers of polysaccharides, and phospholipid bilayer of the cell membrane, disrupt enzyme systems, and compromise the genetic material of bacteria causing the permeabiliziation of the cells (Burt et al., 2007; Arque et al., 2008). It is considered that phenolic compounds not only attack cell walls and cell membranes, but it also interfere with membrane function (electron transport, nutrient uptake, protein, nucleic acid synthesis and enzyme activity). In consequence it’s supposed that phenolic compounds are responsible for the inhibition of microorganisms.

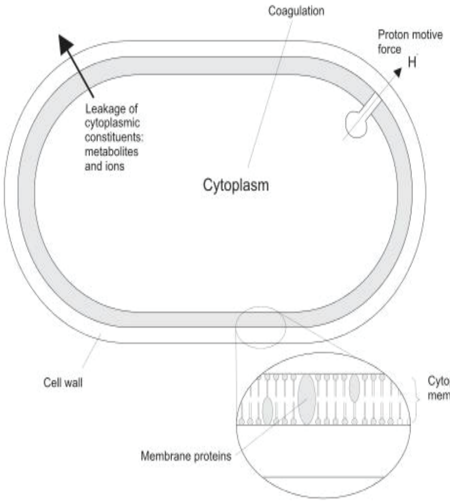

Figure 1. Locations and mechanisms in the bacterial cell thought to be sites of action for EO components: degradation of the cell wall; damage to cytoplasmic membrane; damage to membrane proteins; leakage of cell contents; coagulation of cytoplasm and depletion of the proton motive force (Burt, 2007).

Di Pasqua et al. (2007), Turina et al. (2006) showed that in bacteria, it can occur losing of ions and reduction of membrane potential by the permeabilization of the membranes. Usually, Gram-negative bacteria are less susceptible to antimicrobials, but this doesn’t mean that Gram-positive bacteria are always more sensitive (Burt, 2004).
Because of the change of fluidity of membranes which become abnormally permeable due to

the use of essential oils, it results the leaking of the inner cell components, cytochrome C, calcium ions and proteins and eventually the permeabilization of mitochondrial membranes it leads to the cell death (Cox et al., 2000).

RESULTS AND DISCUSSIONS

Specificity of EOS *in vitro*

Most studied effect of essential oils regarding the antimicrobial have been conducted *in vitro* and it is well known that the antibacterial and antifungal activity of essential oils in food products is usually reduced compared to the *in vitro* work,due to the presence of fats, carbohydrates, proteins, salts and pH which influence the efficacity of volatile oils (Burt, 2007). The question of specificity of the different essential oils also arises.

The antimicrobial activity of essential oils is related to the chemical configuration of the components, the proportions in which they are present and to the synergism that exists between the components of volatile oils (Burt, 2004). Essential oils can be used alone or in combination with other compounds to inhibit the microorganisms, for example in a study made by Dimitrijevic et al. (2006) it was shown that essential oils of *Thymus vulgaris L., Rosmarinus officinalis L.* and *Origanum vulgare L.* in combination with sub-lethal dose of lactic acid noticeably increased the antilisterial activity against *Listeria monocytogenes*, especially of rosemary and thyme oils, but the synergistic effects of the mixtures were reduced with higher concentrations of oils. Other study demonstrated that using the checkerboard method and oregano combined with thyme had additive effects against spoilage organisms, and *Listeria* strains were more sensitive than spoilage bacteria (Gutierrez J. et al., 2004).

In a study realized by Celiktas et al. (2007) it was shown that the antimicrobial activity of the essential oils obtains from *Rosmarinus officinalis* against *Staphylococcus aureus, Proteus vulgaris, Pseudomonas aeruginosa, Klebsiella pneumonia, Enterococcus feacalis, Escherichia coli, Staphylococcus epidermidis, Bacillus subtilis* and *Candida albicans* differs, depending on location and seasonal variations of the plants.

The researchers Benkeblia (2004), Ye C.-L. et al. (2013) have studied the effectiveness of essential oils extracted from the *Allium* plants (garlic and onions) against food spoilage and food-borne pathogenic microorganisms and its antioxidant activity.

According to the results, the essential oils revealed a potent inhibitory antimicrobial effect against *Escherichia coli, Bacillus subtilis, Staphylococcus aureus, Salmomella enteritidis,* and three fungi *Aspergillus niger, Penicillium cyclopium* and *Fusarium oxysporum.* The essential oil obtained from garlic showed the highest inhibition action and the *Allium cepa* EOs exerted a broad antimicrobial spectrum and showed a high antimicrobial action effect on *B. subtilis.* Lalitha et al. (2011) showed that the essential oil of *Allium sativum* had a maximum effect on the inhibition of all the bacteria tested, and recorded a complete inhibition in eight fungi from the tenth tested compared to control.

It has been shown that essential oils can be used against microorganisms as *Aeromonas hydrophila*, *Bacillus sp.* (Lalitha et al., 2011), *Clostridium perfrigens*, *Camphylobacter jejuni*, *Escherichia coli* (Celiktas et al., 2007, Lalitha et al., 2011), *Listeria monocytogenes* (Dimitrijevic S., 2006; Gutierrez J. et al., 2009), molds and yeast (Ye C.-L. et al., 2013), *Pseudomonas sp.* (Celiktas et al., 2007), *Salmonella sp.* and *Shigella sp.* (Bajpai V. K. et al., 2012), *Staphylococcus aureus* (Benkeblia N., 2004), *Vibrio parahaemolyticus*, Gram-positive and Gram-negative bacteria.

In consequence of these studies it can be concluded that the antimicrobial effect of essential oils depends on the location and the variations between seasons, the composition of EOs and the synergism of all molecules or reflect only those of the main molecules present at the highest levels according to gas chromatographical analysis, butit also depends on some factors as temperature, pH, appearance, load of microbial flora and the favorable environment of tested products.

Antimicrobial activity of EOS in food products

There are differences between *in vitro* and in-food trials of plant-origin antimicrobials, mainly because only small percentages of EOs are tolerable in food materials. Finding the most efficient essential oils depends on a number of factors such as type, effects on organoleptic properties, composition, concentration, biological properties of the antimicrobial, the target microorganism and processing and storage conditions of the targeted food product (Gutierrez et al., 2009).

Despite some positive reports regarding the application of plant-origin natural antimicrobials in food industry, two major issues are faced: odors created mostly by the high concentrations and the increased price of these materials (Proestos et al., 2008).

Studies demonstrated that EOs can be used as an alternative preservative and pathogen-control method in food materials such as meat products, fish, vegetables, rice, fruits and dairy products.

The antimicrobial effects of essential oils against various microorganisms from meat products and fish contaminated can be reduced due to the high fat content (Burt, 2004).

EOS of rosemary has antimicrobial effects against *Listeria monocytogenes* from meat products (Caraminana et al., 2008), oregano EOs can be used against *Clostridium botulinum* spores, winter savoy (*Satureja montana*) EOs in combination with other preservatives methods can be used as natural antibacterial substance to control growth of food-borne bacteria and improve quality of minced pork. Busatta et al. (2008) studied the antimicrobial activity in a fresh sausage of marjoram (*Origanum majorana L.*) essential oil against several species of bacteria. Results showed that addition of marjoram essential oil to a fresh sausage exerted a bacteriostatic effect at oil concentrations lower than the MIC, while a bactericidal effect was observed at higher oil concentrations which also caused alterations in the taste of the product.

Wild thyme (*Thymus seryllum*) EOs has a preservative effect and increase the shelf life of fresh-water fish (Oral et al., 2008). Essential oils of *Aloysia sellowii* have antimicrobial effects against a variety of Gram - positive and negative - microorganisms and two yeasts in brine shrimp (Simionatto et al., 2005).

Opposite to meat products and fish, in milk the high water content affects the application of EOs by increasing the transfer and movement of EOs toward the targeted microorganisms (Cava, Nowak et al., 2007). Abdalla et al. (2007) demonstrated that extract of mango seed kernel could inhibit the coliform growth, reduce total bacterial count and have antimicrobial activity against the *Escherichia coli* strain and in the same time extend the shelf life of pasteurized cow milk.

EOs of cardamom, cinnamon, clove inhibits the growth of yoghurt starter culture more than mint oil. In another study, it has been shown that mint oil is effective against *Salmonella enteridis* in low-fat yoghurt and cucumber salad (Burt, 2004).

Regarding to vegetables, the use of essential oils in washing water has a good effect against natural spoilage flora and food-borne pathogens, because of the low fat content of the products. In another study made by Burt (2007), it has been shown that oregano oil was effective against *Escherichia coli O157:H7* and reduced the final populations in eggplant salad.

In rice, the use of sage oil and carvacrol had a significant effect against *Bacillus cereus* (Burt, 2004).

As for fruits, the efficacy of EOs might depend of the pH of the fruits.

It was also tested the antimicrobial activity of essential oils in chocolate held at different temperatures, in dry or humidified environment and observed that lemon flavor applied to chocolate inoculated with *E. coliO157:H7* had the most inhibitory action. Plant extracts tested on chocolate show an enhanced inhibitory effect during storage at 20^0C concluding that their application may provide protection in case of storage at the above temperature or even higher.

It has been shown that the antimicrobial activity of essential oils was diminished in food system as they appeared less efficacious when added to chocolate (Kotzekidou, 2008).

Recently, the essential oils started to be used because of their antimicrobial activity in food packaging, to edible films. Incorporating antimicrobial compounds into edible films provides a novel way to improve the safety and shelf life of ready-to-eat foods. This method of packaging can be used on fresh and minimally processed fruit and vegetable, meat and meat products, poultry, fish, tree nuts (Du Wen-Xian et al., 2011).

In a study made by Seydim (2006) with whey protein isolate (WPI) films containing ratios of oregano, rosemary and garlic essential oils which were tested against *E. coli O157:H7*, *Staphylococcus aureus*, *Salmonella enteritidis, Listeria monocytogenes* and *Lactobacillus plantarum* it was shown that oregano essential oil was the most effective against all the microorganisms tested than those containing garlic and rosemary extracts.

Matan (2012) showed that edible films incorporated with essential oils had antimicrobial effects against some major molds (*Aspergillus flavus*, *Penicillium* sp.) and bacteria (*Staphylococcus aureus*) found on dried fish (*Decapterus maruadsi*). The results showed that film containing anise oil was the most effective against mold and the shelf life of the dried fish was extended by the used of essential oils incorporated in edible films.

CONCLUSIONS

Essential oils contain compounds with antioxidant activity (phenolic compounds) and can be used as preservatives because it can prevent the spoilage of the products and in the same time can increase the shelf life without influencing the properties of food products. As the demand of consumers is to reduce or replace chemical preservatives with natural ones, the compounds from volatile oils can be used because it reduce the secondary effects of chemical preservatives.

In order to prevent the modification of organoleptic properties of food product, it's recommended to add a small concentration of essential oils to the products.

It has been reported that combined methods of application of the EOs with other methods such as hurdle technology and modified-atmosphere packaging improve the flavour and increase shelf life of food products (Burt, 2004).

Still, the use of EOs which has antimicrobial effects compare with the use of synthetic additives is still limited cause of the persistent flavour which can affect the sensorial quality of products, and the high costs of food products.

The use of plant extracts and essential oils in consumer goods is expected to increase in the future due to the fact that volatile oils can be considered as a natural alternative to traditional food preservatives and could be used to enhance food safety and shelf life.

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