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Essential Oils for Applications in Fish and Other Seafood Products

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Abstract

The global concern is to produce products more natural and fresh, less processed and less ready to eat processed food. Due to their nutritional value, fish and other seafood products have been considered among the most important food in human diets and their consumption increased substantially over the past few decades. Seafood is highly perishable food products due basically to microbiological growth and lipid oxidation, which are known to be the principal causes of quality deterioration of such products. Recently, there is an extensive focus on antioxidant and antimicrobial effects of natural preservatives such as essential oils (EOs), as an effective alternative to synthetic additives, to enhance oxidative and microbial stability of foods and extend their shelf life. The antioxidative and antimicrobial activities of some common EOs, either alone or in combination with other preservative systems, in fish and other seafood are mentioned. The main chemical components and principal sources, According to the biological properties of EOs, the major compounds in EOs are present 85% of the oil. As chemical properties, the EOs are consist of a differing family of organic compounds with low molecular weight and they can be divided into different groups depending on their chemical structure: terpenes, terpenoids, aromatic (phenylpropanoids) and other compounds. In the Application of EOs to fish preservation, the effectiveness of a wide range of EOs against lipid oxidation and microbial growth was extensively documented by many researchers. It was reported that oregano EO is the most frequently used for applications as fish preservatives, followed by rosemary and thyme EOs.

Keywords: Essential oils, fish, microbial stability, preservation, oxidation, quality, shelf life, natural additives

Review article

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INTRODUCTION

Nowadays, the global concern is to produce products more natural and fresh, less processed and less ready to eat processed food. Due to their nutritional value, fish and other seafood products have been considered among the most important food in human diets and their consumption increased substantially over the past few decades (Ghanbari et al., 2013; Samples, 2015a).

Essential fatty acids (EFA) are critical aspects for animal tissues in energy production especially seafood. The major EFA in seafood is polyunsaturated fatty acids such as omega 3 and omega 6. Oxidative degradation of lipids produces off-flavor and off-odor which cause the low quality of seafood product (Ramanathan and Das, 1992). To prevent these results from losing product quality, preservation methods are required to apply on seafood products and they will help to extend the shelf life of the product.

Essential oils (EOs) are produced from different parts of plants and their mechanisms have been approved against microorganisms. EOs contain natural antioxidant and antimicrobial agents that are extracted from different parts of the plant as a complex mixture of hundreds of individual aromatic volatile oily compounds (Calo et al., 2015; Jayasena and Jo, 2013). There are more than 3000 types of EOs while 300 from them are commercial needs for applications in food or other industries (Bakkali et al., 2008; Burt, 2004).

Main chemical components and principal sources

According to the biological properties of EOs, the major compounds in EOs are present 85% of the oil while, the other compounds are minor compounds that are present in trace quantities and may have combined with other compounds (Bakkali et al., 2008; Burt, 2004).

As chemical properties, the EOs are consists of a differing family of organic compounds with low molecular weight and they can be divided to different groups depending on their chemical structure: terpenes, terpenoids, aromatic (phenylpropanoids) and other compounds (Bakkali et al., 2008; Hyldgaard et al., 2012). Terpenes are hydrocarbons contains several isoprene units, which have been classified by the number of isoprene units in the molecule (mono-, sesqui- and diterpenes). Terpenoids are different from terpens by containing oxygen and can be classified into alcohols, esters, aldehydes, ketones, ethers, and phenols. Famous terpenoids in EOs are thymol, carvacrol, linalool, linalyl acetate, citronellal, piperitone, menthol, and geraniol, while eugenol and cinnamaldehyde, which are the best-known phenylpropanoids (Hyldgaard et al., 2012; Jayasena and Jo, 2013). The main phenolic compounds are responsible for the preservative effects of EOs: thymol, carvacrol, and eugenol (Burt, 2004; Jayasena and Jo, 2014). In previously published research, they examined several types of EOs such as oregano, rosemary, thyme, laurel, sage, cinnamon, clove, and basil in seafood products used as antimicrobial and antioxidant agents.

Oregano leaves (*Origanum vulgare*) are commercial spices that belong to Mediterranean cuisine used in raw or cooked food because of their pleasant aroma and taste. The antioxidant and antimicrobial activities of oregano EO were examined in different commercial or model food (Goulas and Kontominas, 2007; Vatavali wt al., 2013). It had documented that the carvacrol and thymol are the main compounds responsible for the antimicrobial and antioxidant activity of oregano EO (Rodriguez-Garcia et al., 2016). Also, it was reported that the thyme EO has a high content of phenolic compounds. Thus, thyme (*Thymus vulgaris*) EO can be a potential natural antioxidant and antimicrobial agents (Hyldgaard et al., 2012; Kostaki et al., 2009).

Basil EO was used in flavoring food for several years. Also, basil EO has been reported that it has an effect against microorganisms from its antimicrobial activity (Suppakul et al., 2003). This activity has applied to the major active volatile components, including linalool, methylchavicol, eugenol, methyl eugenol, methyl cinnamate, 1,8-cineole, and caryophyllene (Kuorwel et al., 2011; Perricone et al., 2015).

Recently, many of EOs which are extracted from clove (*Eugenia caryophyllata*) (Emir Çoban & Patir, 2013), sage (Salvia officinalis L.) (Emir Çoban et al., 2016), Zataria multiflora Boiss (Emir

Çoban and Tuna Kelestemur, 2016), turmeric and lemongrass (Masniyom et al., 2012), and lemon (Alfonzo et al., 2017) have been applied on seafood products alone or combination with other preservation methods, was effective in extending the shelf life and improving the quality of the products.

Methods of application

Commonly in the seafood industry, EOs have been applied in seafood products by different methods:
One of them is the direct treatment which is added directly to the seafood products during manufacturing and processing. Also, EOs can be used as edible films and coatings and the addition of EOs to animal feed. Thus, some researchers have been reported the use of edible coating films enriched with EOs as alternative and interesting option in order to reduce the required doses (Dogan and Izci, 2017; Ojagh et al., 2010; Sanchez-Gonzalez et al., 2011; Yuan et al., 2016). in addition, recent research has been documented another technique to reduce the organoleptic effects of EOs using the preparation of micro- and nanoemulsions, which improves not only the antimicrobial and antioxidant stability, but also the functional properties and organoleptic quality of the product (Acevedo-Fani et al., 2016; Alfonzo et al., 2017; Calo et al., 2015; Ozogul et al., 2017; Perricone et al., 2015).

Mechanisms of action

1- Antimicrobial activities

EOs in high concentration can inhibit the bacteria growth (bacteriostatic), that means the microbial cells will recover their reproductive capacity after neutralization of the agent, or to kill Bacterial cells (bactericide) (Swamy et al., 2016). It was documented that lipoteichoic acids in the cell membrane of gram-positive bacteria may facilitate the penetration of hydrophobic compounds of EOs, while the presence of an extrinsic membrane, surrounding the cell wall of gram-negative bacteria limits the diffusion rate of hydrophobic compounds through the lipopolysaccharide layer. That is why gram-positive bacteria are slightly more susceptible to EOs than gram-negative ones (Rodriguez-Garcia et al., 2016; Tongnuanchan and Benjakul, 2014). Even though that the possible modes of action for EOs as antimicrobial agents have been widely reviewed, their exact mechanism of action is not yet clear (Calo et al., 2015; Maqsood et al., 2013;Tajkarimi et al., 2010). Numerous studies were described that the antimicrobial activity of EOs could be attributed to their major constituents mainly the phenolic constituents, also their interaction with minor constituents present in oils (Burt, 2004; Hyldgaard et al., 2012; Jayasena and Jo, 2013; Perricone et al., 2015). Because of the complexity of the chemical composition of EOs, it has been documented that the antimicrobial activity of EOs may not be attributable to a unique mechanism (Burt, 2004). Nonetheless, there was almost a universal agreement on the fact that the hydrophobicity of compounds present in EOs enabled them to pass through the cell wall and cytoplasmic membrane, disrupt the structure of their different layers of polysaccharides, fatty acids and phospholipids and permeabilize them. Additionally, EOs could inhibit various enzyme systems including the enzymes responsible for the regulation of energy and synthesis of structural components (Bakkali et al., 2008; Burt, 2004; Jayasena and Jo, 2013).

2- Antioxidant activities

Previously, synthetic additives such as BHA and BHT were used as antioxidants in food products. Recently, the food industries focused on natural sources for antioxidants due to the safety concern of synthetic chemical toxicity (Vareltzis et al., 1997). Because of that, the using of natural antioxidants has been increased in food processing especially in seafood products for controlling lipid oxidation thus extending the shelf life of the products. Therefore, the effort of extracting natural antioxidants from natural sources has been increased such as phenolic compounds. The use of EOs could be considered as a good alternative since the majority of EOs are classified as generally recognized as safe (GRAS) (Kapetanakou and Skandamis, 2016; Maqsood et al., 2013; Ribeiro-Santos et al., 2017). The EOs application is getting interested as natural antioxidants because of the inherent ability of some of their components to stop or delay the oxidation of lipids and extend the shelf life of the food products (Amorati et al., 2013; Patel, 2015). Several studies demonstrated that the EOs, as antioxidants, have several modes of direct or indirect actions including, among other mechanisms, prevention of chain initiation and free-radical scavenging activity (Maqsood et al., 2013; Rodriguez-Garcia et al., 2016). Also, it was reported that phenolic compounds such as carvacrol, eugenol, and thymol are the main group responsible for the antioxidant activity of Eos (Amorati et al., 2013; Jayasena and Jo, 2014). The principle of phenolic compounds in the retardation of lipid oxidation in fish muscle is mainly because of their redox properties, allowing them to act as hydrogen donors, reducing agents, singlet oxygen quenchers as well as metal chelators (Maqsood et al., 2014; Tongnuanchan and Benjakul, 2014). Several methods have been used to determine the antioxidant performance of EOs.

Application of EOs to fish preservation

Recently, the effectiveness of a wide range of EOs against lipid oxidation and microbial growth was extensively documented by many researchers. It was reported that oregano EO is the most frequently used for applications as fish preservatives, followed by rosemary and thyme EOs (Patel, 2015). Different effects were observed depending on the EO used its concentration, as well as the characteristics of the raw material. However, it should be considered that EOs used as a natural food additive at high concentrations may lead to undesirable sensory properties on treated fish and may even cause allergic reactions. Indeed, some EOs are characterized by a strong odor and flavor which could leave a bad aftertaste, thus reducing the acceptance or liking degree for fish and seafood products (Atares and Chiralt, 2016; Ribeiro-Santos et al., 2017).

CONCLUSION

Different EOs incorporated directly into fish and other seafood, or applied indirectly by other methods, can effectively inhibit or reduce lipid oxidation and growth of various microorganisms. Many EOs could be used alone or in combination with other preservative treatments to further prevent or retard oxidation and microbial spoilage in food systems, especially in fish and fish products, thereby extending the shelf life of these products. Being the principal constituents of EOs, many authors reported that phenolic compounds are mainly responsible for their antimicrobial and antioxidant properties.

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