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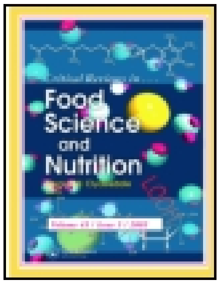

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Essential Oils as Natural Food Antimicrobial Agents: A Review

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Essential Oils as Natural Food Antimicrobial Agents: A Review

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ABSTRACT

Food borne illnesses pose a real scourge in the present scenario as the consumerism of packaged food has increased to a great extend. Pathogens entering the packaged foods may survive longer, which needs a check. Antimicrobial agents either alone or in combination are added to the food or packaging materials for this purpose. Exploiting the antimicrobial property, essential oils are considered as a 'natural' remedy to this problem other than its flavouring property instead of using synthetic agents. The essential oils are well known for its antibacterial, antiviral, antimycotic, antiparasitic and antioxidant properties due to the presence of phenolic functional group. Gram positive organisms are found more susceptible to the action of the essential oils. Essential oils improve the shelf-life of packaged products, control the microbial growth and unriddle the consumer concerns regarding the use of chemical preservatives. This review is intended to provide an overview of the essential oils and their role as natural antimicrobial agents in the food industry.

Keywords essential oils, antimicrobial property, pathogens, packaging, natural

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INTRODUCTION

Food safety is regarded to be the key public health issue being discussed globally (WHO, 2002a). The efforts are directed in response to an increasing number of food safety problems and rising consumer concerns globally. Increasing food borne diseases and enteric diseases forced the researches all over the world to couple new methods to eliminate food borne pathogens in conjunction with the existing ones (i.e. the hurdle concept) (Leistner, 1978). World Health Organisation (WHO) has called to reduce the consumption of common salt as preservative since the increasing risk of cardiovascular disorders (WHO, 2002b). There lies the scope of arousal of innovative methods with a 'green' or natural image; one such possibility is to use essential oils as antimicrobial agents. The essential oils are available in plenty whose advantages can be tapped out in the food industry. This review deals with the essential oils, its mode of action on various pathogens and its impact on packaging sector.

ESSENTIAL OILS (EOs)

Essential oils (also known as volatile or ethereal oils) are complex mixtures of volatile compounds produced by living organisms or from plant materials like flowers, bud, seeds, leaves, wood, fruits, roots, twigs and barks and isolated by physical means only (pressing and distillation) from a whole plant or plant part of known taxonomic origin. An estimated 3000 essential oils are known, many are used for fragrance and flavours. The term 'Essential Oils' was thought to be coined by 'Paracelsus Von Hohenheim', who named the effective component of a drug 'Quinta Essentia' (Guenther, 1948). Turpentine oil was mentioned by Greek and Roman historians. Distillation was used for the production of essential oils in Egypt, India and Persia more than 2000 years ago. The first authenticated writing of distillation of essential oils is ascribed to Villanova (1235-1311), a Catalan physician. Essential oils (EO) are defined as “the product obtained from vegetable raw materials either by distillation with water or steam or from the epicarp of citrus fruits by a mechanical process or by dry distillation” (ISO/DIS 9235.2:1997). The essential oils are proven to have antiviral, antimycotic, antiparasitic, antioxidant and insecticidal properties in addition to the antibacterial action. The phenolic components are responsible for the antibacterial properties of essential oils (Cosentino *et al.*, 1999).

The work to demonstrate bactericidal properties of vapours was initiated by De la Croix in 1881 (Boyle, 1955). The first systematic investigation of the constituents from essential oils is attributed to M. J. Dumas (1800-1884), who analysed the hydrocarbons and oxygen as well as sulphur and nitrogen containing constituents. The present day use of oils in European Union (EU) is in food as flavourings, perfumes (fragrance) and pharmaceuticals (Van de Braak and Leijten, 1999).

The common extraction procedures for the essential oils involve ‘expression’ which is used for citrus and is regarded to be the oldest one; ‘steam distillation’ the most common extraction technique and ‘dry distillation’, the rarest method. The use of liquid carbon dioxide under low temperature and high pressure produce more natural organoleptic effects (Moyler, 1998). Herbal oils extracted using hexane has been shown to exhibit greater antimicrobial activity than the corresponding steam distilled essential oils. Generally, oils produced from herbs extracted during or immediately after flowering possess strong antimicrobial activity. Since oils are volatile, they are to be kept air tight in dark to avoid compositional changes.

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ANTIMICROBIAL EFFECTS OF ESSENTIAL OILS

The hydrophobicity of essential oils enables them to partition the lipid layer of bacterial cell membrane and mitochondrion, making the structures more permeable. This leads to leakage of ions and other cell contents (Lambert *et al.*, 2001), which when exceeds a limit lead to lysis and death (Denyer and Hugo, 1991). The mechanism affects disturbance to cytoplasmic membrane disrupting Proton Motive Force (PMF), electron flow, active transport and coagulation of cell contents. Two possible mechanisms exist whereby cyclic hydrocarbons act on lipid molecules on cytoplasmic membrane. The lipophilic nature of essential oil forces them to accumulate in lipid bilayer and distort lipid-protein interaction. Alternatively direct interaction is also possible (Cosentino *et al.*, 1999).

CARVACROL AND THYMOL

Carvacrol, or cymophenol, a monoterpenoid phenol, is present in the essential oil of *Origanum vulgare*, oil of thyme, oil obtained from pepperwort, and wild bergamot. Carvacrol is able to inhibit the growth of vegetative bacteria and inhibition of diarrhoeal toxin production by *Bacillus cereus*. para-Cymene, the biological precursor of carvacrol, is hydrophobic leads to swelling of the cytoplasmic membrane to a greater extent. When it is used alone, it is not antibacterial; it is found to have synergism along with carvacrol.

Thymol (or 2-isopropyl-5-methylphenol), a natural monoterpene phenol derivative of cymene, isomeric with carvacrol, is found in oil of thyme, and is extracted from *Thymus vulgaris* (common thyme) and various other kinds of plants. Thymol was found to be inhibitory at pH 5.5 than at 6.5. Both of them are able to disintegrate outer membrane of the Gram negative bacteria releasing lipopolysaccharide and increasing permeability of the cytoplasmic membrane to ATP.

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The rate of ATP synthesis was reduced or the rate of ATP hydrolysis was increased. It binds to membrane protein hydrophobicity and change the membrane permeability at low pH by *Staphylococcus aureus* and *Salmonella typhimurium* (Juven *et al*., 1994).

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EUGENOL

Eugenol is a member of the phenylpropanoids class of compounds which is a clear to pale yellow oily liquid extracted from clove oil, nutmeg, cinnamon, basil and bay leaf. Eugenol is responsible for the aroma of cloves. Due to the presence of eugenol, 85% of the clove oil is found to inhibit production of amylase and protease by *Bacillus cereus*. Also it will lead to cell wall deterioration, cell lysis and prevention of enzyme action in *Enterobacter aerogenes*.

CINNAMALDEHYDE

Cinnamaldehyde is the organic compound that gives cinnamon its flavour and odour. This pale yellow viscous liquid occurs naturally in the bark of cinnamon trees and other species of the genus *Cinnamomum*. It is found inhibitive to the growth of *E. coli* O157:H7 and *Salmonella typhimurium*; it does not disintegrate outer membrane or deplete the intracellular ATP pool. According to Skandamis and Nychas (2001) eugenol, coriander, clove, oregano and thyme oils when used at the rate of 5-20 $\mu l g^{-1}$ were found to be effective against *Listeria monocytogenes*, *Aeromonas hydrophila* and spoilage flora in meat products causing marked reduction in the initial number of recoverable cells while mint and sage oils were less effective (Lemay *et al*., 2002). Oregano oil is widely used in packed meat and well studied by Ismaiel and Pierson (1990) against *Clostridium botulinum* spores upto 0.4 $\mu l g^{-1}$. Mint oil at the rate of 5-20 $\mu l g^{-1}$ was found effective against *Salmonella* Enteritidis in low fat yoghurt and inhibition of the starter culture at 0.05-5.0 μlg^{-1}(Bayoumi, 1992). Oregano oil at the rate of 7-21 μlg^{-1} was found effective against *E. coli* O157**:**H7 **(**Skandamis and Nychas, 2000).

In general, the essential oils are more susceptible to Gram positive than for Gram negative (Harpaz *et al*., 2003; Pintore *et al*., 2002) because outer membrane surrounding the cell wall restricts the diffusion of hydrophobic compound through lipopolysaccharide covering. *Aeromonas hydrophila* is more susceptible though it is a Gram negative bacterium (Deans and Ritchie, 1987). Of gram negative bacteria, *Pseudomonas aeuruginosa* is the least sensitive to the action of essential oils.

ROLE OF ESSENTIAL OILS IN ANTIMICROBIAL PACKAGING

Antimicrobial packaging (AMP) is an alternative to the modified atmosphere packaging and addition of preservatives. Antimicrobial agents incorporate into packaging materials control the contamination by reducing the growth rate and maximum growth population and/or extended lag phase of target microorganism or by the inactivation by contact (Quintavalla and Vicini, 2002). To achieve this either the volatile or non volatile antimicrobial agents are incorporated to the polymers or coating the polymer surface using the antimicrobial agents (Appendini and Hochkiss, 2002).

The direct addition of essential oils to food leads to reduction in bacterial population immediately but may also alter sensory characters. Thus the use of essential oils in film production may be an alternate method. The synergistic effects of essential oils depends on low pH, low a_w (water activity), chelators, low oxygen tension, mild heat and raised pressure with additives like sodium chloride, sodium nitrite and nisin with preservatives and technology of

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mild heat treatment, high hydrostatic pressure and anaerobic packaging (Gould, 1996). Combined effect of 2-3% Sodium chloride with mint oil or 0.5% Clove powder (with Eugenol and Eugenyl acetate) is found to have action against *Salmonella* Enteritidis, *Listeria monocytogenes* and *Enterobacter aeruginosa* (Tassou *et al*., 1995). Salt reduces the antibacterial action of carvacrol and p-cymene against *Bacillus cereus* (Ultee *et al*., 2000). Four percent salt has no effect against Gram positive and Gram negative bacteria along with cinnamaldehyde (Moleyar and Narasimham, 1992). Nitrite with oregano oil at the rate of 400 ppm is found to act against *Clostridium botulinum* spore germination and outgrowth (Ismaiel and Peterson, 1990). At pH 7.0, the synergistic action of nisin and carvacrol was greater at 30$^{\mathbf{0}}$C than at 80$^{\mathbf{0}}$C (Periago and Moezelaar, 2001).

The antibacterial activity of essential oils depends on the oxygen availability. The use of vacuum packaging with oregano oil has synergistic effect on the inhibition of *Listeria monocytogenes* and spoilage microorganisms (Tsigarida *et al*., 2000). The inhibitory effect of clove and coriander essential oils on *Aeromonas hydrophila* was found pronounced in vacuum packaging (Stecchini *et al*., 1993). A considerable number of essential oil components are GRAS (Generally Regarded as Safe) and/or approved food flavours. Some like eugenol, menthol, thymol may cause mouth irritation, allergic contact dermatitis when used frequently and even produce spasmolytic or spasmogenic properties. An interaction between essential oils and different components to the food ingredients and additives is opening yet another world. To say clove and oregano oil when contact with iron present in the food gives black pigmentation. The essential oils may not be stable during various processing stages. Cinnamaldehyde decomposes

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to benzaldehyde at 60^{0}C; when combined with eugenol or cinnamon oil becomes stable at 200^{0}C for 30 minutes (Bajpai *et al*., 2011).

Food borne pathogens like *Listeria monocytogenes*, *Salmonella* and *E. coli* O157:H7 cause serious hazards to the public health. The area of interest of essential oils is mainly on improving the shelf life and reduction of serious pathogens. By the advent of ‘green consumerism’ concept (Smid and Goris, 1999) the use and development of herbal products increased where in essential oils attracted cosmetics, food industry and medical sector.

CONCLUSIONS

The incorporation of essential oils in food preservation and packaging provides a better protection from microbes as well as ensures the consumer satisfaction from the view point of ‘green’ earth concept. Various essential oils provide safety from the most important food borne pathogenic bacteria like *Listeria*, *Salmonella*, *Aeromonas*, *Clostridium botulinum*, *Enterobacter*, Staphylococci and their toxins due to their lipophilic action. When added on prescribed amounts, the essential oils improve the organoleptic properties of the foods; the mode of action is not well understood which may open up a new tomorrow of research.

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