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Review

Antimicrobial herb and spice compounds in food

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ABSTRACT

Herbs and spices containing essential oils (EOs) in the range of 0.05–0.1% have demonstrated activity against pathogens, such as *Salmonella typhimurium, Escherichia coli* O157:H7, *Listeria monocytogenes*, *Bacillus cereus* and *Staphylococcus aureus*, in food systems. Application of herbs, spices and EOs with antimicrobial effects comparable to synthetic additives is still remote for three major reasons: limited data about their effects in food, strong odor, and high cost. Combinations of techniques have been successfully applied in several in-food and *in vitro* experiments. This paper aims to review recent in-food applications of EOs and plant-origin natural antimicrobials and recent techniques for screening such compounds.

Contents

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1. Introduction

Strong consumer demand for safe and high-quality foods can be attributed in part to the widespread availability and accessibility of quality health data and information. There are also new concerns about food safety due to increasing occurrence of new food-borne disease outbreaks caused by pathogenic micro-organisms. This raises considerable challenges, particularly since there is increasing unease regarding the use of chemical preservatives and artificial antimicrobials to inactivate or inhibit growth of spoilage and pathogenic micro-organisms (Arques, Rodriguez, Nunez, & Medina, 2008; Aslim & Yucel, 2007; Brandi, Amagliani, Schiavano, De Santi, & Sisti, 2006; Cushnie & Lamb, 2005; Demirci, Guven, Demirci, Dadandi, & Baser, 2008; Friedman, Henika, Levin, & Mandrell, 2006; Ionnouy, Poiata, Hancianu, & Tzakou, 2007; Li, Tajkarimi, & Osburn, 2008; Lopez-Malo vigil, Palou, & Alzamora, 2005; Murdak, Cleveland, Matthews, & Chikindas, 2007; Nguefack et al., 2007; Petitclerc et al., 2007; Turner, Thompson, & Auldist, 2007). As a consequence, natural antimicrobials are receiving a good deal of attention for a number of micro-organism-control issues. Reducing the need for antibiotics, controlling microbial contamination in food, improving shelf-life extension technologies to eliminate undesirable pathogens and/or delay microbial spoilage, decreasing the development of antibiotic resistance by pathogenic micro-organisms or strengthening immune cells in humans are some of the benefits (Abou-taleb & Kawai, 2008; Fisher & Phillips, 2008; Gaysinsky & Weiss, 2007; Gutierrez, Barry-Ryan, & Bourke, 2008a; Lopez-Malo vigil et al., 2005; Nazef, Belguesmia, Tani, Prevost, & Drider, 2008; Patrignani et al., 2008; Periago, Conesa, Delgado, Fernández, & Palop, 2006; Ponce, Roura, Del Valle, & Moreira, 2008; Raybaudi, Mosqueda-Melgar, & Martin-Belloso, 2008;Yamamoto, Matsunaga, & Friedman, 2004).

Antimicrobials are used in food for two main reasons: (1) to control natural spoilage processes (food preservation), and (2) to prevent/control growth of micro-organisms, including pathogenic micro-organisms (food safety). Natural antimicrobials are derived from animal, plant and microbial sources. There is considerable potential for utilization of natural antimicrobials in food, especially in fresh fruits and vegetables. However, methods and mechanisms of action, as well as the toxicological and sensory effects of natural antimicrobials, are not completely understood (Burt, 2004; Davidson, 2006; Gaysinsky & Weiss, 2007; Gutierrez, Rodriguez, Barry-Ryan, & Bourke, 2008b; Lopez-Malo vigil et al., 2005; Moriera, Ponce, Del Valle, & Roura, 2007; Patrignani et al., 2008; Periago et al., 2006; Ponce et al., 2008; Raybaudi, Mosqueda-Melgar et al., 2008; Zaika, 1988). Even without a more comprehensive understanding of how natural antimicrobial substances work, there is a growing effort to develop new effective methods that rely primarily on their use to enhance food safety (Ayala-Zavala et al., 2008; Brandi et al., 2006; Chen et al., 2008; FAO/WHO Codex Alimentarius Commission., 2007; Liu, O'Conner, Cotter, Hill & Ross, 2008; Lopez-Malo vigil et al., 2005; Martinez, Obeso, Rodriguez, & Garcia, 2008; Murdak et al., 2007; Nazef et al., 2008; Oussalah, Caillet, Salmiea, Saucier, & Lacroix, 2004; Pellegrini, 2003; Vagahasiya & Chanda, 2007).

In addition to their flavoring effects, some spices and herbs have antimicrobial effects on plant and human pathogens (Brandi et al., 2006). Food processing technologies such as chemical preservatives cannot eliminate food pathogens such as *Listeria monocytogenesis* or delay microbial spoilage totally (Gutierrez, Barry-Ryan, & Bourke, 2009). Cold distribution of perishable food can help, but it cannot guarantee the overall safety and quality of the product. Moreover, changes in dietary habits and food processing practices and increasing demand for ready-to-eat products. Fruits and vegetables have been followed by increasing reports of food-borne pathogenic micro-organisms because of the presence of pathogens in raw materials (Lanciotti et al., 2004; Li, Tajkarimi, & Osburn, 2008; Li, Zhu et al., 2008).

There are new techniques such as pulsed light, high pressure pulsed electric and magnetic fields for food preservation and controlling pathogens and spoilage micro-organisms in food. However, technologies such as mild heat processing, modified-atmosphere packaging, vacuum packaging and refrigeration are not sufficiently effective, neither for eliminating undesirable pathogens nor delaying microbial spoilage. Moreover, some of these methods, such as vacuum cooling, can increase the probability of food contamination. Incorporation of natural antimicrobials into packaging materials, to protect the food surface rather than the food, has also been developed recently (Abou-taleb & Kawai, 2008; Fisher & Phillips, 2008; Gaysinsky & Weiss, 2007; Gutierrez et al., 2008a; Holley & Patel, 2005; Lanciotti et al., 2004; Li, Tajkarimi et al., 2008; Li, Zhu et al., 2008; Lopez-Malo vigil et al., 2005; Nazef et al., 2008; Patrignani et al., 2008; Periago et al., 2006; Ponce et al., 2008; Raybaudi, Mosqueda-Melgar et al., 2008; Raybaudi, Rojas-Grau, Mosqueda-Melgar, & Martin-Belloso, 2008). A growing body of data indicates that there is considerable potential for utilization of natural antimicrobials in food, especially application to fresh fruits and vegetables, for their oxidative degradation of lipids and improvement of the quality and nutritional value of food, in addition to their strong antifungal effects. EOs derived from spices and plants have antimicrobial activity against *L. monocytogenes*, *Salmonella typhimurium*, *Escherichia coli* O157:H7, *Shigella dysenteriae*, *Bacillus cereus* and *Staphylococcus aureus* at levels between 0.2 and 10 $\mu l\ ml^{-1}$(Burt, 2004).

For example, combined mild heat treatment with addition of cinnamon and clove EOs to apple cider significantly reduced the *D*-value and time to 5-log reduction of *Escherichia coli* O157:H7 (Knight & McKellar, 2007). Application of concentrations of 2.0% of citric acid or up to 0.1% of cinnamon bark oil in tomato juice, followed by treatment with high-intensity pulsed electric fields, successfully achieved the pasteurization level (reduction of at least 5.0 $\log_{10}$ units) (Mosqueda-Melgar, Raybaudi-Massilia, & Martin-Belloso, 2008a, 2008b).

The purpose of this paper is to provide an overview of the data published mostly in the past 10 years on plant-derived compounds that have been reported to be effective against spoilage or pathogenic bacteria, and practical methods for screening these compounds.