Potential Methods for Essential Oil Incorporation in Food Systems

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March 31, 2016

Research Question: What are potential methods for incorporating essential oils into food systems to target foodborne pathogens?

Audience: Agricultural extension agents working in food safety

Documentation Style: Journal of Food Science, an Institute of Food Technologists publication
Introduction

Each year, an estimated 48 million Americans become sick as a result of foodborne illness (Centers for Disease Control and Prevention 2014). Despite all efforts to prevent contamination, outbreaks of foodborne pathogens are unfortunately a common occurrence. Researchers around the world continue to look for novel methods the food industry can use to prevent these outbreaks, and university extension agents play a key role in implementing these methods at manufacturing sites.

In the past few decades, essential oils have become a popular research topic due to their antimicrobial activity. Essential oils (EOs) are defined as volatile compounds isolated by physical means from plant material (Can Baser and Buchbauer 2009). These oils are completely natural and found in many common herbs and spices, including oregano, clove, lavender, cinnamon, and thyme. Thus, there is great consumer acceptance potential in using EOs in place of other food preservatives or cleaning agents. However, the hydrophobic nature and strong sensory characteristics of EOs present challenges when attempting to incorporate them into food systems (Dudley 2015). These challenges bring about the following question: what are potential methods for incorporating EOs into food systems to target foodborne pathogens? This review contains an analysis on three potential incorporation methods (direct integration, edible films, and encapsulation) and evaluates the possibility of their use in industry.

Direct Integration

One obvious method to using EOs in foods is by directly incorporating oils into the food matrix. While incorporating hydrophobic EOs into aqueous products like milk and juice can be difficult,
the presence of other food components (fat, protein, and carbohydrate) may allow for the integration of these oils into products. In some cases, mainly in meat samples, research has been done to determine whether direct integration of EOs can reduce microbial activity of pathogens present.

One early direct integration experiment examined whether sage and peppercorn oils affect the growth of *Salmonella* species in beef (Hayouni and others 2008). At concentrations varying from 0.02-3%, both oils had significant antimicrobial effects. However, concentrations less than 1.5% only resulted in a bacteriostatic (growth inhibiting) effect rather than directly killing the microbes present. These researchers also found that concentrations greater than 1% for sage oil and 2% for peppercorn oil resulted in negative effects on flavor and aroma of the meat. Opposite sensory results were seen in pork meat containing wildflower (*Satureja horvatii*) oil at concentrations up to 20% (Bukvicki and others 2014). Pork meat that was sprayed with the EO scored significantly higher than control meat samples in both flavor and color sensory panels. This study found that the wildflower EO inhibited growth of *Listeria monocytogenes* at concentrations as low as 0.32%, and the oil also exhibited antioxidant activity.

One other direct integration method, tested by Nannapaneni and others (2009), is using EOs as a wash component for raw meats. The researchers found that Valencia orange oil and limonene (also found in oranges) inhibited growth of *Campylobacter* on raw chicken completely when using a 20% oil-water wash. These findings show that perhaps EOs can be used in washing steps instead of incorporation into products to bypass undesirable aroma and flavor effects.
Overall, the use of direct integration will most likely be limited by sensory characteristics of EOs. However, if EOs were used in small concentrations that do not impact flavor profiles, the oils may be able to be used to prevent lipid oxidation and increase shelf life instead of targeting foodborne pathogens (Bukvicki and others 2014). The use of hurdle technology, implementing multiple microbial prevention techniques, may also allow for EOs to be used to prevent pathogen growth while not impacting sensory characteristics of food products.

**Edible Films**

Active packaging methods, including edible films, can be used to extend the shelf life and increase quality of food products (Dainelli and others 2008). Extensive research has been done on different components of edible films, including EOs in combination with other food-grade substances.

Different EOs have had varying rates of success when used in edible films. When tested in whey protein isolate films, 2% oregano oil was effective in inhibiting multiple foodborne pathogens, which garlic being effective at 3% and 4% concentrations (Seydim and Sarikus 2006). This study also found rosemary to be completely ineffective against foodborne pathogens, with similar results seen in gelatin based films (Gomez-Estaca and others 2007). Gomez-Estaca and others also found that when EO edible films were used in combination with high pressure processing, bacterial levels were significantly reduced in smoked sardine samples. Oregano and thyme oils have also been tested in soy protein films encasing beef patties. While *Pseudomonas aeruginosa* (a common spoilage organism) was greatly reduced, a lesser but significant reduction in coliforms (*Escherichica coli*) was observed for both oils (Emiroglu and others
2010). These results mirror previous research, which showed 1% oregano oil in whey protein isolate films was effective in reducing the presence of *E. coli* and *Pseudomonas* spp. on the surface of beef muscle pieces (Oussallah and others 2004).

These studies show that EOs have great potential to be used in edible films, especially in meat-based food products. It is possible that EOs may be better suited for edible film use with leaner meats. If a product has a high fat content, the fatty oils may become fixed in sections of fat rather than spread to areas with higher water content where bacteria are more likely to be present. In the research discussed, methods used to produce the edible films were lengthy, which may not be applicable in industry at current times. However, if a way to mass produce these films efficiency was found, the potential for EOs to be used in industry would be greatly increased. Sensory analysis and consumer acceptance data is also very limited for EO edible films, so this research area must be further explored before edible films could be implemented in industry.

**Encapsulation Methods**

Encapsulation of EOs could serve as the solution to overcome the challenge of oil solubility in aqueous food systems. Encapsulation uses surfactants, amphiphilic molecules that lower surface tension between liquids, to allow water-like and oil-like substances to create a stable dispersion or emulsion (Coupland 2015).

Gaysinsky and others (2007) tested whether Surfynol 485W (a surfactant) and eugenol (clove oil) microemulsions were effective at reducing *L. monocytogenes* and *E. coli* O157:H7 in
varying milk samples. The researchers found that microbial growth was inhibited in full fat (4%) milk, while bactericidal effects against both organisms were seen in 2% and skim milks. However, researchers also determined that unencapsulated eugenol showed the same effects as the microemulsions. Other studies have confirmed the effect of eugenol on these pathogens, while also examining the effect of carvacrol and Surlynol 485W (Perez-Conesa and others 2011). Both oils were equally effective in inhibiting E. coli, while eugenol was more effective than carvacrol in inhibiting L. monocytogenes. Encapsulation methods using lecithin (an emulsifier found in soy) have also been researched. Donsi and others (2011) found that the inhibitory and bactericidal effects of terpene oil were significantly increased when the oil was encapsulated using lecithin. The study also showed that these emulsions in orange and pear juice inactivated microbes without significantly altering juice properties.

With many food-grade surfactants and emulsifiers on the market, there are countless ways that EOs could be integrated into food via encapsulation. Each oil likely has its own affinity for certain surfactants, and thus encapsulation will likely be used on a case-by-case basis instead of having a standard EO encapsulation used throughout industry. Researchers have also showed that while some EOs may be bactericidal in encapsulated form, others may only inhibit growth from occurring (Donsi and others 2011). If these EOs cannot be incorporated into food systems effectively, encapsulations may be useful as food-grade cleaners or sanitizers in manufacturing settings.
Conclusion

The various studies discussed in this review show that EOs can be incorporated into foods successfully to inhibit or kill pathogenic food microbes. Due to the complex and varying nature of food products, not every EO integration method will be successful in every case. Further research in this field may lead to an EO profile for different food products, which would allow industry members to see which oils are most effective in their product, and how the oil can then be incorporated into the food. Before the incorporation techniques discussed can be implemented in industry, pilot-scale trials of EO films and sanitizers must be completed to determine if experimental results can be completed on this larger scale. By having a knowledge of EO incorporation methods, extension agents can better assist food manufacturers determine if EOs can be their next step in preventing foodborne outbreaks in their products.
Works Cited


Coupland JN. Lecture notes: FDSC 400, Food Chemistry. 28 Sept 2015.


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