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Use of Edible Films Containing Plant and Spice Essential Oils with Fungistatic and Fungicidal Effects in Foods

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ABSTRACT

Plant and spice essential oils have superior antimicrobial activity. Some plant extracts exhibit strong antifungal activity against undesirable fungi in foodstuffs during storage period. Generally, phenolic and terpene compounds are major contributors to this action. Plant extracts such as thyme, garlic, clove and cinnamon could inhibit the growth of spoilage and/or pathogen fungi species, mainly *Aspergillus* sp., *Penicillium* sp., *Mucor* sp., and *Cladosporium* sp.. In addition to being barrier properties for oxygen, carbon dioxide, lipid, moisture and flavours, edible films or coatings incorporated with essential oils (Eos) could be used to protect foods even after the package is opened. K-sorbate, nisin and natamycin are commonly used as fungicide in the production of dairy and meat products. The growth of pathogen and spoilage species mainly at the surface of foods could be limited by the application of edible films incorporated with Eos. There is limited information on the antifungal effects of edible films with Eos in various food applications. It was reported that whey protein isolate films (WPI) incorporated with thyme and garlic Eos can provide a better antifungal reduction against *Penicillium* sp. than natamycin on Kashar Cheese in 7 days. Natural antifungal effectiveness of the films to extend the self-life of packed foods, increasing consumer trends for natural foods, enhancing food quality and safety, decreasing packaging wastes and preventing environmental pollution are some advantages of the edible films with Eos. In this review, the effect of Eos addition on the antifungal activity of edible films was reviewed.

Key Words: Plant extracts, Edible films, Antifungal activity

Fungistatik ve Fungisidal Etkili Bitki ve Baharat Esansiyel Yağları İçeren Yenilebilir Filmlerin Gıdalarda Kullanımı

ÖZET

Bitki ve baharat esansiyel yağları güçlü antimikrobiyal aktiviteye sahiptir. Bazı bitki ekstraktlarının depolama boyunca gıda maddelerinde istenmeyen küfler üzerine geniş etki spektrumuna sahip olduğu bilinmektedir. Genel olarak, bu inhibitör etkiye en fazla katkıda bulunan bileşikler, fenolik ve terpenlerdir. Bozulma ve/veya patojen etkili küf cinslerinin (örneğin *Aspergillus* sp., *Penicillium* sp., *Mucor* sp. ve *Cladosporium* sp.) gelişimi kekik, sarımsak, karanfil ve tarçın gibi bazı bitki ekstraktları ile inhibe edilebilmektedir. Esansiyel yağlar ile birleştirilen yenilebilir filmler veya yenilebilir kaplamalar, ambalaj açılsa bile O_2, CO_2, lipid, nem ve aroma özelliklerini koruyucu olması yanında gıda maddelerini korumayı sağlayabilmektedir. Potasyum sorbat, nisin ve natamisin, fungusit olarak süt ve et ürünlerinde yaygın olarak kullanılmaktadır. Ambalajlı ürünlerin raf ömrünü uzatma, tüketicilerin doğal gıdalara eğilimini arttırma, gıda kalitesi ve güvenliğini arttırma, ambalaj atıklarını azaltma ve çevre kirliliğini önlemek için filmlerin doğal antifungal etkisinin avantajları önemlidir. Gıdalarda sentetik koruyucu maddelerin kullanım oranını azaltan veya yerini alabilen doğal katkı maddeleri üzerine yapılan araştırmalarda, patojen ve bozulma etmeni cinslerin özellikle yüzeyde yayılmasını,

yenilebilir filmlerle birleştirilen esansiyel yağ uygulaması ile sınırlanabildiği tespit edilmiştir. Çeşitli gıda uygulamalarında esansiyel yağlı yenilebilir filmlerin antifungal etkileri hakkında ait sınırlı bilgi vardır. Bu çalışmada, esansiyel yağların yenilebilir filmlere ilavesinin antifungal etkileri özetlenmiştir.

Anahtar Kelimeler: Bitki ekstraktları, Yenilebilir filmler, Antifungal aktivite

INTRODUCTION

Mould contamination on food surfaces is major cause of food spoilage, which causes significant flavour defects, discoloration, quality problems, and economical consequences and furthermore represents a potential health risk by producing of toxin metabolites (mycotoxins) [1]. Antimicrobial substances can be added into the product formulation, coated onto the surface of food or incorporated into food-packaging materials [2]. Using of chemical preservatives (such as benzoats, sorbates, propionic acids, etc.) in foods limited by law in most countries to relatively low levels and to specific foods. Antimicrobial agents can be directly applied by spraying or dipping on food surface. Natamycin has been used to prevent fungal growth in foods more than 30 years. It is used mainly for the surface treatment for cheeses and dry sausages [3]. However, direct surface application has some disadvantages in that it causes quick diffusion and it needs higher concentrations. Instead, the use of edible film or edible coating incorporated with antimicrobial agents for improving the preservation of packaged foods slows down their release and helps keeping high concentrations of the active compounds on the product surface for extended periods of time [2,4,5].

Essential oils (Eos) derived from plants are rich sources of volatile terpenoids and phenolic compounds. Such compounds have the potential to inactivate pathogenic bacteria, fungi and yeasts on contact and in the vapor phase. Edible films can incorporate antimicrobial agents to provide microbiological stability, since they can be used as carriers of a wide number of additives that can extend product shelf life and reduce the risk of pathogenic microorganisms' growth on food surfaces. Edible films containing Eos can be used to protect food against contamination by undesired microorganisms [6,7,8].

ANTIFUNGAL ACTIVITY of EDIBLE FILMS INCORPORATED with ESSENTIAL OILS

Moulds have powerful arsenal of hydrolytic enzymes which can cause a high degree of deterioration of edibles and responsible for considerable economic losses. Food contamination with fungi especially its toxigenic strains producing of secondary metabolites is a major concern, which has received world wide attention due to their deleterious effects on human and animal health as well as their importance in international food trade [9]. Synthetic preservatives can be useful in controlling quantitative and qualitative losses of food commodities due to fungal infestation. However, there is an increasing interest in developing and using bio-based active films, which are characterized by antimicrobial and antifungal activities in order to improve food preservation and to reduce the use of chemical preservatives [10].

During recent years, natural products have been demonstrated to be effective replacements for several synthetic chemicals used against fungal contamination. The recommendation of herbal products as 'generally recognized as safe' (GRAS) as food additive in different developed countries may lead interest in plant based food preservative to protect the food commodities. One such alternative way is the use of essential oils as antimicrobial additives [11]. Over 30,000 different components have been isolated from these plant oils. The compounds containing phenol groups being those most used in the food industry [12]. Volatile substances from different aromatic plants have proven to be efficient antifungal against food spoiling mould [13].

Edible coatings are applied to processed foods to restrict the movement of moisture and gases, especially O_2 and can reduce dehydration and oxidation as well as the resulting undesirable changes in color, flavor and texture and show promise as environment-friendly quarantine treatments [14]. Edible films, as carriers of antimicrobial compounds, constitute an approach for incorporating plant essential oils on food surfaces Incorporating antimicrobial compounds into edible films or coatings provides food safety and shelf life of ready-to-eat foods. It can be used both to impart antimicrobial activities and to enhance barrier properties of the films [15].

Edible films incorparated with plant and spice essential oils on food products has received attention in recent years because of their advantage over synthetic antimicrobials and films. Inhibitory effects of thyme, oreganum, mint, cinnamon, clove, citrus tree, garlic, bay tree Eos on undesirable fungi have been reported by some researchers [16-18]. Antibacterial effects of coating films with Eos against *Listeria monocytogenes*, *Escheriachia coli* O157:H7*, Staphylococcus aureus*, *Salmonella enteritidis*, *Pseodomonas aeroginosa* have been studied [5,15,19,20] and it has been suggested that the films have the potential to be used as active biodegradable films with strong antibacterial effects. However, there is limited knowledge about the possibilities of using edible films including plant and spice Eos showing fungistatic and/or fungicidal effects in food products. Sachez-Gonzlez *et al*. [21]. searched for physical properties of edible chitosan films containing bergamot essential oil and their inhibitory action on *Penicillium italicum* and found that chitosan films with the maximum bergamot oil content led to a total inhibition of the fungus growth during the first 5 days at 20°C. Also, similar antifungal effect on *Fusarium solani* has been showed using with 4 mg/L chitosan in a liquid

nutrient medium by Kendra and Hadwiger [22]. Sarıkus [23] researched on whey protein isolate films incorporated with oregano, garlic and rosemary Eos against *Penicillium* sp. during kashar cheese storage and determined that the antifungal properties of the films containing Eos had important decrease than control groups and the main inhibitory effect was observed at 7th day cause of diffusing Eos into whey proteins samples. These films might be preferred as chemical preservatives for microbial inactivation.

CONCLUSION

Fungal contamination of food products is a chronic problem in developing countries and it leads to a decline in quality and quantity of foodstuffs. Pathogenic fungi alone cause a nearly 20% reduction in the yield of major food and cash crops. Many fungi species represent a serious risk for consumers because of production of dangerous secondary metabolites such as aflatoxins. Synthetic preservatives have long been used to prolong the shelf life of food products. Since there is a public tendency towards natural food products, scientists specialized in the food engineering have long investigated alternatives for food preservation. Some plant or spice Eos can be used food preservatives due to their strong antimicrobial activity. The application of edible or coating films containing Eos can improve food safety by eliminating fungal spread, and they also leave no detectable residues after storage. The incorporation of Eos in edible films would be an alternative antifungal application to control of fungal growth.

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