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Chapter

Introductory Chapter: Active Antimicrobial Food Packaging

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1. Introduction

Food spoilage is the most matter of concern for growers, retailers and consumers; because, foods can be easily deteriorated in a short time unless precautions are taken. Although processing of raw foods by various unit operations preserves the foods up to consumption, the processed foods mostly need to be packaged for a safe retailing and consumption. The basic functions of a food packaging are protection, containment, convenience and communication. However, these are found passive, whereas active functions are needed nowadays [1].

The term 'active packaging' basically refers to shifting protective role of passive packaging to an active role. This means to actively change the conditions of the package within its atmospheric gas composition of inner and/or outer surface of the package to extend the shelf life of packed foods. Antioxidants, enzymes, aromatic compounds, nutraceuticals, essential oils and antimicrobial compounds are used as emitters (active releasing systems) or absorbers (active scavenging systems) in active packaging. European Regulation EC No 450/2009 defines the active packaging as '*deliberately incorporate components that would release or absorb substances into or from the packaged food or the environment surrounding the food*' [1, 2].

Moisture, odour, flavour or gases in the package such as oxygen, carbon dioxide, ethylene are absorbed or emitted by active releasing systems (emitters) or active scavenging systems (absorbers). Active releasing systems are mainly used as antioxidant or antimicrobial carbon dioxide releaser, whereas active scavenging systems (absorbers) are used for oxygen, moisture and ethylene scavenger or absorber [1, 2].

Active releasing systems are using an active compound (green tea extract, tocopherols, butylated hydroxytoluene, citric acid, sodium bicarbonate, etc.), where incorporated to the film or tray structure, while active scavenging systems are using sealed small sachets carrying an active compound (iron, ascorbic acid, photosensitive dyes, palladium, zeolites, etc.) in the packaging. However, the kind of scavenger use in the package is taking concerns for elders and children who might consume the scavengers falsely or the accidental breakage of scavenger sachets might result to an undesired consumption of scavenger material, such as iron, palladium, catechol and oxidative enzymes. It should be outlined that scavenger use in Asian market was positively implemented when compared to European market [2].

Active antimicrobial food packaging is an emerging technology in food packaging, because consumers are demanding more natural foods with less additive usage in the food formulations. In this point, antimicrobial compounds are incorporated into the packaging materials (film and/or tray) or coating onto the packaging

surface, or immobilising them in sachets to combat with spoiling microorganisms and pathogens in foods. Therefore, this kind of usage reduces the addition of required amount of active compounds in the food formulations [1].

Minimal usage versus instant usage of antimicrobials displays equal or higher antimicrobial activity by release mechanism. Another advantage of active packaging is that additives are released in a controlled manner, while using the additives in food formulations might not be fully effective; because, additives could be consumed by reactions in foods. Besides, aerobic microbial spoilers have chance to be effectively controlled, because the volatile antimicrobials are released into the package headspace in vapour phase. Hence, some of the antimicrobials (bacteriocins, enzymes, organic acids, nano-sized metal oxides and bacteriophages) are handled as non-volatile basis agents in active antimicrobial food packaging and need to be directly contacted with the food, whereas volatile agents do not need a direct contact between food and packaging materials. The fact is that antimicrobial activity penetrates every corner of the package and provides surface protection owing to the gaseous characteristic of the agent [3–5].

Essential oils, extracted compounds of various plants or animals, bacteriocins, enzymes, organic acids, nano-sized metal oxides and bacteriophages are commonly studied for use in antimicrobial packaging in numerous researches [3, 4]. Flowers, buds, leaves, stem, bark and seeds are the common materials used for their essential oils (EOs). Plants synthesise two kinds of oils, which are fixed oils and essential oils. Esters of glycerol and fatty acids are defined as fixed oils, whereas EOs are composed of volatile, organic compounds originating from a single botanic source, that provide the flavour and fragrance of the plant [6]. The performance of EOs for antimicrobial and antioxidant activities depends on the plant's botanical characteristics, season, harvesting and extraction conditions, as well as complexity of the foods such as pH, water activity and lipid content affects the performance of EOs, while reproducibility, organoleptic acceptance, migration and allergic reactions of the EOs are limiting factors for use in real packaging conditions [4].

Allergic contact dermatitis is the most common type of adverse reaction of EOs, where cinnamon bark, laurel leaf and tea tree are the reported EOs. The possible toxicity of the EOs is the major concern in food packaging that governed by regulations. Some EOs contain potential eye and airway irritation compounds; therefore, the safety of EOs should be checked when used in food packaging, because EOs are used for their antimicrobial effect in the vapour phase that may result in unwanted respiratory diseases. The reason is, volatile organic compounds are also present in some essential oil constituents and is defined by the US Environmental Protection Agency as '*any compound of carbon, excluding carbon monoxide, carbon dioxide, carbonic acid, metallic carbides, or carbonates, and ammonium carbonate, which participates in atmospheric photochemical reactions*'. In fact, EOs are not a significant cause of respiratory disease; however, inhaled fragrant molecules can trigger attacks in people with asthma or multiple chemical sensitivity. To prevent the EOs-based hazards, limiting the doses and concentrations is a simple and effective way in daily intake. However, in case of the packaging applications, migration limits are important when manufacturing plastics for food contact, where published by European Commission [4, 6].

The research-oriented studies of food scientists and packaging engineers have a leading role in the packaging community. Fabricating an active packaging material is provided by various processing methods that affect film structure and property, which determines the release rate and finally the stability of the active compound. The key word is release rate. The interaction between the packaging material (acted as carrier) and the active compound (acted as releaser) determines the release rate, which have a direct effect on the food quality. The commercial processes of

active packaging films involve the cast film and blown film processes. The processing of films follows the order: melting a polymer resin, extruding the polymer melt through a die, stretching and cooling the melted polymer into a film. When required, more than two polymers can be blended using a chaotic mixer [5].

The success of the produced controlled release packaging material is laid on a conceptual framework that determined by Yam and co-workers [5]. The framework is mainly structured on process, structure, property and food parameters. The latter is basically structured on food research, while the formers are structured on packaging research basis. The required shelf life depending on the storage conditions, as well as package contact and the subjected food composition is governed by target release rate of the active compound from packaging material. Stability of active compound/s and release rate, properties of packaging material (e.g. gas permeability) are related with the package structure, morphology of blended polymer and localization of active compounds. These are affected by processing methods such as cast film, blown film, smart blending (chaotic advection), lamination/co-extrusion, solution casting/coating. Type and ratio of the polymer/s and the property of active compound are also determinative in the outlined framework [5].

There are a number of published articles on the current chapter in literature. However, it was our aim to reflect a brief introduction on active antimicrobial food packaging rather than to provide an extensive chapter to the reader. Recently documented reviews for active food packaging by Janjarasskul and Suppakul, Yildirim et al., Ahmed et al. and Ribeiro-Santos et al., as well a review highlighting sachet use in antimicrobial food packaging by Otoni et al. are recommended for further reading [2, 4, 7–10].

The fact is that a number of studies are made by casting method or solvent process to prepare active films in laboratories. Therefore, many of them failed to adapt to the real packaging processes. Some of the reported researches are successfully implemented to the industrial applications [10]. Applications subjected to trade will be summarised in the following statements. An organic compound allyl isothiocyanate (AITC) is used in sheets, labels and films in Japanese market using Wasaouro™ trademark. A bacteriocin, natamycin-based, antifungal coating under the brand name SANICO®, is available for use in cheeses and sausages. Carbon dioxide sachets for use as emitters to provide suppressing microorganism growth and preventing package collapse in modified atmosphere packaging (MAP) is also commercially available under the Verifrais™ brand. However, UltraZap XtendaPak contents have both antimicrobial agents and CO_2 emitter for meat, poultry and seafood packaging. *Salmonella* spp., *Campylobacter* spp. and *Escherichia coli* growth in fresh meat are controlled by using silver nanocomposite films under the brand names Biomaster®, Irgaguard®, Surfacine®, Aglon®, d2p®, Ionpure® and Bactiblock®. An antimicrobial paper, Food-touch®, carrying silver-based additive is used during transportation of fresh fish fillets [8].

In future, to gain the sustainability in active food packaging, tailor-made packaging solutions will be needed for specific food products. Besides, the trend today is using bio-degradable agro-polymers and animal-derived polymers in active food packaging to reduce the waste of packaging materials, especially plastics. This is because of the fact that globally we waste millions of tonnes of plastics in the environment, and those plastic debris threatens the whole ecosystem, which we share with plants and animals [11].

For a sustainable ecosystem, starch, proteins (e.g. casein, whey, soy, gluten, corn maize), polylactic acid, polyhydroxyalkanoate, polyhydroxybutyrate, chitosan are used for their biodegradability both in researches and industrial applications in active packaging [10]. Relatively, high cost and mechanical features of the natural biodegradable polymers versus the synthetic polymers are the limiting factors for their usage in food packaging. However, mechanical performances (tensile strength,

elongation at break, etc.) and barrier properties (gases, water vapour) could be increased by blending with common synthetic polymers, such as polyethylene (PE), polypropylene (PP) and plasticizers (water, glycerol, glycol, etc.) [11].

The performance of the polymer blends depends on three main parameters, which are miscibility, compatibility and morphology. The preferred method in industries is melt blending, which is found economic and proper to combine two or more dissimilar characteristics of polymers. Currently, the strategy for compatibilization processes to produce high-performance polymer blends is being undertaken. Therefore, the biodegradable polymers are expected to decrease the amount of conventional polymers usage, such as PE and PP, in the packaging production chain [11].

Apart from this introductory chapter, this book is composed of four chapters and aimed to introduce the reader with active antimicrobial food packaging, as well as regarding concerns of the consumers on food additives. An overview of using natural antimicrobial agents is summarized in Chapter 1, which meet the consumer demands on replacing natural antimicrobials instead of synthetic additive usage in the food industry. Examples for using native plants of Mexico for developing active antimicrobial films are provided in Chapter 2, as an article. Active films, carbohydrates, and proteins as well are used for fabrication. Chapter 3 gives detailed information on protein usage in active antimicrobial food packaging. The use of active compounds in edible films is outlined in Chapter 4.

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