Food Chemistry 240 (2018) 505–513

Contents lists available at ScienceDirect

Food Chemistry

journal homepage: www.elsevier.com/locate/foodchem

Review

Edible films and coatings in seafood preservation: A review

Samira Dehghani [a], Seyed Vali Hosseini [b,*], Joe M. Regenstein [c]

[a] Department of Food Science and Technology, College of Agriculture & Natural Resources, University of Tehran, Karaj, Iran
[b] Department of Fisheries, College of Agriculture & Natural Resources, University of Tehran, Karaj, P.O. Box: 4111, Iran
[c] Department of Food Science, Cornell University, Stocking Hall, Ithaca, NY, USA

ARTICLE INFO

Article history:
Received 8 April 2017
Received in revised form 29 June 2017
Accepted 10 July 2017
Available online 11 July 2017

Keywords:
Edible films
Edible coatings
Seafood quality
Seafood shelf-life

ABSTRACT

Seafood is highly perishable and has a short shelf-life. During storage many reactions occur leading to changes in quality such as endogenous chemical and enzymatic reactions. The safety and shelf-life are related to the presence of food spoilage and pathogenic microorganisms. Despite improved manufacturing facilities and implementation of effective process control procedures such as the Hazard Analysis Critical Control Point system by seafood companies, the number of seafood-related foodborne illnesses has increased. Edible coatings can improve the quality of fresh and frozen products by retarding microbial growth, reducing lipid oxidation and moisture loss, and functioning as a carrier of food additives such as antimicrobial and antioxidant agents. Biodegradable edible coatings have various advantages over synthetic coatings such as being edible and generally being more environmentally friendly. This paper reviews the application of various types of natural bio-polymer and different active ingredients incorporated into the films and their effects on seafood quality attributes.

Contents

1. Introduction

Any type of thin layer of material used for enrobing (i.e., coating or wrapping) various foods to extend the shelf-life of the food product that may be consumed together with that food is considered to be an edible coating or film. Recently, edible coatings and films have receivedconsiderable attention because of their advantages compared to synthetic films. The most important is that they can be safely consumed with the packaged products (Bourtoom, 2008). Edible coatings/films provide a replacement and/or fortification of the natural layers at the product surfaces to prevent moisture losses, gas aromas and solute movements out of the food, while selectively allowing for controlled exchange of important gases, such as oxygen, carbon dioxide, and ethylene, which are

* Corresponding author. Fax: +98 26 3224 5909.
E-mail addresses: samira.dehghani@ut.ac.ir (S. Dehghani), hosseinisv@ut.ac.ir (S.V. Hosseini), jmr9@cornell.edu (J.M. Regenstein).

http://dx.doi.org/10.1016/j.foodchem.2017.07.034
0308-8146/

involved in food product respiration (Embuscado & Huber, 2009). Furthermore, the materials that are used for this purpose can completely coat the food or can be used as a continuous layer between food components (Guilbert, 1995).

The increased interest in edible coatings has been motivated by increasing consumer demand for safe, convenient, and stable foods, and the awareness of the negative environmental effects of non-biodegradable packaging. Biofilms are produced from edible and generally renewable resources, and in most cases will degrade more readily than polymeric materials. Even if the films are not consumed, they generally will still contribute to the reduction of environmental pollution (Bourtoom, 2008; Donhowe & Fennema, 1993).

Although edible coatings and films have a similar definition, there is a difference. Generally, edible films are prepared separately and then applied to the surface of the food, whereas coatings are formed directly onto the food surfaces (Cordeiro de Azeredo, 2012). Research has shown that both methods can enhance the organoleptic characteristics of packaged seafood when properly formulated. Furthermore, with the incorporation of antibacterial and antioxidant agents, they can function to retard oxidation and/or delay microbial spoilage. However, their permeability and mechanical properties are generally poorer than synthetic films (Kester & Fennema, 1986) and this will limit their use to specific applications. With further research, some of these limitations will be overcome.

Although edible films and coatings are not meant to entirely replace traditional packaging, the adequacy of food protection can be improved by combining primary edible packaging and secondary nonedible packaging. Secondary packaging is usually required for handling and hygienic reasons (Cordeiro de Azeredo, 2012).

Biodegradable edible films and coatings, such as waxes, have been used for centuries to prevent the loss of moisture and to create a shiny fruit surface. The use of films in foods dates back to the 12th century in China where waxes were used to coat citric fruits to retard water loss. The first edible film used for food preservation was made in the 15th century from soymilk (Yuba) in Japan (Sánchez-Ortega et al., 2014). As recently as 1967, edible films had very little commercial use, and were limited mostly to wax coatings of fruits and vegetables. During the intervening years, a significant business grew out of this concept (i.e., in 1986, there were about ten companies offering such products, while by 1996, the number grew to ~600 companies). Today, edible films are used with a wide variety of foods, with total annual revenue exceeding $100 million US dollars (Embuscado & Huber, 2009). Other novel methods to keep foods safe are also being used including combinations of various preserving technologies such as refrigeration, controlled atmosphere storage, and sterilization by UV or gamma radiation. Nevertheless, for many kinds of foods, coating with an edible film continues to be one of the most cost effective ways to retain their quality and safety.

Consumption of seafood has increased during recent years as consumers have become more aware of its nutritional benefits and of the health concerns associated with other meat products such as chicken and beef. However, the composition of fish flesh makes it favorable for the rapid growth and propagation of spoilage microorganisms and common food-borne pathogens (Sedigh-Jasour, Ehsani, Mehryar, & Naghibi, 2015).

Fish quality is very subjective in nature and is a very complicated concept, which includes nutritional (Pietrowski, Tahergorabi, & Jaczynski, 2012), microbiological, biochemical and physiochemical attributes. Fish is a more perishable product than other muscle foods and its freshness degrades after death due to various biochemical reactions (e.g., changes in protein and lipid content, and the formation of biogenic amines and hypoxanthine) and microbiological spoilage (Matak, Tahergorabi, & Jaczynski, 2015). This results in the deterioration of sensory quality and nutritional value of fish. Preservation of fish is important to prevent the loss of this nutritionally rich natural resource (Mohan, Ravishankar, Lalitha, & Gopal, 2012).

Edible films and coatings can be used to provide physical protection (Min, Harris, & Krochta, 2005) to protect food products from mechanical damage, and from physical, chemical and microbiological activities. They also can be edible, biocompatible, nontoxic, and serve as both a barrier and a carrier of food additives (e.g., antioxidants and antimicrobials).

Biodegradable edible films and coatings may be categorized according to the type of material from which they are derived. Each chemical class has its inherent advantages and limitations when used for films. Polysaccharides, proteins and lipids are the three main materials used for this purpose. Polysaccharides are widely available and usually cost effective. Most of them are neutral, although some gums are negatively charged. Due to the presence of a large number of hydroxyl and other polar groups in their structure, hydrogen bonds have a crucial function in film formation and final characteristics. Negatively charged gums like alginate, pectin, and carboxymethyl cellulose (CMC), depending on the pH, tend to have different properties (Cordeiro de Azeredo, 2012; Qiu, Chen, Liu, & Yang, 2014). Film-forming proteins are derived from animals (e.g., casein, whey protein concentrate and isolate, collagen, gelatin, and egg albumin) or plants (e.g., corn, soybean, wheat, cottonseed, peanut, and rice). The main mechanism of formation of protein films includes denaturation of the protein initiated by heat, solvents, or a change in pH, followed by association of peptide chains through new intermolecular interactions (Cordeiro de Azeredo, 2012). Protein-based films adhere well to the hydrophilic surfaces of meat and can provide barriers for oxygen and carbon dioxide diffusion while not stopping water diffusion (Min & Oh, 2009; Rodriguez-Turienzo et al., 2011; Sánchez-Ortega et al., 2014).

Unlike polysaccharides and proteins, lipids are not biopolymers and are not able to form cohesive films. Therefore, they are either used as coatings or incorporated into biopolymers to form composite films, giving a better water vapor barrier, due to their low polarity (Cordeiro de Azeredo, 2012).

For seafood, a barrier against both moisture and oxygen migration can be beneficial (Arfat, Benjakul, Vongkamjan, Sumpavapol, & Yarnpakdee, 2015; Li, Li, Hu, & Li, 2013). Incorporation of different additives into the coating has the advantage of allowing for the slower release of these compounds from the film. Currently these additives are usually organic acids, essential oils and plant extracts, bacteriocins, proteins and/or chitosan, each of which has different effects on lipid oxidation, and proteolytic and microbial decay (Sánchez-Ortega et al., 2014).

The aim of this paper is to review the application of various types of natural bio-polymers such as polysaccharide, protein and lipid in edible films and coatings. In addition different active ingredients incorporated into the films and their effects on seafood quality attributes as well as prolonging shelf life were reviewed.

2. Materials used for edible films and coatings with seafood

The number of materials that can be used in the seafood industry is limited. Obviously, the materials must be able to form a film. It must also be able to be dispersed or dissolved in an appropriate food safe solvent that is also compatible with the necessary plasticizers, antioxidants and antimicrobial agents, flavors, etc. For food, the potential materials can also be classified as: lipids (e.g., acylglycerol, fatty acids and waxes), hydrocolloids (e.g., polysaccha-