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Review

Edible films from pectin: Physical-mechanical and antimicrobial properties - A review

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ABSTRACT

Pectin is one of the main components of the plant cell wall chemically constituted by poly α1–4-galacturonic acids. According to its degree of esterification with methanol, pectin can be classified as high methoxyl pectin or low methoxyl pectin. In food industry, pectin is listed as generally recognized as safe (GRAS) by the Food and Drug Administration and is used as gelling, stabilizing, or thickening agent in food products such as jams, yoghurt drinks, fruity milk drinks, and ice cream. Due to its biodegradability, biocompatibility, edibility, and versatile chemical and physical properties (such as gelation, selective gas permeability, etc), pectin is a suitable polymeric matrix for the elaboration of edible films intended as active food packaging. Active packaging is a packaging system which possesses attributes beyond basic barrier properties that are achieved by adding active ingredients in the packaging material and/or using functionally active polymers. When the packaging system has antimicrobial activity, the packaging limits or prevents the microbial growth by extending the lag period and reducing the growth rate of microorganisms. This review describes the main methods for elaborating pectin edible films, principal characterization techniques for determining their physical-mechanical properties, and applications of pectin edible films as antimicrobial food packaging. Finally, legislation and future trends regarding the use of pectin edible films are also discussed.

Contents

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1. Introduction

The current global market has experienced an increasing consumer demand for more natural foods meeting the criteria of high quality and safety. This has lead companies and researchers to explore different ways to improve their productivity in terms of maintaining quality, freshness, and food safety, such as using sustainable materials in food packaging (Mahalik & Nambiar, 2010). Moreover, edible film research has undergone rapid expansion in the past twenty years, due to increased consumer interest in health, nutrition, food safety, and environmental issues. World production of plastic resins increased around 25-fold, while less than 5% of all plastics were recycled, leading to a rapid accumulation of plastics in the environment (Sutherland et al., 2010). In the United States alone, the increased plastic production resulted in 31 million tons of plastic waste in 2010, representing 12.4% of total Municipal Solid Waste—more commonly known as trash or garbage (EPA, 2011). Food wraps account for million tons of waste in landfills every year, putting a serious burden on the environment. As a result, research works related to the use of biopolymers has emerged as an alternative, due to their biodegradability. Biopolymers have been studied regarding their film-forming properties to produce edible films intended as food packaging (Azeredo et al., 2009).

Structuring biopolymers, such as polysaccharides, proteins, and lipids have been used for the formulation of edible films. Recent reviews have focused on edible films based on lipids (Debeaufort & Voilley, 2009), protein (Ramos, Fernandes, Silva, Pintado, & Malcata, 2011) and on polysaccharides such as chitosan (Dutta, Tripathi, Mehrotra, & Dutta, 2009), hemicelluloses (Hansen & Plackett, 2008) and starch (Jiménez, Fabra, Talens, & Chiralt, 2012). Moreover, extensive publications have presented very well and wide reviews regarding the development and application of edible films (Cagri, Ustunol, & Ryser, 2004; Campos, Gerschenson, & Flores, 2011; Falguera, Quintero, Jiménez, Muñoz, & Ibarz, 2011; Gennadios, Hanna, & Kurth, 1997; Guilbert, Gontard, & Cuq, 1995; Janjarasskul & Krochta, 2010). However, to the best of our knowledge literature related to pectin-based edible films is quite scarce and there is no review article solely devoted on pectin-based edible films so far in the literature.

Thus, this review highlights specifically the development of edible films made from pectin and the characterization of these films. Antimicrobial activity, their application on food preservation, and related legislation of pectin edible films are also discussed. Finally, future trends regarding the use of pectin edible films are presented.

2. Pectin as polymeric matrix for elaboration of edible film

An edible film is defined as a packaging material, which is a thin layer of edible material placed on or between food components (McHugh, 2000). Different structural materials have been used in edible film elaboration, such as proteins, lipids and polysaccharides. Polysaccharides include cellulose, chitosan, starch and pectin. Pectin is one of the main components of the plant cell wall, contributing to tissue integrity and rigidity and it is considered one of the most complex macromolecules in nature (Jolie, Duvetter, Van Loey, & Hendrickx, 2010). The main industrial sources for pectin extraction are apple pomace and citrus peels (Videcoq, Garnier, Robert, & Bonnin, 2011).

Chemically, pectin is poly α1–4-galacturonic acids (Fig. 1a), with varying degree of methylation of carboxylic acid residues and/or amidated polygalacturonic acids (Fig. 1b) (Mishra, Banthia, & Majeed, 2012; White, Katona, & Zodda, 1999).

Methoxylated carboxyl groups are obtained by esterification with methanol of carboxyl groups of galacturonic acid. On the other hand, amidated carboxyl group are obtained when some of the galacturonic acid are converted with ammonia to carboxylic acid amide.

According to the degree of esterification (DE) with methanol, which is the ratio of esterified galacturonic acid groups to total galacturonic acid groups (Farris, Schaich, Liu, Piergiovanni, & Yam, 2009; Sila et al., 2009), pectin can be classified as high methoxyl pectin (HMP) or low methoxyl pectin (LMP). HMP has over 50% of their carboxyl groups esterified (DE $>$ 50), while LMP have a DE $<$ 50. Their DE affects gelling properties of pectins. In this way, LMP forms gel in presence of multivalent ions, which acts as a bridge between pairs of carboxyl groups of different pectin chains. On the other hand, HMP forms gel in acidic media with the addition of different sugars such as sucrose or glucose (Mishra et al., 2012; Videcoq et al., 2011).

Different intermolecular interactions are involved in the gelation of pectins. The gelation of LMP involves electrostatic interactions between the cations and the negative charged cavities formed by polymer chains, where the cations are inserted. This is known as the egg box model (Fig. 2) and this process is similar to the gelation of alginates. Moreover, egg-boxes formed between two

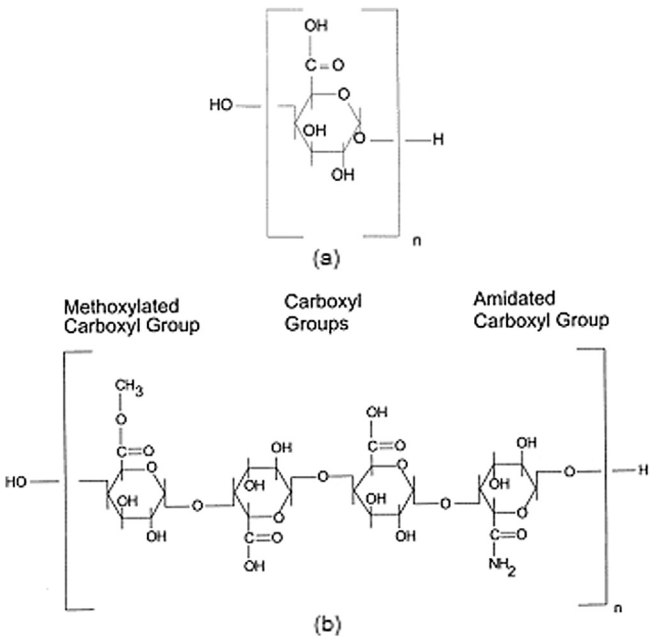

Fig. 1. Chemical structure of polygalacturonic acid (a) and representative chemical structure of pectin showing typical repeating groups (b). With permission from White et al. (1999).

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