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Extraction of agar from *Gelidium sesquipedale* (*Rodhopyta*) and surface characterization of agar based films

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ABSTRACT

The chemical structure of the agar obtained from *Gelidium sesquipedale* (*Rhodophyta*) has been determined by ^{13}C nuclear magnetic resonance (^{13}C NMR) and Fourier transform infrared spectroscopy (FTIR). Agar (AG) films with different amounts of soy protein isolate (SPI) were prepared using a thermo-moulding method, and transparent and hydrophobic films were obtained and characterized. FTIR analysis provided a detailed description of the binding groups present in the films, such as carboxylic, hydroxyl and sulfonate groups, while the surface composition was examined using X-ray photoelectron spectroscopy (XPS). The changes observed by FTIR and XPS spectra suggested interactions between functional groups of agar and SPI. This is a novel approach to the characterization of agar-based films and provides knowledge about the compatibility of agar and soy protein for further investigation of the functional properties of biodegradable films based on these biopolymers.

1. Introduction

Interest in biodegradable polymers has increased recently in response to public concerns over the growing environmental problems caused by plastic waste after disposal and by depletion of non-renewable resources (Freile-Pelegrín et al., 2007). Therefore, biopolymers, natural polymers derived from renewable sources, such as polysaccharides, proteins, or lipids, are being used to produce biodegradable films (Fabra et al., 2009; Guerrero, Beatty, Kerry, & de la Caba, 2012; Leceta, Guerrero, Cabezudo, & de la Caba, 2013).

With regard to polysaccharides, the great variety of structures provides films with a wide range of properties. In this context, red marine seaweeds (*Rhodophyta*) are the source of some promising biopolymers since they contain considerable amount of the agar polysaccharide, which is a complex mixture of polysaccharides having the same backbone chain structure. In seaweeds, agar fulfils a function analogous to that of cellulose in terrestrial plants, although it differs because marine seaweeds require a more flexible structure to resist currents and waves motion (Rochas & Lahaye, 1989). Agar is a hydrophilic colloid consisting of polysaccharides that have the ability to form reversible gels simply by cooling a hot aqueous solution. It is composed of alternating 1,3-linked D-galactose and 1,4-linked 3,6 anhydro-L-galactose units. This disaccharide can be substituted by sulfate esters and methoxyl, and may also carry pyruvic acid residues (Duckworth & Yaphe, 1971). The type, amount, and location of these substitutes strongly affect the physical properties of the gel and therefore, its functionality (Freile-Pelegrín & Murano, 2005). Agar forms a slightly viscous solution after solubilization in hot water and then becomes a thermoreversible gel when the temperature is brought down. It could be an alternative source for biodegradable films since it shows high mechanical strength with moderate water resistance (Phan, Debeaufort, Voilley, & Luu, 2009; Wu, Geng, Chang, Yu, & Ma, 2009).

Soy protein is also a renewable polymer that can also be used in the manufacture of biodegradable films (Liu et al., 2010). Soy protein is the major coproduct of soy bean oil and it is readily available. Soy proteins are composed of a mixture of albumins and globulins, 90% of which are storage proteins with globular structure, consisting mainly in 7S and 11S globulins (Kinsella, 1979). The behaviour of proteins is determined by the amino acid composition, molecular size, and environment. Protein conformation also affects functionality; in globular proteins the more polar charged groups are oriented towards the surface. Moreover, non-covalent forces (hydrophobic interactions, hydrogen bonding, and electrostatic attractions) are involved in protein–protein and protein–solvent interactions, which influence the overall functional properties (Guerrero & de la Caba, 2010).

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