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Characterization and antimicrobial analysis of chitosan-based films

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ABSTRACT

Chitosan-based films for food packaging applications were prepared by casting and dried at room temperature or heat-treated in order to study functional properties and antimicrobial activity. In all cases, films were flexible and transparent, regardless of chitosan molecular weight, glycerol content, and temperature. Regarding antimicrobial activity, chitosan film forming solutions showed antimicrobial behaviour against *Escherichia coli* and *Lactobacillus plantarum*. It was also observed that the bacteriostatic property of chitosan-based films against bacteria employed in this study was notably affected by temperature. Moreover, temperature produced significant variation in the functional properties of chitosan-based films, such as colour, wettability, resistance against UV light and mechanical properties. In good agreement with this behaviour, total soluble matter (TSM), fourier transform infrared (FTIR) spectroscopy, thermo-gravimetric analysis (TGA) and X-ray diffraction (XRD) results suggested a change in the chemical structure of chitosan films, possibly due to Maillard reaction when heat treatment was used.

1. Introduction

The world market for plastic films is dominated by petroleum-derived polymers in a wide range of industrial applications and, in particular, in food packaging. In any field, manufacturers must satisfy economical, social, legal, and environmental concerns, so the balance between good properties and sustainability must be taken into account, and material selection becomes critical to face environmental demands and the need for sustainable products (Leceta et al., 2013). Nowadays, there is an increasing interest in biopolymers, natural and biodegradable polymers, as an alternative to commodity polymers in terms of raw material supply and waste product generation. In this context, chitin is the second most abundant biopolymer after cellulose and chitosan is the biopolymer obtained from deacetylation of chitin, which is the major structural component of the exoskeleton of invertebrates and the cell walls of fungi (Knorr, 1991; Pillai et al., 2009; Rinaudo, 2006). In addition, since most biopolymers are either biodegradable or compostable, it can also be argued that chitosan could fit with the 'cradle-to-cradle' concept, which means that on disposal it could become 'food' for the next generation of materials (McDonough and Braungart, 2002).

On the other hand, although the use of conventional packaging materials such as commodity polymers and their derivatives is effective for food preservation, the environmental problems that their disposal create contribute to increase the interest of manufactures in the food industry and scientists specialized in food engineering in new polymers with antimicrobial activity. The growing consumer demand for foods without chemical preservatives has focused efforts in natural antimicrobials and the use of active bio-based films is one of the most promising ways, being chitosan one of the most perspective active films (Aider, 2010; Sánchez-González et al., 2011). The antimicrobial activity of chitosan against different groups of microorganisms such as bacteria (Bulwan et al., 2012; Doulabi et al., 2013; Fernandez-Saiz et al., 2008; Kristo et al., 2008) and fungi (Assis and De Britto, 2011; Avila-Sosa et al., 2012; Martínez-Camacho et al., 2010; Sebti et al., 2005) has received considerable attention in recent years. However, research has been mostly confined to biomedical applications (Kong et al., 2008). Chitosan has inherent antimicrobial activity owing to the fact that long positively charged chitosan molecules interact with negatively charged bacteria causing disruption on the cell (Coma et al., 2003; Zivanovic et al., 2005). Chitosan's bactericidal efficacy depends on various factors that can be classified into four categories: microbial factors related microorganism species; intrinsic factor of chitosan, including molecular weight and concentration; physical state, solution or film; and environmental conditions like pH and temperature (Kong et al., 2010).

Owing to its renewable, biodegradable, and antimicrobial character, chitosan is a potential material for its use as food packaging film. Nevertheless, pure chitosan films are fragile and need plasticizers to reduce frictional forces between the polymer chains, as hydrogen bonds or ionic forces, thus improving mechanical properties (Olabarrieta et al., 2001; Srinivasa et al., 2007; Suyatma et al., 2005). Plasticizers act as internal lubricant weakening intra and intermolecular interactions and increasing the mobility of biopolymeric chains. As a consequence, free volume increases,

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