Thermal and antimicrobial properties of chitosan–nanocellulose films for extending shelf life of ground meat

Danial Dehnad a, Habibollah Mirzaei a, Zahra Emam-Djomeh b, Seid-Mahdi Jafari a, b, Saeed Dadashi b

a Department of Food Materials and Process Design Engineering, Faculty of Food Science and Technology, University of Agricultural Sciences and Natural Resources, Beheshti Avenue, Gorgan, Iran
b Department of Food Science and Technology, Faculty of Agriculture Engineering and Technology, College of Agriculture and Natural Resource, University of Tehran, Karaj, Iran

A B S T R A C T

Chitosan–nanocellulose biocomposites were prepared from chitosan having molecular weight of 600–800 kDa, nanocellulose with 20–50 nm diameters and various levels of 30, 60 and 90% (W/W CHIT) for glycerol. Agitation and sonication were used to facilitate even dispersion of particles in the polymer matrix. The nanocomposites were examined by differential scanning calorimetry, X-ray diffraction and agar disc diffusion tests; finally, the film was applied on the surface of ground meat to evaluate its performance in real terms. Chitosan–nanocellulose nanocomposites showed high Tg range of 115–124 °C and were able to keep their solid state until the temperature (Tm) range of 97–99 °C. XRD photographs revealed that nanocellulose peak completely disappeared after their addition to chitosan context. Agar disc diffusion method proved that the nanocomposite had inhibitory effects against both gram-positive (S. aureus) and gram-negative (E. coli and S. enteritidis) bacteria through its contact area. Application of chitosan–nanocellulose nanocomposite on the ground meat decreased lactic acid bacteria population compared with nylon packaged samples up to 1.3 and 3.1 logarithmic cycles at 3 and 25 °C after 6 days of storage, respectively.

© 2014 Elsevier Ltd. All rights reserved.

1. Introduction

An area of growing interest, these days, is the preparation of antimicrobial edible films applied for controlling foodborne microbial outbreaks mainly caused by minimally processed fresh products (Güçbilem, Yemencioğlu, & Arslanoğlu, 2007). Chitosan (CHT), the cationic (1–4)-2-amino-2-deoxy-β-D-glucan, is industrially produced in various quality grades from chitin, the second most abundant polysaccharide in nature (Muzzarelli, 2012; Tome et al., 2013; Muzzarelli et al., 2012). Chitin and chitosan are natural antimicrobial compounds against an extensive variety of microorganisms including bacteria, yeasts and moulds (Vuk, Hollingsworth, Leroux, Salmieri, & Lacroix, 2011). Chitosan is a non-toxic and biodegradable compound and has excellent performance in forming films (Mayachiew, Devahastin, Mackey, & Niranjani, 2010). Chitosan films have successfully been used as packaging materials for the preservation of food quality (Fernandes et al., 2009), which motivated us to select this carbohydrate polymer as a matrix context for preparing desirable edible films.

Cellulose consists of β-D-glucopyranose units joined together by β-(1–4)-glycosidic bonds and could be found in wood, cotton, hemp, etc. (Khan et al., 2012). Cellulose nanocrystals have low densities, high elongation moduli and tensile strengths (Dadashi, 2011; Klemm, Heublein, & Fink, 2005); besides, they have high biodegradability rates and are less expensive than other nanofillers (Hansson et al., 2013). Nanocellulose (n-cellulose) particles are very suitable nanomaterials for the production of cheap, lightweight, and very strong nanocomposites; meanwhile, they are more effective than their micrized counterparts to reinforce polymers (Azeredo et al., 2010).

Nanocomposites (NCPs) are novel polymer matrices which have been incorporated by nanofillers having at least one dimension in nanoscale (Persson & Oksman, 2006). At the same time, chitosan-cellulose compounds are of particular interest because of the structural similarity between these two biopolymers (Fernandes et al., 2009). Khan et al. (2012) incorporated 1–10% (w/w) n-cellulose particles with 5–10 nm width into chitosan and analyzed mechanical and barrier properties of prepared