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ScienceDirect
Carbohydrate Polymers 72 (2008) 403–409
Carbohydrate Polymers
www.elsevier.com/locate/carbpol

Characterization and effect of edible coatings on minimally processed garlic quality

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Received 14 December 2006; received in revised form 10 July 2007; accepted 11 September 2007
Available online 20 September 2007

Abstract

The main benefits of edible active coatings are their edible characteristics, biodegradability and increase in food safety. In this study the physical properties of the agar-agar based (1%) coatings incorporated with 0.2% chitosan and 0.2% acetic acid, as well as their effects on coating of minimally processed garlic cloves were evaluated. Moisture loss of coated garlic cloves was, on average, three times lower when compared to the control samples (no coated garlic cloves). There was a marked increase in color difference values (ΔE^*) for control cloves compared to the other treatments. Filamentous fungis and aerobic mesophilic were inhibited on garlic cloves coating incorporated with acetic acid + chitosan antimicrobial compounds. During 6 days-storage, at 25 °C, the filamentous fungis and yeasts count was maintained between in 10^2 and 10^3 CFU g^{-1} for the coated garlic cloves and around 10^6 CFU g^{-1} for the control. The coatings provided significant reduction ($p < .05$) in clove respiration. Coated garlic cloves, had a respiration rate (≈30 mg CO_2 h^{-1} kg^{-1}) halved compared to the non-coated garlic cloves. Water vapor transmission was lower for the films added with chitosan. These films showed no visible color difference, possibly because of the reduced thickness, since chitosan films tend to have a more intense shade.

Keywords: Agar; Edible coating; Chitosan; Garlic; Minimal processing

1. Introduction

Functional edible active coatings may contribute to prolong minimally processed food shelf life, working as barrier to gases, water vapor, solutes and guaranteeing microbiological safety (Park, 1999; Weng, Chen, & Chen, 1999). Spoilage and pathogenic microorganisms usually grow on food product surfaces. The incorporation of antimicrobial agents into packaging flexible films (coatings) is, therefore, an alternative to this problem (Weng et al., 1999). In addition, the potential of edible coatings for aroma retention and as an oxygen barrier makes them of interest for food and packaging technologies (Miller & Krochta, 1997).

Although the use of films and edible coatings in food quality preservation is not a recent concept, researches in this field have recently been intensified. The factors that contribute to the renewed interest include the consumer's demand for high quality food, environmental concerns in relation to the accumulation of non-biodegradable packaging and opportunities to create new markets for the production of films from renewable resources (Gennadios, Hanna, & Kurth, 1997; Rosa, Franco, & Calil, 2001). Edibility, biodegradability and increased food safety are the main benefits of active edible films. Their environmental friendly aspects make them alternatives in packaging systems, without the ecological costs of the synthetic non-biodegradable materials. In the future, they will be able to replace partially or totally conventional synthetic packaging (Krochta & Mulder-Johnston, 1997).

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0144-8617/$ - see front matter
doi:10.1016/j.carbpol.2007.09.012

Freile-Pelegrin et al. (2007) investigated the biodegradation behavior and functionality of agar. Accelerated weathering exposure of agar films suggests that outdoor climate parameters play a significant role in the degradation process. Both photodegradation and fluctuations in ambient temperature and humidity lead to deterioration in morphological, structural and mechanical agar film properties during early stages (30–45 days) of exposure, due to the decrease in molecular size and number of sulfate groups. These changes alter agar crystallinity, leading to formation of micro-fractures and polymer embrittlement. These chemical and morphological conditions promote microbial and fungal attacks.

Some plant organs, such as garlic cloves, are wrapped in a natural packaging (peel). This barrier regulates the transport of oxygen, carbon dioxide, moisture and, also, reduces the loss of flavor and aroma (Miller & Krochta, 1997). Minimally processed garlic loses this barrier and, therefore, the maintenance of the appropriate atmosphere for the product must be established by other means, if the shelf life is to be maintained. In this manner, not only O_2 and CO_2 concentrations, but also the moisture loss must be taken into consideration (Soares, Geraldine, Puschmann, & Teles, 2002). The interest in the quality and microbiological safety of minimally processed garlic, besides the reduction of non-biodegradable packaging waste, promotes the use of some properties of agar-agar based edible coatings incorporated with natural additives such as chitosan and acetic acid.

Plasticizing agents can be essential to overcome the brittleness of the biopolymeric films, by reducing the intermolecular forces, thus improving the mechanical properties. Glycerol is shown to improve film flexibility, reduce film puncture strength, elasticity and water vapor barrier properties of wheat gluten films (Gontard, Guilbert, & Cuq, 1993). The presence of a polyol as a plasticizer in chitosan/gelatin blends was found to impart an enhanced mobility to the polymer blend and mechanical strength and higher gas/water permeation rates proportional to the total plasticizer content (Arvanitoyannis, Nakayama, & Aiba, 1998). Arvanitoyannis, Kolokuris, Nakayama, Yamamoto, and Aiba (1997), studied the physical properties of chitosan-poly(vinylalcohol) blends plasticized with sorbitol and sucrose and concluded that the tensile strength decreased proportionally to the plasticizer content whereas the percentage elongation increased considerably, particularly in the case of sorbitol. Addition of fatty acids did not influence significantly the mechanical properties of chitosan films (Srinivasa, Ramesh, & Tharanathan, in press).

Chitin is an abundant naturally occurring biopolymer and is found in the exoskeleton of crustaceans, in fungal cell walls and in other biological materials (Andrady & Xu, 1997). It is mainly poly(β-(1-4)-2-acetamido-D-glucose), which is structurally identical to cellulose except that a secondary hydroxyl on the second carbon atom of the hexose repeat unit is replaced by an acetamide group. Chitosan is derived from chitin by deacetylation in an alkaline media. Therefore, chitosan is a copolymer consisting of β-(1-4)-2-acetamido-D-glucose and β-(1-4)-2-amino-D-glucose units with the latter usually exceeding 80%. Chitosans are described in terms of degree of deacetylation and average molecular weight and their importance resides in their antimicrobial properties in conjunction with their cationicity and their film-forming properties (Muzzarelli, 1996).

The objectives of the present work were to evaluate some physical properties of edible active agar-agar based coatings, incorporated with chitosan and acetic acid, as well as their effects on the coating of minimally processed garlic, in relation to its physiological and microbiological characteristics. Thickness, gramature, water vapor transmission and color characteristics of films were tested. Respiration rate, mass loss, color alteration and microbial count were evaluated in the final product.

2. Materials and methods

2.1. Edible coatings

All coatings were produced with polymeric agar-agar pure powder (Biobras) at a concentration of 1% (w/v) in distilled water, and melted in the microwave (Intelloware, LG). Glacial acetic acid and chitosan (87% deacetylation, Polymar) were used as additives. Three types of edible coatings were produced: without additives (RC1), incorporated with 0.2% of acetic acid (RC2) and incorporated with 0.2% of chitosan (from 1% chitosan and 1% acetic acid distilled water solution) (RC3).

2.2. Edible coating application on garlic cloves

Approximately 10 kg of Chonan Garlic, from the local market, were thrashed, peeled and sanitized, according to methodology described by Soares et al. (2002), stored in poly(ethylene terephthalate (PET) boxes (around 150 g of garlic per box) and coated with edible film. The edible coating, still liquid, was placed inside the boxes (15% of garlic mass) over the cloves. Boxes were kept at 25 °C for 9 days.

2.3. Final product analysis

2.3.1. Respiration rates

Garlic clove respiration rate was estimated by carbon dioxide gas quantification, with infrared gas analyzer (IRGA, model LCA 2), in an open system consisted of an acrylic tube (200 mL) coupled to an air change pump. The respiration rate was estimated in milligrams (mg) of CO_2 per kilogram (Kg) of fresh material per hour (h). Whole bulbs and cloves recently thrashed, the peel and the cloves coated with RC1, RC2 and RC3 were analyzed.

2.3.2. Color

Superficial color alterations were monitored with a colorimeter (HunterLab, model Miniscan XE). CIELab