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Chitosan based powder coating technique to enhance phytochemicals and shelf life quality of radish shreds

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ABSTRACT

Minimally processed radish forms an important segment of the rapidly growing minimally processed industry worldwide. Radish shreds have a short shelf life thus necessitating the use of chemical additives. However, demand for natural preservatives in foods has increased. Chitosan is a natural antimicrobial biopolymer with a good film forming ability. Hence, it is used as an edible coating on whole and fresh cut fruits and vegetables. The present investigation explored powder coating technique using purified chitosan and chitosan lactate for shelf life extension of shredded radish. Macro perforated LDPE resealable pouches were used to pack the samples. Samples were stored at 10 °C for 10 d. Physicochemical characteristics, phytochemicals, antioxidant activity, respiration rate and color were analyzed periodically. The study also determined microbial load and sensory acceptability in the stored samples. Chitosan treated samples exhibited a lower degree of weight loss, respiration rate, titrable acidity, % soluble solids and higher content of phytochemicals, moisture, and pH compared with control samples. The treated samples also exhibited better sensory acceptability, lower exudate volume, lesser browning and lower microbial load compared to control. This indicated better potential marketability of the coated radish shreds. Chitosan powder coating could be used as an efficient technique for quality maintenance and shelf life extension of radish shreds with feasibility for large scale application.

1. Introduction

A tremendous growth in the fresh cut industry has been witnessed in the past few decades. This is due to increased public demand for convenience foods and also due to improved awareness about the health benefits associated with the consumption of fruits and vegetables. However, the highly perishable nature of minimally processed produce creates a major challenge to preserve their freshness. Various detrimental changes occur due to tissue wounding which include browning, weight loss and increased susceptibility to microbial spoilage (Gonzalez-Aguilar et al., 2010). This calls for increased research efforts to develop inexpensive and effective strategies that minimize such undesirable changes and help in delivering quality products with better shelf life stability to the consumers.

Several preservation technologies such as physical decontamination methods (irradiation, electrolyzed water and ozone treatment), use of cold chains, controlled and modified atmospheric storage are used to meet this requirement (Corbo et al., 2010). Higher capital and maintenance costs associated with these techniques limit their application. Use of chemical sanitizers like chlorine, hydrogen peroxide and sulphites is questioned from the viewpoint of safety. Disadvantages associated with the above methods combined with consumer preference for natural additives have necessitated the search for safer alternatives.

Natural biodegradable compounds having antimicrobial activity are being recognized as safer and environmental friendly alternatives. Chitosan, a non toxic, high molecular weight polymer derived from the partial deacetylation of chitin, is one such compound. Its excellent coating ability, broad antimicrobial activity and compatibility with other substances has prompted its application as a coating on fruits and vegetables (Shahidi et al., 1999).

Fresh cut radish is a minimally processed vegetable gaining popularity. Radish roots are good sources of vitamin C, B-complex vitamins and minerals like manganese and phosphorus. They act as diuretics, as anti scorbutic-agents, promote better digestion, regulate blood pressure and cure respiratory ailments. Minimally processed radish is an important constituent in mixed salads, preferred for its strong and unique flavor. Its demand is increasing in countries such as Brazil (del Aguila et al., 2006). It is also a popular starting material for preparing dehydrated products and pickles in Japan, China and Korea.

However, sales are hindered because of rapid deterioration during storage mainly due to browning and development of off- flavors.

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In a study reported by del Aguila et al. (2008) browning in fresh-cut radish could not be controlled by use of antioxidants such as citric acid and ascorbic acid.

Application of bio-based coatings is one of the low cost techniques that could effectively increase the shelf life of fresh cut produce. Chitosan is established as a successful coating material for whole fruits and vegetables but application in fresh cut produce is investigated only in the past decade. Some fresh cut fruits and vegetables treated with chitosan include peeled litchi, sliced red pitayas and fresh cut broccoli, to name a few (Dong et al., 2004; Chien et al., 2007; Moreira et al., 2011). In all these studies, chitosan coating has been applied using the dip technique.

The dip technique has several disadvantages, chiefly the large quantity of coating solution required for complete immersion of the commodity, leading to longer preparation time. Quality alteration also occurs in the solution after single use, thereby preventing its reuse. Spray coating is considered as a better alternative to dip coating but is more suited for whole fruits and vegetables. For fresh cut produce, leaching of pigments and nutrients from the surface into the dip or spray solution occurs, which causes undesirable changes in the produce. Keeping in view the above drawbacks, a powder coating technique was developed as an alternative to dip and spray coating methods. It is less time-consuming and also helps to minimize the amount of required coating material. Powder coating using salt, sugar and other compounds is used on some processed foods like potato chips, popcorn and candies mainly to impart flavor and color (Khan et al., 2012). Electrostatic powder coating using cellulose and natamycin improved the shelf life of freshly shredded cheese (Elayedath and Barringer, 2002). The present investigation explores the use of chitosan powder coating on fresh cut radish. This chitosan powder coating technique has been successfully used to improve shelf life quality of carrot shreds (Pushkala et al., 2012).

Modified atmosphere packaging (MAP) along with low temperature storage is considered suitable for fresh cut produce (Hirata et al., 1995). Beneficial MAP can be achieved within packages by wisely choosing the packaging material to help maintain appropriate oxygen and carbon dioxide levels (Sandhya, 2010). Macro perforated MAP is a simple, cost effective technique to achieve this by punching macro perforations in the film package (Rai and Singh, 2011). This allows desirable gaseous diffusion across the packages. LDPE is a suitable packaging material for storage of fresh cut fruits and vegetables (Robertson, 2006). Therefore, macro perforated LDPE was selected as the appropriate package and combined with the bio-based powder coating technique.

The objective of this study was, thus, to study the effect of two forms of chitosan as powder coating on the physicochemical parameters, bioactive compounds, microbial quality, consumer acceptance and marketability of radish shreds stored in macro perforated LDPE packages.

2. Materials and methods

2.1. Plant material and processing

Radish roots were procured from the local market at Anantapur, Andhra Pradesh, India. Topped radishes free from physical and pathological damage were selected.

Surface dirt was removed by washing the roots with tap water. The roots were disinfected by dipping in 0.4% sodium hypochlorite solution for 5 min, followed by rinsing under running water, draining and surface drying. The roots were then peeled using a hand peeler and shredded using a vegetable shredder, to obtain shreds of about 2–3 mm thickness and 35–40 mm length.

2.2. Preparation of coating material

Minimally processed radish was coated with two forms of chitosan, namely, purified chitosan and chitosan lactate. Purified chitosan was prepared (El Ghaouth et al., 1992) from chitosan flakes (molecular weight 161 kDa and degree of deacetylation 85%) procured from Panvo organics, Chennai, India. The purified chitosan flakes were ground to mesh size 20 to obtain a fine powder. Chitosan lactate powder was procured from Zeal Pharma Ltd., Gujarat, India.

2.3. Application of chitosan coating

Radish shreds were divided into three batches I, II and III. Batch I served as control, whereas batches II and III were subjected to powder coating using purified chitosan and chitosan lactate powder, respectively, at 0.2% concentration. This concentration was decided based upon the results of a preliminary study which evaluated concentrations of 0–0.5%. Radish shreds were spread as a thin layer in polypropylene trays. Chitosan powder was applied uniformly over the surface of the shreds, followed by thorough mixing to ensure adequate coating. The samples were coded as C (control/uncoated), CH (purified chitosan powder coated) and CL (chitosan lactate powder coated).

2.4. Packaging and storage

The samples were distributed into seven sets of 100 g each in macro perforated LDPE resealable pouches (15 cm × 13 cm; 6 mm thickness) for shelf life study. Ventilation area of 8 cm^2 was provided, dispersed over the whole pouch by sixteen holes each of 0.5 cm diameter. The packages were stored at 10 °C for 10 d and sampling was carried out at periodic intervals.

2.5. Analysis

Periodic analysis of the samples was carried out on days 0, 5 and 10 of storage. The microbial load and sensory acceptability of the samples was assessed on the initial and seventh day of storage.

2.5.1. Physico-chemical analysis

The samples were analyzed for various physicochemical parameters. For the determination of physiological loss in weight (PLW), model packages in triplicates were kept aside and accurately weighed at periodic intervals throughout the storage period. To estimate pH, 10 g of sample was macerated with 100 mL of distilled water and allowed to stand for 30 min. The pH of the supernatants obtained was read with a calibrated pH meter (Elico India L1-120 model). Titrable acidity was determined by boiling 10 g of sample in distilled water for an hour, making up to a known volume and titrating aliquots against 0.1 N NaOH using phenolphthalein as indicator to a pH of 8.1. Total acidity was expressed in percentage of malic acid (Ranganna, 1986). The total soluble solids concentration was determined using digital refractometer and expressed as percentage soluble solids.

Procedures, namely juiciness index and exudate volume, were devised to quantify the leakage of juice from the cut surface, since it is important from the point of view of consumer acceptance and marketability.

To quantify the juiciness index, juice was extracted from a weighed amount of sample using a hand-operated juicer and the volume of juice in mL was measured. The juiciness index was calculated with the following formula: Juiciness index (mL/kg) = 1000 × Y/X, where, Y = quantity of juice obtained (mL) and X = weight of sample taken (kg).