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Effects of chitosan coating on shelf life of cold-stored litchi fruit at ambient temperature

Yueming Jiang[a,b,*], Jianrong Li[b], Weibo Jiang[c]

[a]College of Food Science, Biotechnology and Environmental Engineering, Zhejiang Gongshang University, Hangzhou 310035, PR China
[b]South China Botanic Garden, The Chinese Academy of Sciences, Guangzhou, LeYiJu 510650, PR China
[c]School of Food Science, China Agricultural University, P.O. Box 204, Qinghua Donglu, Haidian, Beijing 100083, PR China

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Abstract

Postharvest pericarp browning of litchi fruit results in an accelerated loss in shelf life and a reduced commercial value. Visual quality was lost in only 6 h at ambient temperature when fruit were removed from storage at 2 °C, due to browning. The experiment was conducted to test the role of chitosan coating in inhibiting skin browning and extending shelf life of cold-stored litchi fruit at ambient temperature. Litchi fruit were treated with 2 g chitosan/100 g solution and then stored for 20 days at 2 °C and 90–95% relative humidity (RH), prior to shelf life evaluation at 25 °C and 80–90% RH. Changes in polyphenol oxidase (PPO) activity, anthocyanin concentration, colour index, eating quality and concentrations of total soluble solids and titratable acidity were measured. The effects of chitosan coating on disease incidence were also evaluated. Application of chitosan coating delayed the decrease in anthocyanin content, the increase in PPO activity and the changes in colour index and eating quality, reduced the decrease in concentrations of total soluble solids and titratable acidity, and partially inhibited decay. The results suggested that treatment with chitosan coating exhibited a potential for shelf life extension at ambient temperature when litchi fruit were removed from cold storage.

Keywords: Chitosan; Coating; Fruit; Litchi; Shelf life

1. Introduction

Litchi (*Litchi chinensis* Sonn.) is a tropical and subtropical fruit of high commercial value for its white, translucent aril and attractive red colour (Holcroft & Mitcham, 1996). Although litchi fruit can be stored for about 20 days at a low temperature range of 2–5 °C, the fruit can deteriorate rapidly due to peel browning when removed from the cold storage (Jiang & Li, 2003). Thus, the major limitation in litchi marketing is the rapid lose of the red color after harvest (Nip, 1988; Jiang, Yao, Lichter, & Li, 2003). Postharvest browning of litchi fruit was generally thought to be a rapid degradation of anthocyanins caused by polyphenol oxidase (PPO), producing brown by-products (Lee & Wicker, 1991; Jiang, 2000). Postharvest treatments, such as sulphur fumigation and acid dip can effectively inhibited PPO activity and thus delay loss of red skin colour of litchi fruit (Zauberman et al., 1991). However, alternative chemicals for colour control without toxic effects in harvested litchi fruit are needed because of concerns for food safety and restrictions in the use of chemicals (Jiang et al., 2003).

Application of semi-permeable coatings with modified atmosphere of CO_2 and O_2 under small storage environment conditions has been shown to improve the storability of perishable crops (Cisneros-Zevallos &

*Corresponding author. Department of Plant Resources, South China Institute of Botany, Guangzhou, LeYiJu 510650, PR China. Tel.: +86 20 37252525; fax: +86 20 37252831.
E-mail address: ymjiang@scib.ac.cn (Y. Jiang).

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Krochta, 2002; Lee, Park, Lee, & Choi, 2003). For example, coating treatments delayed fruit ripening of cherimoya, banana and pear through modifying the internal atmospheres (Banks, 1984; Amarante, Banks, & Ganesh, 2001; Yonemoto, Higuchi, & Kitano, 2002). Similar results were obtained in pears and apples using edible coatings (Amarante et al., 2001; Bai, Hagenmaier, & Baldwin, 2003). Chitosan (a high molecular weight cationic polysaccharide) is soluble in dilute organic acids and could theoretically be used as a preservative coating material for fruits. The coating is also safe (Hirano et al., 1990) and shows antifungal activity against several fungi (El Ghaouth, Arul, Grenier, & Asselin, 1992; Li & Yu, 2001; Romanazzi, Nigro, Ippolito, Di Venere, & Salerno, 2002). Previous studies indicated that chitosan coating had the potential to prolong storage life and control decay of many fruits, such as strawberry, peach and table grape (Du, Gemma, & Iwahori, 1997; El Ghaouth, Arul, Ponnamapalam, & Boulet, 1991; Romanazzi, Nigro, & Ippolito, 2003). Zhang and Quantick (1997) and Jiang and Li (2000) reported that application of 2 g chitosan/100 g solution was the most effective in delaying browning when litchi and longan fruits were stored at low temperature. However, the effect of the chitosan coating on shelf life at ambient temperature of litchi fruit removed from cold storage has not been investigated.

The objective of this study was to examine the effects of the treatment with 2 g chitosan/100 g solution on the shelf life of the cold-stored litchi fruit at ambient temperature.

2. Materials and methods

2.1. Plant materials and treatments

Fruit of litchi (*Litchi chinensis* Sonn.) cv. Huaizhi at the commercially mature stage were harvested from an orchard in Guangzhou. Fruit were selected for uniformity, shape, colour, and size, and any blemished or diseased fruit discarded. The fruits (50 kg) were randomly distributed into two groups prior to treatments. To prepare 3000 ml of 2 g chitosan/100 g solution, 60.0 g of chitosan (Crab shell chitosan, Sigma Chemicals) was dispersed in 2500 ml of distilled water to which 150 ml of glacial acetic acid was added to dissolve the chitosan. The pH of the solution was adjusted to pH 5.0 with 1 mol/l NaOH and the solution was made up to 3000 ml. Fruit were allowed to dry for 4 h at 25 °C after 1 min dipping. In this study, 2 g chitosan/100 g solution was used because the concentration was the most effective in delaying browning and extending storage life when litchi and longan fruits were stored at low temperature (Zhang & Quantick, 1997; Jiang & Li, 2000). Fruits dipped in the acid solution without chitosan, pH 5.0, were used as control. The treated and control fruit were packaged in plastic boxes ($18 \times 26 \times 32$ cm; 300 fruit/box), then overwrapped with plastic bags, and finally stored for 20 days at 2 ± 1 °C and 90–95% relative humidity (RH). After 20 days of storage, the fruit were removed from cold storage and then held for 18 h under ambient conditions (25 °C, 80–90% RH) for evaluation of fruit quality, concentrations of total soluble solids and titratable acidity, PPO activity and anthocyanin content. The experiments were conducted in sequential 2 years. Similar results were obtained from the two experiments. The data from the experiment in 2002 were presented.

2.2. Fruit quality evaluation

Appearance was assessed by measuring the extent of the total browned area on each fruit pericarp, using 300 fruit during shelf life evaluation, on the following scale: 1 = no browning (excellent quality); 2 = slight browning; 3 = <1/4 browning; 4 = 1/4–1/2 browning; 5 = >1/2 browning (poor quality). The browning index was calculated as Σ (browning scale × percentage of corresponding fruit within each class). Fruit at higher than 2.0 (browning index) was considered unacceptable for marketing.

Disease incidence was monitored by randomly collecting 300 fruit and then recording the percentage of fungal growth or bacterial lesions on the fruit surface. Eating quality of fruit pulp was assessed hedonically using a trained six-member panel. At each withdrawal, 30 fruit were randomly selected and rated on the scale of 1 = poor to 9 = excellent. Fruit at higher than a scale of 6.0 was considered for consumer acceptance.

2.3. Measurements of total soluble solids and titratable acidity

The concentrations of total soluble solids and titratable acidity were analysed during shelf life evaluation. Visible fugal mycelia on fruit surface were removed carefully using a rod with a small cotton ball. Pulp (20 g) from 15 fruit was homogenized in a grinder and then centrifuged at 15,000 g (Beckman J20-2) for 20 min. The supernatant phase was collected to analyse for: total soluble solids, °Brix, using a hand refractometer (J1-3A, Guangdong Scientific Instruments) and titratable acidity, g citric acid on a fresh weight (FW) basis, determined by titration with 0.1 M NaOH.

2.4. Enzyme assay and protein determination

Visible fugal mycelia on fruit surface were removed carefully using a rod with a small cotton ball. Peel (6.0 g) from 15 fruit was homogenized in 30 ml of 0.02 M phosphate buffer (pH 6.8) containing 0.6 g of polyvinylpyrrolidone (insoluble) in an ice bath. The