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Effects of chitosan coating on postharvest life and quality of longan fruit

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Abstract

The effects of chitosan coating in extending postharvest life of longan fruits and maintaining their quality were investigated. The fruits were treated with aqueous solutions of 0.5, 1.0 and 2.0% chitosan, respectively, and then stored at 2°C and 90% relative humidity. Changes in respiration rate, polyphenol oxidase (PPO) activity, colour, eating quality, and weight loss were measured. The effect of chitosan coating on disease incidence was also evaluated. The application of chitosan coating reduced respiration rate and weight loss, delayed the increase in PPO activity and the changes in colour, and eating quality, and partially inhibited decay of fruit during storage. Furthermore, increasing the concentration of chitosan coating enhanced the beneficial effects of chitosan on postharvest life and quality of the fruit.

Keywords: Chitosan; Postharvest life; Longan fruit

1. Introduction

The longan (*Dimocarpus longan* Lour.) fruit is a highly attractive subtropical fruit but it has a very short shelf life under normal ambient conditions (Jiang, 1999a; Paull & Chen, 1987; Reed, 1986; Tongdee, 1994). The fruit is non-climacteric and harvest is judged by eating quality and appearance in colour (Lu et al., 1992; Saranant, 1992). Deterioration is associated with skin desiccation, colour loss and disease development, however it can be delayed by low temperature storage (Jiang, 1999b; Kader & Arpaia, 1992; Prapaipong & Rakaiyatham, 1990). Storage of longan fruit in sealed polyethylene bags or plastic containers also retards colour loss and extends shelf life (Lu et al.).

Application of semi-permeable coatings has been shown to improve the storability of perishable crops (Lowings & Cutts, 1982). For example, Pro-long coating delayed banana ripening through modifying the internal atmospheres (Banks, 1984), and similar results were obtained in pears and apples coated with Nutri-Save™ (Davis, Elson & Hayes, 1988). Zhang et al. (1997) found that an edible coating based on sucrose esters of fatty acids significantly delayed pericarp browning of litchi fruit. 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 (Allan & Hadwiger, 1979; El Ghaouth, Arul, Ponnamapalam & Boulet, 1991; El Ghaouth, Arul, Grenier & Asselin, 1992; Hirano & Nagao, 1989). Thus (due to its ability to form a semi-permeable film) chitosan coating might be expected to modify the internal atmosphere as well as to decrease transpiration losses in fruits. Studies by Du, Gemma & Iwahori (1997), El Ghaouth et al. (1991), El Ghaouth, Arul et al. (1992b), and Zhang and Quantick (1997), indicated that chitosan coating had the potential to prolong the storage life and control decay of strawberry, tomato, peach, pear, kiwifruit and litchi.

The objective of our research was to assess the potential of chitosan coating in extending postharvest life and maintaining quality of longan fruit during storage at low temperature.

2. Materials and methods

2.1. Plant materials

Mature yellow fruits of longan (*D. longan* Lour.) cv Shixia were harvested from a commercial orchard in

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Guangzhou. Fruits were selected for uniformity, shape, colour, and size, and any blemished or diseased fruits were discarded. The fruits were randomly distributed into groups of 18 fruit. For each treatment, three replicates were used. To prepare 500 ml of 0.5, 1.0 or 2.0% chitosan solution, 2.5, 5.0 or 10.0 g of chitosan (Crab20 shell chitosan, Sigma Chemicals) were dispersed in 400 ml of distilled water to which 25 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 made up to 500 ml. Fruit were allowed to dry for 4 h at 25°C after dipping. Fruits dipped in the acid solution without chitosan, pH 5.0, were used as control. They were placed in punnets (18 fruit/punnet) and stored at 2±1°C and 90% relative humidity for progressive assessments.

2.2. Respiration measurement

To measure respiration rate, nine fruits (about 200 g) were sealed in a 1.2-l glass chamber for 2 h, and a 1-ml gas sample was withdrawn with a gas-tight hypodermic syringe and analysed by gas chromatography (GC-9A) equipped with alumina packing (80-100 mesh) in a copper column (3.175×457.2 mm) and a thermal conductivity detector. The respiration rate was expressed as ml CO_2/kg (fresh weight)/h.

2.3. Polyphenol oxidase (PPO) assay and protein determination

Peel (3.0 g) from six fruits was homogenized in 10 ml of 0.02 M phosphate buffer (pH 6.8) at 4°C. The homogenate was centrifuged at 19 000 *g* (Beckman J20-2) for 20 min and then supernatant was collected to assay PPO activity according to the method of Jiang (1999a), by measuring the oxidation of 4-methylcatechol. The increase in absorbance at 410 nm at 25°C was automatically recorded for 3 min, using a spectrophotometer (Beckman, DU-7), One unit of enzyme activity was defined as the amount which caused a change of 0.001 in absorbance per minute. The protein content was determined according to the dye-binding method of Bradford (1976) with albumin bovine serum as the standard.

2.4. Fruit quality evaluation

Appearance was estimated by measuring the extent of the total browned area on each fruit pericarp 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 grade was calculated using the following formula: $\sum$ (browning scale×percentage of corresponding fruit within each class). Disease development was monitored by collecting fruits and recording the percentage showing visible fungal growth or bacterial lesions on the surface. Weight loss was also determined. Eating quality of fruit pulp was assessed hedonically using a six-member panel. At each withdrawal, 12 fruits were randomly selected and rated on the scale of 1 poor to 9 = excellent.

2.5. Measurements of total soluble solids, titratable acidity, and ascorbic acid

After 30 days of storage, total soluble solids, titratable acidity, and ascorbic acid of fruit pulp were analysed. Pulp (20 g) from six fruits 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, using a hand refractometer (J1-3A, Guangdong Scientific Instruments); titratable acidity,% citric acid, determined by titration with 0.1 MNaOH; and ascorbic acid by 2,6-dichlorophenolindophenol titration (Chen, Li & Chen, 1986).

3. Results

3.1. Effects of chitosan coating on respiration rate and PPO activity

Respiration rate and polyphenol oxidase activity decreased markedly when longan fruits were stored at low temperature; however, they increased at the later stage of storage (Figs. 1 and 2). The treatments with chitosan coating reduced respiration rate and PPO activity, or delayed the increases in the respiration rate and PPO activity. The increase in respiration rate of fruit during later storage could be related to disease development. In strawberry, increase in respiration rate

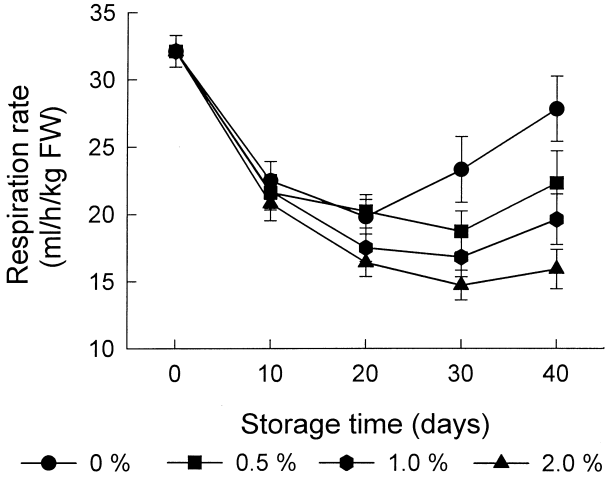

Fig. 1. Effect of chitosan coating on respiration rate of longan fruit during storage at 2°C. Each value is the mean for three replicates, and vertical bars indicate the standard errors.

associated with postharvest diseases was reported (El Ghaouth et al., 1991). The longan is a non-climacteric fruit, and the ripening is not accompanied by an upsurge of respiratory activity (Lu et al., 1992).

3.2. Effects of chitosan coating on fruit quality

As shown in Figs. 3–6, eating quality in longan fruit decreased as the period of storage increased, while colour grade, weight loss, and disease development increased. After 30 days of storage, the initial bright colour of the control fruit had largely disappeared, and about 30% of the fruit had begun to rot. Compared with the control, the fruit treated with 2% chitosan remained a bright colour and about 95% of the treated fruit did not rot until 30 days after storage. However, disease development significantly increased as storage time was extended to 40 days. In this study, increasing concentrations of chitosan were generally more effective for longer storage period. No off-flavours in chitosan-treated fruits were detected because the low temperature of storage reduced physiological metabolism.

3.3. Effects of chitosan coating on total soluble solids, titratable acidity, and ascorbic acid

The titratable acidity and contents of total soluble solids and ascorbic acid decreased (Table 1), which was consistent with decline in eating quality. The fruit treated with 2% chitosan had a higher ascorbic acid content than either of the other treatments or the control, which can be attributed to low respiration (Fig. 1).

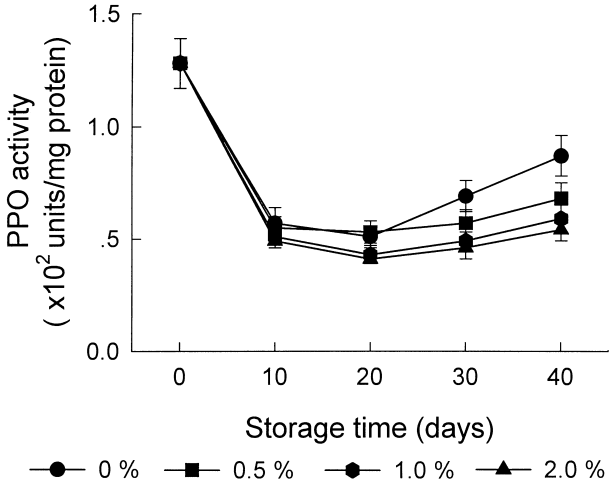

Fig. 2. Effect of chitosan coating on polyphenol oxidase activity of longan fruit during storage at 2°C. Each value is the mean for three replicates, and vertical bars indicate the standard errors.

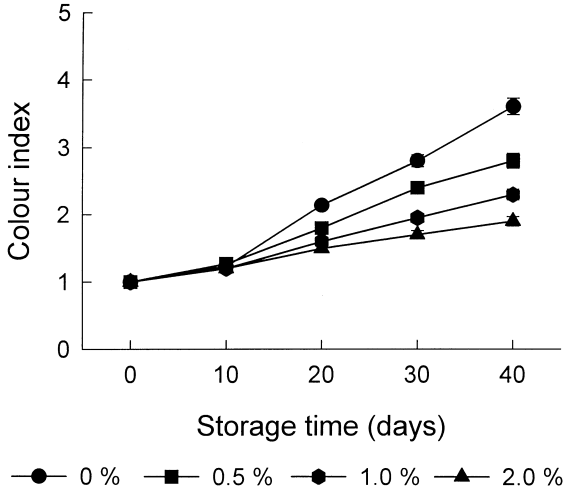

Fig. 4. Effect of chitosan coating on colour index of longan fruit during storage at 2°C. Each value is the mean for three replicates, and vertical bars indicate the standard errors.

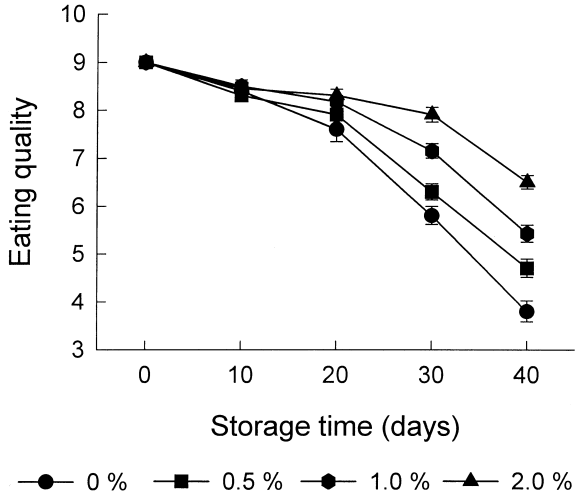

Fig. 3. Effect of chitosan coating on eating quality of longan fruit during storage at 2°C. Each value is the mean for three replicates, and vertical bars indicate the standard errors.

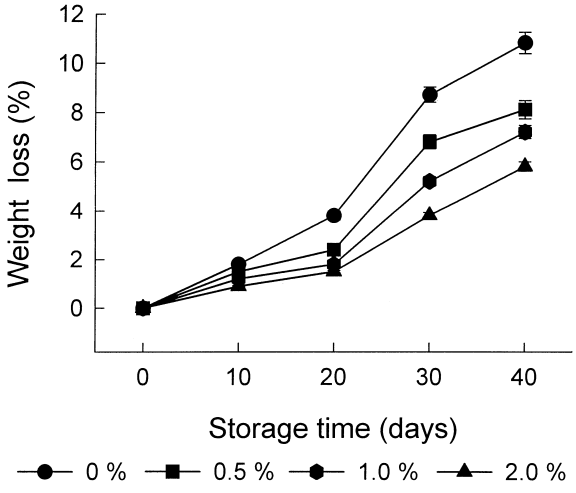

Fig. 5. Effect of chitosan coating on weight loss of longan fruit during storage at 2°C. Each value is the mean for three replicates, and vertical bars indicate the standard errors.

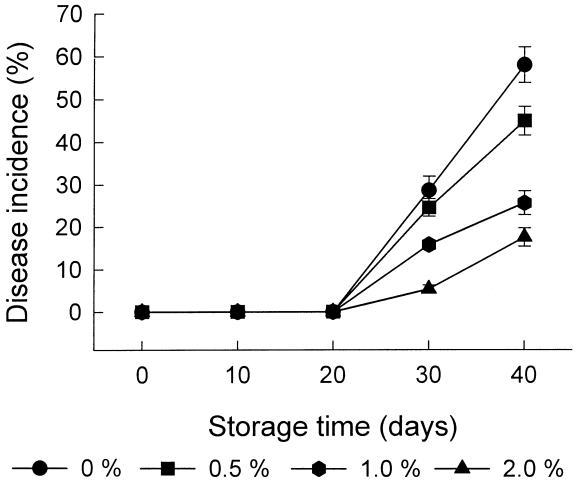

Fig. 6. Effect of chitosan coating on disease incidence of longan fruit during storage at 2°C. Each value is the mean for three replicates, and vertical bars indicate the standard errors.

4. Discussion

Coating fruits with semi-permeable films has been shown to retard ripening by modifying the endogenous CO_2 and O_2 and to cease lower respiration rates (Banks, 1984; El Ghaouth et al., 1991; Lowings & Cutts, 1982). In our studies, the application of chitosan coating delayed the change in eating quality, reduced respiration rate and weight loss, and partially inhibited the increase of PPO activity of longan fruit which is associated with peel discoloration. This implies that the chitosan coating may form a protective barrier on the surface of the fruit and reduce the supply of oxygen.

In some research, chitosan coating has inhibited the growth of some fungi (Allan & Hadwiger, 1979; El Ghaouth et al., 1991). In this study, treatments with chitosan coating delayed the increase in decay of stored longan fruit (Fig. 6), indicating that the chitosan coating reduced pathogen growth in some way. Since attack by pathogens is also a major factor causing discoloration of the fruit, inhibiting decay could be partially beneficial in delaying peel browning. Furthermore, increasing the concentration of chitosan coating markedly enhanced the beneficial effects.

We suggest that the application of chitosan coating could be beneficial in extending postharvest life and maintaining quality and, to some extent, controlling decay of longan fruit. In using chitosan for decay control, we consider that it may be suitable in treatment of fruit stored for shorter periods (e.g. 3 weeks) or for short-distance transport and distribution. However, for longer storage, chitosan coating to control discoloration and decay in longan fruit, in combination with the partial use of fungicides, such as thiabendazole, could be better.

Table 1
Analyses of longan fruit after 30 days of storage at 2°C[a]

Chitosan (%)	Total soluble solids (%)	Titratable acidity (%)	Ascorbic acid (mg/100 g pulp)
Before storage	23.1	0.14	53.6
After storage			
0	18.9 cd	0.08 c	38.8 d
0.5	19.3 c	0.08 c	42.9 c
1.0	21.2 ab	0.11 ab	46.8 b
2.0	21.7 a	0.12 a	50.4 a

[a] Means within a column followed by the same letter are not significantly different at $P < 0.05$.

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