Peach gum polysaccharides-based edible coatings extend shelf life of cherry tomatoes

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Abstract Cherry tomato is a nutritious, but highly perishable fruit. Peach gum polysaccharides (PGPs) can form edible films with antioxidant and antibacterial activities. The effects of PGP-based edible coatings on cherry tomatoes during hypothermic storage (4 °C) were investigated. PGP-based edible coatings effectively maintained firmness, decreased weight loss, inhibited respiration rate and delayed the changes in total acidity, ascorbic acid and sugar content of cherry tomatoes during hypothermic storage (4 °C) compared with those of the control ($p < 0.05$). The results indicate that using PGP-based edible coating is a promising method to extend the shelf life of cherry tomatoes.

Keywords Cherry tomato · Peach gum · Polysaccharides · Coatings

Introduction

Cherry tomato, a type of tomato, is smaller in size than other types and has tomato-like flavour and firm texture (Ergun et al. 2006). Cherry tomato is rich in antioxidants, such as carotenoids, ascorbic acid and phenolic

compounds, thereby possessing beneficial effects (Raffo et al. 2002). Cherry tomato is highly perishable because of its rich nutrient content, and its shelf life only ranges from 5 to 7 days after harvest. Therefore, practical methods for extending its shelf life must be developed.

Edible coatings possess a semipermeable barrier; they reduce solute migration, gas exchange, moisture evaporation, respiration and oxidative reaction rates and suppress physiological disorders in fruits (Wu and Chen 2013). Edible coatings have been used for extension of postharvest storage of fruits and vegetables (Allegra et al. 2016; Raffo et al. 2002; Singh et al. 2016).

The peach belongs to the subfamily *Prunoideae* of the family *Rosaceae*; species in this family produce copious gum exudates from the tree trunk, especially after mechanical injury followed by a microbial attack (Simas et al. 2008). Peach gum usually consists of polysaccharides with varying bioactivities, such as hypolipidaemic and hypoglycaemic (Ding et al. 2010), antioxidant (Yao et al. 2013a, b) and antibacterial activities (Yao et al. 2013a, b). However, the effects of peach gum polysaccharide (PGP)-based edible coatings on the preservation of cherry tomatoes have not been reported.

This study aims to investigate the use of PGP-based edible coatings to extend the shelf life of cherry tomatoes. The effects of PGP-based edible coatings on firmness, weight loss, respiration rate, total acidity, ascorbic acid and sugar contents of cherry tomatoes were studied.

Methods and materials

Materials

Dried peach gum was purchased from Shandong Dingli Rubber Industry Co. Ltd. (Shandong, China). Cherry

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tomatoes were purchased from a local farmer's market (Haizhou, Lianyungang, China). All other chemicals were of reagent grade.

Preparation of PGPs

Dried peach gum was pulverised and sifted through a 100-mesh sieve to yield a fine powder with approximately 8% moisture content (dry basis). Powdered peach gum was suspended in distilled water to obtain a suspension with a concentration of 1% (w/v). The suspension was extracted in a water bath at 90 °C for 6 h and then centrifuged at $5000\times g$ for 10 min. The supernatant was concentrated to ~10% (w/v). The proteins were separated using the Sevag method, and the extracts were precipitated with three volumes of absolute ethanol, filtered with a Whatman GF/A filter paper and freeze dried.

PGP characterisation

Total sugar content in the product was determined using standard methods by Hou (2004). Monosaccharide composition was determined using the procedure reported by Sheng et al. (2007).

Dipping and storage conditions of cherry tomatoes

Dipping solutions contained 1% PGPs. The cherry tomatoes were first dipped into these solutions and fully immersed for 3 min. The residual dipping solutions on the surface of cherry tomatoes were dripped off for 2 min. The cherry tomatoes were kept at 4 °C until the excess dipping solution was drained. Then, these cherry tomatoes were placed on plastic-coated wire racks inside plastic containers and stored at 4 °C for 12 days.

Firmness determination

Firmness of the cherry tomatoes was recorded on a TA-XT2 texture analyzer (Texture Technologies Corp. Scarsdale, NY, USA) according to the procedure of Rojas-Grau et al. (2005). Firmness was expressed as the peak force required to penetrate the cherry tomatoes by 10 mm with a 5 mm diameter probe.

Weight loss

The weight of cherry tomatoes was determined during storage to evaluate the efficacy of PGP coatings as moisture barriers. The percentage weight loss was calculated by weighing cherry tomatoes every 2 days.

Measurement of respiration rate

The effect of coatings on respiration rate was measured by analysing the headspace gas composition according to the methods of Wu and Chen (2013). Respiration rate was expressed by milligrams of carbon dioxide released per kilogram in an hour.

Chemical analysis

Total acidity was assayed by alkali titration method (Li 2003). Ascorbic acid was determined according to the ultraviolet rapid determination method (Zheng et al. 2000). Protein content was determined according to the Coomassie brilliant blue colorimetric method (Bradford 1976).

Statistical analysis

All data are presented as mean $\pm$ S.D. Statistical analysis was performed using Statgraphics Centurion XV Version 15.1.02. A multifactor ANOVA with posterior multiple range test was used to determine significant differences.

Results

Ash, moisture, protein and total sugar contents in the PGP products were 0.3, 2.7, 6.1 and 90.2% (w/w), respectively. All product samples consisted of water-soluble white powders. Monosaccharide composition analysis with gas chromatography showed that the PGPs consisted of arabinose (~53%), galactose (~33%) and uronic acid (~12), similar to that reported by Qian et al. (2011).

The firmness of both control and PGP coating treatment groups decreased in 12 days of hypothermic storage. The firmness of PGP coating treatment group was consistently higher than that of the control group ($p < 0.05$). Coating with PGPs effectively inhibits tissue softening, which could be due to the decrease in pectin degradation caused by decreased water loss and respiration rate as a result of the surface coatings (Fig. 1). In this study, PGP coatings delayed the softening of cherry tomatoes, thereby suggesting a promising formula that is ideal for inhibiting tissue softening.

When cherry tomatoes were exposed to an environment with a lower relative humidity, weight loss tends to occur. After 12 days of storage, control cherry tomatoes lost around 2.7% of their weight, whereas coated cherry tomatoes only lost 0.4% of their weight. PGP coatings play an important role in water loss prevention (Fig. 2).

Fig. 1 Firmness of cherry tomatoes during storage at 4 °C. Values are means of three replicates. Vertical bars represent standard deviation

Fig. 2 Weight loss of cherry tomatoes during storage at 4 °C. Values are means of three replicates. Vertical bars represent standard deviation

During hypothermic storage, the respiratory rate of the cherry tomatoes in each group first increased and then decreased. The respiratory climacteric period of the PGP coating group was longer than that of the control group, and the respiratory peak was delayed by 2 days (Fig. 3).

The total acidity of cherry tomatoes decreased, and those of the control group decreased rapidly during hypothermic storage. After 12 days of hypothermic storage, the total acidity of the tomatoes in the control group decreased by 51.61%, whereas the total acidity of the tomatoes in the PGP coating group only decreased slightly and decreased by only 29.03% (Fig. 4).

The ascorbic acid content of the two groups increased first and then decreased with the storage time. However, the change of ascorbic acid content of the PGP coating group lagged behind the control group, and the peak of the PGP coating group lagged behind the control group by 2 days (Fig. 5).

The total sugar content of the two groups increased during hypothermic storage. However, the changes of total

Fig. 3 The respiration rate of cherry tomatoes during storage at 4 °C. Values are means of three replicates. Vertical bars represent standard deviation

Fig. 4 The total acidity of cherry tomatoes during storage at 4 °C. Values are means of three replicates. Vertical bars represent standard deviation

sugar in the PGP coating group were smaller than those in the control group (Fig. 6).

Discussion

During storage, the tissue turgor of fruits and vegetables decreases due to water loss, and the original flesh disappears, showing weak and wilting morphology, decreasing its commercial value. Firmness of cherry tomatoes tends to decrease as a result of acid degradation of pectin (Wu et al. 2016) and should be addressed by any minimal technique. PGPs formed a protective layer on the surface of cherry tomatoes and inhibited respiration and evaporation, thereby resulting in less water loss of the treated samples compared with the control group.

Respiration still occurs in fruits and vegetables even after picking. Cherry tomato is a respiration climacteric fruit, and it quickly enters the respiration climacteric

Fig. 5 The ascorbic acid content of cherry tomatoes during storage at 4 °C. Values are means of three replicates. Vertical bars represent standard deviation

Fig. 6 The total sugar content of cherry tomatoes during storage at 4 °C. Values are means of three replicates. Vertical bars represent standard deviation

period; respiration peak appears under normal temperature. Afterwards, the respiration rate decreases gradually, and the fruit soon becomes soft and decays (Wu et al. 2016). The respiration climacteric period of the PGP-coated group was extended because PGP coating might have an effect comparable to air conditioning. The oxygen in the tissues was continuously consumed with respiration, whilst CO_2 was released. When coated with PGPs, high CO_2 and low O_2 pressure environment formed and delayed postharvest respiration peak of cherry tomatoes, respectively, thereby inhibiting the respiration of cherry tomato, reducing the loss of organic ingredients and prolonging the shelf life of cherry tomato.

After harvest, accumulation of matter in fruit and vegetable stops and the synthesis process gradually weakens, whereas the hydrolysis process of various substances continuously strengthens. The stored fruits and vegetables are gradually consumed or converted, decomposed and recombined by enzyme catalysis; as a result, changes in the

tissue and cell morphology, structure, characteristics and other aspects occur (Fagundes et al. 2014).

Before harvest, numerous organic acids accumulate in cherry tomatoes. During the maturation process, some organic acids are converted to sugar. At the same time, more organic acids are decomposed because of the enhancement of respiratory energy caused by respiration in fruits and vegetables, thereby resulting in a decrease in acidity and an increase in total sugar. The total sugar organic acids and acidity of the cherry tomato treated with PGP coatings changed slightly.

Ascorbic acid is a representative nutrient in fruits and vegetables. Ascorbic acid content in cherry tomato was high, but the prototype ascorbic acid was easily oxidised and lost during the preservation period. Ascorbic acid content in the fruit increased initially, showing that there is a ripening process in cherry tomato during storage. The ascorbic acid content peak of the PGP coating group was delayed by 2 days compared with the control group, showing that the PGP coating could block the oxidation of prototype ascorbic acid.

Conclusions

Decrease in firmness, weight loss, high respiration rate, decrease in acidity and ascorbic acid and increase in total sugar reduce the shelf life of cherry tomatoes. PGP-based coating treatments effectively inhibited tissue softening, decreased weight loss and respiration rate and delayed the changes in total acidity, ascorbic acid and sugar content in cherry tomatoes during storage. Therefore, treatment of cherry tomatoes with 1% PGPs is a promising method for preserving cherry tomatoes.

Compliance with ethical standards

Conflict of interest The authors have declared that no conflict of interests exist.

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