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Effect of preharvest and postharvest application of chitosan coating on storage quality of nectarines

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Nectarine is a climacteric fruit and exhibits increased ethylene production, respiration rate, changes in fruit texture, colour, aroma and other biochemical and physiological attributes during fruits ripening. It has a limited storage life depending upon the cultivar. The coating of fruit with edible materials has been reported to act as a barrier to moisture and oxygen during postharvest handling and storage. Different compounds have been used as coating materials in fruits including alginate, cellulose, chitosan, chitin, lipids, milk protein, starch and wax with varying success towards extending shelf life and maintaining fruit quality. Chitosan coating had the potential to inhibit decay and hence prolong the storage life of a variety of produce including strawberries, tomatoes, citrus fruit, peaches, pears and kiwi fruit. In this study biodegradable coatings, based on chitosan, were applied to nectarine, cv Diamond Ray, in order to find environmentally friendly, healthy treatments with which better preserve fresh fruit quality and safety during postharvest cold storage. Physicochemical properties (weight loss, °Brix, titratable acidity, colour and texture) were determined throughout cold storage. Four treatment were investigated: (1) preharvest chitosan (10 g l^{-1}) applications, (2) pre and postharvest chitosan (10 g l^{-1}) applications, (3) postharvest chitosan (10 g l^{-1}) application (4) control, without application. Preharvest chitosan-treated nectarines were firmer and had higher soluble solids content than control ones. Also pre and postharvest application fruits showed high soluble solids content and texture values and the highest titratable acidity. Hence it can be concluded that chitosan in preharvest treatments has the potential to preserve valuable attributes and prolong the shelf-life of postharvest nectarines, presumably of its property to inhibit the ripening and senescence process of postharvest fruits.

Keywords: Diamond Ray, weight loss, titratable acidity, colour, texture.

Introduction

Postharvest quality losses in nectarines are caused predominantly by metabolic changes, mechanical damage, reduction in pulp firmness, physiological disorders and decay. Thus there is a need to develop methods for controlling postharvest decay of nectarine fruits. In trying to reduce these losses, authors have studied new genotypes (Manganaris et al., 2006) and have examined pre-harvest conditions, harvesting procedures, post-harvest treatments like coatings (Li and Yu, 2000), cold storage (Girardi

et al., 2005) and controlled atmosphere (Zhou et al., 2000). Edible coatings, a new strategy used to extend shelf-life and to improve food quality of whole fruits and fresh-cut fruits, have been applied to many products (Asgar et al., 2011). Coatings on products create a barrier to external elements that can reduce solutes migration, respiration, moisture loss and oxidative reaction rates (Barbosa et al., 2011, Cè et al., 2012, Duan et al., 2011). Chitosan has been one of the most promising coating materials for fruits. Chitosan is a biopolymer which has been the object of considerable interest for applications in agriculture, biomedicine, biotechnology, and food industry due to its biocompatibility, biodegradability, and bioactivity. Chitosan was reported to prolong storage life and control decay of several fruit (Bautista-Baños et al., 2006, Oberland et al., 2005). The objective of this study was to determine if a chitosan coating can control the decay and maintain the quality of nectarine fruit during postharvest storage.

Material and methods

Fruit material

Nectarine, cv Diamond Ray, were hand harvested at commercial picking. The nectarines were selected for uniformity, colour, absence of deformity or disease and size. Four treatments were considered:

1. Preharvest treatment
2. Postharvest treatment
3. Preharvest treatment and postharvest treatment
4. Without treatment (control)

Preharvest treatments

The trials were carried out in a commercial orchard located in the Cuneo Province in the north-west of Italy, an important fruit growing district in Piedmont Region. The trees were selected for uniformity of production and ripening. The canopy of Diamond Ray trees was sprayed with a solution of commercial chitosan (Chitoplant[®], Agritalia, Italy) (10 g l⁻¹). Spraying used a back pump (WJR2525, Honda, Japan) to deliver the equivalent volume of 1000 l/ha. Two treatments were made: 20 and 10 days before harvest. Untreated trees were used as controls. Commercial formulations of chitosan have the advantage of more practical use, as viscosity is lower than that of the biopolymer dissolved in acid solution.

Postharvest treatments

Film forming solution was prepared dissolving 10 g l⁻¹ of Chitoplant[®] (Agritalia, Italy), a commercial chitosan formulation, in deionized water with continuous shaking until the solution became clear. No plasticizer was added, in according with Chiabrando and Giacalone (2013). The nectarines were randomized and immersed for 1 min in the tested solutions and then allowed to drip off at room temperature. Nectarines immersed in deionized water were used as the control. Samples nectarines were than stored at 0°C.

Quality analysis

After 1, 7, 14, 23 and 30 days of storage a sample of 15 nectariness was removed randomly from each treatment and analysed for weight loss, firmness, soluble solid content, titratable acidity and colour. Weight loss was determined by weighting each

nectarine at 7 day intervals during storage. Values are reported as percent of weight loss per initial fruit weight.

Pulp firmness was determined using a hand penetrometer (TR Fruit Test 327, Italy) with an 8-mm tip, and results expressed in Newtons (N) (means of 30 values). For each fruit, two readings were taken in the equatorial region of the fruit after the skin was removed. The readings were taken on opposite sides of the fruit. Total soluble solids (TSS) content was determined in the juice of single fruit with a digital refractometer Atago PR-101 (Atago, Japan) at 20°C and results expressed as °Brix (means of 15 fruits). Titratable acidity (TA) was determined by titration with 0.1 N NaOH up to pH 8.1, using 10 ml of diluted juice in distilled H₂O and results were expressed as meq/L. Skin colour analysis was performed at 1, 7, 14, 23 and 30 days of cold storage at 0°C. L*, a*, and b* values were determined at two points along each side of the nectarines using a Minolta chromameter (CR400; Minolta, Japan).

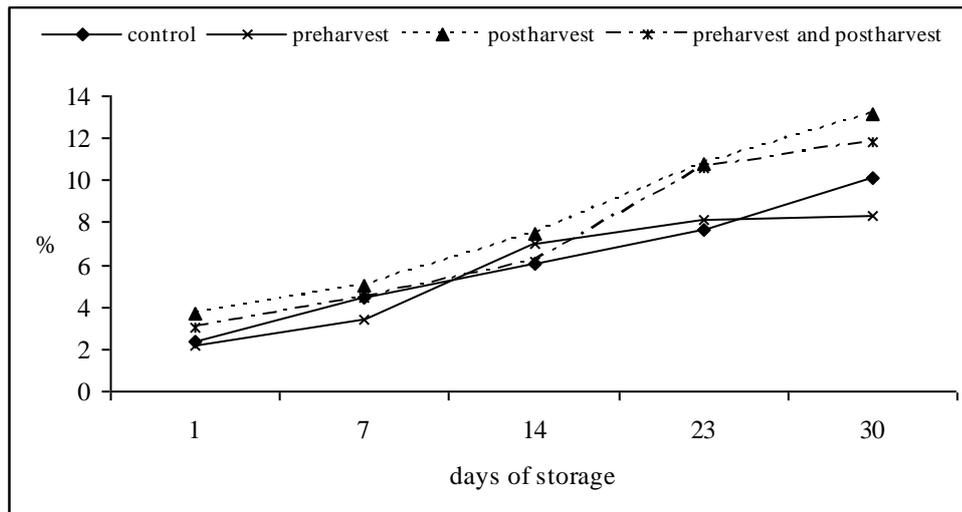
Statistical analysis

The experimental design was completely randomized with three replications. Data were analyzed by analysis of variance using statistical procedures of the STATISTICA ver. 6.0 (Statsoft Inc., Tulsa,OK,USA). The source of variance was the chitosan treatments. Tukey's test HSP (honestly significant differences) was used to determine significant differences among treatment means. Means values were considered significantly different at $P \leq 0.05$.

Results

Chitosan application reduced the postharvest weight loss of nectarines when applied in preharvest, and pre plus postharvest compared to control and to postharvest treatments, which showed the higher weight loss during storage. The effects were not statistically different from each other (Fig. 1).

Fig. 1. Evolution of weight loss (%) during cold storage of nectarines.



The concentrations of total soluble solids increased and titratable acidity and firmness decreased over time during postharvest storage (Tab. 1). In particular, preharvest application of chitosan was effective in reducing significantly firmness losses during postharvest storage, in according with Li and Yu (2000). For soluble solids content, chitosan treated nectarines showed the higher values during postharvest storage, compared to the control. The most effective treatment in controlling postharvest acidity losses of nectarines was chitosan application in pre plus postharvest treatment (Tab. 2). The faster decrease in acidity gave rise to a faster senescence (Asgar et al., 2011). The higher levels of total soluble solids and titratable acidity in the pulp of the nectarines coated with chitosan may be due to protective O₂ barrier or reduction of oxygen supply on the fruit surface which inhibited respiration (Jiang and Li, 2000; Yonemoto et al., 2002). The impact of the chitosan on O₂ and CO₂ concentrations in relation to fruit respiration requires investigation. The levels of titratable acidity were correlated with the antibrowning efficacy of the treatments. Han et al. (2004) reported that in raspberry and strawberry, the chitosan coatings slowed down the changes in titratable acidity, effectively delaying fruit ripening. During storage, very little reduction in hue angle and lightness was observed in all the treatments (Table 2). Preharvest chitosan application showed the higher L values during storage, and also the higher h values at the end of storage period compared to control (Table 2). Thus, preharvest treatment with chitosan coating delayed the browning and lightness loss of nectarines skin colour. Similar results was also obtained in postharvest chitosan application. Samples fruits of this treatment showed, at the end of storage period, significant higher values of L and h compared to control, in according with Jiang et al. (2005). This result is probably due because chitosan solutions have antioxidant capacity and the use of chitosan as an antioxidant and anti-browning agent is widespread in the food industry (Devlieghere et al., 2004).

Table 1. Quality parameters of nectarines during cold storage. Different letters indicates the value is statistically different from that corresponding to control ($P \leq 0.05$).

| parameter | treatments | days of storage at 0°C | | | | |
|------------------------|--|------------------------|----------|----------|---------|----------|
| | | 1 | 7 | 14 | 23 | 30 |
| SSC (°brix) | | | | | | |
| | control | 11.69 bc | 12.02 | 11.89 b | 11.87 c | 12.12 b |
| | preharvest application | 12.73 b | 12.46 | 12.94 a | 12.94 b | 13.8 a |
| | postharvest application | 12.23 b | 12.76 | 12.14 ab | 12.77 b | 13.52 a |
| | preharvest and postharvest application | 13.02 a | 12.46 | 12.35 ab | 13.63 a | 13.51 a |
| texture (N) | | | | | | |
| | control | 52.78 | 58.66 a | 54.94 | 43.95 | 40.22 ab |
| | preharvest application | 56.21 | 60.13 a | 55.82 | 49.05 | 43.75 a |
| | postharvest application | 55.13 | 54.83 b | 53.56 | 46.60 | 36.78 b |
| | preharvest and postharvest application | 55.23 | 54.54 b | 55.82 | 49.54 | 41.49 ab |
| acidity (meq/l) | | | | | | |
| | control | 112.55 b | 113.18 b | 95.69 c | 79.13 b | 72.92 b |
| | preharvest application | 127.7 a | 89.57 d | 103.35 a | 79.09 b | 71.48 b |
| | postharvest application | 115.34 b | 126.28 a | 97.18 b | 96.17 a | 72.74 b |
| | preharvest and postharvest application | 128.64 a | 109.6 c | 98.19 b | 94.84 a | 76.9 a |

Table 2. Colour parameters of nectarines during cold storage. Different letters indicates the value is statistically different from that corresponding to control ($P \leq 0.05$).

| parameter | treatments | days of storage at 0°C | | | | |
|------------------|--|------------------------|---------|---------|---------|----------|
| | | 1 | 7 | 14 | 23 | 30 |
| Lightness | | | | | | |
| | control | 25.74 b | 26.14 b | 25.29 b | 26 a | 26.11 ab |
| | preharvest application | 28.01 a | 27.01 a | 26.25 a | 24.42 b | 27.59 a |
| | postharvest application | 26.08 b | 26.57 b | 24.12 b | 26.28 a | 26.59 a |
| | preharvest and postharvest application | 26.42 b | 28.68 a | 26.48 a | 23.73 b | 25.51 b |
| Hue angle | | | | | | |
| | control | 34.94 a | 31.05 c | 30.81 b | 30.39 b | 31.59 b |
| | preharvest application | 34.59 a | 32.68 b | 33.18 a | 31.71 b | 34.25 a |
| | postharvest application | 32.29 b | 31.58 c | 30.43 b | 35.64 a | 33.67 a |
| | preharvest and postharvest application | 34.35 a | 33.72 a | 33.73 a | 31.75 b | 33.34 a |

Conclusion

Chitosan, as a semi-permeable coating, can maintain the qualities of the treated fruit and prolong its storage life. It could be considered that chitosan coating slows down the aging process of nectarines by decreasing quality losses and maintaining membrane integrity. In particular, preharvest chitosan-treated nectarines were firmer and had higher soluble solids content than control ones. Also pre and postharvest application fruits showed high soluble solids content and texture values and the highest titratable acidity. Hence it can be concluded that chitosan in preharvest treatments has the potential to preserve valuable attributes and prolong the shelf-life of postharvest nectarines, presumably of its property to inhibit the ripening and senescence process of postharvest fruits. However, in order to determine the feasibility of using chitosan coatings on a commercial scale, extensive postharvest storage tests are necessary.

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