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Full Length Research Paper

Hot water and chitosan treatment for the control of postharvest decay in sweet cherry (*Prunus avium* L.) cv. Napoleon (Napolyon)

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The effectiveness of chitosan and hot water treatments, alone or in combination, to control storage decay of sweet cherries, (*Prunus avium* L.) was investigated. In single treatments, chitosan was applied by postharvest dipping or preharvest spraying at 0.5 and 1.0% concentrations; hot water treatments at were applied for 5 and 10 min. Sweet cherries were kept in storage at and 98% relative humidity. Rot incidence was evaluated after 30 and 60 days storage life. Chitosan and hot water treatments applied alone significantly reduced decay. A combined treatment with 0.5% chitosan and hot water at for 5 and 10 min after 30 days of storage life was the best in controlling decay. In addition to reducing postharvest decay, combined treatment with 0.5% chitosan and hot water at for 5 min after 60 days of storage life showed good result in compartion to other treatments. The results indicate that the combination of hot water and chitosan treatments is a valid strategy to improve the existing ones already used in controlling postharvest decay of sweet cherries.

Key words: Hot water, chitosan, sweet cherry, decay, storage.

INTRODUCTION

Postharvest decay may result in serious economic losses to sweet cherries, a commodity of economic importance in many production areas worldwide. The use of synthetic fungicides to control postharvest diseases of sweet cherries is not allowed by European legislation, and there is a clear need for alternative natural materials for postharvest disease control that reduce fungal decay and carry lower risks for consumers. Biological control with yeast antagonists (Dündar and Göçer, 2001), hot water and hot air treatments (Wild, 1990; Schirra and D'Hallewin, 1997; Özdemir and Dündar, 2001), modified atmosphere packaging (Özdemir and Kahraman, 2004), sodium bicarbonate (Smilanick et al., 2005), and chitosan treatment (Chien et al., 2007) are natural alternatives to synthetic chemical postharvest treatments for disease control in sweet cherry. Short-duration (as brief as 20 s) hot water treatment (HWT) is one physical method that can effectively reduce postharvest decay on fresh fruits and vegetables (Ben-Yehoshua et al., 2000; Lanza et al., 2000). For example, Lanza et al. (2000) reported that hot water dip at 52°C for 180s was as effective as non-heated imazalil in controlling postharvest decay of lemon. In addition, brushing grapefruit for 20s with 56, 59 or 62°C water reduced decay by 20, 5 or 1%, respectively, compared to the control (Porat et al., 2000). A wide range of fruit ripening processes are affected by heat, such as color (Cheng et al., 1988; Tian et al., 1996), ethylene synthesis (Ketsa et al., 1999), respiration (Inaba and Chachin, 1988), fruit softening and cell wall metabolism (Lurie and Nussinovich, 1996), volatile production (McDonald et al., 1999). Postharvest heat treatment also can reduce chilling injury in many kinds of fruits during subsequent low temperature storage as well as reduce pathogen level and disease development (McDonald et al., 1999; Lurie, 1997). Heat treatments may affect postharvest quality in several ways. It has a direct effect on fungal growth, it may induce antifungal substances and the wax layer may melt into wounds and stomata (Schirra et al., 2000). Ferguson et al. (2000) present a survey of studies on the effect of heat treatments on

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postharvest quality in fruits.

Edible coatings such as chitosan has antifungal (Wojdyla et al., 2001) and eliciting properties (Hirano, 1999). The polymer has generally been applied in postharvest treatments (Cheah et al., 1997; Romanazzi et al., 2001b), and there are a few examples of preharvest application (Romanazzi et al., 1999c; Reddy et al., 2000). Coating citrus fruit with chitosan was effective in controlling fruit decay caused by *Penicillium digitatum* Sacc. and *Penicillium expansum* Link (Chien et al., 2007) and rots including gray mould and blue mould caused by *Botrytis cinerea* and *P. expansum* in sweet cherry fruit were reduced by preharvest spraying or postharvest dipping of chitosan (Romanazzi et al., 2003). In addition chitosan, have shown antimicrobial functions against the growth of certain microorganisms (Park et al., 2005; Zhang and Quantick, 1998). Edible coatings can possibly control the internal gas atmosphere of the fruit, minimizing fruit respiration rate (Park, 1999) and may serve as a barrier to water vapor, reducing moisture loss and delaying fruit dehydration (Baldwin et al., 1995). Chitosan-treated strawberries have shown a range of changes that are related to a slowed ripening, such as increased titratable acidity (TA) (El Ghaouth et al., 1991; Zhang and Quantick, 1998; Reddy et al., 2000; Han et al., 2004; Chaiprasart et al., 2006; Hernandez-Munoz et al., 2006; Vargas et al., 2006; Mazaro et al., 2008), with delayed changesin pH (Han et al., 2004; Hernandez-Munoz et al., 2006; Vargas et al., 2006), antocyanin content (El Ghaouth et al., 1991; Zhang and Quantick, 1998; Reddy et al., 2000; Vargas et al., 2006), soluble solids content (SSC) (Chaiprasart et al., 2006; Vargas et al., 2006; Ribeiro et al., 2007), and with reduced ethylene production (Mazaro et al., 2008). Changes in enzyme activities in coated strawberries has been shown to involve chitinase, chitosanase and -1,3-glucanase (El Ghaouth et al., 1992a; Zhang and Quantick, 1998), and phenylalanine ammonia-lyase (PAL), which increased three-fold in treated berries (Romanazzi et al., 2000). Moreover, a decreased respiration rate (El Ghaouth et al., 1991; Devlieghere et al., 2004; Vargas et al., 2006) and hydrogen peroxide production (Romanazzi et al., 2007b) have been shown in fruit treated with the biopolymer.

MATERIALS AND METHODS

Sweet cherries (*Prunus avium* L., cv "Napoleon") were picked in the khoy orchards. Immediately after harvest the fruits were brought to the laboratory. Safe and unwounded fruits were selected for preliminary tests. Fruit were surface-sterilized with 2% sodium hypochlorite for 2 min at room temperature rinsed with tap water in order to remove the heavy dirt, pesticides and fungal spores that are covering the fresh harvested produce and allowed to dry at room temperature and then the fruits were dipped in hot water of wide range of temperatures from various exposure times from 5 and 10 min, and sweet cherries were dipped in 0.5 and 1.0% concentrations chitosan and a total treated combinations were examined. After such hot water dipping and chitosan coating, both treated and non-treated (control) fruits were stored for months in the cold storage at 98% relative humidity. The following fruits with pitting, decay or abnormal softening during storage were defined as heat or chitosan damaged fruits.

Table 1. Influence of hot water dipping temperatures on decay reduction percent of sweet cherry measured.

Treatment condition	Decay reduction (%)
Control	2.5[a]
50°C for 5 min after 30 days	1.2[b]
50°C for 10 min after 30 days	1.0[b]
50°C for 5 min after 60 days	2.5[a]
50°C for 10 min after 60 days	2.7[a]

For each fruit, texture was determined using a TA.XT.Plus Texture Analyzer (Stable Microsystems, Godalming, UK) interfaced to a personal computer. Interfaced to a personal computer, content of soluble solids by an Atago PR-101 refractometer (Japan) at 22°C and titratable acidity was determined by titrating diluted juice samples to pH 8.2 using 0.1 N NaOH. A panel of five trained judges gave scores for overall quality on a scale from disease severity according to the following empirical scale: 0 = healthy berry; 1 = one very small lesion (beginning of infection); 2 = one lesion 10 mm^2 in size; 3 = several lesions or 25% of the berry infected; 4 = 26 to 50% of the berry surface infected, sporulation present; and 5 = more than 50% of the berry surface infected, sporulation present (Romanazzi et al., 2006).

Statistical analysis

A completely randomized factorial design with ten replications was used. Each treatment was applied to 10 replicates of 25 fruits per each. An analysis of variance (ANOVA) was used to analyze difference between means and the Duncan test was applied for mean separation at $P \leq 0.05$. All analyses were done with SPSS and MSTAT-C statistical software.

RESULTS

Effect of hot treatment on decay sweet cherry fruits

Table 1 shows the decay reduction percent of sweet cherry fruits treated at hot water.

The results are better at 5°C for 5 and 10 min after 30 days than control fruits. At 5°C water treatment for 5 and 10 min after 60 days of storage had the same level of decay as control.

Effect of chitosan treatment on decay sweet cherry fruits

Table 2 shows the decay reduction percent of sweet cherry fruits treated at chitosan. Chitosan 0.5 and 1% after 30 days storage had better results than control fruits and chitosan 1% after 60 days had worst result than the other treatments.

Table 2. Influence of chitosan on decay reduction percent of sweet cherry measured.

Treatment condition	Decay reduction (%)
Control after 30days	1.3[d]
Chitosan 1% after 30 days	1.4[d]
Control after 60 days	2.5[a]
Chitosan 0.5% after 60 days	2.0[b]
Chitosan 1% after 60 days	2.5[a]

Table 3. Influence combination of hot water and chitosan on decay reduction percent of sweet cherry measured.

Treatment condition	Decay reduction (%)
Control after 30days	3.0[a]
Chitosan 0.5% after 30 days and 5°C for 5 min	1.0[d]
50°C for 10 min and chitosan 0.5% after 30 days	1.0[d]
50°C for 5 min and chitosan 1% after 30 days	1.5[c]
50°C for 10 min and chitosan 1% after 30 days	1.7[c]
Control after 60 days	3.0[a]
50°C for 5 min and chitosan 0.5% after 60 days	3.0[a]
50°C for 10 min and chitosan 0.5% after 60 days	2.8[a]
50°C for 5 min and chitosan 1% after 60 days	2.3[b]
50°C for 10 min and chitosan 1% after 60 days	2.8[a]

Effect combination of hot water and chitosan treatmentes on decay reduction of sweet cherries

Table 3 shows the decay reduction percent of sweet cherry fruits treated at combination of hot water and chitosan. After 30 weeks of storage at 50°C for 5 and 10 min of the fruit dipped in water, 0.5% of chitosan trearment had least decay of sweet cherry fruits. The Table 3 show, combination of hot water and chitosan treatment had better results than alone treatments.

Conclusion

Chitosan and hot water treatments were effective in reducing decay of sweet cherries; the interaction between chitosan and hot water treatments was significant in reducing decay, and total rots in 30 and 60 days after storage. Several examples of combinations of alternative means for controlling postharvest decay have been reported in the literature. The inhibitory effect of chitosan on decay derives from the combination of its antifungal and eliciting properties. Indeed, chitosan inhibits the *in vitro* growth of many fungi, including some species causing decay on fruits and vegetables (Allan and Hadwiger, 1979); in tests performed with *B. cinerea*, *Monilinia laxa*, and *Alternaria alternata* on sweet cherries, a reduction of radial growth was observed (Romanazzi et al., 2001b). Chitosan and hot water were also able to induce resistance in the host by increasing chitinase and b-1,3-glucanase in oranges, strawberries and raspberries (Fajardo et al., 1998; Zhang and Quantick, 1998), and phenylalanine ammonia-lyase (PAL) activity in table grapes (Romanazzi et al., 2000, 2002). Moreover, it increased the level of 6- methoxymellein, the principal phytoalexin of carrots (Reddy et al., 1999). Physical treatments elicit responses in harvested commodities, increasing enzymatic activity (e.g. PAL, and peroxidase) related to host resistance against pathogens (Wilson et al., 1994); resistance responses in sweet cherries, strawberries, and table grapes have also been suggested for short hot water treatments(Romanazzi et al., 2001a). In addition, subatmospheric pressures remove ethylene from the tissues (Burg and Burg, 1965), thus delaying senescence of commodities and, indirectly, reducing their susceptibility to pathogens (Lougheed et al., 1978). A direct effect of short hot water treatments on the main decay-causing fungi of sweet cherries can be excluded, however (Romanazzi et al., 2001a).

DISCUSSION

The purpose of the present study was to evaluate the feasibility of combined application of a chemical edible coatings chitosan treatment and physical hot water treatment to control postharvest rots of sweet cherries. These results are in agreement with previous investigations; as reported in the introduction of the present. Postharvest chitosan and heat treatments of sweet cherries did not influence important quality factors like colour and content of soluble solids and titratable acidity. The heated fruits were less firm than the controls. The chitosan and heat treatments had no negative effect on sensoric quality. The heated fruits scored slightly better in the panel tests then unheated fruits. However, the difference was not statistically significant. Postharvest chitosan and heat treatments of sweet cherries reduced the fruits susceptability to decay, chitosan had the stronger effect. However, the fruits treated with hot water chitosan solution had the least decay.

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