Effects of Different Postharvest Heat Treatments on Decreasing Decay, Reducing Chilling Injury and Maintaining Quality of Nectarine Fruit

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Summary

The goal of this research was to evaluate the efficiency of heat treated nectarine fruit (*Prunus persica* var. *nectarina* 'Diamond Ray') on maintaining the quality parameters after 4 week storage in NA (normal atmosphere) at 0°C and 5 days at 20°C (shelf life). Fruits were harvested closer to "ready-to-eat" maturity from a commercial orchard near Zadar (Croatia). The investigated postharvest treatments were hot air (hot air treatment till fruit reaches 45°C near stone – HAT 45/24) and immersion in hot water at a temperature of 48 °C for 6 minutes (HWD 48) and 52°C for 2 minutes (HWD 52). Fruit quality parameters (firmness, soluble solids, total acidity, pH) were also investigated. HAT 45/24 reduced weight loss and maintained firmness more than control or hot water treatments. Overall, heat treatments had a pronounced effect on decreasing decay, reducing chilling injury and maintaining quality of climacteric nectarine fruit. These treatments may extend the storage life by preventing both pathological and physiological disorders.

Key words

nectarine, storage, heat treatment, quality, decay, chilling injury

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Introduction

Nectarine fruit are harvested in high ripening stage due to very late accumulation of aroma compounds in fruit. It is considered that nectarines are ripened when they rich minimal or higher although not full maturity (Crisosto et al., 2007). Nectarine fruit due to their climacteric properties at room temperature continues ripening which induces deterioration and decay of fruit. That and their fast firmness loss demands cold fruit storage at 0 to 3°C (Buescher and Griffith, 1976; Wang et al., 2003; Wang Liguori et al., 2004; GuiXi et al., 2005). During that period the fruit are susceptible to chilling injuries (CI) and attack of phytopathogenic fungi such as *Monilinia laxa*, *Rhizopus stolonifer*, *Botrytis cinerea* and *Penicilium sp.* that degradates fruit quality and consumers acceptance. Those fungi cause high postharvest losses (Snowdon, 1991; Margosan et al., 1997; Çelik et al., 2006; Crisosto et al., 2007; Jemric et al., 2011). Use of postharvest fungicides is prohibited in EU (Karabulut et al., 2004), so alternative methods are investigated. Lurie (1998) reports that heat treatments are effective in control of losses due to phytopathogen fungi. Hot water dip (HWD) can be effective method, especially for organically grown crops, which, untreated with chemical fungicides, are prone for controlling plant pathogens, nematodes and insect pests (Fallik, 2004; Lurie et al., 2004; Karabulut et al., 2010), for some physiological disorders (Lurie, 1998; Fallik, 2004; Jemric et al., 2006; Pecina et al., 2007) or postharvest decay (Mari et al., 2007). Significant advantage of HWD is also maintaining the quality of stored fruit (Lurie, 1998; Malakou and Nanos, 2005). Such treatment that can preserve fruit quality and reduce pathogen attack and decay would be an advantageous method for stored peach or nectarine and minimizing storage losses (Jemric et al., 2011). Hot water dipping at 48°C for 12 min and 6 min can significantly reduce occurrence of *Monilinia laxa* on peach and nectarine respectfully during storage (Jemric et al., 2011). The aim of this study was to investigate different temperature and heating method on controlling postharvest losses of new cultivar in Croatia 'Diamond Ray' due to pathogens and chilling injuries.

Material and methods

Nectarine 'Diamond Ray' fruits were obtained from the commercial orchard in area Ravni kotari near Zadar. Fruit were harvested in optimal maturity stage for storage. Fruit with no visual symptoms of pathogens were selected for heat treatments and as control fruit. Experimental fruit were treated with hot water at 48°C for 6 (HWD 48°C) and at 52°C for 2 min (HWD 52°C). Other fruit was treated with hot air (HAT 45/24°C) according to Obenland et al. (2005). After the treatments, treated and control fruit were stored in cooling room (at 0°C temperature and RH 90%) for 4 weeks. After 4 weeks of storage and 5 days of shelf life -market simulation (20°C and RH 70%) fruit were examined for the pathogen symptoms and sporulation structures on affected fruits.

Standard quality measurements were conducted before treatments, after 4 weeks of storage and after 4 weeks of storage plus 5 days of shelf life. Fruit weight was measured on 30 fruits before treatment. Of those fruits 15 were weighed immediately after 4 weeks of storage, and other 15 were weighed and measured after shelf life. Fruit weight measurements were conducted with analytical scale (Mettler P1210) at two decimals in grams. Soluble solid concentration (SSC) was measured with hand refractometer (Carl Zeiss, Germany). Total acids (TA) were measured by titrimetric method with 0.1 M NaOH on 5 ml of fruit juice and calculated as equivalent of malic acid. Maturity index was calculated as SSC/TA ratio. Juice reaction (pH) was measured with pH-meter LAB 870 SET (Schott Instruments, Germany). Fruit was considered decayed once fungal mycelia appeared on the peel or calyx. Decay was expressed as a percentage of the total initial fruit number. Chilling injuries were detected visually, counted and index was calculated as CI/total fruit ratio.

Effects of treatments were analyzed by ANOVA and significance of differences among means was tested applying the LSD test at $P < 0.05$ using the SAS Statistical package ver. 9.00 (SAS Institute, Cary, USA).

Results and discussion

Result of fruit quality testing (Table 1) shows that there was no changes in fruit quality among the treatments, except in weight loss, firmness and EC. As maturity index (SSC/TA ratio) is important indicator of maturity stage (Kader, 1999), all treatments were measured for SSC/TA ratio. The data in Table 1 shows that there is no significant difference among all treatments including control. Hot air treatment surprisingly had lower weight loss and higher firmness compared with control. That shows that HAT 45/24, even when lasting for more than two hours without humidity control, can preserve fruit weight and firmness. All other measured parameters did not show difference among the treatments and control.

Phytopathogenic fungi can cause great losses of nectarine fruit during storage (Snowdon, 1991; Crisosto et al., 2007). Figure 1 shows that HAT 45/24 significantly reduced those losses caused by all tested pathogens, except *Botryis cinerea*. Pathogens

Table 1. The quality of heat-treated nectarine 'Diamond Ray' fruit after 4 WK of storage at 0°C and 5 d of shelf life at room temperature (mean and SD)

Treatment	Weight Loss (%)	Firmness (kgcm^{-2})	SSC (%)	TA (as malic) (%)	SSC/TA	pH
Control	12.05 ± 4.68 ab	0.75 ± 0.17 b	10.20 ± 0.30 a	0.54 ± 0.06 a	19.21 ± 2.48 a	3.70 ± 0.03 a
HAT 45/24°C	8.45 ± 2.00 c	0.92 ± 0.22 a	10.10 ± 0.35 a	0.52 ± 0.01 a	19.33 ± 0.34 a	3.70 ± 0.02 a
HWD 48°C 6'	10.04 ± 2.40 bc	0.87 ± 0.20 ab	10.30 ± 1.25 a	0.56 ± 0.07 a	18.30 ± 0.17 a	3.71 ± 0.06 a
HWD 52°C 2'	15.25 ± 6.24 a	0.92 ± 0.22 a	10.60 ± 0.46 a	0.54 ± 0.12 a	20.11 ± 4.34 a	3.90 ± 0.40 a

Note: Means within the column followed with the same letter are not significantly different (LSD test at P≤0.05 level)

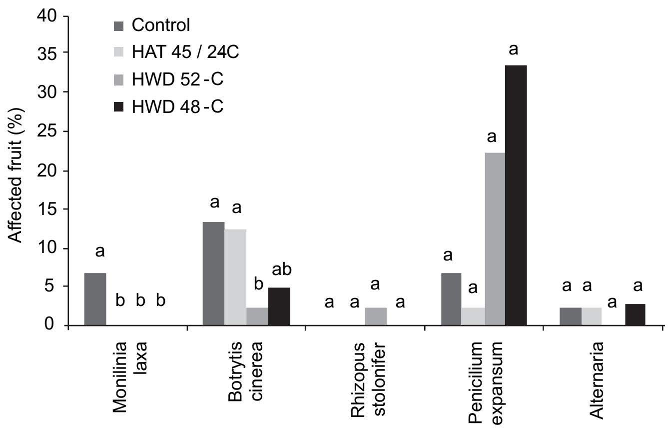

Figure 1. Percentage of patogen infected fruit of heat-treated nectarine 'Diamond Ray' fruit after 4 WK of storage at 0°C and 5 d of shelf life at room temperature

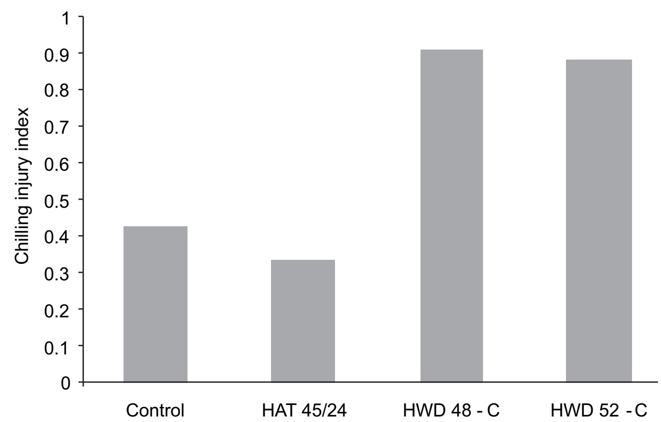

Figure 2. Appearence of chilling injury on heat-treated nectarine 'Diamond Ray' fruit after 4 WK of storage at 0°C and 5 d of shelf life at room temperature

Monilinia spp. that are the most important postharvest pathogens on peach and nectarine fruit (Snowdon, 1991; Crisosto et al., 2007; Jemric et al. 2011) were entirely reduced by HAT 45/24 and water treatments. However, water treatments, have even increased occurrence of *Penicillium expansum* comparing with control. The reason could be higher moisture that fruit were exposed during treatments and temperature of the fruit was probably increased to optimal for *P. expansum* growth. Treatment temperature and duration are very important factors for an effective application of hot water treatments for postharvest disease control (Fallik, 2004) that can be limiting factor to the application of heat treatments at a large commercial scale due to its potential heat damage to fruit (Lurie, 1998; Fallik, 2004; Karabulut et al., 2010). *Rhizopus stolonifer* and *Alternaria spp.* did not showed any serious threats.

Flesh redness was the only symptom of CI that occurred. While water treatments enhanced occurrence of CI, HAT 45/24 showed slight decrease of occurrence of CI (Figure 2). HAT treatment lasted for almost 2 hours so fruit had more time to develop Heat Shock Proteins (HSP) that prevent appearance of CI. The protective effect of heat treatment against CI in tomatoes has been correlated with the accumulation of heat shock proteins (HSPs) in the fruit tissue. Under stress, fruits synthesize specific proteins, and their accumulation has a role in protecting the tissue from possible damage. The evaluated temperatures initiate synthesis of these HSP and maximal production was found after 24 hours at 50°C hot water dips for 1 min (Ilic and Fallik, 2005).

Conclusion

The results in this work show that postharvest heat treatments application can be beneficial for extending shelf-life and market quality of nectarine fruits. Hot water dipping at 48°C for 6 minutes and at 52°C for 2 minutes shows good effect in controlling fungi disease and maintaining fruit quality. HAT 45/24 is also useful treatment for controlling postharvest pathogen disease, and can be used for preventing of appearance of CI. The disadvantage of hot air treatment is too long treatment duration which brings into question use of this treatment in commercial cold storage. Further studies are required to fully understand the role of hot air treatment as a tool in scheduling market supply, provided the application is carried out at the nectarine fruit.

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