DEVELOPMENT OF A HIGH TEMPERATURE CONTROLLED ATMOSPHERE QUARANTINE TREATMENT FOR POME AND STONE FRUITS

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Abstract

The research presented describes how a technology called Controlled Atmosphere Temperature Treatment System (CATTS), can be used as a quarantine treatment against insect pests of apples, pears and sweet cherries. High temperature forced air has not been useful for these temperate fruit because the heat dose required to kill the target insect pests (codling moth and western cherry fruit fly) caused unacceptable damage to fruit market quality. Heating a commodity in a controlled atmosphere was shown to reduce the heat dose required for controlling the insect pest without damaging fruit quality.

1. Introduction

Export of agricultural commodities to foreign markets is a major interest of the United States. Temperature treatments, such as heat shock, have been shown to affect both the fecundity and mortality of codling moth (Neven 1994, 1998, Neven et al., 1995, Neven et al., 1996, Yokoyama et al., 1991). Other researchers have shown that short-term high temperature treatments of apples prior to long term cold storage improves quality and lengthens shelf life (Klein 1994, Klein et al., 1992, Klein et al., 1990, Lurie et al., 1991, Neven et al., 2000a). We have shown that the rate of heating can effect apple and pear quality (Neven et al., 2000a) and codling moth mortality (Neven 1998). There is an indication that a short-term heat shock of pears may provide decay control and therefore improve storage (Neven, unpublished).

When heat is applied in a controlled atmosphere, the duration of the treatment to achieve optimal insect mortality can be greatly reduced, thereby, potentially reducing loss of fruit quality (Neven et al., 1996, Shellie et al., 1997). Knowledge of this effect on insects has led to the development of a Controlled Atmosphere/Temperature Treatment System (CATTS) (Neven et al., 1996). Using CATTS, we have shown that the total duration of a heat treatment can be reduced in time by 25 to 50kPa with the addition of controlled atmospheres (Neven et al., 1996; Shellie et al., 1997). The advantage of reduced treatment times helps to preserve fruit quality. We report the development of quarantine treatments for apples, pears and sweet cherries using CATTS.

2. Materials and methods

Pome Fruit

Five cultivars of apple (‘Delicious’, ‘Golden Delicious’, ‘Granny Smith’, ‘Fuji’, ‘Gala’) and one cultivar of winter pear (‘d’Anjou’) were tested in the 1998-1999 seasons. For each cultivar, fruit were separated into 24 treatment groups of four replicates with 20 fruit per replicate (80 fruit per treatment). Treatments consisted of 1 rate of heating, 12°C/h, under air (RA) or a controlled atmosphere (CA) (1kPa O₂, 15kPa CO₂) environment, to two final temperatures (44°C and 46°C), with three time points taken to
maximal times of 6 and 3 hours, respectively. Dew point was regulated to 2°C below the fruit surface temperature. Air speed was controlled to 2 m/s. Fruit temperatures (2 core, 1 surface), dew point, and air speed were recorded at 1 minute intervals throughout the treatments. Untreated fruit were used as controls. Fruit were held at room temperature (20°C) until treated. After treatment, fruit were packed into apple boxes and stored for 3-5 days at 4°C until transported to a controlled atmosphere (CA) facility. Controlled atmosphere storage conditions for ‘Delicious’, Golden Delicious’, ‘Granny Smith’, ‘Fuji’, and apples and ‘d’Anjou’ pears were 1kPa O2, 1kPa CO2, at 0-1°C. CA conditions for ‘Gala’ apples were 1.5kPa O2, 2kPa CO2, at 0-1°C. Fruit were removed from CA after 90 days, ripened for 7 days at room temperature, and assessed for various quality parameters.

Quality evaluation consisted of objective and subjective color, firmness, soluble solids content (SSC), titratable acidity (TA), and evaluation for defects (rot, scald, and internal browning) were performed as described in Neven et al. (2000a).

Sweet Cherry

Previous research indicated that pitting and reduced storage life were a problem for CATTS treated sweet cherries (Neven et al., 2000b). We compared unheated, heat only, heat + 10kPa CO2, and heat + 15kPa CO2 treatments (47°C for 25 min) of both ‘Bing’ and ‘Rainier’ sweet cherries. The general protocol for CATTS treatments were as described in Neven et al. (2000b). Two parameters of the treatment, dew point regulation and sodium hypochlorite concentration, were altered to address pitting, while modified atmosphere packaging (MAP) was used to extend storage life. During the heat treatment, dew point was regulated to 2°C below the surface temperature of the fruit to keep condensation from forming on the fruit. After treatment, hydrocooling was performed in 5°C water containing 50 ppm sodium hypochlorite, half of the recommended amount. Half of the fruit were packaged in and stored under regular atmospheres while the other half were packaged in MAP according to the patent #5,565,230. Fruit were stored at 2°C for 14 and 21 days, after which quality assessments were made.

Market quality evaluations consisted of objective and subjective fruit and stem color, firmness, soluble solids content (SSC), titratable acidity (TA), and evaluation for defects (pitting, bruising, rot) were determined as described in Neven et al. (2000b).

3. Results

Apple and Pear Quality

Fruit treated with heat alone were not as firm as fruit treated with the combination heat plus CA. All heat treated fruit were firmer than untreated control fruit. Heat-treated fruit stored as long as the untreated control fruit. In ‘Golden Delicious’ apples, sunburn was more prevalent in control fruit but not as common in heat-treated fruit. ‘Gala’ apples were more susceptible to internal breakdown after heat plus CA treatments. ‘Red Delicious’ apples withstood the treatments very well. ‘Fuji’ apples had severe water core and did not withstand more than 90 days of storage. ‘Granny Smith’ apples stored for 150 days showed a dramatic suppression of storage scald in the heat-treated fruit. Control fruit had 100% scald while heat-treated fruit were virtually untouched by storage scald. ‘Anjou’ pears survived the treatments very well with no scald in the heat-treated fruit and a delay of ripening of approximately 2 to 3 days. In all heat-treated fruit, the Brix/acid ratio (SS/TA) was increased.

Cherry Quality

By controlling the dew point in the chamber the intensity of the pitting was reduced, but not the number of pits. It is possible that hydrocooling may cause the pitting after the heat treatment. It is possible that either forced air cooling or hydrocooling initially in room temperature water may reduce the number of pits. With the addition of MAP we were able to obtain 21 days of storage with CATTS treated cherries. All other quality parameters, fruit and stem color, firmness, soluble solids, titratable acidity, and rot were acceptable and comparable to control fruit.
4. Discussion

Pome Fruit Treatments

There was no difference in quality between heat only and heat plus CA treatments. Scald was not noticed in any heat treatment. Firmness was either unchanged, or in many cases, increased after storage and ripening. There is evidence that ripening in winter pears is actually delayed and synchronized (as suggested by a reduced standard error in sample measurements). Decay development was suppressed for many of the cultivars. Fruit were not hydrocooled or treated with any other postharvest chemicals to control scald or decay organisms.

These treatments show great promise as either replacements for MeBr fumigation or even as alternatives to extensive cold storage treatments to meet quarantine security. Also, this treatment would meet organic standards. Treatments used in this study will kill codling moth either immediately (when longer treatment times are used) or following a cold storage period of 30 days at 2°C to 5°C (when shorter treatment times are used). Added benefits of firmer fruits and control of storage scald are a definite plus for these treatments. Also, this is the only postharvest treatment, aside from long term cold storage (which does not control codling moth in less than 90 days) which provides excellent quality pears.

Sweet Cherry Treatments

Controlling the dew point appeared to reduce the pitting of CATTS treated fruit. However, it remains unclear whether pitting was an effect of the formation of carbonic acid during the high CO2 CATTS treatment since no significant differences were found in pitting between treatments in air, 10kPa and 15kPa CO2. The addition of MAP to CATTS treated cherries extended the storage life of the cherries to 21 days. The ability to use MAP will help in transport and storage of cherries treated with CATTS.

Cherry stem color, firmness, and titratable acidity were affected by fumigation with methyl bromide and by CATTS treatments. Untrained preference panelists rated heat-treated and methyl bromide fumigated cherries similar to non-treated, control cherries. Hydrocooling prior to heating, and cooling method after heating had no effect on cherry quality after storage. Heated cherries stored for 14 days at 1°C in 6 kPa oxygen with 17 kPa carbon dioxide had similar market quality as heated cherries stored in air.

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References

Yokoyama, V.Y., Miller, G.T. and Dowell, R.V.. 1991. Response of codling moth (Lepidoptera: Tortricidae) to high temperature, a potential quarantine treatment for exported commodities. J. Econ. Entomol., 84:528-531.