PHYTOTOXICITY TO CITRUS AND STONE FRUITS FROM POSTHARVEST COLD AND HEAT TREATMENTS AS ALTERNATIVES TO METHYL BROMIDE

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Both cold and heat can be effectively used to kill insects infesting citrus and stone fruits. Phytotoxicity to the fruit as a result of such treatments, however, is an important consideration as even a small amount of injury may render the fruit unmarketable. We have been studying different means of reducing the phytotoxicity to citrus and stone fruit due to cold and heat treatment and attempting to better understand the mechanisms by which it occurs.

Cold treatment (CT) is an approved alternative to methyl bromide (MB) fumigation of citrus fruit for quarantine control of several Tephritid fruit flies. Temperature required is between 0.0-2.2°C and duration varies between 10 to 22 days, depending on the exact temperature used and the fruit fly species involved. Some citrus, as lemons, are chilling sensitive, however, and often develop objectionable peel injury symptoms after CT that reduce quality of the fruit and may predispose fruit to increased decay rates. We found early-season desert lemons to be particularly susceptible to chilling injury (CI). In our tests we held lemons at 1±0.5° for 3 weeks CT followed by 4 weeks at 10° to simulate transit and marketing temperatures.

We found curing, holding fruit for several days before CT, was beneficial for reducing CI. Of several curing temperatures tested, 15°C always reduced CI more than did 5, 20, 25, 30 or 35°. Curing fruit at 15° for 1 or 2 weeks reduced CI more than curing for 3 or 4 weeks. When curing at 20° 2 weeks provided more benefit than did curing for 1 week only. Curing lemons at 30 or 35° before CT caused more injury to fruit than did CT alone without any curing. We also tested curing for 1 week at 5, 15 or 30° or at all combinations of any two of those temperatures for 1 week for each temperature, 2 weeks total, and found that any treatment involving 15° provided more protection from CT than did 5° alone or any combination with 5° in it. Any curing treatment with 30° in it caused fruit to have more CI than non-cured cold-treated fruit. The most injurious curing treatments were 30° alone or the 30° + 30° combination treatments. CI susceptibility of lemons varied markedly between experiments as did the benefit of curing fruit before CT.

A reduced MB dose followed by various short CT's is also approved as a quarantine treatment for fruit fly control. The MB dose required is less than when MB is used alone, and the CT's are warmer and shorter than when CT is used alone. We have tried the MB + CT combination treatments with navel oranges and lemons, but find that the fruit in our tests always developed unacceptable rind injury. The maximum allowed interval between the end of MB fumigation and the start of CT is 24 hours. In some tests passive aeration for 24 hours was nearly useable, with only a little injury to the fruit, but in most tests there was objectionable rind injury, even with the 24 hour aeration. We are testing forced aeration of the fruit following the MB fumigation and before the CT. Tests are still in progress.

To gain an understanding of how CI occurs, the release and internal localization of d-limonene, an essential oil present in the flavedo, was determined for chilling-injured and non-injured lemons. This was done to evaluate whether or not essential oils might be involved in the development of CI and to assess the possible use of d-limonene as a predictor of the onset of this injury. Chilling injury in the form of pitting and browning of the flavedo was apparent after 1 week at 1°C and

increased in severity thereafter. Release of d-limonene increased with increasing injury, although d-limonene release lagged behind the development of injury. Curing the fruit prior to storage at 1°C greatly reduced both injury and d-limonene release. Investigations using confocal microscopy indicated that essential oils were present both in oil glands and in bodies outside of the glands. No obvious disruption of the oil glands or of the oil bodies was observed in chilling-injured fruit. Flattening of cells above the oil glands was often visible in chilling-injured fruit and may be partly responsible for surface pitting of the flavedo. Oil gland collapse was noted only in later stages of injury development. Results do not support a primary role for essential oils in the development of CI, however, their abundance in the flavedo, the fact that they are released from the flavedo during the development of CI, and their known phytotoxicity makes it likely that essential oils may have some responsibility for the development of CI.

Short treatment times make hot-water immersion an attractive consideration as a non-chemical alternative to MB. Phytotoxicity to the treated commodity has, however, been a severe problem hindering the adoption of hot water immersion as a quarantine treatment. Based on an earlier report that sucrose was beneficial in reducing the phytotoxicity of surface hot-water disinfection of peaches, we tested the ability of another solute, NaCl, to lessen the deleterious effects of hot water treatments used to disinfest nectarines of fruit fly. Hot water treatment for 25 minutes at 50°C without any added NaCl caused severe damage in the form of pigment loss, browning and pitting to all 6 cultivars of nectarine tested. Although all cultivars were badly injured, there were cultivar differences in the amount of injury that occurred. Addition of NaCl to a concentration of 200 mM in the hot-water treatment solution, however, dramatically decreased the phytotoxicity of the treatment, reducing the average injury rating from 3.9 (severe damage) to 1.9 (slight damage). NaCl acted to greatly reduce the amount of water entering the fruit during hot-water treatment, this being a likely reason for the reduced phytotoxicity. Even though NaCl was effective in reducing hot-water phytotoxicity, the amount of damage that did occur during an insecticidal treatment directed toward fruit fly was still sufficient to render the fruit unmarketable. Hot water treatments of lesser severity, however, may benefit from addition of NaCl into the treatment solution.