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Condition of Florida Grapefruit after Exposure to Vapor Heat Quarantine Treatment

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Abstract. **Experimental vapor heat (VH) tests [43.5C for 5 hours, 1009" relative humidity (RH)] were conducted to determine treatment effects to freshly harvested Florida grapefruit *(Citrus paradisi* Macf.). VH treatment reduced peel pitting 5-fold compared to control fruit after 5 weeks of storage (4 weeks at 10C + 1 week at 21C) and did not cause peel discoloration or rind breakdown. There was no difference in volume between treated and nontreated fruit after 1 week of storage or in weight loss after 5 weeks. Also, peel color, total soluble solids concentration, acidity, and pH were not affected by VH treatment. Fruit were slightly less firm after VH treatment and remained less firm throughout storage, compared with control fruit. The VH treatment tested is a potentially viable alternative quarantine treatment for control of the Caribbean fruit fly *[Anastrepha suspensa* (Loew)] because it is not phytotoxic to grapefruit and has been reported effective for disinfestation of this pest in grapefruit.**

Fresh grapefruit exported from Florida to Japan either must be harvested from groves within geographic zones that are certified free of the Caribbean fruit fly (CFF) or subjected to an approved chemical or physical quarantine treatment. Fumigation with ethylene dibromide (EDB) to control CFF in grapefruit was officially terminated by the Environmental Protection Agency in 1987, and since then, only cold treatment (CT) and fumigation with methyl bromide (MB) are approved quarantine treatments. MB is not used on Florida citrus because dosages approved for CFF control damage grapefruit rind. The approved time/temperature regimes for applying CT range from 0.6C for 11 days to 2.2C for 17 days (Plant Protection and Quarantine Manual, 1985). The particular time/temperature regime used depends on the estimated intensity of a potential infestation by the CFF in fruit. All fruit to be subjected to CT must first be temperature-acclimated by a process of conditioning; without it, symptoms of serious chilling injury (CI) would damage the rind. For Florida grapefruit, Hatton and Cubbedge (1982) found that a conditioning period of 7 days at 15C before exposing fruit to CT eliminated or greatly reduced CI rind breakdown. There are, however, problems in consistently applying CT under commercial conditions: 1) the temperature and relative humidity (RH) during fruit conditioning and the CT regime must be precisely controlled, 2) the threshold tolerance of grapefruit rind to CI from the CT (temperature and time durations) vanes within (Kawada et al., 1978) and among (Grierson and Hatton, 1977) seasons, and 3) CT is generally not applied to early season fruit because they are considered more susceptible to CI than fruit harvested later in the season (after 1 Jan.). Therefore, the Florida citrus industry continues to seek refinements to CT or alternative treatments, such as high-temperature dry air (Sharp, 1989), vapor heat (VI-I), and heated water (Sharp, 1985) that may provide security against the CFF without injury to fruit.

The first use of VH as a quarantine treatment in Florida and Mexico was documented in 1929 to kill eggs and larvae (immatures) of the Mediterranean fruit fly *[Ceratitis capitata* (Wied.)] in oranges and grapefruit (Baker, 1944). VH is an approved quarantine treatment against the Mexican fruit fly *[Anastrepha ludens* (Loew)] for grapefruit, orange, tangerine, mango, and certain vegetables (Plant Protection and Quarantine Manual, 1985). The VH treatment was also found to be effective, from both entomological and horticultural evaluations, against the melon fly *[Dacus cucurbitae* Coquillett] on eggplant (Furusawa et al., 1984). VH currently is not an approved quarantine treatment for CFF control in grapefruit; however,

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control fruit were slightly firmer (0.2 units) than those exposed to the VH treatment (Table 1); however, objective measurements recorded after the final storage regime showed no difference in fruit firmness due to treatment (data not shown). Fruit weight loss was ≈0.5% per week during the total storage period and did not differ among treatments.

Aging symptoms were observed, but affected <2% of the fruit and were not significantly different among treatments ($P < 0.05$) even after the 5th week of storage at 21C (data not shown). Also, no differences among treatments were observed for external peel-surface appearance [average rating, 1.0% (fresh) initially and 1.8% (fairly fresh) after 5 weeks].

In general; there were no differences among treatments for Hunter 'L', 'a', or 'b' values before or after VH treatment or after each week of storage. Average of the 'L' values ranged from 81.4 before VH treatment to 77.5 after the 5th week of storage, indicating that fruit became darker as storage duration increased. The 'a' value for peel color increased from – 5.7 to – 2.0 during storage, indicating that chlorophyll depleted from peel as storage time increased; there was no treatment effect. The yellow component of color ('b' value) remained relatively constant during storage (range 56.0-59.0) and did not differ among treatments.

Fruit volume changed slightly less ($P < 0.05$) in VH-treated fruit immediately after treatment (– 0. 1%) than for those not treated (- 1.1%) or treated with TBZ (0.5%), but after storage for 1 or 7 days, there was no significant difference among treatments (ranges – 1.4% to – 2.0% and – 2.0% to – 2.7%, respectively). This indicates that the VH treatment will not cause swelling or puffiness of fruit peel.

No differences were found in TSS, Ac, or pH among treatments after 5 weeks of storage. TSS averaged 10.3% initially, and after 5 weeks of storage, Ac averaged 1.6% and 1.4%, respectively, and pH remained constant at 2.9.

Pitting was observed on some grapefruit in this study and in grapefruit held for other purposes during the 1988-89 season, even though the fruit were held at 10C, the recommended storage temperature. We conclude that the VH treatment had a conditioning effect on peel tissue, because pitting was reduced compared to control fruit. This is a beneficial effect, especially during those seasons when peel tolerance to chilling stress is atypically low.

Additional study of the effects on grapefruit following VH treatment are needed before concrete conclusions on the potential of VH as a viable alternative to CT for quarantine purposes can be made. We need yet to ascertain if currently recommended storage at 10C following CT, as used for Florida grapefruit that are harvested late in the season, is also optimum following VH treatment. If lower than 10C storage following VH treatment is possible without CI, then the feasibility for reduced decay during long-term storage may be an additional benefit. The reduction in CI (i.e., in pitting) found following the VH treatment, compared to that observed for control fruit, merits continued investigation.

The VH procedure was also less damaging to grapefruit peel than the hot water immersion treatment at 43.3C for 5 h, which was found to cause peel discoloration and increased decay in grapefruit (Miller et rd., 1988). For more comprehensive conclusions, variables, such as grapefruit cultivars, rootstock, and harvesting season, need to be tested.

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