lished, dosimetry within the fruit being irradiated would have to be monitored closely.

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EFFECTIVENESS OF VARIOUS POSTHARVEST TREATMENTS FOR MANGO DECAY CONTROL

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Abstract. **Unheated (26-32°C) and heated (53°C) suspensions of benomyl, imazalil and prochloraz were compared as postharvest treatments for control of anthracnose (*Colletotrichum gloeosporioides*) of 'Tommy Atkins' and 'Keitt' mangos (*Mangifera indica* L.). Mature-green mangos were immersed for 20 seconds in an unheated suspension or 3 minutes in a heated suspension. Fruit were then held for 16 days at 13°C followed by ripening at 24°C before examining for decay. Heated dip treatments affected fruit quality of both cultivars. Treatment for 3 min at 53°C in tap water, 0.2% benomyl, 0.2% imazalil, 0.2% prochloraz, and 0.05% benomyl plus 0.05% prochloraz satisfactorily controlled anthracnose after 16 days storage at 13°C.**

Mango (*Mangifera indica* L.) production throughout the world, including Florida has increased dramatically over these past 40 years. Florida now has 2,600 acres (1,040 ha) of mangos producing a crop valued at $5,825,000 (1). Probably the most serious pest which threatens mango production and marketing throughout the world is mango anthracnose caused by *Collectotrichum gloeosporioides* (Penz.) Sacc. (11). Mango anthracnose is the most common decay of Florida grown mango fruit which comes from preharvest infected green fruit (4, 11, 12).

Anthracnose free fruit is near to impossible in spite of rigorous field applications of fungicides which have been shown to be effective in reducing the disease (5, 9). Once *C. gloeosporioides* establishes itself in the fruit of mango it becomes difficult to control and up to the year 1972 fungicidial washes and dips applied at harvest had little affect on the disease (11, 12). In the early 1960's researchers from Puerto Rico and Florida reported successful use of hot water for the control of mango anthracnose (8, 11). These findings stimulated some commercial use of a hot water bath to control anthracnose, but most failed because the systems were inadequate to control water temperature and slowed packing procedures. At present, one packer uses a hot water system which can treat large numbers of fruit in a short period. In 1972, Spalding and Reeder (12) reduced anthracnose decay for 4 weeks by dipping the green mature fruit in benomyl or thiabendazole combined with 130°F tap water.

This paper reports the results of comparative trials of fungicides added to ambient tap water and hot water for the control of mango anthracnose.

Material and Methods

The green mature mango fruits naturally infected with anthracnose used throughout were 'Tommy Atkins' harvested in July 1987 and 'Keitt' harvested in August 1987.

The fruits were randomized into three equal samples of nine fruit each for 'Keitt' (27 fruit total), and three samples of 11 fruit each for 'Tommy Atkins' (33 fruit total) for each treatment. All fruits were washed, dried and treated within 24 hours after harvest. Each test for the two mango cultivars was repeated three times. The fungicides used were methyl 1-(butylcarbamoyl)-2-benzimidazole-carbamate (benomyl) at 0.05 and 0.2%, 1-[2-(2,4-dichlorophenyl)-4-ethyl-1,3-dioxolan-2-yl-methyl]-lH-1,2,4-triazole (imazalil) at 0.2% and 1-(N-propyl)-N-(2-(,4-6-(trichlorophenoxy)ethyl)carbamoyl)imiddazole (IUPAC) (prochloraz) at 0.05 and 0.2%.

The fruits were dipped in water or fungicides at 26-32°C for 20 sec. or 53°C for 3 min as shown in Table 1 and 2. After treatment, the mangos were air dried, repacked in commercial flats and stored at 13°C for 16 days. After storage for 16 days to simulate storage and transportation time, the fruits were transferred to 24°C for ripening. Inspections were made daily and data were recorded for severity of decay, injury and ripeness as the fruits became fully ripe.

Results and Discussion

Results with the two mango cultivars, Tommy Atkins and Keitt, are shown in Tables 1 and 2. Hot imazalil delayed ripening for 'Tommy Atkins', but not 'Keitt' whereas the cold imazalil had no effect on ripening of either cultivar. Hot benomyl plus prochloraz markedly suppressed

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Table 1. 'Tommy Atkins' mangos-combination heated water/fungicide dips (1987) for decay control.

Treatment[z]	Days to soften	% ripe color	Lenticel spotting index[y]	Scald index[y]	Flesh breakdown index[y]	Decay index[y]		% probable acceptability
						Anth[x]	SER[x]	
Unheated dips 25-32°C/20 sec.								
Water (3 min.)	10.6	93.6	1.3	1.0	2.0	4.1	2.6	40.4
0.2% benomyl	10.9	95.9	1.8	1.0	1.8	3.6	2.1	50.5
0.2% imazalil	10.0	91.2	1.8	1.0	2.5	3.1	2.0	58.6
0.2% prochloraz	11.2	92.2	2.1	1.0	1.8	2.0	2.2	68.1
0.05% prochloraz	11.1	93.1	1.6	1.0	1.8	2.0	3.1	52.5
0.05% benomyl + 0.05% prochloraz	11.3	92.4	1.9	1.0	1.6	2.4	2.6	64.9
Heated dips 128°/3 min.								
Hot water	10.8	98.1	3.7	1.0	2.1	1.6	1.7	78.6
0.2% benomyl	10.5	93.5	3.8	1.3	1.9	2.4	1.5	77.8
0.2% imazalil	9.1	95.2	4.5	8.6	4.3	1.0	2.1	0.0
0.2% prochloraz	11.6	82.6	4.7	1.9	2.1	1.3	1.9	66.7
0.05% prochloraz	10.3	98.3	3.2	1.2	2.0	1.3	1.5	85.9
0.05% benomyl + 0.05% prochloraz	11.1	39.0	5.9	2.5	2.4	2.2	1.5	47.5

[z]Mean percentages for the treatments were based on four replications, repeated three times.
[y]Injury and decay were rated on a scale of 1 to 9 with 1 = none, 3 = trace, 5 = slight, 7 = moderate and 9 = severe.
[x]"Anth" = anthracnose and "SER" = stem-end rot.

coloring for 'Tommy Atkins', whereas hot water enhanced coloring for 'Keitt'. All treatments increased lenticel spotting. Cold benomyl plus prochloraz on 'Keitt' mangos was more severe for spotting than the other unheated treatments. However, limited spotting was much more pronounced with the hot treatments than with the unheated treatments. Scald injury from the hot treatments was more serious on 'Keitt' fruit, than on 'Tommy Atkins'. Scald injury was very serious with the hot imazalil dip and was more severe on 'Tommy Atkins' than 'Keitt'. Flesh breakdown developed in both heated and unheated dip treatments of 'Tommy Atkins' mangos but none developed in any 'Keitt' fruit. Anthracnose was not severe on either cultivar during this season, as shown in Tables 1 and 2, but was higher in the 'Keitt'. Several factors accounted for the low incidence of disease, an abnormally dry summer and disease tolerance in 'Tommy Atkins'. Heated treatment for 3 min at 53°C in tap water, benomyl, imazalil, prochloraz, or benomyl plus prochloraz satisfactorily controlled anthracnose after 16 days storage at 13°C. Dip treatment of mature green 'Tommy Atkins' and 'Keitt' mangos for 20 sec in unheated benomyl, imazalil, prochloraz, and benomyl plus prochloraz at 26-32°C provided no control of anthracnose after storage for 16 days at 13°C. Overall percent acceptability was 85.9 for 'Tommy Atkins' dipped in hot prochloraz while that of the 'Keitt' fruit dipped in hot water, benomyl, and 0.2 and 0.05% prochloraz was 86.4, 83.6, 87.7, and 85.2 percent, respectively. The increase in

Table 2. 'Keitt' mangos-combination heated water/fungicide dips (1987) for decay control.

Treatment[z]	Days to soften	% ripe color	Lenticel spotting index[y]	Scald index[y]	Flesh breakdown index[y]	Decay index[y]		% probable acceptability
						Anth[x]	SER[x]	
Unheated dips 25-32°C/20 sec.								
Water (3 min.)	7.7	46.2	1.8	1.0	1.0	5.6	3.2	28.4
0.2% benomyl	8.0	42.7	2.4	1.0	1.0	4.2	1.8	61.7
0.2% imazalil	7.7	34.1	2.1	1.0	1.0	2.2	1.5	80.2
0.2% prochloraz	7.1	36.2	2.5	1.1	1.0	1.9	2.2	75.3
0.05% prochloraz	8.9	44.1	2.6	1.0	1.0	2.9	2.5	64.2
0.05% benomyl + 0.05% prochloraz	8.3	44.6	3.5	1.0	1.0	2.6	2.0	75.3
Heated dips 128°/3 min.								
Hot water	8.0	50.1	2.8	1.1	1.0	1.9	1.7	86.4
0.2% benomyl	8.1	45.4	5.1	1.7	1.0	1.9	1.5	83.6
0.2% imazalil	8.1	34.3	5.0	4.6	1.0	1.0	1.1	54.3
0.2% prochloraz	7.4	31.2	5.0	2.5	1.0	1.1	1.2	87.7
0.05% prochloraz	8.7	47.6	4.2	1.6	1.0	1.4	1.5	85.2
0.05% benomyl + 0.05% prochloraz	8.8	42.2	7.0	4.0	1.0	1.2	1.4	61.7

[z]Mean percentages for the treatments were based on four replications, repeated three times.
[y]Injury and decay were rated on a scale of 1 to 9 with 1 = none, 3 = trace, 5 = slight, 7 = moderate and 9 = severe.
[x]"Anth" = anthracnose and "SER" = stem-end rot.

mango anthracnose control with hot benomyl, hot prochloraz and hot water supports reports by others (2, 3, 6, 7, 8, 10, 11, 12, 14). However, none of the researchers reported injury with hot imazalil or hot prochloraz as was noted in this study. Injury with hot imazalil at 0.2% was very serious. However, in previous studies (13) hot imazalil at 0.1% controlled anthracnose without injury to the mangos. In spite of the use of several of these fungicides (3, 6, 7, 10, 14) further studies are necessary to answer the questions of disease control and fruit injury in relation to fungicide concentration and water temperature. These data are not to be construed as a postharvest mango anthracnose control recommendation until cleared for this purpose by State and Federal regulatory agencies.

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INFLUENCE OF HIGH-TEMPERATURE CONDITIONING ON PEEL INJURY AND DECAY OF WAXED OR FILM WRAPPED FLORIDA GRAPEFRUIT AFTER LOW-TEMPERATURE STORAGE[1]

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Abstract. **Grapefruit (*Citrus paradisi* Macf.) waxed or film-wrapped were conditioned (CON) for 72 hr at 34°C, 95% RH (HiRH) or at 34°C, 30% RH (LoRH) or were nonconditioned (NONCON). Postcuring storage was 4 weeks at 10, 4 or 1°C for NONCON fruit and 4 or 1°C for CON fruit followed by 1 week at 21°C. CON fruit tended to have less chilling injury (CI) than NONCON fruit after 3 or 4 weeks' cold treatment at 4 or 1°C. NONCON fruit stored at 10°C generally had the least CI and NONCON stored at 1 and 4°C tended to have the most, compared to other treatments. There was no significant difference ($P < 0.05$) in CI for NONCON or CON (HiRH or LoRH) fruit held at 1 or 4°C, but after 3 or 4 weeks' storage, CON fruit tended to have less CI than similarly held NONCON fruit. CON fruit stored at 1°C had higher incidences of penicillium rot than those stored at 4°C or NONCON fruit stored at 10°C after the total 5 weeks' storage regime. CON fruit stored at 1 or 4°C were consistently less fresh (higher freshness index values) than NONCON fruit stored at 10, 4 or 1°C. Film wrapping reduced weight loss, maintained fruit freshness, reduced pitting, and reduced the development of penicillium rot compared to waxed fruit. Although conditioning tended to reduce CI compared to nonconditioning of fruit during low-temperature storage, the incidences of CI that developed were excessively high and did not significantly reduce decay development.**

Prolonged exposure of grapefruit to low-temperature postharvest storage usually results in chilling injury (CI) manifested as rind pitting or rind discoloration (scald). The principal objectives of developing methods to store grapefruit at low temperature are 1) prevent development of CI, 2) reduce decay (16), and 3) maintain fruit freshness and flavor. Mold rots caused by *Penicillium* spp. are the most prevalent postharvest decays of Florida citrus fruit (17). Recently, low-temperature treatments are replacing ethylene dibromide (EDB) for control of insect pests, such as the Caribbean fruit fly in postharvest storage. Alternative methods that provide successful quarantine treatments without causing CI are needed. Japan is a major importer of Florida grapefruit; 9.2 million boxes or 22% of Florida fresh market grapefruit for the 1986-1987 season. Most of the grapefruit exported to Japan from Florida will require

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