Comparison of Hot-Water Spray and Immersion Treatments for Control of Postharvest Decay of Papaya

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ABSTRACT

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An experimental hot-water spray treatment (54 C) for 3 min was as effective as the commercial immersion treatment (48 C) for 20 min in controlling postharvest diseases of papaya fruits. The treatments were evaluated after simulated transit periods of 7 and 14 days at 10 C. Stem-end rots and anthracnose were controlled adequately both by spray and immersion treatments. A post-heat-treatment application of thiabendazole further reduced disease incidence both in sprayed and immersed fruits.

Stem-end rots and anthracnose continue to cause major postharvest losses of papayas during storage and shipment (4). Immersion of papayas in hot water (48 C) for 20 min has been the principal postharvest treatment for decay control since about 1964, when this method was first applied on an industry-wide scale (2). Adequate decay control during marketing is achieved for air shipments, provided 1) orchards are sprayed regularly to keep field infections at a low level, 2) the temperature in the hot-water dip tank is carefully regulated, and 3) fruit is refrigerated and marketed within 7–10 days of harvest (1,3,5,8). To improve handling efficiency, a hot-water spray system was designed by Hundtoft and Akamine (7,8). However, no attempt was made to determine the effect of the spray system on decay control or to compare the hot-water spray with commercially used immersion methods for control of specific postharvest diseases.

Because industry was reluctant to adopt a hot-water spray method without further testing, we compared the spray treatment with the standard immersion method, alone and in combination with postharvest fungicide treatments, and determined types and levels of disease in simulated surface shipments of 7–14 days in cold storage at 10 C.

MATERIALS AND METHODS

The optimum combinations of time and temperature variables for the spray treatment were selected on the basis of previous studies (6–8). Fruit temperatures immediately after treatment were obtained by inserting thermocouples 4 mm below the fruit surface. Papaya fruits at colorbreak to one-fourth ripe were selected from field bins, randomized into packing cartons (20 fruits per treatment sample), and treated by 1) hot-water spray (54 C), 1.5 min; 2) hot-water spray, 3 min; 3) hot-water immersion (48 C), 20 min followed by a 20-min cold-water

Table 1. Postharvest hot-water treatments to control decay of papaya fruit

Treatment[v]	Disease-free (%)	Stem-end rot[w] (%)	Anthracnose (%)	Other rots (%)	Fruit color[x] (rating)
Storage 7 days (eight replicates)					
No treatment	43.5 a[y]	50.8 a	7.8 a	10.4 a[z]	7.4 a
Hot water					
Spray, 1.5 min	88.2 b	9.8 b	0.0 c	2.9 b	7.3 b
Spray, 3 min	87.5 b	9.8 b	0.6 c	1.8 b	6.3 b
Immersion	85.2 b	5.6 c	2.4 b	9.3 a	5.6 c
Storage 14 days (nine replicates)					
No treatment	21.5 a	65.5 a	16.03 a	17.5 a	7.4 a
Hot water					
Spray, 1.5 min	56.0 b	37.0 b	5.5 b	5.0 b	7.0 b
Spray, 3 min	68.5 b	26.0 bc	3.0 b	21.0 a	6.6 c
Immersion	54.0	18.0 c	6.5 b	29.5 a	6.7 c

[v] Spray treatment was at 54 C for 1.5 and 3 min and immersion treatment was at 49 C for 20 min. The 7- and 14-day simulated transit periods at 10 C were separate experiments.

[w] *Ascochyta caricae-papayae, Botryodiplodia theobromae, Phomopsis* sp., *Fusarium* sp., and *Colletotrichum gloeosporioides*.

[x] 0 = Mature green and 9 = full ripe.

[y] Means within an experiment not followed by the same letter are significantly different at $P = 0.05$ according to Duncan's multiple range test.

[z] Mostly *Stemphylium* sp.

Table 2. Papaya fruit temperatures measured by thermocouples placed 4 mm below the fruit surface immediately after exposure to hot-water treatment

Application method	Hot-water treatment: Time (min)	Hot-water treatment: Temperature (C)	Subsurface temperature of papaya fruit (C)
No treatment	...	...	22.2 ± 0.3
Spray	1.5	54	43.0 ± 0.3
Spray	2.0	54	44.2 ± 0.3
Spray	2.5	54	45.2 ± 0.2
Spray	3.0	54	45.6 ± 0.2
Immersion	20.0	49	45.2 ± 0.2

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Table 3. Postharvest disease control using hot-water treatments combined with thiabendazole

Treatment[u]	Disease free (%)	Stem-end rot (%)	Anthracnose[v] (%)	Chocolate spot[v] (%)	Other rots[w] (%)
		Experiment 1			
No thiabendazole					
No heat	36.7 a[x]	55.0 a	4.4 a	...	5.6 ab[y]
Spray	61.7 bc	32.2 b	6.1 a	...	3.3 a
Immersion	50. 6 ab	23.3 bc	5.5 a	...	15.0 b
With thiabendazole					
No heat	63.9 bcd	30.0 b	2.2 a	...	3.9 ab
Spray	81.1 d	13.3 cd	3.3 a	...	3.3 a
Immersion	76.7 cd	6.7 d	4.4 a	...	13.9 b
		Experiment 2			
No thiabendazole					
No heat	3.3 a	91.7 a	34.2 a	43.3 a	10.8 a[z]
Spray	16.7 ab	69.2 b	25.8 a	18.3 bc	5.0 ab
Immersion	21.7 b	60.0 b	26.7 a	24.2 b	11.7 a
With thiabendazole					
No heat	54.2 c	15.8 c	23.3 ab	5.0 d	6.7 ab
Spray	72.5 c	0.0 d	19.2 ab	7.5 d	0.8 b
Immersion	84.2 d	0.8 d	5.8 b	5.0 d	8.3 ab

[u] Thiabendazole concentration about 4 mg/kg fruit. Hot-water spray treatment was at 54 C for 1.5 min in Exp. 1 and at 54 C for 3 min in Exp. 2. Hot-water immersion treatment was at 49 C for 20 min. Storage temperature and time was 10 C for 14 days. Each experiment was replicated six times.

[v] *Ascochyta caricae-papayae, Botryodiplodia theobromae, Phomopsis* sp., *Fusarium* sp., and *Colletotrichum gloeosporioides.*

[w] Both symptom types caused by *C. gloeosporioides.* Chocolate spot symptom was prevalent only in Exp. 2.

[x] Means within an experiment not followed by the same letter are significantly different at $P = 0.05$ according to Duncan's multiple range test.

[y] Mostly *Stemphylium* sp.

[z] Mostly *Phomopsis* and other rots.

spray; and 4) no treatment. For combination fungicide-heat treatments, thiabendazole (98% a.i.) was suspended at 4 g/L in a 1:1,000 dilution of a food-grade xanthan gum (Keltrol, Kelco Division, Merck & Co., Rahway, NJ). Thiabendazole was applied at 0.5 ml per papaya with a jet pipette as described by Couey and Farias (6). This method provided a uniform application of the fungicide, which resulted in a final thiabendazole concentration of about 4 mg/kg of fruit. After treatment, the fruit was stored at 10 C for 7 or 14 days. Papayas were removed to a ripening room held at room temperature (20–25 C) for 7 days and evaluated for disease incidence. Because more than one type of decay may occur on a single fruit, the percentages will not total 100.

When disease incidence was high, the *Colletotrichum gloeosporioides* rots were divided into two symptom types, anthracnose and chocolate spot. Fruit color was evaluated on a scale of mature green equal to zero to full ripe equal to 9.

RESULTS AND DISCUSSION

The hot-water spray treatment controlled disease as effectively as the hot-water immersion treatment after simulated transit periods of 7 and 14 days at 10 C (Table 1). The immersion treatment and the 3-min spray were more effective against the stem-end rot complex than the 1.5-min spray treatment, but the fruit treated by immersion and the 3-min spray methods had an increase in Stemphylium rot that may have resulted from heat injury. Both heat treatments slightly inhibited color development. Extensive experience with the commercial hot-water immersion treatment has shown that heat injury, usually in the form of superficial scald, occasionally occurs (1). We believe inhibition of color development and increased susceptibility to Stemphylium rot are more subtle forms of heat injury.

Achieving proper fruit temperature is important in effective disease control (Table 2). An effective heating system must have sufficient heat input to compensate for the heat lost to the fruit and environment. Futhermore, the flow of water over the fruit must be sufficient to achieve a high rate of heat transfer. In our experiments, these conditions were met by providing an excess of hot water in the reservoir and by pumping at a rate of 50 L/m^2 of conveyor surface per minute. We estimate that each fruit was exposed to 1 kg of water during the 1.5-min exposure. These factors are discussed in detail by Hundtoft and Akamine (8).

Application of thiabendazole to fruit immediately after heat treatment reduced stem-end rot, anthracnose, and chocolate spot but had no effect on Stemphylium rot. The reduction of anthracnose and chocolate spot were only apparent when the incidence of these diseases was high on the untreated control (Table 3, experiment 2). Thiabendazole was also effective for postharvest control of anthracnose in previous tests (6) when high levels of anthracnose occurred on untreated control fruits (25–44%). Thiabendazole alone was as effective as any of the hot-water treatments alone.

These experiments demonstrate that when carefully applied, a short hot-water spray treatment is as effective as the commercially used, hot-water immersion treatment for decay control in papaya. When combined with thiabendazole, both treatments substantially reduced disease, even after a 7-day ripening period that was longer than the usual commercial practice (8). It is likely that the hot-water spray treatment combined with thiabendazole will provide adequate decay control and reduce treatment costs because of the efficient use of the heat.

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