

## QUALITY OF CARAMBOLAS SUBJECTED TO HOT WATER IMMERSION QUARANTINE TREATMENT

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*Additional index words.* Caribbean fruit fly, *Anastrepha suspensa* (Loew), *Averrhoa carambola* L.

**Abstract.** Hot water immersion has been developed as a quarantine treatment for carambolas, *Averrhoa carambola* L., infested with the Caribbean fruit fly, *Anastrepha suspensa* (Loew) (Diptera: Tephritidae). This paper reports the effects of that treatment on market quality of carambolas. Tart carambolas became soft and discolored a few days after immersion in hot water. The sweet cv. Hew 1 became spotted 15 min after the treatment, but nine other sweet cultivars suffered no immediate adverse effects after hot water immersion at 43.3-46.4°C for 55-85 min or 46-46.4°C for 35-55 min. However, shelf life of treated sweet carambolas was reduced 1-4 days. 'Arkin' carambolas did not tolerate immersion in 49°C water for 25 min. Total acids and soluble solids were not affected by hot water immersion.

A hot water immersion quarantine treatment for carambolas, *Averrhoa carambola* L., infested with Caribbean fruit fly, *Anastrepha suspensa* (Loew) (Diptera: Tephritidae), has been developed whereby the fruit are submerged at 46-46.4°C (114.8-115.5°F) for 45 min (3). That treatment reduced the shelf life of carambolas by 1-4 days, and it damaged tart carambolas (which contain five times the oxalic acid of sweet carambolas) and the sweet cultivar 'Hew 1' (3). This research reports on the quality of carambolas subjected to different temperature and time hot water immersions.

### Materials and Methods

Carambolas used in the studies were from J. R. Brooks & Son, Inc., Homestead, Florida, ('Arkin', 'Golden Star', 'Star King') and the Subtropical Horticulture Research Station (SHRS), Miami, Florida ('Arkin', 'Demak', 'Sri-Kembangan', 'Butts Dwarf', 'Key West', 'Hew 1', 'Hart', 'Fwang Tung', 'B 10', and 'Wheeler'). 'Golden Star' and 'Star King' are tart cultivars, the rest are sweet.

Twenty-five to thirty undamaged, freshly picked carambolas of each cultivar were immersed for 25-85 minutes in a water bath (Model 260, Precision Scientific, Inc., Chicago, IL) or a hot water immersion appliance (5) containing water at 43.3-43.7°C (110-111°F), 46-46.4°C (115-116°F), and 49-49.4°C (120-121°F). Treated and control (untreated) carambolas were subsequently stored at 13°C (55°F) for 7-17 days and then held at 23°C (73°F) to induce ripening. Observations on color, ripening, softness, and decay were made. When the carambolas ripened they were sliced to observe internal appearance, and informal taste tests were performed by personnel of the SHRS. Total acids and soluble solids were determined by titration and refractometry (Abbe Model refractometer, Fisher Scien-

tific Company, Pittsburg, PA), respectively, according to standard methodology (1). Color was quantified in the Judd-Hunter system (2) using a colorimeter calibrated with a white #05-1456 standard (Pacific Scientific, Colorgard System, Model 05, Silver Spring, MD). Data resulting from Judd-Hunter measurements are Lh, which measures intensity from 0 (black) to 100 (white), ah, which measures green (negative value) to red (positive value), and bh, which measures blue (negative value) to yellow (positive value). Tests were repeated, and data were analyzed using the ANOVA and GLM procedures (4).

### Results and Discussion

The tart carambolas 'Golden Star' and 'Star King' did not tolerate immersion in water at any of the time-temperature combinations used. One to three days after treatment these cultivars turned a dull yellow compared to the normal yellow of ripe carambolas. In the Judd-Hunter color system, the color of heated 'Golden Star' (mean  $\pm$  standard deviation) was: Lh = 47.0  $\pm$  10.3; ah = -2.42  $\pm$  1.46; bh = 14.7  $\pm$  3.84. The color of ripe, untreated 'Golden Star' was: Lh = 43.4  $\pm$  9.20; ah = 0.42  $\pm$  4.80; bh = 20.9  $\pm$  4.88. Heat treated tart carambolas also became soft, yielding to gentle pressure, at the same time as the color changed. Untreated tart carambolas remained fairly firm until they began to rot; however, they rotted about 25% faster than treated tart carambolas. When ripe, heat treated 'Golden Star' and 'Star King' carambolas were homogenized in a blender, the homogenate readily separated into two parts: a white, particulate fraction which floated on a pale yellow-green liquid. Ripe, untreated tart carambolas and both heat treated and untreated ripe 'Arkin' (a sweet cv.) carambolas yielded a uniform pale orange liquid upon homogenization which did not readily separate.

The sweet cv. Hew 1 developed brown spots over the fruit surface about 15 minutes after removal from the hot water at all time-temperature combinations. Hot water immersed carambolas of the other sweet cvs. tested were indistinguishable from the untreated controls during storage

Table 1. Number of days to 50% of carambolas still marketable at 23°C after immersion in water at 46-46.4°C for 40 min followed by storage at 13°C for 12 days.

Cultivar	Days to 50% marketability	
	Untreated <sup>z</sup>	Treated <sup>z</sup>
Arkin	10 a	8.2 a
Demak	10 a	6.3 ab
Wheeler	9 a	6.5 ab
Butts Dwarf	9 a	6.0 ab
Key West	8 a	6.0 ab
Fwang Tung	8 a	6.0 ab
Hart	8 a	6.0 ab
Sri Kembangan	8 a	6.0 ab
Hew 1	8 a	3.3 b

<sup>z</sup>Means followed by the same letter within columns are not significantly different at the 5% level, Tukey's HSD Test, 2-3 replicates per cv.

Table 2. Number of days to 50% of 'Arkin' carambolas still marketable at 23°C after hot water immersion treatments and subsequent storage at 13°C for 12 days.

Treatment	Days to 50% marketable <sup>2</sup>
Untreated	11.0 a
43.3-43.7°C for 85 min	7.8 b
46-46.4°C for 55 min	7.6 b
49-49.4°C for 40 min	3.5 c

<sup>2</sup>Means followed by the same letter are not significantly different at the 5% level, Tukey's HSD Test.

at 13°C (55°F). However, the shelf life of these cvs. was reduced upon placement at room temperatures (Table 1). The shelf life of treated 'Hew 1' was reduced more than the other cvs. because anthracnose initiated at the brown spots shortly after removal from cold storage.

Shelf life of heat treated 'Arkin' carambolas was reduced compared to the control at three temperature-time combinations (Table 2). Number of days to 50% marketability at 49-49.4°C was significantly shorter than the other two treatments studied. 'Arkin' carambolas immersed at that temperature for 25-40 minutes developed round black spots 1-3 days after treatment. The damage was different than that observed on 'Hew 1' immersed at 46-46.4°C; on 'Hew 1' the blemishes had irregular borders and were not as dark. There were no significant differences in number of days to 50% marketability for 'Arkin' carambolas immersed in 43.3-43.7°C water for 85 minutes and 46-46.4°C water for 55 minutes (Table 2).

Softening of heat treated sweet carambolas was directly proportional to ripening and decay. Unlike tart carambolas, sweet carambolas did not turn soft as a direct result of hot water immersion.

Hot water immersion did not affect the Judd-Hunter color readings of 'Arkin' carambolas (Table 3). Although there sometimes were tendencies for treated sweet carambolas to appear slightly advanced in ripening (turning yellow) or acquire a slightly darker yellow tone, those subtle differences were not statistically substantiated from colorimeter readings.

Table 3. Color ratings (Judd-Hunter system) for ripe 'Arkin' carambolas subjected to hot water immersion followed by storage at 13° for 14 days and 23°C until ripe.

Treatment	Lh <sup>2</sup>	ah <sup>2</sup>	bh <sup>2</sup>
Untreated	44.23	-0.32	19.68
43.3-43.7°C for 85 min	44.24	0.42	20.44
46-46.4°C for 55 min	43.40	-0.04	19.45

<sup>2</sup>No significant differences at the 5% level.

Table 4. Acid content (ml 0.1N NaOH per 100 g of fruit) and percentage soluble solids of 'Arkin' carambolas subjected to hot water immersion treatments.

Treatment	ml 0.1N NaOH <sup>2</sup>	% soluble solids <sup>2</sup>
43.3-43.7°C for 85 min	63.2	8.3
46-46.4°C for 55 min	62.0	7.9
46-46.4°C for 35 min	61.5	8.0
43.3-43.7°C for 70 min	60.6	7.9
43.3-43.7°C for 55 min	57.3	8.0
Untreated	56.9	7.6
46-46.4°C for 45 min	56.0	7.9

<sup>2</sup>No significant differences at the 5% level.

There were no significant differences in total acids or soluble solids among different time-temperature hot water immersion treatments and untreated (control) 'Arkin' carambolas (Table 4).

Interior appearance and taste of sliced, sweet carambolas were not affected by hot water immersion. Heated, sliced tart carambolas were a dull yellow on the inside (similar to the peel color), but tasted the same (very acidic) as untreated tart carambolas.

In conclusion, tart carambolas did not tolerate hot water immersion. Hallman and Sharp (3) noted that tart carambolas comprise a small and declining share of the fresh market. Of 10 sweet cultivars tested only 'Hew 1' did not tolerate hot water immersion. Currently, 'Hew 1' comprises an insignificant share of the carambola market. If the hot water immersion quarantine treatment is to be used in the future, growers should be discouraged from planting 'Hew 1'. Other potential carambola cultivars should be tested for tolerance to hot water immersion before a decision is made to plant them in commercial groves. The other nine sweet cultivars tested tolerated hot water immersions at 46-46.4°C or lower, but did not tolerate treatment at 49-49.4°C. However, shelf life of treated carambolas was reduced significantly.

#### Literature Cited

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