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Quality of Carambolas Subjected to Postharvest Hot Water Immersion and Vapor Heat Treatments

Guy J. Hallman
U.S. Department of Agriculture, Agricultural Research Service, Subtropical Horticulture Research Station, 13601 Old Cutler Road, Miami, FL 33158

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Abstract. **'Arkin' carambolas *(Averrhoa carambola* L.) were subjected to the fruit fly quarantine treatments of hot water immersion at 43.3 to 43.6C for 55 or 70 rein, 46.0 to 46.3C for 35 or 45 rein, or 49.0 to 49.3C for 25 or 35 rein, or vapor heat at 43.3 to 43.6C for 90 to 120 rein, 46.0 to 46.3C for 60 or 90 rein, or 49.0 to 49.3C for 45 or 60 min. Marketability, color, weight loss, internal appearance, flavor, total acids, and soluble solids content were determined. The 49.0 to 49.3C treatments resulted in excessive damage to the carambolas 2 to 4 days after treatment. There were no statistically significant differences in the variables measured among the other treatments and control; however, heat-treated carambolas appeared duller in color than control fruits. Overall, fruit treated at 46.0 to 46.3C lost significantly more weight than that treated at 43.3 to 43.6C.**

Carambolas grown in Florida must be treated to kill eggs and larvae of Caribbean fruit fly *[Anastrepha suspensa* (Loew)] if they are to be shipped to areas where the fly does not exist and might become established. Research on quarantine treatments for carambolas infested with the Caribbean fruit fly has been completed for hot water immersion (Hallman and Sharp, 1990) and vapor heat (Hallman, 1990b). A hot water immersion quarantine treatment of 46.0 to 46.4C for 45 min has been reported to reduce the market life of 'Arkin' carambolas significantly (Hallman, 1990a; Hallman and Sharp, 1990). In a separate study, the recommended vapor heat treatment of 46.0 to 46.3C for 90 min did not reduce market life of 'Arkin' compared with untreated fruits (Hallman, 1990b). We directly compared the effects of hot water immersion and vapor heat quarantine treatments on quality and market life of carambolas.

Mature 'Arkin' carambolas weighing 50 to 215 g were obtained from a commercial grower on four dates (replicates) between Oct. and Dec. 1989.

Previously described vapor heat and hot water immersion equipment were used to treat the carambolas (Hallman, 1990b; Hallman and Sharp, 1990). Carambolas were weighed and then immersed in water at 1) 43.3 to 43.6C for 55 or 70 rein, 2) 46.0 to 46.3C for 35 or 45 rein, or 3) 49.0 to 49.3C for 25 or 35 min. Carambolas from the same lot were simultaneously weighed and treated with vapor heat at 1) 43.3 to 43.6C for 90 or 120 rein, 2) 46.0 to 46.3C for 60 or 90 rein, or 3) 49.0 to 49.3C for 45 or 60 min. At the same temperature, more time is required to achieve quarantine security with vapor heat than with hot water immersion (Hallman, 1990b; Hallman and Sharp, 1990). Forty carambolas were used per treatment (including an untreated control) in each replicate.

Every 2 to 3 days the carambolas were rated for visual quality (marketability). A

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carambola was discarded if ≥10% of the surface area (not including rib edges) was discolored due to aging, damage, or disease.

when the carambolas were ripe (yellow-orange peel) color was quantified with a calorimeter (model CR-200, Minolta, Osaka, Japan) in the Judd-Hunter system (Francis, 1980). Twenty readings were taken per treatment using a light projection tube with a 22-mm-diameter tip and holding the tip flat on the sides of ribs. Rib sides were selected randomly with the exception that damaged, diseased, or otherwise discolored surfaces were excluded.

After the color readings were made, the carambolas were weighed and sliced to observe internal appearance. Informal sensory tests (normal or abnormal flavor being recorded) were conducted by personnel of the Subtropical Horticulture Research Station. Carambola tissue (50 g), including peel, was taken from seven randomly chosen carambolas in each treatment for total acid analysis by titration to pH 8.1 with 0.1 N NaOH (Assn. Official Analytical Chemists, 1984). Five of the seven fruit were selected to determine content of soluble solids (SSC) using a refractometer (Abbe, Fisher Scientific, Pittsburgh).

All quantitative data were subjected to analysis of variance (SAS Institute, 1985).

Carambolas exposed to hot water immersion or vapor heat at 49.0 to 49.3C showed considerable brown spotting and scalding 2 to 4 days after treatment and were considered unmarketable. They were not subjected to further analyses.

The data were analyzed as a 2 x 2 x 2 factorial (excluding the control), with the factors being treatment type (hot water immersion and vapor heat), temperature (43.3 to 43.6 and 46.0 to 46.3 C), and time (short and long). A significant (95% confidence level) treatment type × time interaction was found for the b value of color (F value = 14.84). The b value was significantly higher (more yellow) for the long vapor heat treatments (22.5) than for the short ones (20.6).

Fruit treated at 43.3 to 43.6C lost significantly less (99% confidence level) weight (4.3%) than that treated at 46.0 to 46.3C (5.0%) (F value = 35.9).

When the control was included and the analyses were treated as randomized complete blocks, there were no significant differences among the means for any of the factors quantified (median shelf life 9.5 ± 0.1 days; weight loss 4.6 ± 0.2 days; color values L, 44.4 ± 0.4; a, 1.37 ± 0.04; b, 21.4 ± 0.3; acid content 57.1 ± 0.8 ml 0.1 NaOH/100 g tissue; SSC, 8.0% ± 0.1%). The heat-treated carambolas often appeared duller and slightly darker than the control; however, this was not substantiated by calorimeter readings. This difference was noted previously (Hallman, 1990a, 1990b).

Empirical observations on internal appearance and taste of ripe carambolas subjected to the various treatments (except to 49.0 to 49.3C, which injured the fruit) revealed no apparent differences.

The hot water immersion quarantine treatment was not more damaging to carambolas than the vapor heat treatment. In previous studies that indicated that the hot water immersion was more damaging, hot water immersion (Hallman, 1990a; Hallman and Sharp, 1990) of the carambolas was followed by cold storage, whereas in the study with vapor heat (Hallman, 1990b) the treated carambolas were not cold stored. Also, temporal variations could account for previously reported differences in response of carambolas to the two quarantine treatments; the previously cited hot water immersion studies had been performed from Sept. 1988 to Feb. 1989, but the vapor heat studies were performed in Sept. 1989.

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