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Tolerance and Responses of Harvested Mango to Insecticidal Low-oxygen Atmospheres

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Abstract. **'Keitt' mangoes *(Mangifera indica* L.) were stored for 0 to 5 days at 20C in a continuous flow of an insecticidal low-O_2 atmosphere (0.2% to 0.3%, balance N_2). Fruit were evaluated every day after exposure to a low-O_2 atmosphere and again after being held in air at 20C for 5 days. There was no fruit injury, organoleptic fruit quality was not lowered due to the low-O_2 atmosphere, and fruit ripened normally. These results indicate that applying low-O_2 atmospheres postharvest can be used to control insects in mangoes.**

Low O_2 concentrations (≤0.5%), alone or in conjunction with high CO_2 concentrations (≥50%), can be used to control insects in fresh horticultural crops (Brandl et al., 1983; Gaunce et al., 1982; Yahia and Vazquez-Moreno, 1993; Yahia et al., 1989, 1992). Most fresh fruit and vegetables do not tolerate these extreme atmospheres for prolonged periods (Kader and Morns, 1977), but some can tolerate them for short periods (Delate and Brecht, 1989; Ke and Kader, 1992; Yahia and Carrillo-Lopez, 1993; Yahia and Kader, 1991; Yahia and Vazquez-Moreno, 1993; Yahia et al., 1989, 1991, 1992). 'Keitt' mangoes were tolerant to insecticidal low-O_2 (0.03% to 0.26%) and high-CO_2 (70% to 80%) atmospheres for up to 5 days at 20C (Yahia and Vazquez-Moreno, 1993; Yahia et rd., 1989). The O_2 concentration is more important than that of CO_2 in reducing the time to kill insects (Brandl et al., 1983). Therefore, it would be preferable to implement only treatments based on insecticidal low-O_2 atmospheres.

The objective of this work was to determine the tolerance of mangoes to insecticidal low-O_2 atmospheres.

Mangoes were harvested at Huatabambo, Sonora, Mexico, and transported to the laboratory at Hermosillo (360 km). Fruit were sorted, cleaned, and classified by size and color. Fruit of uniform size, shape, and maturity and those free from defects were used. Respiration was measured in 10 fruit and initial quality was evaluated in 30 fruit. The rest of the fruit were stored in air or in a controlled atmosphere (CA) at 20C. A CA was achieved with a mixture of air and N_2 (0.3% O_2, balance N_2) at a rate of 250 ml·min^{-1}. Air-stored fruit were placed in corrugated boxes wrapped in low-density polyethylene film with enough holes to maintain a humid [80% to 85% relative humidity (RH)] but nonmodified atmosphere.

Individual fruit were used as replicates. A sample of 27 fruit was taken daily (for 5 days) from the CA. Nine fruit were evaluated immediately, nine were transferred to air at 20C and evaluated after 5 days, and nine were maintained in air at 20C for sensory evaluation. During each evaluation (immediately after fruit were removed from the CA and again after 5 days in air), fruit were tested for injury incidence and organoleptic quality changes. A comparable number of fruit stored continuously in air was used as the control.

Gas mixtures (O_2 and CO_2) and respiration rate (CO_2 production) of air- and CA-stored fruit were analyzed as described by Yahia et al. (1992).

Fruit were evaluated for flesh firmness and skin color. Firmness was measured as the penetration force on six pared points of each fruit using a firmness tester (model DFG 50; Chatillon & Son, New York) with an 8-mm tip. Skin color was estimated visually.

Sensory analysis was carried out on day 15 of the experiment using a balanced incomplete-block design (Cochran and Cox, 1957) with 10 untrained judges. Panelists were asked to assess the presence of external and internal injury and off-odors and off-flavors, and to evaluate the fruit for aroma, texture, flavor, skin and pulp colors, and overall acceptability, using hedonic scales of 0 to 5. Aroma, texture, and flavor were evaluated under red light to prevent bias from skin and pulp colors. The hedonic scales used by the panelists were as follows: characteristic odor and flavor, 0 = flat, 1 = very weak, 2 = weak, 3 = moderate, 4 = strong, and 5 = very strong; texture, 1 = very soft, 2 = soft, 3 = intermediate, 4 = firm, and 5 = very firm; skin color, 1 = green, 2 = slightly green, 3= slightly yellow, and 4 = yellow; pulp color, 1 = white, 2 = creamy, 3 = yellow, and 4 = orange; overall acceptability, 1 = dislike extremely, 2 = dislike moderately, 3 = neither like nor dislike, 4 = like moderately, and 5 = like extremely.

Analysis of variance and mean separations were calculated using SAS software (SAS Institute, 1988).

The O_2 content around the CA-stored fruit varied from 0.2% to 0.3% and that of CO_2 varied from 0.1% to 0.2%. This atmosphere delayed fruit ripening, as indicated by changes in respiration rate (Fig. 1), flesh firmness, and skin color (Fig. 2). The respiration rate of CA-stored fruit was low (<10 ml CO_2/kg per h) compared to that of fruit stored continuously in air (>30 ml CO_2/kg per h) (Fig. 1). CA-stored fruit suffered minimum losses in flesh firmness, while those stored continuously in air softened rapidly (from 75 to 15 N) during the frost 6 days of storage (Fig. 2). Firmness decreased significantly in CA-stored fruit when they were transferred to air at 20C and evaluated after 5 days. However, these fruit still

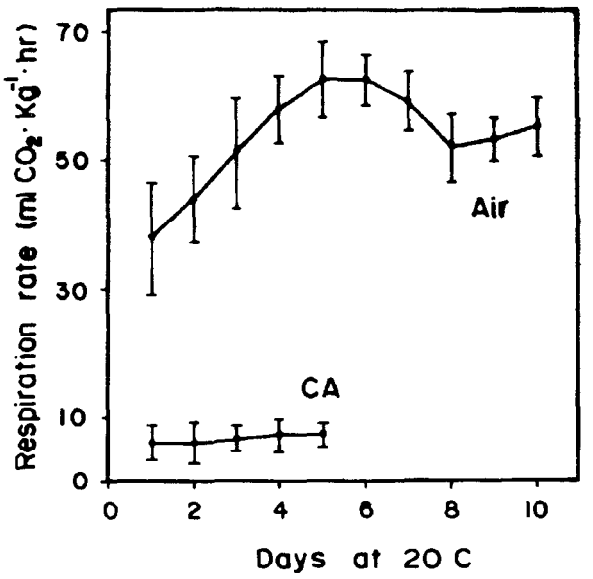

Fig. 1. Respiration rate (in milliliters of CO_2 per kilogram per hour) of mangoes stored in a controlled atmosphere (CA) (0.2% to 0.3% O_2 and 0.1% to 0.2% CO_2) or in air at 20C. Vertical bars represent the SD of the mean.

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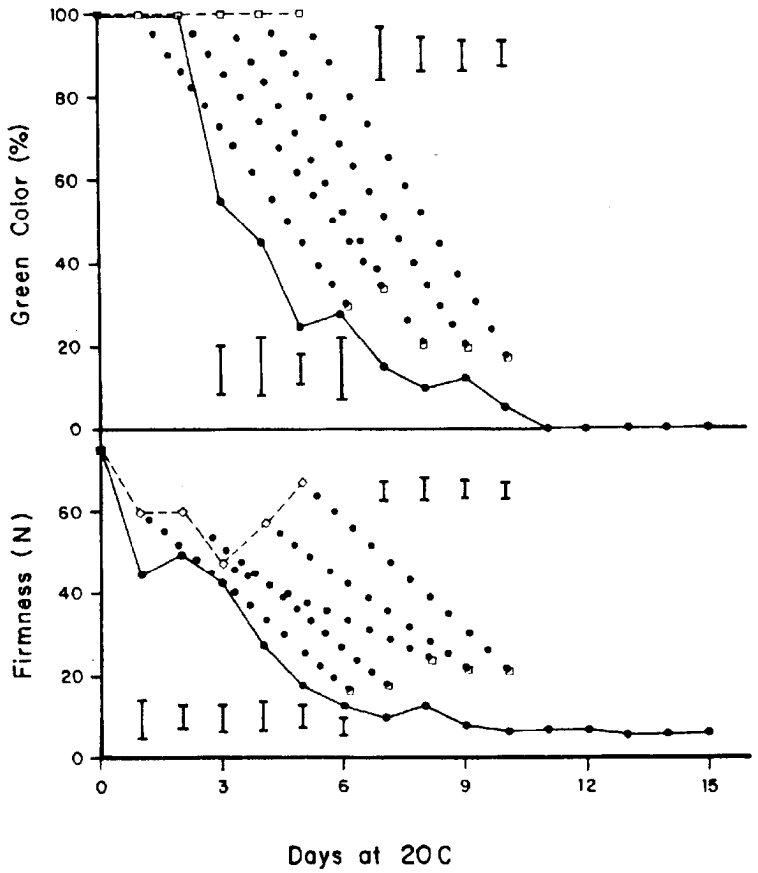

Fig. 2. Changes in green skin color (percentage) and firmness (in Newtons) of mangoes stored in air (•—•—•), a controlled atmosphere (CA) (0.2% to 0.3% O_2 and 0.1% to 0.2% CO_2) (❑), or air after storage in a CA (• • •) at 20C. Vertical bars represent least significant differences at $P \leq 0.05$.

were slightly firmer than comparable fruit stored continuously in air. Air-stored fruit lost their green color, while those stored in the CA remained green. Fruit transferred from the CA to air yellowed, but they still were slightly greener than fruit stored continuously in air. The results agree with those of other studies in which short-term storage of other fruit in a low-O_2 atmosphere decreased respiration rate, ethylene production, flesh firmness, and color losses (Ke and Kader, 1992; Yahia and Kader, 1991; Yahia et al., 1991, 1992).

The results of the sensory evaluation conducted after fruit ripened showed that there was no injury and that there were no off-flavors or off-odors. There were no differences in aroma, texture, skin and flesh color, or overall acceptability between fruit stored continuously in air and those transferred to air after storage in a CA (Fig. 3). This result indicates that the fruit suffered no injury and that their organoleptic quality was not lowered in these insecticidal atmospheres. Fruit stored in a CA for ≥3 days and then transferred to air had slightly lower flavor scores (2.5 to 3.5) than those stored continuously in air (4.0), probably because the former were less ripe at the time of the evaluation.

Based on the results reported in this study, we conclude that 'Keitt' mangoes are tolerant to insecticidal low-O_2 atmospheres (<0.5%). Although studies are needed to determine the mortality of various insects (especially fruit flies) in these atmospheres, we assume that the 5 days tolerated by mangoes are sufficient to control many important insects (Ke and Kader,

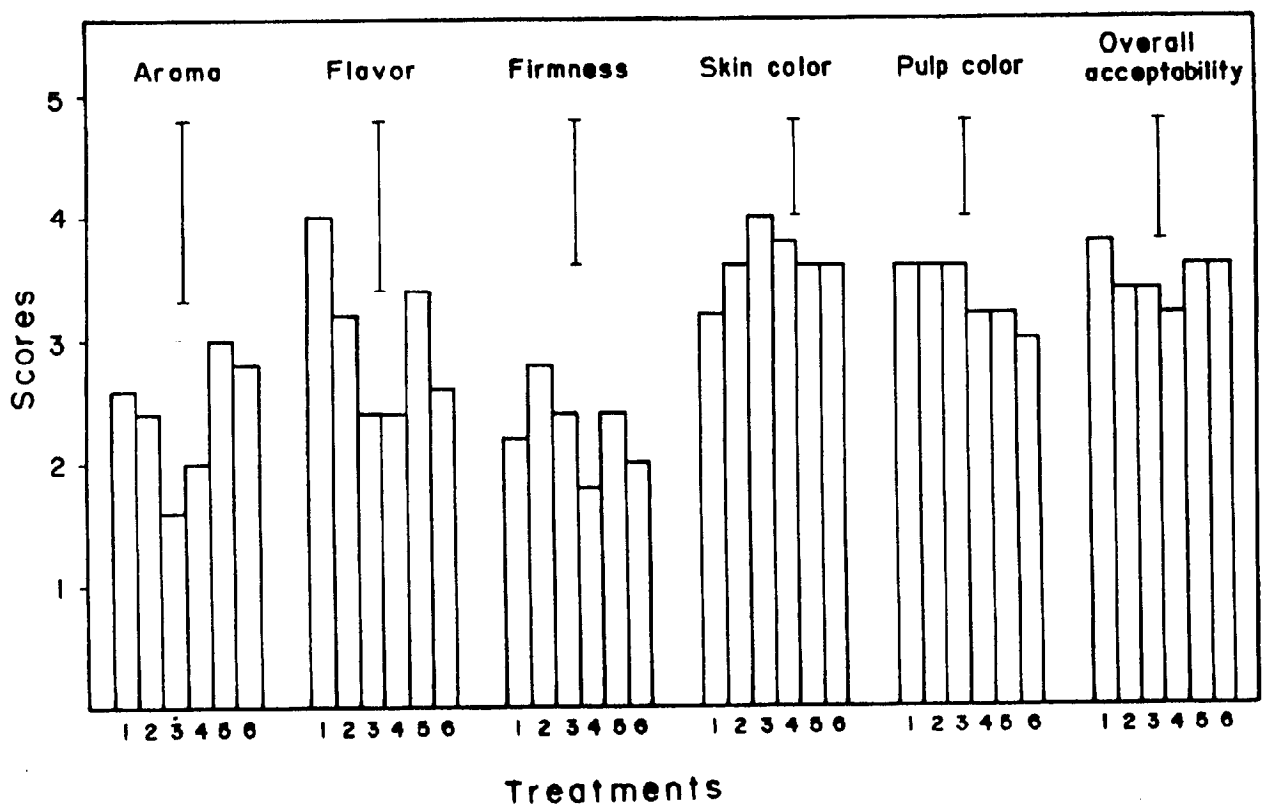

Fig. 3. Sensory evaluation scores of mangoes stored in a controlled atmosphere (CA) (0.2% to 0.3% O_2 and 0.1% to 0.2% CO_2) at 20C: 1 = 15 days in air, 2 = 1 day in a CA + 14 days in air, 3 = 2 days in a CA + 13 days in air, 4 = 3 days in a CA + 12 days in air, 5 = 4 days in a CA + 11 days in air, and 6 = 5 days in a CA + 10 days in air. Vertical bars represent least significant differences at $P \leq 0.05$.

1992). Using insecticidal atmospheres to control insects would be an excellent alternative to using existing chemical and hot-water treatments. Studies are needed to determine the tolerance levels of other mango cultivars before this treatment can be recommended for commercial use.

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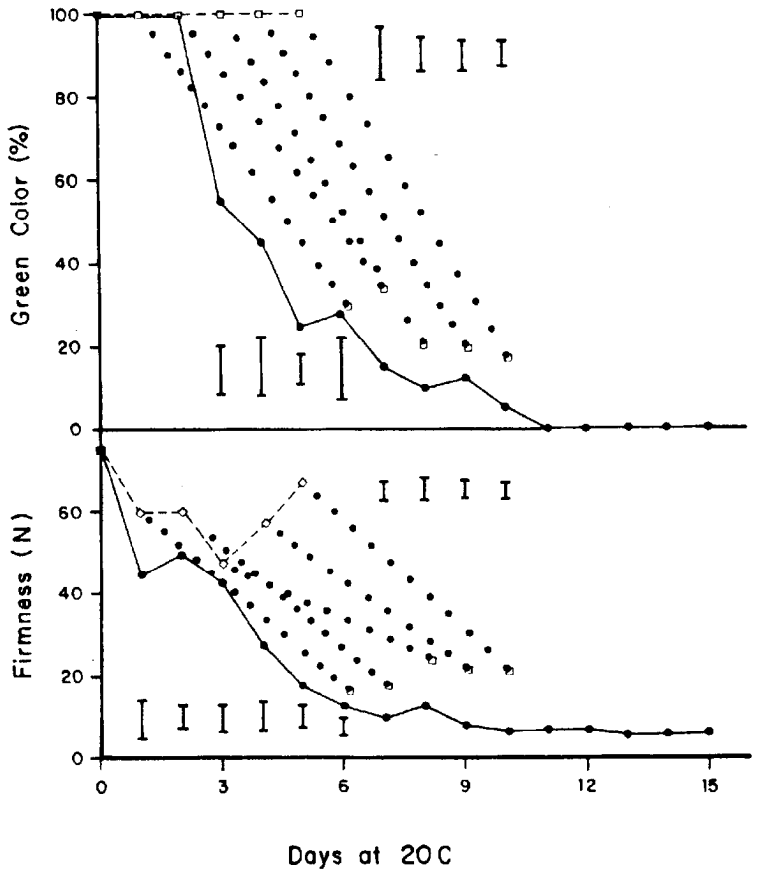

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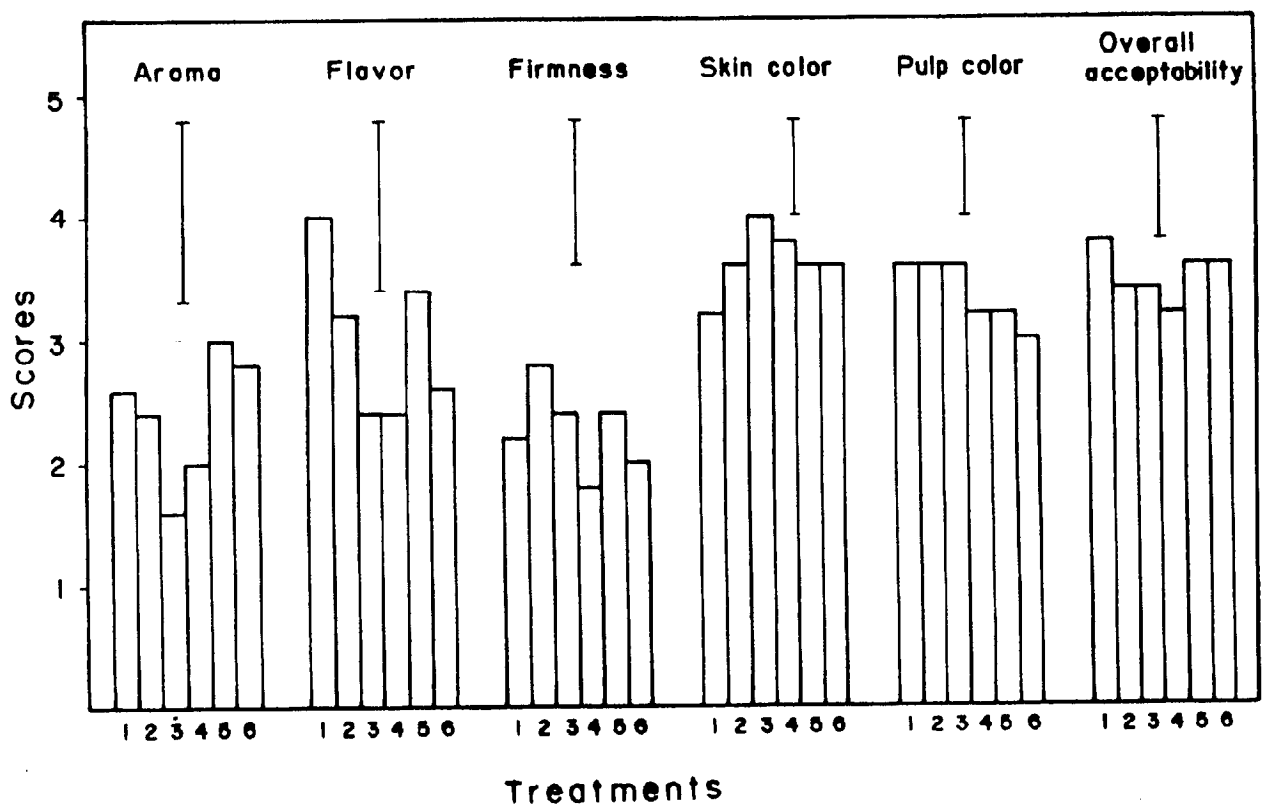

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