Postharvest Response of Winter Squash to Hot-water Treatment, Temperature, and Length of Storage

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Summary. Winter squash are grown in northwestern Mexico for export to distant markets. During transport, fruits deteriorate and develop fungal rots. Squash (Cucurbita maxima Duch. 'Delica') was given hot-water dips at 50C for 0, 3, 6, 9, and 12 min and stored at 10 and 20C with 75% RH for 4, 8, and 12 weeks. The highest weight loss (11.3%) was in fruits without hot water treatment stored at 20C for 12 weeks—weight losses were 3.6% 7.2% and 10.2% in the 4-, 8-, and 12-week storage periods, respectively. At 10C, the weight losses were 3.4% 6.8% and 7.6% for the same periods, respectively. ß-carotene content increased from 36.2 to 54.2 mg/100 g after 4 and 8 weeks of storage, respectively, but declined to 42.8 mg/100 g after 12 weeks. Chlorophyll content decreased as temperature and storage period increased, changing from 16.7 to 10.8 mg/liter² at 10 and 20C and from 16.9 to 15.8 mg/liter² and 8.8 mg/liter² at 4, 8, and 12 weeks, respectively. Fruits had decay caused by Rhizopus and Aspergillus. Weight loss, ß-carotene and chlorophyll contents, and decay were not affected by length of hot-water treatment. General appearance was better in fruits stored at 10 than at 20C.

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Vegetable growing in Sonora, Mexico, for export markets has increased in the past decade as farmers look for new crops to replace the low-income grains and legumes. From 1000 to 1300 ha of winter squash are grown during the summer/fall season and picked and shipped in December, mainly to the Japanese market. Although postharvest losses have not been estimated, it is clear that losses due to fungal rots are sometimes extensive. Heat treatments have been effective in maintaining the quality of some fruits after harvest (Klein and Lurie, 1992). Francis and Thomson (1965) reported that hot-water treatments reduced the loss in 'Butternut' squash caused by fungi. However, Hawthorne (1989) found that dipping fruits of four winter squash cultivars in water at 50C did not affect the incidence of rots. Information relating to the effect of hot-water treatment on the postharvest behavior of winter squash is limited.

Francis and Thomson (1965) reported high weight loss values for 'Butternut' squash when stored at 21 to 24C for 120 days, but there was no effect on weight loss in fruits treated with water at 54, 60, and 65C. Schales and Isenberg (1963) reported that curing several winter squash varieties for 3 weeks at 27C did not improve their storagelife. Holmes (1951) found that 'Butternut' squash lost 28% in weight at the end of storage for 188 days, and 16% and 20% at 63 and 90 days, respectively.

ß-carotene content increased in the C. maxima cultivar ESAL 7506 and C. maxima × C. moschata hybrids during storage at 20C for 70 days (Pedrosa et al., 1983). On the other hand, Dabrowski et al. (1989) found that ß-carotene content of different C. maxima cultivars increased from 5% to 180% in the first month of storage, and declined thereafter. Changes in chlorophyll content in stored winter squash have not been reported. Chlorophyll degradation was enhanced during treatment of 'Golden Delicious' apples at 38C for 4 days, they then ripened normally, but slower than in nonheated fruit at 20C (Lurie and Klein, 1990). In contrast, the same researchers reported in 1992 that chlorophyll degradation in mature-green tomatoes was inhibited during a heat treatment at 38C for 3 days; the fruits, however, developed an intense red color when transferred to 20C for 5 days.

In this study we report on the effect of hot-water treatment, temperature, and length of storage on weight loss, ß-carotene and chlorophyll contents, storage rots, and general appearance of winter squash.

Materials and methods

The squash were grown from March to July 1991. Fertilization, irrigation, pest control, and general handling of the crop was performed following the usual local practices for winter squash (Flores, 1992; Navarro, 1992). After picking, fruits were washed and stored at 22C and 67% RH for 10 days, after which fruits were dipped in hot water at 50C for 0, 3, 6, 9, and 12 min. Fruits were stored at 10 and 20C and 75% RH for 4, 8, and 12 weeks. Chlorophyll was extracted from 1-g samples of fruit skin using 50 ml of acetone. Quantification was done spectrophotometrically at 640 and 660 nm. The extraction of ß-carotene was done at 0C under red light to avoid degradation. Cold hexane (22 ml) and acetone (28 ml) were added to 1-g fruit samples. The samples were homogenized for 1 min, left in ice for 30 s, and then filtered under vacuum. N₂ was injected during homogenization to avoid oxidation. Cold water (5 ml) was added to separate the two phases, and the final volume of hexane was measured. Absorbance was measured at 445 nm, and quantification was made according to a standard curve for ß-carotene. Weight loss was estimated by weight differences at the sampling dates. Fruit appearance and storage rots were judged visually.

Results and discussion

Weight loss was increased by storage temperature and length of storage, being highest in response to storage time. Hot-water treatments had only minor effects on weight loss (Fig. 1). The same general trend was reported by Francis and Thomson (1965), Holmes (1951), and Schales and Isenberg (1963). However, Dabrowski et al. (1989) reported high weight loss values (42% to 43%) after 4 months of storage at 10 to 12C and 60% to 80% RH. In our study, the highest weight loss (11.3%) was obtained for fruits stored at 20C for 12 weeks without hot-water treatments. However, these fruits did not show any sign of shriveling.
ß-carotene content changed significantly only in response to length of storage (Fig. 2C). ß-carotene increased after 8 weeks of storage from 36.2 to 54.2 mg/100 g, but then decreased to 42.8 mg/100 g after 12 weeks of storage. This trend was more obvious in fruits stored at 20 than at 10°C. ß-carotene content of winter squash was reported to increase after 30 days (Dabrowski et al. 1989) and 70 days (Pedrosa et al. 1983) of storage. In our study, no consistent differences in ß-carotene content were found in response to hot-water treatments (Fig. 2A) or to storage temperature (Fig. 2C).

The chlorophyll content decreased as temperature and length of storage increased (Fig. 3). The concentration declined from 16.7 to 10.8 mg liter⁻¹ at 10 and 20°C, respectively. A decline in chlorophyll content was observed from 4 to 8 weeks of storage (16.9 to 15.8 mg liter⁻¹), but a large decrease occurred from 8 to 12 weeks (15.8 to 8.6 mg liter⁻¹). Small differences in chlorophyll content were found in response to hot-water treatments. Treatment for 9 min resulted in the highest concentration—16.3 mg liter⁻¹. Yellowing was noticeable after 8 weeks of storage. All fruits stored at 20°C for 12 weeks showed yellowing, but only three showed yellowing at 10°C for the same storage period.

About 27% of fruits stored at 20°C had rots, but, at 10°C, only one fruit treated for 3 min and 8 weeks of storage showed decay (data not shown). No differences in storage rots were obtained in response to hot-water treatments. The results are similar to those obtained by Hawthorne (1988). It is likely that a more appropriate temperature of hot-water treatments for winter squash would be 60°C, as previously reported by Francis and Thomson (1965). Both Aspergillus spp. and Rhizopus spp. were observed in decaying fruits. C. maxima cultivars of winter squash were reported to be affected under market conditions by several species of Aspergillus and Rhizopus (Rath et al., 1990) and by other fungi known to cause postharvest losses in fruits, such as Alternaria, Sclerotinia (Abdel-Rahim, 1988), Fusarium, and Didymella (Hawthorne, 1988).

Fruit appearance was better at 10 than at 20°C and after storage for 4 rather than 8 or 12 weeks (results not shown). No specific pattern was observed for fruit appearance in response to hot-water treatments.

**Conclusions**

Weight and chlorophyll losses increased and fruit appearance deteriorated as the temperature and storage period increased. ß-carotene content was affected only by storage period. We conclude that the hot-water treatments (50°C for 3, 6, 9, or 12 min) used in this study caused no detrimental or desirable effects on fruit quality, and did not decrease storage rots. Further studies are needed before any hot-water treatment can be recommended for use on winter squash. We recommend that winter squash (C. maxima Duch cv. Delica) be stored for 8 weeks at 10°C and 75% RH, conditions under...
which fruits will maintain good appearance and less storage rots for up to 8 weeks, and thus can reach distant markets with better quality.

**Literature Cited**


