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

Rosa Marina Arvayo-Ortiz[1], Sergio Garza-Ortega[1], and Elhadi M. Yahia[2]

Additional index words. *Cucurbita maxima,* chlorophyll, ß–carotene, storage rots, weight loss, general appearance.

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·liter^{-1} at 10 and 20C and from 16.9 to 15.8 mg·liter^{-1} and 8.8 mg·liter^{-1} 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.

[1]*Departamento de Agricultura y Ganaderia, Universidad de Sonora, A.P. 305, México.*

[2]*Departamento de Posgrado en Alimentos, Facultad de Química, Universidad Autonoma de Queretaro, Queretaro, 76010, México. To whom all correspondence should be addressed.*

The cost of publishing this paper was defrayed in part by the payment of page charges. Under postal regulations, this paper therefore must be hereby marked advertisement *solely to indicate this fact.*

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 storage life. 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 then 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. N_2 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.

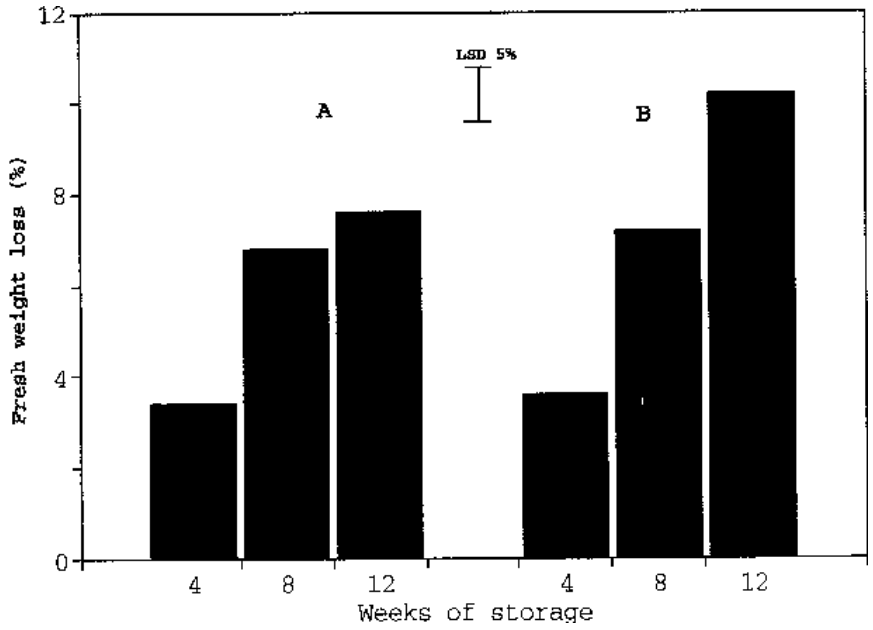

Fig. 1. *Fresh weight loss (percent) of winter squash (*Cucurbita maxima *Duch. cv. Delica) fruits treated with hot water at 50C for 0, 3, 6, 9, and 12 min and then stored at 10 (A) and 20C (B) for 4, 8, and 12 weeks. Each value is an average of 30 measurements.*

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 10C. 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 20C, 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 20C for 12 weeks showed yellowing, but only three showed yellowing at 10C for the same storage period.

About 27% of fruits stored at 20C had rots, but, at 10C, 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. These 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 60C, 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 20C 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.

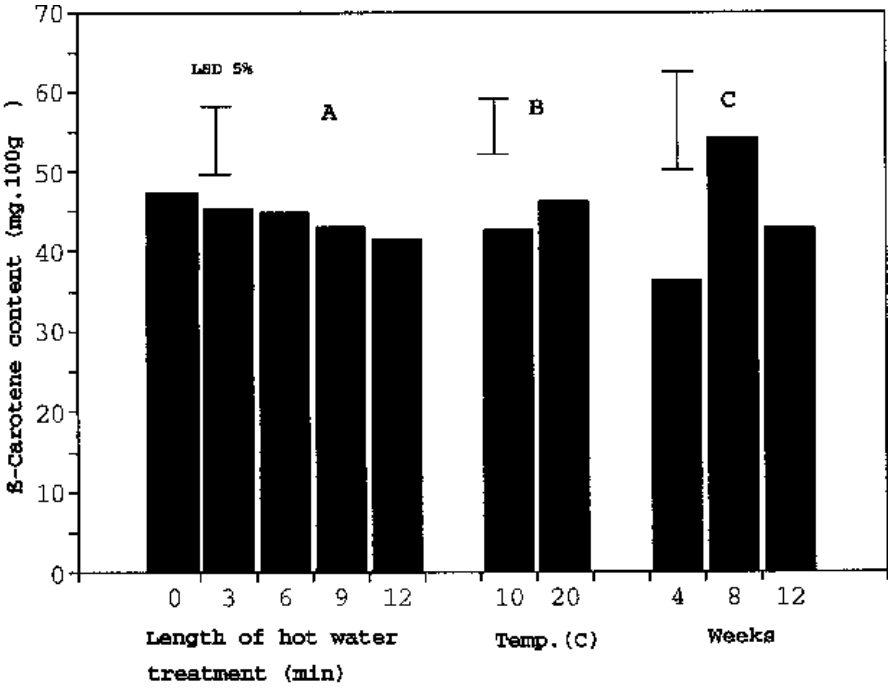

Fig. 2. *ß–carotene content (mg/100 g) of winter squash (*Cucurbita maxima *Duch. cv. Delica) fruits treated with hot water at 50C for 0, 3, 6, 9, and 12 min (A) and then stored at 10 and 20C (B) for 4, 8, and 12 weeks (C). Each value is an average of 30 (A), 60 (B), and 18 measurements (C).*

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 (50C 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 10C and 75% RH, conditions under

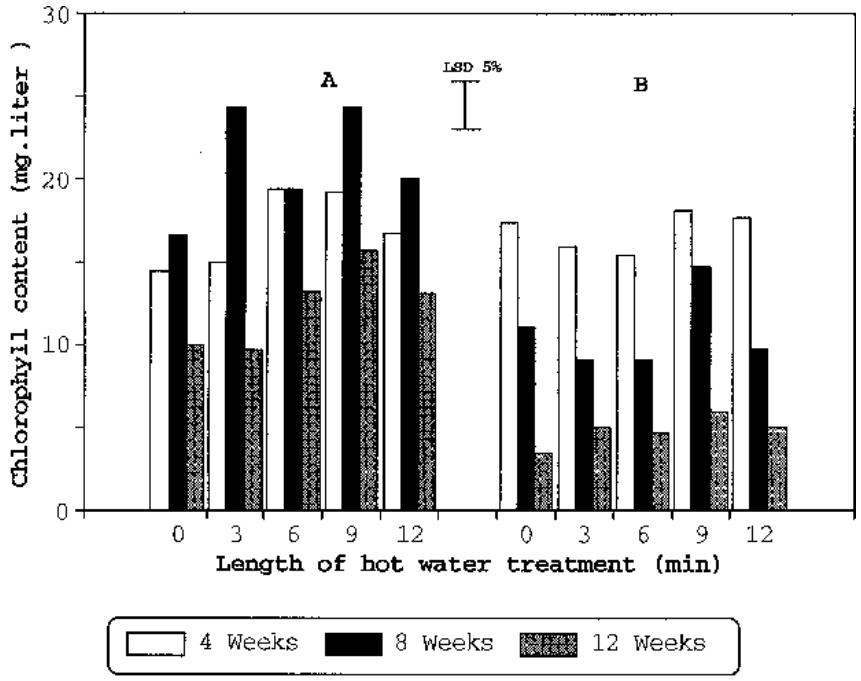

Fig. 3. *Total chlorophyll content (mg·liter^{-1}) of winter squash (*Cucurbita maxima *Duch. cv. Delica) treated with hot water at 50C for 0, 3, 6, 9, and 12 min and stored at 10 (A) and 20C (B) for 4, 8, and 12 weeks.*

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

Abdel-Rahim, A.M. 1988. Postharvest fungal diseases of some vegetables in Kuwait. Arab J. Plant Protect. 6:83–87.

Dabrowski, A., J. Galazka, and S. Zalewski. 1989. Technological properties, nutritional value, and storage properties of new pumpkin varieties. Acta Alimentaria Polonica 15:153–159.

Flores, E. 1992. Aspectos generales del cultivo de la calabaza kabocha (*Cucurbita maxima* Duch) en la Costa de Hermosillo. Departemento de Agricultura y Ganaderia. Disertación de licenciatura, Universidad de Sonora.

Francis, F.J. and C.L. Thomson. 1965. Optimum storage conditions for Butternut squash. Proc. Amer. Soc. Hort. Sci. 86:451–456.

Hawthorne, B.T. 1988. Fungi causing storage rots on fruits of *Cucurbita* spp. N.Z. J. Expt. Agr. 16:151–157.

Hawthorne, B.T. 1989. Effects of cultural practices on the incidence of storage rots in *Cucurbita* spp. N.Z. J. Crop Hort. Sci. 17:49–54.

Holmes, A.D. 1951. Factors that affect the storage life of Butternut squashes. Food Technol. 9:372–373.

Klein, J.D. and S. Lurie. 1992. Heat treatments for improved postharvest quality of horticultural crops. HortTechnology 2:316–320.

Lurie, S. and J.D. Klein. 1990. Heat treatments of ripening apples: Differential effects on physiology and biochemistry. Physiol. Plant. 78:181–186.

Lurie, S. and J.D. Klein. 1992. Ripening characteristics of tomatoes stored at 12C and 2C following a prestorage heat treatment. Sci. Hort. 51:55–64.

Navarro, R. 1992. Producción de Kabocha. Taller sobre producción de hortalizas. Memorias. SARH, INIFAP, CIRNO, CAECH. Hermosillo, Sonora, México.

Pedrosa, J.F., V. W.D. Casali., S.S. Cheng., M.I. F. Chitarra, and V.D. de Carvalho. 1983. Changes in composition of squashes and pumpkins during storage. Pesquisa Agropecuaria Brasileira 18:29–32.

Rath, G.C., D. Mishra and N.C. Nayak. 1990. A note on fungi causing rotting of cucurbits in Orissa markets. Orissa J. Agr. Res. 3:161–162.

Schales, F.D. and F.M. Isenberg. 1963. The effect of curing and storage on chemical composition and taste acceptability of winter squash. Proc. Amer. Soc. Hort. Sci. 83:667–674.

Flowering and Seed Yield in Three Species of Prairie Plants

Julia L. Bohnen and
Anne M. Hanchek[1]

Additional index words. *Tradescantia ohiensis, Dalea purpurea, Spartina pectinata,* native plants, establishment, flowering

Summary. Production of native seeds and seedlings for landscaping and restoration is an expanding horticultural industry in Minnesota, but seed yields of many species from wild stands are often small and vary widely in quality. In this work, we document phenological development and seed yield in cultivated and prairie-grown plants for *Tradescantia ohiensis* Raf. (Ohio spiderwort), *Dalea purpurea* Vent. (purple prairie clover), and *Spartina pectinata* Link (prairie cordgrass) at the Minnesota Landscape Arboretum. For *T. ohiensis*, seed yield under cultivation was significantly greater than in the prairie both seasons, with 2.5 g of seed recovered per plant in 1993. Under cultivation, seed yield of established *D. purpurea* was triple that of the prairie, yielding 34 seeds per inflorescence. *S. pectinata* grown under cultivation from seedlings or rhizome divisions produced seed in the first and second seasons, respectively, while plants in the prairie remained vegetative. Two-year-old seedlings produced 38 seeds per spike. Field cultivation of these native plant species resulted in increased seed yield and improved growth, while allowing phenological monitoring and the use of species-specific harvest practices.

Department of Horticultural Science, University of Minnesota, St. Paul, MN 55108.

Research conducted at the Minnesota Landscape Arboretum, Chanhassen. Minnesota Agricultural Experiment Station publication number 21189, partially funded by a grant from the Legislative Commission on Minnesota's Resources. From a thesis submitted by J.L.B. in partial fulfillment of the requirements for a MS degree in horticulture. Our thanks to the Minnesota Native Wildflower/Grass Producers Assn., the Minnesota Dept. of Agriculture, and to Arboretum volunteers Jo Nielsen, Kathryn McFadden, and Sue Tracey. The cost of publishing this paper was defrayed in part by the payment of page charges. Under postal regulations, this paper therefore must be hereby marked advertisement *solely to indicate this fact.*