Research Updates

Cultivar, Packaging, and Storage Temperature Differences in Postharvest Shelf Life of Okra

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Summary. Okra stored at 3C in 12.7- μ m high-density polyethylene (HDPE) bags developed less chilling injury than fruit stored in plastic boxes. Okra held in HDPE bags at 12.5C for 8 days had more decay and reduced overall appearance than fruit held in plastic boxes. 'Emerald Green' okra lost more weight in storage than the other four cultivars regardless of temperature or storage duration, while 'Blondy' had the most decay. 'Annie Oakley' and 'Clemson Spineless' had better shelf life than the other cultivars.

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Okra [*Abelmoschus esculentus* (L.) Moench] is a warm-season crop, and the immature pods are used primarily for processing and the fresh market. Okra has a shelf life of 7 to 10 days when stored at 12.5C and 90% to 95% relative humidity (RH) (Hardenburg et al., 1986). Fresh okra deteriorates quickly during storage due to tenderness and a high respiration rate (Hardenburg et al., 1986). To reduce respiration and weight loss, most vegetable commodities are kept at temperatures below 10C; however, okra is chilling-sensitive and develops water-soaked lesions, dark ribs, and surface pitting when stored at temperatures below 10C (Ilker, 1976).

Postharvest dips, packaging, and controlled-atmosphere (CA) storage have been somewhat successful in extending okra shelf life. Singh et al. (1980) found that storing okra at room temperature in 400-gauge polyethylene (PE) bags increased shelf life by 5 to 6 days compared to unpackaged okra. The use of 40- μ m PE bags in conjunction with low-temperature storage (4.4C) reduced weight loss and prevented color changes without causing chilling injury in okra (Fontenot et al., 1987). Aderiyi (1985) found that okra dipped in a solution of 500 ppm ascorbic acid and stored in cellophane bags at 2C showed no chilling injury and had an improved shelf life of 28 days. Ilker and Morris (1975) reported reduced chilling injury on okra dipped in solutions of calcium and potassium salts before storage. Okra held at 5C in CA (5% to 10% CO₂) had reduced chilling injury (Ilker, 1976).

The objectives of these experiments were to compare the chilling sensitivity of okra cultivars and evalu-

ate okra stored in a high-density polyethylene (HDPE) packaging material.

Materials and Methods

In a preliminary study, 'Clemson Spineless' okra was stored in 12.7- μ m HDPE bags (E.I. DuPont de Nemours and Co., Wilmington, Del.) or 44- μ m PE pressure-sealed bags (Dow Brands, Indianapolis). After 7 days of storage at 5C, weight loss was 0.6% and 0.33% for HDPE and PE bags, respectively. Since okra stored in HDPE bags had less decay and was more acceptable than that stored in the PE bags, HDPE bags were used for further studies.

The shelf life of five okra cultivars stored in HDPE bags at recommended and chilling temperatures was determined. The cultivars were: 'Annie Oakley' (hybrid), 'Clemson Spineless' (commercial standard), 'Emerald Green' (smooth, no ridges), 'Burgundy' (dark red), and 'Blondy' (light green). Ten pods of marketable length (< 10 cm) and quality per cultivar were placed in HDPE bags (25 × 25 cm) or plastic boxes (10.2 × 10.2 × 6.7 cm with five 0.5-cm-diameter ventilation holes on the bottom) covered with dome lids (12 × 12 × 4.3 cm with four 0.5-cm-diameter ventilation holes) and stored at 80% ± 5% RH at 12.5 or 3C for 8 days. Pods were evaluated every 4 days for weight loss, decay incidence, chilling injury, and overall appearance. A nine-point scale was used for rating subjective characteristics. The rating for overall appearance was 1 = unacceptable, 5 = marginally acceptable, and 9 = highly acceptable. Decay and chilling incidence (CI) were rated as 1 = no decay/no CI, 5 = 50% decay/CI, and 9 = more than 75% decay/CI. Every 4 days, CO₂ concentrations in bags and boxes were determined by injecting 1-ml gas samples into a Hewlett Packard 5890 gas chromatograph equipped with a thermal conductivity detector and a 1.85-m stainless steel column packed with Poropak N 80/100. The study was conducted over 2 years and was replicated twice in each year.

Results and Conclusions

Carbon dioxide concentrations in the boxes of okra remained near ambient levels, while CO₂ was ≈ 2% in bags held at 3C and 4% to 6% in bags held at 12.5C.

Weight loss of okra in bags was similar among cultivars, storage dates,

and temperatures (data not shown). Okra stored in HDPE bags lost much less weight (0.8%) than those stored in boxes (4% and 11% for 4 and 8 days, respectively). Although weight loss from okra held in boxes was high, it was two to four times less than that reported for unpackaged okra held under similar temperatures (Fontenot et al., 1987).

Cultivar and storage duration, but not temperature, significantly affected weight loss of okra held in boxes. Weight loss was similar among cultivars and temperature treatments for 4 days of storage (data not shown). After 8 days of storage, 'Emerald Green' lost more weight than 'Clemson Spineless' or 'Blondy' held at either 12.5 or 3C (Fig. 1). The differences among cultivars may have been due to morphological differences in the pods; marketable-size 'Blondy' and 'Clemson Spineless' were larger in diameter and shorter than 'Emerald Green'.

Incidence of decay was higher for pods stored at 12.5C than at 3C, regardless of storage duration or package (data not shown). Okra stored at 3C had no decay, even after 8 days of storage. At 12.5C decay ratings were ≈ 2.4 for all cultivars stored 8 days in boxes. 'Blondy' stored in bags at 12.5C had more decay (2.3 and 3.9 after 4 and 8 days, respectively) than the other cultivars (1.3 and 2.5 after 4 and 8 days, respectively).

Chilling injury symptoms occurred only on okra stored at 3C and was more prevalent on okra stored in boxes than on those in bags. Fontenot et al. (1987) also found less chilling injury on okra stored in PE bags than on unpackaged okra. Chilling injury on boxed okra may have been more obvious due to the higher weight loss of these pods. An increased rate of chilling injury corresponding to increased weight loss has been reported for citrus (Wardowski et al., 1973).

Chilling injury ratings were similar among cultivars held in boxes after 4 days of storage (2.0). After 8 days of storage in boxes, chilling injury ratings of 'Burgundy' pods (4.3) were higher than 'Clemson' pods (3.1). Chilling injury on bagged okra was similar among cultivars and was 1.6 and 2.6 after 4 and 8 days of storage, respectively. Chilling injury characteristics differed slightly among cultivars (Table 1).

Fig. 1. Percent weight loss of okra cultivars Annie Oakley (AO), Blondy (BL), Burgundy (BU), Clemson Spineless (CL), and Emerald Green (EM) stored in plastic dome-lid boxes for 8 days at 3 or 12.5C. Bars represent LSD ($P \leq 0.05$).

The overall appearance of okra deteriorated between 4 and 8 days of storage at both temperatures (Fig. 2). At 3C there were no differences among okra cultivars stored in bags, and okra held in bags had a better appearance than those in boxes. After 4 days at 3C, 'Burgundy' held in boxes had a better appearance than 'Emerald Green', which was limp and pitted. After 8 days at 3C, 'Annie Oakley' and 'Burgundy' pods held in boxes were worse overall than 'Clemson Spineless'. These differences were mainly due to more chilling injury on 'Burgundy' pods than on 'Clemson Spineless' pods. On day 8 'Burgundy' pods were limp and exhibited chilling injury (Table 1).

On day 4 okra pods held at 12.5C had a better appearance than those held at 3C for all cultivars and both packages. At 12.5 C okra pods stored in bags were worse overall than those stored in boxes. 'Burgundy' okra stored at 12.5C had the best overall appearance ratings after 4 days in boxes and after 4 and 8 days in bags. After 8 days in boxes, 'Blondy' pods had darkened ridges and gray mold and the worst appearance of all cultivars.

Summary

Okra stored in bags lost less weight than those in boxes, regardless of temperature or cultivar. At 3C okra pods held in bags or boxes had chilling injury, but it was more extensive in boxed okra. Decay was least and overall appearance best for pods stored at 3C in bags compared to all other treatments.

Based on this research, 'Annie Oakley' and 'Clemson Spineless' had a better shelflife than the other cultivars. At 12.5C pods stored in plastic boxes with lids had better overall appearance and less decay than pods stored in bags. Therefore, okra held at 12.5C should be stored in ventilated packages to reduce decay and weight loss.

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Table 1. Chilling symptoms of five okra cultivars after 8 days of storage at 3C.

Cultivar	Chilling symptoms
Annie Oakley	Pitting, dark ridges, black specks on calyx
Blondy	Pitting, pod browning, dark ridges
Burgundy	Pitting on tips, faded calyx and pod color
Clemson Spineless	Pitting, water-soaked lesions on pod
Emerald Green	Pitting, mostly on tips of pods

Fig. 2. Overall appearance ratings of okra cultivars Annie Oakley (AO), Blondy (BL), Burgundy (BU), Clemson Spineless (CL), and Emerald Green (EM) after 4 or 8 days of storage at 3 or 12.5°C. Rating scale used was 1 = highly acceptable, 5 = marginally acceptable, 9 = unacceptable. Bars represent LSD ($P \leq 0.05$).

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