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Postharvest Shelf Life of Sweet Basil *(Ocimum basilicum)*

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Abstract. Shelf life (defined by visual quality) of freshly harvested greenhouse-grown sweet basil was maintained for an average of ≈ 12 days at 15C. Chilling injury symptoms were severe at storage temperatures of 5C and below. Shelf life was found to be only 1 and 3 days at 0 and 5C, respectively. Moderate chilling injury was noted at 7.5 and 10C. Harvesting sweet basil later in the day (i.e., 1800 or 2200 HR) increased shelf life by almost 100% when harvested shoots were held at 10, 15, and 20C, compared to harvesting at 0200 or 0600 HR. However, the time of day of harvest did not alter the development of visual chilling injury symptoms or improve shelf life at 0 or 5C.

Fresh-cut culinary herbs have become increasingly popular in recent years. Although herb production is expanding to meet this demand, the quality of herbs at the retail market is sometimes unacceptable. One problem is that some fresh herbs are chilling-sensitive, yet are commonly handled with fruits and vegetables. Limited information is available on postharvest storage and handling practices for fresh herbs and on their tolerance to short-term exposures to chilling temperatures (Hardenburg et al., 1986).

One of the most highly consumed fresh herbs, sweet basil, is sensitive to chilling injury (CI). Saltveit and Morns (1990) reported that basil is chilling-sensitive, but did not identify a specific chilling temperature. Joyce et al. (1986) noted that CI symptoms developed at 0C and suggested that storage at 5 to 7C was optimal for long-term basil storage.

King et al. (1982) found that tomato *(Lycopersicon esculentum* Mill.) seedlings exposed to chilling temperature in the hours just before dawn were injured far more than seedlings exposed to chilling temperatures between noon and midnight. They proposed that diurnal changes in carbohydrates correlated with chilling sensitivity (King et al., 1988). To our knowledge, no one has yet determined if harvest time during the day could influence subsequent CI of basil.

Retailers often hold sweet basil at room temperature to avoid CI, although these conditions can potentially cause desiccation or enhance growth of decay organisms. No shelf life data for sweet basil at room temperatures have been reported.

The purpose of this study was to characterize visual shelf life of sweet basil as influenced by temperatures from 0 to 25C. In addition, we wished to determine if harvest time during the day would influence subsequent shelf life, development of CI symptoms, or both. In all cases, experiments were conducted with basil packaged in perforated polyethylene to minimize the effect of desiccation on shelf life, as suggested by Joyce et al. (1986).

Materials and Methods

Sweet basil seeds (Sieger Seed, Imlay City, Mich.) were sown in 11-cm (600-ml) plastic azalea pots with two seeds in each of three holes ≈ 1.5 cm deep using a commercial peat-perlite–vermiculite mix. The seedlings were thinned after 2 weeks to three equally spaced plants per pot. This method of sowing and thinning had been found in preliminary experiments to produce more biomass than one or two plants per pot (data not shown).

Plants were grown in a computer-controlled greenhouse under 24/20C day/night cycles. In all experiments, plants received at least 12 h of light either naturally or using 400-W high--pressure sodium lamps, and were irrigated weekly with 225 mM 20N–20P-20K. Basil shoots were harvested by cutting just below the second fully expanded node from the growing point after ≈ 6 weeks of growth. Each harvested shoot contained six to eight leaves and weighed 4 to 6 g. Unless otherwise stated, basil shoots with leaves were harvested at ≈ 1400 HR on sunny days. Harvested shoots were placed in unsealed plastic bags at time of harvest and rapidly transported to the laboratory (≈ 22C) for packaging.

Two shoots (six to eight leaves each) were sealed per 20 × 20-cm package constructed from 127-µm-thick, low-density polyethylene film (LDF 501, Dow Chemical Co., Midland, Mich.) using a Magneta 620 heat sealer (Packaging Aids Corp., San Francisco). Shoots with bruised or damaged leaves were not used. Four 26.5-gauge needle holes (≈ 0.4 mm in diameter) were punched through each package to facilitate O_2 and CO_2 exchange. The entire procedure of harvesting and packaging took < 90 min in all experiments (harvesting, 30 rein; packaging, 60 rein). Basil packages were held in darkness under black plastic for the duration of all experiments.

Four packages each of basil were placed in controlled-temperature chambers at 0, 5, 10, 15,20, and 25C, all less than +1C, and covered with black plastic to maintain darkness. Basil was inspected daily at 1400 HR and rated visually for the presence of necrosis, surface molds, water soaking, chlorosis, and leaf abscission. Shelf life was defined as the time until the first obvious sign of deterioration, based on visual analysis only. The entire experiment was repeated weekly six times beginning in July 1988 and ending in Aug. 1988. The data were pooled and analyzed as a simple two-way analysis of variance (ANOVA) with temperature x harvest date. The effect of harvest date was not significant.

In a second experiment, packaged sweet basil was held at 0, 2.5, 5, 7.5, or 10C for 0, 1, 2, or 3 days before transfer to 20C, with five packages per treatment. Four days from packaging, all basil shoots were analyzed visually for the extent and location of CI symptoms, such as tissue soaking and blackening. Basil cuttings were inspected for any noticeable lesions. This entire experiment was repeated three times. The data were analyzed as a two-way ANOVA with temperature and duration as the main factors.

In a third experiment, sweet basil shoots were harvested every 4 h beginning at 0200 HR and ending at 2200 HR. Shoots were processed and packaged after each harvest as described above, and four packages were placed immediately in controlled chambers set at 0,5, 10, 15, 20, and 25C. The packages were handled and evaluated as described previously, except that observations were made daily at 1600 HR. The entire experiment was conducted three times during Aug. and Sept. 1988, and the data were analyzed as a three-way ANOVA with harvest time, temperature, and harvest date as the main factors.

Results and Discussion

The average shelf life of packaged sweet basil was longest at 15C (Table 1), where > 95% of the packages lasted 7 days or more (Fig. 1). Eight packaged cuttings lasted longer than 13 days, with one cutting lasting 29 days (Fig. 1). The shelf life was eventually limited by the development of surface molds and/or chlorosis of the older tissue. Visual shelf life ranged from 2 to 14 days at 20C, with an average of >1 week (Table 1, Fig. 1). At 20C, 50% of the packages remained visually acceptable for 7 to 9 days. The average shelf life was nearly 1 week (Table 1) at 25C, although 60% of the packages were visually acceptable for 6 days or less.

Shelf life was reduced at temperatures ≤ 10C compared to 15C (Table 1). Chilling injury

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Table 1. Average shelf life, based on appearance, of packaged sweet basil cuttings as influenced by temperature. Cuttings were harvested at 1600 HR. Mean ± SD based on 24 packages at each temperature.

Temp (°C)	Shelf life (days)
0	1.6 ± 0.6
5	3.2 ± 1.2
10	8.3 ± 2.7
15	12.5 ± 5.4
20	7.3 ± 3.0
25	6.8 ± 2.4

symptoms at 10C were limited to the youngest unexpanded leaves on some of the sweet basil. In these cases, CI was evidenced by water-soaked regions that eventually became necrotic. Shelf life ranged from 3 to 14 days at 10C (Fig. 1), primarily determined by whether or not CI symptoms developed. There was definite evidence of CI at 5C, and 75% of the packages was judged unsalable after only 3 days. Chilling injury symptoms were severe at 0C, and the majority of the tissue eventually turned black.

Exposure to 0C for only 1 day, followed by transfer to 20C for 4 days, caused CI symptoms on 100%. of the packaged sweet basil (Fig. 2). Short-term exposures to 2.5C also induced CI, although the rate of symptom expression was less than at 0C (Fig. 2). Three days of exposure at 5C were required before symptom development limited the salability of the basil. Symptoms developed only after 3 days of exposure to 7.5 or 10C, and affected only 8% of the packages in both cases (Fig. 2). No further lesions developed after transfer to 20C. However, slightly sunken or discolored regions continued to degenerate until the affected area was completely necrotic.

Harvesting sweet basil in the second half of the day significantly improved the visual shelf life only for storage temperatures ≥ 10C (Fig. 3). There was a nearly two-fold increase in

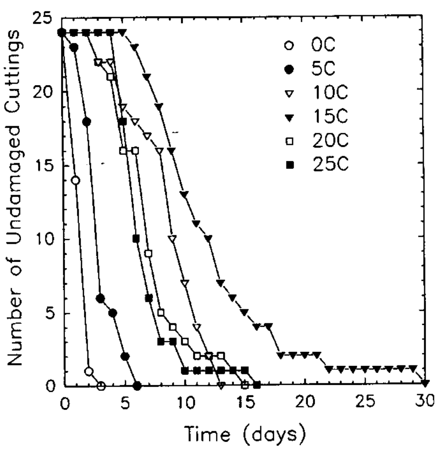

Fig. 1. The effect of temperature on the number of undamaged packaged sweet basil cuttings over time. Cuttings were classified as damaged if there were any observable lesions. The total number of cuttings for each temperature treatment was 24.

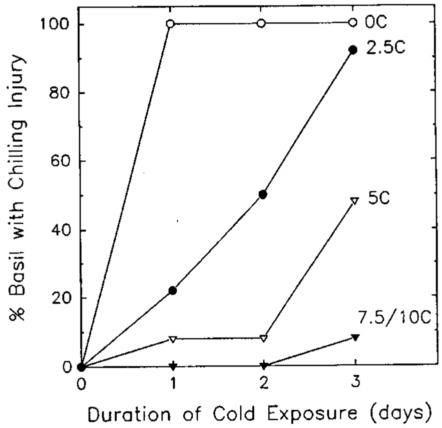

Fig. 2. Development of chilling injury symptoms on packaged sweetbasil with increasing time of exposure at low temperatures while stored in the dark.

shelf life of sweet basil harvested at 1800 HR compared with 0200 or 0600 HR when held at 10 or 20C. This effect of time of day of harvest was also substantial at 15C, with an increase in shelf life of 170%.

Surprisingly, no alleviation of CI symptoms was observed on shoots from basil stored at 0, 5, or 10C when harvested at times later in the light period, as was reported for tomato seedlings (King et al., 1982). The difference in response may relate to the use of intact vs. detached plant material, or may represent a basic difference in plant response. In a separate experiment, 24 out of 24 unprotected plants exposed to 5C developed CI symptoms within 1 day, compared to 3 days for packaged shoots. Protection from heat loss and water loss through the polyethylene packages may have affected the response. Wilson (1976) reported that CI on green bean *(Phaseolus vulgaris* L.) plants was prevented for 7 to 10 days simply by enclosing the plants in polyethylene bags. The symptoms of CI in green bean plants were wilting and pitting of leaf tissue, which are enhanced by water loss. In our experiments, there was little modification of O_2 or CO_2 in the packages (data not shown).

The observation that shelf life of cut sweet basil harvested later in the day was greatly improved at 15 to 25C suggests that diurnal changes did take place. Whether these changes were related to carbohydrate accumulation, as suggested by King et al. (1988), or other factors, was not determined. Whatever the changes, they did not enhance resistance to chilling injury.

There was no evidence that the packaged sweet basil lost an appreciable amount of essential oil during extended storage at ≥ 15C, although no chemical tests were conducted. Leaves retained their characteristic odor and flavor.

The longest shelf life of sweet basil was found at 15C. In contrast to the report of Joyce et al. (1986), CI symptoms were noted at 10C and were severe at ≤ 5C. Possibly, the "optimum" storage temperature may be just above 10C, although this was not tested in this study.

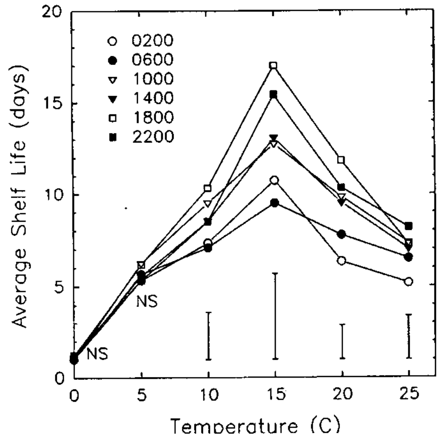

Fig. 3. The effect of time of day of harvest and temperature on the average shelf life of packaged sweet basil stored in the dark. The bars represent the $HSD_{0.05}$ for treatment mean separation at each temperature. Harvest times were 0200 to 2200 HR.

Preharvest temperatures could alter the chilling sensitivity of harvested shoots, which could explain the differences between the current results and those of Joyce et al. (1986).

Perforated polyethylene packages were used in these experiments to limit water loss, as suggested by Joyce et al. (1986) and practiced commercially. In separate experiments, we found that sweet basil readily took up water when the cut stems were placed in water. At 15 to 25C, root initials were observed on the lower portions of the basil stems after holding them in water or polyethylene packages after 1 to 2 weeks.

The results from this study suggest that, for maximum shelf life, sweet basil should be harvested near the end of the light period and stored above 10C with protection from water loss. When bruising and other damage was avoided, shelf life of sweet basil was nearly 2 weeks. Shelf life was found to be longer at 20 and 25C than at 0 and 5C, although 1-to 2-day exposures to 5C could be tolerated with no observable CI symptoms.

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