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Dark-storage Temperature and Duration Influences Flowering and Quality Retention of Hibiscus

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Abstract. **Pot-grown 'Angie Physic' hibiscus *(Hibiscus rosa-sinensis* L.) plants at the tight bud and blooming stages were stored in darkness for 3, 6, or 9 days at 4.5, 10.0, 15.5, 21.0, 26.5, or 32.0C, and then placed in a greenhouse for 21 days. Plants showed the least amount of damage at 10.0 or 15.5C or when stored for 3 days. Plants stored at 10.0 or 15.5C had delayed flowering, larger and more flowers, less flower bud and leaf abscission, and a higher plant quality. Storage for 6 or 9 days resulted in plants with smaller and fewer flowers, greater bud and leaf abscission, less fresh weight, and a lower quality.**

Shipping potted flowering plants to market with minimum loss of quality is a major problem in the floriculture industry. Plants usually are in transit for several days and may be exposed to darkness and temperature extremes. Nearly 50% of all damage claims are attributed to shipping temperatures not being maintained within a desirable range (Conover, 1980). Duration of storage also may affect plant quality. Many tropical and subtropical plants often exhibit no signs of physical damage upon arrival at their destination, but develop brown, water-soaked areas (Conover and Poole, 1980; Marousky and Harbaugh, 1980a), wilting (Conover and Poole, 1980; Marousky and Harbaugh, 1980a), necrotic lesions (Marousky and Harbaugh, 1980a), cellular damage (Wilkins et. al., 1982), and sometimes die (Marousky and Harbaugh, 1980a) after several days of storage. Plants are therefore accepted without the knowledge that development of damage symptoms was induced during transit. Some plants are susceptible to chilling injury (CI) when exposed to air at 7 to 10C (Conover and Poole, 1981; Healy et al., 1981; Marousky and Harbaugh, 1980a; Sutcliffe, 1977). Some foliage plants can tolerate low temperatures for a short time, but prolonged exposure to the same temperature caused CI (Marousky and Harbaugh, 1980a).

High air temperatures can also cause severe dehydration and yellowing of potted plants (Collins and Blessington, 1983; Conover, 1980; Sutcliffe, 1977). *Ficus benjamina* leaves had reduced chlorophyll concentration as temperature increased during dark storage (Collins and Blessington, 1983).

Potted hibiscus as flowering plants are rapidly gaining popularity due to their dark foliage and colorful and prolific flowers. However, abscission of flower buds and leaf yellowing have been observed on hibiscus in the marketplace. The above is particularly true with plants that have been shipped and stored. The objective of this study was to determine the effects of temperature and duration of dark storage on subsequent flowering and quality of pot-grown hibiscus.

Uniform rooted cuttings of 'Angie Physic' hibiscus were potted one per 15-cm pot (1.5 liters) in Mar. 1985. The growing medium consisted of 2 sphagnum peat : 1 perlite : 1 vermiculite (by volume) amended with 7.1 kg of dolomite/m^3 and 74 g of FTE/m^3 (a micronutrient source; W.R. Grace and Co., Fogelsville, Pa.). Plants were pinched to 10 to 12 cm in height 2 weeks after potting, leaving an average of 10 leaves per plant. Plants were grown in a greenhouse under natural daylength with a maximum light intensity of 1570 $\mu mol \cdot s^{-1} \cdot m^{-2}$, and at 21 to 30C. Osmocote 14N–6.2P–11.6K was applied to the soil surface at a rate of 6 g/pot 14 days after potting. Plants were fertilized with 200 ppm N from a 20N–8.6P–16.8K water soluble fertilizer (W.R. Grace and Co.) at every watering during the first 5 weeks, then increased to 400 ppm N for the remainder of the production period.

A 6 × 3 factorial experiment in a nested design was initiated on 24 May 1985 with six storage temperatures (4.5, 10.0, 15.5, 21.0, 26.5, or 32.0C) and three storage durations (3, 6, or 9 days). Each hibiscus plant had one or two flowers when moved into temperature-controlled chambers and they

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Table 1. Postharvest effects of temperature and duration of dark storage on flowering, plant quality, and subsequent growth of 'Angie Physic' hibiscus at the flowering stage.

Treatments	Flower diam (mm)	Days to anthesis	Total no. flowers per plant	Total no. abscised buds	No. leaves dropped	Fresh wt (g)	Plant grade[z]
Storage temp (°C)							
4.5	33	4	6	16	40	146	2.9
10.0	83	12	19	3	18	217	3.8
15.5	91	11	19	2	16	211	4.1
21.0	56	4	12	16	47	268	3.7
26.5	56	5	8	22	74	227	2.9
32.0	29	3	5	25	82	235	2.9
Storage duration (days)							
3	83	7	17	9	20	270	4.2
6	49	6	11	15	52	214	3.4
9	42	6	7	18	66	168	2.5
Significant effects[y]							
Storage temp (ST)	L**Q**	L**Q**	L**Q**	L**Q**	L**Q**	L**Q**	L**Q**
Storage duration (SD)	L**Q**	NS	L**	L**	L**Q**	L**	L**
STL × SDL	NS	NS	**	NS	**	NS	NS
STL × SDQ	NS	NS	NS	**	**	NS	NS
STQ × SDL	**	**	*	NS	**	**	**
STQ × SDQ	*	NS	NS	*	NS	NS	NS

[z]1 = poor; 3 = good; 5 = excellent quality.
[y]Linear (L); quadratic (Q). Nonsignificant (NS); P = 0.05 (*) or 0.01 (**).

were watered throughout the storage period as needed. Data collected during the dark storage were: diameter of the first flower on those plants having flowers opened following the initiation of dark storage, total flower number, number of total abscised flower buds and leaves. There was one plant as an experimental unit replicated five times for each treatment combination.

Following dark storage, plants were transferred to the greenhouse used earlier and observed for 21 days. During this period, plants were fertilized at every watering with 200 ppm N from the same fertilizer source used previously. Number of flowers and abscised flower buds and leaf drop were again recorded and added to data collected during the dark storage.

At the termination of a given treatment (21 days after storage), fresh weight (plants severed at the soil line) and overall plant quality (1 = poor, not salable; 3 = good, salable; 5 = excellent quality) were determined. A similar experiment using plants at the tight flower bud stage was also conducted. Since the results were similar in the two experiments, only results from the first experiment are reported. Analysis of variance was performed on all data, and treatment differences were separated by single degrees of freedom.

Temperature had a major impact on flowering and quality of hibiscus that received dark storage. Flower diameter was greatest at 15.5C (Table 1). Temperature extremes (4.5 and 32.0C) reduced flower size substantially. Flower bud opening was delayed at 10.0 and 15.5C. Similar findings have been reported with hybrid geranium (Armitage et al., 1981). It has also been reported that temperatures of ≤18C delayed flowering of various species (Albrecht and Ladd, 1984; Armitage et al., 1981; Healy et al., 1981; Wilkins et al., 1982). The premature flowering at extreme temperatures may have been induced by ethylene from the plant following cold or heat stress.

The greatest number of flowers and the least number of abscised buds were associated with holding at 10.0 or 15.5C (Table 1). Total flower number was inversely related to storage duration, and number of abscised flower buds increased linearly with the increase in storage duration.

Chilling injury was obvious on all the plants stored at 4.5C, and became more severe with longer exposure times (data not shown). Symptoms of CI included wilted leaves and leaf tissues that appeared water-soaked and spotted with necrotic areas. Heavy fertilization during production may have increased the sensitivity of the plants to CI (Poole and Conover, 1983).

Although leaf drop on plants stored at 4.5C was lower than in those stored at 26.5 or 32.0C, plants that had been stored at 4.5C had much less fresh weight due to the reduced subsequent growth. Fresh weight peaked at 21.0C (Table 1). Similar results have been reported with *Ficus benjamina* (Collins and Blessington, 1983). The two highest temperatures caused severe leaf drop. Leaf chlorosis became more severe on plants stored at 21.0C or above. The loss of leaf chlorophyll and development of leaf yellowing in *Kalanchoe blossfeldiana* was shown to be faster at 33C than at 23C (Marousky and Harbaugh, 1980b). Overall plant quality 21 days after removal from dark storage was highest for those plants previously stored at 15.5C.

When plants were stored for >3 days, flower diameter, number of flowers, fresh weight, and overall plant quality decreased (Table 1). Number of abscised buds and leaf drop increased as storage duration increased. Marousky and Harbaugh (1980b) found that leaves of *Kalanchoe blossfeldiana* became more chlorotic and contained less chlorophyll after 3 days in dark storage. The time for the first flower bud to open was unaffected by the duration of dark storage.

Results from this experiment indicate that damage to pot-grown flowering hibiscus during transit may be minimized by shipping them at low, but nonchilling, temperatures. To maintain maximum flowering and best plant quality, 'Angie Physic' hibiscus plants should be held no more than 3 days in darkness and at 10.0 to 15.5C.

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