The content of ascorbic acid in nonbruised tissue was not related to blackspot susceptibility. 'Lemhi Russet', a susceptible clone, had the highest ascorbic acid content of all clones in nonbruised tissue (Table 1). 'Russet Burbank', also susceptible, contained about 50% less ascorbic acid than 'Lemhi Russet'. These results confirm previous reports (3, 12) that there is no relationship between initial ascorbic acid content and blackspot susceptibility.

Although cellular damage was apparent in bruised core sections of all clones, blackspot developed within 24 hr after bruising in only two of 15 cores in BC9289-1, and three of 15 cores in 'Centennial Russet'. Blackspot developed in 10 of 15 cores in 'Lemhi Russet' and 13 of 15 cores in 'Russet Burbank' during this same time period. Differences in ascorbic acid content of bruised and nonbruised tissue were significant in two of the four clones (Table 1). 'Centennial Russet' tubers contained about 8% higher ascorbic acid in bruised tissue than nonbruised tissue. However, bruised tissue of 'Lemhi Russet' contained about 11% less ascorbic acid than nonbruised tissue, resulting in a significant interaction between clones and bruise. There was no relationship between bruising and ascorbic acid content in 'Russet Burbank' or BC9289-1.

Ascorbic acid oxidation has been closely related to darkening of damaged plant tissue (1, 8). Even after blackspot developed in 'Lemhi Russet' (between 6 and 12 hr after bruising), the differences in ascorbic acid content between bruised and nonbruised tissue were not great. The mean ascorbic acid content of bruised 'Lemhi Russet' tissue was 23% less than nonbruised tissue after 24 hr (Table 1), the largest difference observed in any of the clones. This difference is much less than would be expected if complete oxidation of reducing substances was required for pigment formation (1, 7).

Ascorbic acid has been reported to increase in sound cells next to a damaged area in potato tubers (6). Only 5% to 15% of the cells in a blackspot area may be damaged and discolor (10). Therefore, it may be difficult to differentiate between changes in ascorbic acid content of undamaged cells next to a bruise and the oxidation of ascorbic acid in damaged cells.

The relationship between ascorbic acid content of tubers and time of incubation at 28°C varied between clones (Table 1). There was no significant relationship between ascorbic acid content and time for BC9289-1. The relationship was linear for 'Russet Burbank', with ascorbic acid content decreasing significantly with time. The relationship between ascorbic acid content and time of incubation at 28° in 'Lemhi Russet' was both linear and cubic. Ascorbic acid content increased between 0 and 3 hr, then decreased (Table 1). The relationship between ascorbic acid content and time was cubic for 'Centennial Russet', with ascorbic acid levels higher after 24 hr of incubation at 28° than at 0 hr, resulting in a significant interaction between clones and time. Changes in ascorbic acid content during incubation at 28° occurred to a similar extent in both bruised and nonbruised tissue of all clones (Table 1). The mean ascorbic acid content of the clones increased 7% between 0 and 3 hr, but decreased by 14% between 3 and 24 hr after treatment. Therefore, these changes may have been a response to handling conditions rather than to bruising.

The hypothesis tested in this experiment was that blackspot-resistant clones would exhibit a different pattern of change in ascorbic acid content following bruising than susceptible clones. However, the results indicate that the content of ascorbic acid in bruised and nonbruised tissue, and changes in ascorbic acid content with time after bruising, were not related to blackspot susceptibility.

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Postharvest Handling of Bud-cut Freesia Flowers

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Abstract. **The opening of *Freesia hybrida* Bailey flowers cut in the tight bud stage was promoted by treatment with sucrose and 200 mg·liter^{-1} 8-hydroxyquinoline citrate. A pulse treatment for 24 to 48 hr with 20% sucrose resulted in complete inflorescence development and prolonged vase life. Reduced sucrose concentrations or increased pulse durations were not as effective. Pulse-treating flowers with 20% sucrose for 24 hr prior to 3 days of simulated shipping improved subsequent flower opening and vase life.**

Freesia is an important cut flower crop in Europe, and its production in the United States has increased in recent years. Freesia offers an excellent alternative crop for northern greenhouses, since its production is dependent on low temperatures. The demand for cut freesia flowers is increasing due to increased availability, their attractive scent, and their relatively long vase life.

Little information is available on the postharvest handling of cut freesia flowers. It has been reported that inflorescences harvested prior to the opening of the first floret fail to open 100% of their flowers before senescing (8). In addition, flowers opening on tight-bud harvested inflorescences are not as large and colorful as those opening on stems harvested at the normal commercial stage (8).

Bud opening is a technique whereby flowers harvested at the tight bud stage are opened

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Table 1. Effects of stage of harvest, germicide, and sucrose concentration on the opening and vase life of cut freesia inflorescences.

Stage of harvest	Pulse solution[z]	Time to commercial stage (days)	Florets open	Vase life (days)[x]
			Day 6[y]	
Commercial	---	0[w]	5.5	11.8
Tight bud	DI H_2O	3.0	2.5	9.2
Tight bud	8 HQC 200 mg·liter^{-1}	2.5	2.7	10.2
Tight bud	8 HQC + 5% sucrose	2.0	3.3	10.5
Tight bud	8 HQC + 10% sucrose	1.8	5.7	10.7
Tight bud	8 HQC + 15% sucrose	1.7	5.8	10.8
Tight bud	8 HQC + 20% sucrose	1.3	6.5	11.5
Tight bud	8 HQC + 25% sucrose	1.2	7.0	12.0
Contrasts[v]				
Commercial vs. tight bud		**	**	**
DI H_2O vs. HQC		*	NS	*
Sucrose concn				
Linear		**	**	**
Quadratic		NS	*	NS

[z]Cut inflorescences were pulse-treated wtih solutions for 24 hr.
[y]Open flowers were counted 6 days following their transfer from pulse solutions to water.
[x]Vase life as determined by the wilting of the last open flower of each inflorescence.
[w]Means of eight replicate inflorescences.
[v]Single degree of freedom contrasts.
NS,*,**Nonsignificant or significant at the 5% and 1% levels, respectively.

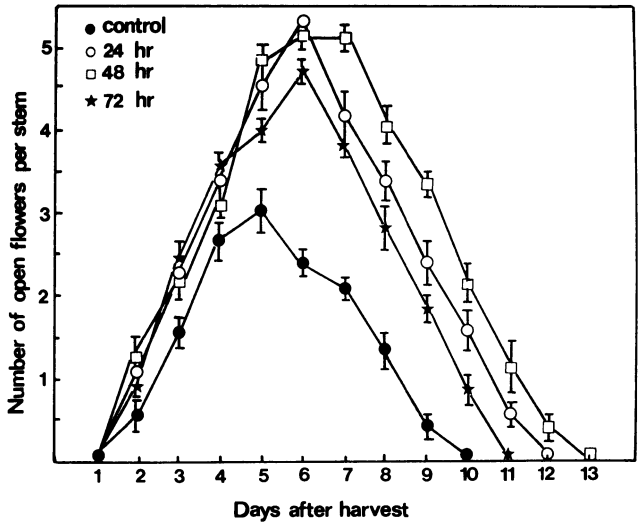

Fig. 1. The influence of pulse duration with 20% sucrose and 200 mg·liter^{-1} 8-HQC on flower opening of bud-cut freesia. Means of eight replicate stems. Vertical bars represent ± SE.

off the plant in vase solutions often containing carbohydrates (1–7). This procedure has been reviewed recently (5). The advantages of bud opening include: a) economical packing and shipping, b) reduced shipping damage, and c) increased flexibility in marketing period. This technique had been applied to various flowers, including chrysanthemum (1, 6), rose (4), carnation (1, 4), and gladiolous (1, 7). Previous studies have suggested freesia can be harvested successfully at the tight-bud stage and subsequently opened if treated with solutions containing sucrose (2). The purpose of this study was to determine optimum sucrose concentration and treatment duration for opening bud-cut freesia flowers.

Freesia hybrida cv. Aurora were grown from corms in a controlled environment greenhouse with 12°C (night) and 18° (day) temperatures. Flowers were cut either at the tight-bud stage (≈3 days before the opening of the first floret) or at the normal commercial stage (first floret open). Solutions were prepared from reagent-grade sucrose in combination with 200 mg·liter^{-1} 8-hydroxyquinoline citrate (HQC). Following harvest, stems were recut under water to 10-cm lengths, pulse-treated with solutions for various durations, and then transferred to deionized (DI) water for evaluation of bud-opening and vase life. Flowers were held under cool-white fluorescent light (2.0 W·m^{-2}), 12-hr day) at 22° and 60% RH during pulse treatment and subsequent evaluation. At various times following transfer to water, the number of open flowers per inflorescence was recorded. An individual flower was considered open when the petals separated. Vase life was considered terminated when the last open flower wilted and lost decorative value. At this point, any unopened flowers were recorded. In each experiment, eight replicate flowering stems were used per treatment.

Effect of stage of harvest. Harvesting freesia inflorescences at the tight-bud stage reduced rate and extent of flower opening in comparison to flowers harvested at the typical commercial stage (Table 1). Although physiologically younger at harvest, bud-cut flowers exhibited shorter vase life than more mature harvested flowers (Table 1). Harvesting freesia in the bud stage resulted in incomplete inflorescence development, with more than 30% of their flowers failing to open by the termination of their vase life. Similar results were reported previously (8).

Effects of HQC and sucrose concentration. Vase solutions containing carbohydrates usually contain a germicide and acidifying agent to reduce bacterial contamination (5). The germicide HQC was used at the rate of 200 mg·liter^{-1} alone or in combination with various concentrations of sucrose. Pulsing bud-cut freesia flowers with HQC for 24 hr promoted flower opening and increased vase life in comparison to DI water (Table 1). The addition of sucrose to the HQC pulse solution at concentrations ranging from 5% to 25% reduced the time required to reach commercial stage and increased linearly the number of flowers open 6 days after transfer to water (Table 1). The vase life, as judged by the senescence of the last open flower, was extended with increasing sucrose concentrations. In general, sucrose concentrations above 10% were necessary for complete inflorescence development as determined by unopened flowers at the termination of vase life.

Effect of pulse duration. An advantage of pulse-treating flowers over continuous treatment is the limited time in which flowers must remain in treatment solutions, allowing the flowers to be treated for improved bud opening by a single handler along the marketing chain. In the second experiment, the effects of duration of pulse treatment on bud opening of freesia were determined. Flowers were harvested at the tight-bud stage and pulse-treated with 20% sucrose and 200 mg·liter^{-1} HQC for 24, 48, or 72 hr. A group of control flowers were held in 200 mg·liter^{-1} HQC for 24 hr and then transferred to water. Vase life evaluations were conducted on all treatments beginning 24 hr after initiation of treatments. Regardless of pulse duration, treating flowers with 20% sucrose improved flower opening and increased vase life compared to HQC alone (Fig. 1). Pulsing with 20% sucrose for 72 hr resulted in fewer open flowers than pulse treatments of shorter duration. Furthermore, flowers pulsed for 72 hr with sucrose showed evidence of injury as necrosis of the petal tips. High concentrations of sugar have been reported to damage certain cut flowers (3, 4).

Effect of simulated shipping. The possibility of pretreating flowers prior to shipping was tested in another experiment. Flowers were harvested at the tight-bud stage, pulsed with 20% sucrose containing 200 mg·liter^{-1}

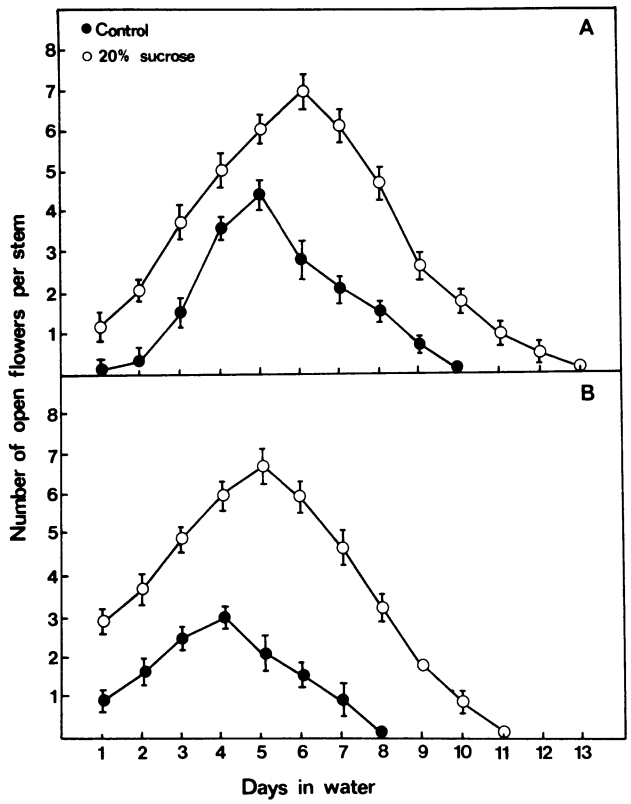

Fig. 2. The influence of a 24-hr pulse treatment with 20% sucrose and 200 mg·liter^{-1} 8-HQC on opening of bud-cut freesia following a 3-day period of simulated shipping. Stems transferred to water following pulse (**A**) or held at 4°C for 3 days to simulate shipment (**B**). Means of eight replicate stems. Vertical bars represent ± SE.

HQC for 24 hr, then immediately placed in water or packed dry by wrapping the stems in polyethylene-backed paper and placing at 4°C for 3 days to simulate shipping. Flowers were evaluated for bud-opening and vase life upon being placed in water, either immediately following pulse treatment or following simulated shipping. Groups of control flowers were pulsed with 200 mg·liter^{-1} HQC for 24 hr prior to simulated shipping. A 3-day period of simulated shipment reduced the rate and extent of flower opening, as well as vase life of bud-cut freesia flowers (Fig. 2). Bud-opening subsequent to the simulated shipping period was promoted by a pulse treatment of 20% sucrose received prior to the storage treatment.

From these experiments it is clear that freesia can be opened successfully off the plant when harvested at an immature or tight-bud stage. Bud opening and vase life are improved with a 24-hr pulse treatment of 20% sucrose and 200 mg·liter^{-1} of the biocide HQC.

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