than fruit that was bagged, but differences were not significant. No significant differences existed in the total retail store losses for sampling among the marketing seasons and between flesh-colored fruit.

Projecting our loss figures to the grapefruit volumes delivered to metropolitan New York during 1981–83, we estimate a yearly average of about 2550 MT of grapefruit culls at the retail level. Since the low cull incidence (1.4%) found at wholesale was within acceptable tolerances, retail outlets probably received defective fruit in routine grapefruit deliveries. Based on our examination, we estimate about 1000 MT of defective fruit were wholesaled annually during our test period.

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Susceptibility of 'Marsh' Grapefruit to Chilling Injury is not Related to Endogenous Calcium Levels in Flavedo Tissue

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Additional index words. *Citrus paradisi*, low temperature storage, canopy position

Abstract. **'Marsh' grapefruit (*Citrus paradisi* Macf.) harvested from the exterior canopy positions pitted more severely during storage at 5°C than did fruit harvested from the interior canopy of the same tree. The flavedo tissue of interior and exterior canopy fruit had similar calcium contents. Severity of pitting within a single lot of fruit also was not significantly correlated ($r = -0.24$ NS) to the calcium content of the peel. Thus, the variation in susceptibility of grapefruit to chilling injury does not appear to be related to endogenous calcium content of the flavedo tissue.**

Freshly harvested grapefruit stored at temperatures below 10° to 12°C frequently develop surface pitting, a symptom of chilling injury (5, 7, 8, 9). Susceptibility to chilling injury varies throughout the season; fruit harvested at midseason generally are less susceptible to chilling injury than fruit harvested earlier or later in the season (8, 9). Fruit harvested from interior canopy positions of the tree are less susceptible to chilling injury than fruit harvested from exterior canopy positions (5, 7). Furthermore, the shaded surface of exterior canopy fruit is less susceptible to chilling injury than the sun-exposed surface of the same fruit (7). The mechanism responsible for differences in susceptibility of grapefruit to chilling injury is not known. Reduced susceptibility to chilling injury has been correlated positively with elevated levels of reducing sugars and/or proline in the peel (6, 8, 9), but the role that these metabolites play in the resistance to chilling injury is not known.

Chilling injury of avocados was negatively correlated with endogenous Ca levels, and infiltrating Ca into avocados prior to low temperature storage reduced chilling injury (1). Other postharvest disorders, such as bitter pit of apples (11) and cork spot of pears (10), also have been attributed to low endogenous Ca levels. Calcium has been implicated in membrane integrity (2). Since it is generally agreed that chilling injury results from direct effects of low temperature on the flexibility of membranes of chilling-sensitive plant tissues (3), it is possible that chilling injury of grapefruit may be associated with low endogenous Ca levels in the peel tissue. These experiments were designed to test that hypothesis.

'Marsh' grapefruit were harvested separately from the interior and exterior canopy positions of mature trees from 3 different groves during February and March 1984. Thirty interior and 30 exterior canopy fruit from each tree were stored in fiberboard cartons at 5°C for 5 weeks. The fruit were not washed to minimized any mechanical injury which might contribute to the development of chilling injury symptoms. Chilling injury was rated after 21 and 35 days of storage on a scale of 0 to 5 (0 = no injury, and 5 = severe injury). The total score for the lot was divided by the maximum possible score (30

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Table 1. Chilling injury index and Ca content in the flavedo tissue of 'Marsh' grapefruit stored at 5°C.

	Chilling injury index[z]		
Fruit Lot	21 days	35 days	Ca (mg g^{-1} dry wt)[y]
Grove 1			
Interior	2	14	7.1 ± 1.9
Exterior	6	35	10.0 ± 0.9
Grove 2			
Interior	3	14	11.1 ± 1.6
Exterior	18	33	11.4 ± 2.0
Grove 3			
Interior	15	---[x]	7.3 ± 1.0
Exterior	46	---	8.3 ± 1.9

[z]Chilling injury index of exterior canopy fruit was significantly greater ($P < 5\%$, paired t test) than that of interior canopy fruit.
[y]Mean ± SD. Means were not significantly different from each other at 5% level.
[x]Pitting became too severe after 21 days to keep fruit for additional storage.

Table 2. Calcium content in the flavedo tissue of the abaxial and adaxial sides of 'Marsh' grapefruit.

Orientation	Ca (mg g^{-1} dry wt)[z]
Abaxial side	9.06 ± 1.97
Adaxial side	9.61 ± 1.76

[z]Mean ± SD. Means were not significantly different from each other at 5% level.

was rated after 21 and 35 days of storage on a scale of 0 to 5 (0 = no injury, and 5 = severe injury). The total score for the lot was divided by the maximum possible score (30 fruit × a score of 5 = 150) to give the chilling injury index. An index of 10 represents unmarketable fruit.

Calcium determinations were made only on flavedo tissue, since chilling injury symptoms are restricted primarily to the outer layers of the peel. The flavedo was removed in 5-mm strips from around the equatorial position of 6 fruit from each canopy position and harvest. The strips were cut into 5-mm lengths and dried overnight in a drying oven at 60°C. One gram samples of the dried tissue were placed in platinum crucibles and dry ashed in a muffle furnace at 500°. The resulting white fine powder was dissolved in 2 ml of concentrated HNO_3 and then diluted volumetrically to 100 ml with deionized glass distilled water. Calcium content was determined with a Perkin-Elmer 503 Atomic Absorption Spectrophotometer at a wavelength of 422.7 nm and compared to a Ca standard.

Exterior canopy fruit from one grove were marked for orientation prior to harvest. The peel from the sun-exposed (abaxial) and shaded (adaxial) sides of the fruit were analyzed for Ca separately.

Fruit harvested from interior canopy positions developed significantly less pitting after 21 and 35 days of storage at 5°C than fruit harvested from exterior canopy positions (Table 1). Calcium levels in the flavedo tissue of interior and exterior canopy fruit were not different. In addition, Ca levels in the flavedo tissue of the sun-exposed surface were not different from the shaded surface of the same fruit (Table 2). The sun-exposed surface previously was found to be more susceptible to chilling injury than the shaded surface of the same fruit (7).

The severity of pitting in fruit stored at 5°C for 4 weeks was not significantly correlated ($r = -0.239$, n = 12) with the Ca level in the flavedo tissue. Calcium content of fruit exhibiting no chilling injury symptoms was similar to the Ca content in the flavedo tissue of fruit which was severely pitted (data not shown). Calcium content of the tissue also did not change during storage at 5° for 5 weeks.

In contrast to chilling injury of avocados (1), no evidence was obtained in this study to indicate that chilling injury of grapefruit is related to the endogenous Ca content of the flavedo tissue. Nagy et al. (4) recently reported only minor variations in the endogenous Ca levels in grapefruit peel throughout the season. However, seasonal trends in susceptibility to chilling injury consistently have been observed (8, 9). Thus, the variation in susceptibility of grapefruit to chilling injury does not appear to be related to endogenous Ca levels of the flavedo tissue. However, a certain threshold level of Ca in the tissue may be necessary to maintain membrane integrity and thereby enable grapefruit to resist injury during storage at low temperatures.

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Chemical Control of Vegetative Growth in Citrus Trees by Paclobutrazol

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Additional index words. 'Minneola' (*Citrus paradisi* x *C. reticulata*) tangelo, growth regulation, morphactin

Abstract. **Paclobutrazol (PP333) [(2RS,3RS)-1-(4-chlorophenyl)-4, 4-dimethyl-2-(1,2,4-triazol-1-yl-)pentan-3-ol] sprays applied to 'Minneola' tangelo trees, at 500 or 1000 ppm, before the onset of summer flush, markedly reduced total growth, number of shoots, and internode length. Soil treatments (0.4 and 0.8 g per square meter) had only a small effect, probably because of the short time from application to flush inception. Sprays of Morphactin (an auxin transport inhibitor), at 250 and 500 ppm did not reduce growth, but rather enhanced it by increasing the number of emerging shoots. The spring flush of the same trees also showed effects of paclobutrazol soil treatments, whereas other treatments were not different from control. Paclobutrazol sprays on comparable 'Minneola' trees just before the spring flush also reduced this growth. Paclobutrazol may become a tool for the control of vegetative growth of mature citrus trees.**

The chemical control of vegetative growth in citrus trees has not yet been attained. Growth retardants, effective on many deciduous woody perennials, have almost no effect on vegetative growth rates of citrus and other evergreen trees (6). Some of those retardants, however, influence flowering and fruit dimensions (7, 4). Other growth regulators have effects too strong to be acceptable, such as those growth inhibitors which prevent regrowth of branches (2) but cannot be used to retard shoot elongation.

A reliable chemical which would reduce shoot elongation would therefore be of great practical interest. Although it seems logical to use an inhibitor of biosynthesis of naturally occurring gibberellins, those which have been tried until now have had little effect, especially when sprayed on leaves. (1) Paclobutrazol has been reported as very effective in reducing growth of different plants, including deciduous fruit trees (3, 9, 10). Tests of paclobutrazol on mature citrus trees have given some success, and these results

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