Table 2. Decay of 'Bearss' lemons stored at 1° or 10°C for 21 days plus 2 weeks at 21°.[z]

Treatment			Decay (%)		
			Immediately after	After holding at 21°C	
C_2H_4 (ppm)	Oleocellosis	Temp. °C[y]	21 days' storage	7 days	14 days
0[x]	−	1	0.0 b[w]	76.2 a	90.6 a
0[x]	+	1	0.2 b	82.6 a	93.8 a
0	−	1	0.0 b	0.7 c	2.2 e
0	+	1	0.0 b	2.5 c	5.1 de
0	−	10	0.2 b	0.2 c	0.3 e
0	+	10	0.3 b	0.7 c	0.8 e
1	−	1	0.0 b	5.4 c	9.7 de
1	+	1	0.0 b	7.3 c	12.7 d
1	−	10	0.3 b	0.8 c	1.2 e
1	+	10	0.1 b	0.4 c	0.6 e
Commercial pack		1	0.0 b	33.3 b	47.3 b
Commercial pack		10	20.3 a	28.6 b	32.5 c

[z]Each treatment represents 900 fruit obtained from 4 harvests of 4 groves.
[y]Relative humidity ranged from 80% to 92%.
[x]Control.
[w]Mean separation in columns by Duncan's multiple range test, 5% level.

stored at 10°C (Table 2). After 7 days holding at 21°, decay increased in all treatments, particularly the commercial pack stored at 1° and the control fruit that was not cured and kept continuously at 1°. Without considering the method of degreening and the presence of oleocellosis, and excluding the control and commercial pack fruit, the decay average was unacceptably high (7.4%) in fruit stored at 1° and held 14 days at 21°, whereas it was minimal (average 0.7%) in fruit stored at 10° and held 14 days at 21°. Decay was predominantly green mold, caused by *Penicillium digitatum* Sacc., that enters the fruit through injured tissue (5). The treatments which showed the highest amount of decay generally also showed the highest incidence of CI.

As with CI, the method of curing and the presence of oleocellosis had no significant effect on decay development. Size of fruit likewise was not related to CI or decay development.

A low-temperature (1°C) storage period does not appear to be a feasible alternative to EDB as a quarantine treatment against the Caribbean fruit fly, because of resulting poor lemon fruit condition. If ways could be found to ameliorate the CI, however, a low-temperature storage could be used.

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Wholesale and Retail Losses in Grapefruit Marketed in Metropolitan New York

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Additional index words. cullage, parasitic diseases, disorders, injuries

Abstract. **Losses in white- and red-flesh grapefruit (*Citrus paradisi* Macf.) retailed in metropolitan New York during 1981–83 were 3.6%. There was no difference between the 2 types of fruit. Florida-grown grapefruit had a retail cullage loss of 3.5%. No significant difference in loss occurred between store-prepackaged and loose fruit during retail. Parasitic diseases were responsible for almost half of the culls; rind breakdown and mechanical damage accounted for most of the remainder. Sampling at the wholesale level revealed a potential cullage of 1.4%.**

The consumption of fresh grapefruit in metropolitan New York is exceeded only by potatoes, lettuce, oranges, and apples (9). The volume of this major citrus crop delivered to the New York market in 1982 was almost 71,000 MT, a 30% increase from 1977 (9). Florida supplies the New York market with more than 90% of its grapefruit, and California supplies most of the remainder.

As a continuance of a USDA study of market losses of major fresh fruit and vegetable crops (1, 2, 3, 4, 5, 6, 7, 10), this report deals with the condition of grapefruit at wholesale and the subsequent extent of loss in retailing the crop in metropolitan New York. The information could provide valuable guidelines for reducing losses and preserving product quality.

Information on the wholesale condition of grapefruit was obtained by visiting the New York City Terminal Market at Hunts Point and warehouses of leading food chain organizations in metropolitan New York periodically from 1981 to 1983. The receivers permitted us to examine grapefruit on their premises shortly after delivery. When the cause of waste could not be determined immediately the culls were brought to our laboratory, and the cause(s) identified through macroscopic and microscopic examination and culturing of microbial pathogens.

Retail losses were obtained through cooperation of 9 supermarkets, a minimum of 2 each from low, middle, and high income locations in metropolitan New York. Stores were visited once or twice weekly throughout most of the year. Fruit displayed in some stores often were from the same lot(s) sampled previously at wholesale.

Data were obtained from store personnel or from our examination of the fruit. Loss data were based on a 1–3 day test period each week. When necessary, the cull specimens were brought to the laboratory for a definitive diagnosis.

More than 59,000 white- and red-flesh grapefruit were examined at terminal market wholesale outlets and food-chain distribution warehouses during the 3-year study (Table 1). Florida and California fruit made up 85.7% and 12.8% of the total, respectively, with the remainder from Texas and Arizona. Of the 815 culls (1.4%), parasitic activity ac-

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Table. 1 Incidence and causes of grapefruit culls in wholesale samples and in retail stores (1981–83).

Marketing level and fruit	Fruit examined	Parasitic diseases		Physiological disorders		Physical injuries		Total	
	No.	No.	%	No.	%	No.	%	No.	%
Wholesale									
White	43,175	419	1.0	48	0.1	80	0.2	547	1.3
Red	15,923	248	1.6	7	<0.1	13	0.1	268	1.7
Total	59,098	667	1.1	55	0.1	93	0.2	815	1.4
Retail									
White	102,452	1732	1.7	1041	1.0	999	1.0	3772	3.7*
Red	71,464	1071	1.5	602	0.8	819	1.2	2492	3.5*
Total	173,916	2803	1.6	1643	0.9	1818	1.0	6264	3.6*

*Significantly different from wholesale by analysis of variance, 5% level.

Table 2. Incidence and causes of retail cullage of Florida grapefruit.

Marketing season and kind of fruit	Fruit examined no.	Green mold rot[z] (%)	Stem-end rot (%)	Sour rot (%)	Other rots[y] (%)	Rind breakdown (%)	Pitting, chilling injury (%)	Soft shrivelled (%)	Mechanical injuries (%)	Other[x] (%)	Total (%)
1980–81											
White											
Loose	10,502	0.9	0.1	0.1	<0.1	0.6	0.1	0.1	1.1	0.3	3.3[w]
Bagged	5030	0.7	<0.1	0.1	0.1	0.2	0	0	0.4	0.2	1.6
Red											
Loose	10,451	1.1	0.3	0.1	0.1	0.3	0.1	<0.1	0.9	0.3	3.1
Bagged	1612	0.5	<0.1	0.1	0.1	0.1	0	0	0.3	0	0.9
1981–82											
White											
Loose	34,467	0.7	0.7	0.2	0.1	0.6	0.2	0.4	0.9	0.3	4.1
Bagged	13,178	2.3	0.4	0.3	0.2	0.5	0.2	0.1	0.8	0.6	5.4
Red											
Loose	18,324	1.0	0.6	0.3	0.1	0.2	0.2	0.5	0.8	0.9	4.6
Bagged	2636	0.6	0.2	0	0.1	0.3	<0.1	0	0.1	0.3	1.6
1982–83											
White											
Loose	27,399	1.1	0.2	0.1	0.1	0.4	<0.1	0.4	0.7	0.1	3.2
Bagged	9035	1.4	0.2	<0.1	0.1	0.1	<0.1	<0.1	<0.1	<0.1	2.0
Red											
Loose	21,813	0.8	0.2	0.1	0.1	0.3	<0.1	0.4	0.6	0.3	2.7
Bagged	2186	0.6	0.2	0.1	0.1	0.6	0	0.1	0.6	0.5	2.1
1980–83											
White											
Loose	72,368	0.9	0.4	0.1	0.1	0.5	0.1	0.4	0.8	0.3	3.7
Bagged	27,243	1.7	0.2	0.2	0.1	0.3	0.1	<0.1	0.5	0.4	3.6
Red											
Loose	50,588	0.9	0.3	0.1	0.1	0.3	0.1	0.3	0.7	0.5	3.5
Bagged	6434	0.6	0.2	<0.1	<0.1	0.4	<0.1	<0.1	0.2	0.2	1.6

[z]Includes a small amount of blue mold rots (*Penicillium italicum* Wehmer).
[y]Rots by species *Alternaria, Phytophthora, Fusarium*, anthracnose and unidentified fungi and melanose.
[x]Field scars, insect injuries, aging, skin discoloration, mottling, water soaked rinds and freezing damage.
[w]There were no significant differences among fruit, 5% level.

counted for 82% (Table 1). The remaining culls resulted from nonparasitic disorders and physical injuries. No significant differences in loss existed between the white- and red-flesh grapefruit. The cull incidence of 1.4% at the wholesale level was much lower than the estimated 13% loss for grapefruit reported by Friedman in 1960 (8). The sharp decrease doubtlessly was due to the improved effectiveness of postharvest fungicides, such as the benzimidazole compounds, that are used currently.

At the retail level, almost 174,000 grapefruit were examined. More than 6000 fruit or 3.6% were culled and discarded. This loss was in close agreement to the retail loss of 3% reported by Friedman (8). Whereas parasitic diseases caused most of the retail loss, physical injuries, principally mechanical, produced a substantial number of culls. No significant difference was found between the white- and red-flesh grapefruit in any of the major cull categories (Table 1).

Although no significant differences in losses were found between white- and red-flesh grapefruit within the wholesale and retail samples, losses between the 2 marketing levels were significantly different (Table 1).

Florida is the major supplier of grapefruit to the New York market, and a detailed analysis of grapefruit losses from that state is presented in Table 2. Heavy volumes of Florida grapefruit usually arrive on the New York market from October through May. Retail losses for all grapefruit during the entire study period were 3.5%; 3.6% occurred in white-flesh fruit and 3.3% in red-flesh fruit. More loss was observed in the latter fruit when it was retailed loose (3.5%) than when prepackaged, i.e., bagged (1.6%). The difference was not significant, however, because of the widespread variation in the sample data. Similarly no differences existed in the white-flesh fruit. Penicillium rots, nearly all caused by *P. digitatum* Sacc. (green mold rot), were the most prevalent retail store decays every year, regardless of flesh color and whether the fruit was merchandized loose or prepackaged in plastic film or open mesh bags. Penicillium rots accounted for about 70% of the parasitic losses. Stem-end rots (*Diplodia* and *Phomopsis* spp.) were next in importance, causing about 20% of the losses. Rind breakdown was the leading cause of loss in the fruit that was affected by nonparasitic diseases. Grapefruit that was merchandized loose had more mechanical injuries 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

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.

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