Table 2. Weighted discrepancy between perceived importance and perceived proficiency in the various subject matter areas, all respondents, USA, 1984.

Subject matter area	($\bar{X}$ importance − $\bar{X}$ proficiency)	$\bar{X}$ importance	Weighted discrepancy
Pest identification and control	0.69	4.55	3.17
Plant disorder diagnostic techniques	0.51	4.30	2.21
Weed identification	0.52	3.99	2.07
Home fruit production	0.38	4.37	1.67
Recommended cultivars	0.41	4.05	1.66
Ornamental plant identification	0.38	3.91	1.49
Home Vegetable gardening	0.20	4.62	0.93
Fruit plant/product identification	0.21	3.90	0.83
Edible and poisonous plants/products	0.26	3.05	0.80
Lawn establishment and care	0.18	4.08	0.75
Soils	0.19	3.87	0.74
Herb identification	0.23	2.65	0.62
Landscape installation and maintenance	0.13	3.56	0.45
Fertilizers, plant nutrition	0.06	3.96	0.25
Pruning ornamental plants	0.04	3.96	0.16
Landscape design	< 0	3.20	< 0[z]
Horticultural equipment, materials, and supplies	< 0	3.23	< 0
Wildlife control in home plantings	< 0	2.95	< 0
Fruit and vegetable storage	< 0	3.17	< 0
Nuts and nut growing	< 0	2.54	< 0
Plant/product quality attributes	< 0	2.87	< 0
Floral design	< 0	1.92	< 0
Economics of gardening	< 0	2.91	< 0
Vegetable plant/product identification	< 0	3.87	< 0
Plant propagation	< 0	3.11	< 0

[z]No ranking is implied by order of listing of items < 0.

Literature Cited

1. Borich, G.D. 1980. A needs assessment model for conducting follow-up studies. J. Teacher Educ. 21(3):39–42.
2. Caffarella, R.S. 1982. Identifying client needs. J. of Ext. 20(4):5–11.
3. Dillman D.A. 1978. Mail and telephone surveys: the total design method. Wiley, N.Y.
4. ECOP Agr., For. and Related Ind. Subcommittee Rept on a Survey of States Home Hort. Programs. 1979. Home horticulture education. ES-USDA, Washington, D.C.
5. Gomez, R.E. and L. Palmer. 1982. Directory of state extension horticultural specialists. USDA Ext. Ser., Washington, D.C.
6. Kerlinger, F.N. 1973. Foundations of behavioral research, 2nd ed. Holt, Rinehart and Winston, N.Y.
7. Nickens, J.M., A.J. Purga III, and P.O. Noriega. 1980. Research methods for needs assessment. Univ. Press of America, Washington, D.C.
8. Quick, S. and K. Davis. 1979. A self reporting evaluation tool. J. of Ext. 17(6):20–25.

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Reducing Susceptibility of Grapefruit to Chilling Injury during Cold Treatment

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Additional index word. *Citrus paradisi*, postharvest disorders, Thiabendazole, decay

Abstract. **With the expected ban on ethylene dibromide fumigation, cold exposure remains the only quarantine treatment for citrus fruit against the Mediterranean fruit fly. Following a cold treatment, 'Marsh' grapefruit (*Citrus paradisi* Macf.) developed chilling injury (CI), mostly in the form of slight peel pitting on 3% to 10% of the fruit depending on the season and on other factors. There was no difference in the incidence of CI between fruit treated at 0°C for 10 days or at 2.2° for 16 days as regulations require. The cold treatment also enhanced decay development during long-term storage of the fruit at 11°. Mold rots developed on CI peel pitting, and their incidence increased from 1.7% to 3.5% during a storage period of 12 weeks. The presence of the fungicide Thiabendazole (TBZ) in the wax coating of the fruit reduced the incidence of CI by more than 50%. Delayed cooling, i.e., keeping the freshly harvested packed fruit for 6 days at 17°C prior to initiation of cold treatment, reduced the incidence of CI by the same extent. By combining a TBZ treatment with delayed cooling, the susceptibility of grapefruit to CI can be reduced, and cold treatment can be practiced with a low risk of CI and subsequent decay development.**

Fumigation of citrus fruit with ethylene dibromide (EDB) to eliminate the Mediterranean fruit fly *Ceratitis capitata* (Wied) and other flies, is being practiced according to plant quarantine requirements of several countries importing the fruit. Such treatments are effective in controlling the pests but sometimes result in peel injury to the fumigated fruit (1). Moreover, a ban on the use of EDB makes it necessary to treat the fruit by other means. An alternative method — cold treating the fruit by keeping it at low storage temperatures — has been authorized by the USDA for imported fresh fruit (13). The regulation requires that citrus fruit be kept at 0°C for 10 days or at 2.2° for 16 days after its pulp has reached the required temperature, usually 2 to 4 days after commencement of the cold treatment (3). However, since citrus fruit, particularly grapefruit and lemon, are sensitive to chilling injury (CI) (4, 5, 10), cold treatment may cause peel injury. Although grapefruit susceptibility to CI is seasonal (5), it is affected also by fruit position within the canopy and by biotic and environmental factors (7, 8, 9). However, the incidence of CI is determined mainly by the storage temperature and by the length of time during which the fruit is exposed to the CI-inducing temperature (6, 10).

In recent years, several fruit treatments which reduce the susceptibility of grapefruit to CI during storage have been reported. These include treatment of the fruit with CO_2 (6) or with the commonly used fungicide Thiabendazole (TBZ) (11, 12, 14), which also reduce the incidence of EDB fumigation injury (2), coating or wrapping of the fruit with various materials (14), and delayed storage (5, 6, 7, 8).

Since the cold treatment of grapefruit, as specified by the USDA, may not only cause CI to the fruit shortly after the treatment but also might adversely affect the length of its subsequent cold storage period, we tested the response of the fruit to this procedure with the objective of reducing its susceptibility to CI.

Freshly harvested 'Marsh' grapefruit were graded, washed, and disinfected in the packinghouse and coated with either a water emulsion wax ('natural wax'), which did not contain polyethylene, or with a polyethyl-

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Table 1. Incidence of chilling injury (CI) in cold-treated grapefruit.

Treatments		Incidence of CI (%)[z]	
Storage conditions	TBZ present in the wax	1st season	2nd season
Storage at 0°C for 10 days followed by storage at 11°C for 12 weeks[y]	−	2.7 ± 0.8	10.0 ± 1.8
	+	1.6 ± 0.4	4.0 ± 1.4
Storage at 2.2°C for 16 days followed by storage at 11°C for 12 weeks	−	3.7 ± 1.0	11.8 ± 1.8
	+	1.6 ± 0.6	3.8 ± 1.6
Continuous storage at 11°C (Control)	−	0.7 ± 0.3	0.7 ± 0.2
	+	0.3 ± 0.2	0.2 ± 0.2

[z]Values of CI represent the average values (± SE) of several laboratory tests carried out each year. Most of the CI was in the form of slight pitting and only approximately 25% of the values in the table represent medium or severe pitting. The incidence of brown-staining of the rind was negligible. Statistical analysis was performed on percentages after an arcsin transformation.
[y]The temperatures indicated are of the fruit pulp and were reached before commencement of the cold treatment period.

ene-containing wax, with or without the addition of TBZ (0.4%). The waxes were obtained from the following wax producers: Safepack Products Ltd., Makhteshim Chemicals Works, Ltd., and Broshar (Chemicals) Ltd. The fruit were wrapped individually in paper and packed in cartons. One to 2 days after packing, the fruit were subjected to cold treatments by placing the cartons in a forced air cooler at a temperature of −0.5° to 0°C for 2 to 4 days, until the fruit pulp reached a temperature of either 0° (−0.3° to 0°) or 2.2° (1.8° to 2.2°). The fruit then were kept at these temperatures for the periods specified by the USDA, i.e., for 10 days at 0° or for 16 days at 2.2°. Other fruit were kept for 4 additional days at each temperature to test the potential susceptibility of the fruit to CI. Control fruit, which did not undergo these cold treatments, were kept at 11°. The relative humidity in the storage rooms was 80% to 85%. Following cold treatments all fruit were stored at 11° (85% to 90% RH) for a period of 12 weeks. At the end of this storage period, the fruit were transferred to 17° for an additional 2-week period to simulate shelf life conditions.

Fruit were examined immediately following the cold treatments and every 4 weeks thereafter to determine the incidence of CI as previously defined (10). Also evaluated were the development of decay (decayed fruit were discarded), changes in fruit color, and chemical composition of the fruit juice.

Laboratory tests with at least 560 fruit per treatment (4 to 8 replications), as well as large, semi-commercial experiments (with 5000 fruit examined per treatment, 80 to 100 replications) were carried out during 2 consecutive years.

No significant differences in color or chemical composition were found in fruit subjected to the different cold treatments. Within 4 weeks of completing the cold treatments, CI and, in some cases, subsequent fungal rots, developed on the peel of the fruit stored at 11°C.

Despite some differences in the results of individual tests in each season and between the 2 seasons (due to different climatic conditions, dates of picking and regions and orchards from which the fruit were picked), in all laboratory tests the cold treatment resulted in an increased incidence of CI. This increase was similar under both sets of cold treatments tested (Table 1). Whereas waxing the fruit markedly reduced CI (Table 2), the presence of TBZ in the wax further decreased the incidence of CI in all tests (Tables 1 and 2). Delayed cooling, i.e., holding the fruit for 6 days at 17°C (88% to 92% RH) prior to commencement of the cold treatment, reduced the incidence of CI (Table 2). Another treatment which reduced CI was coating the fruit with a polyethylene-containing wax, when compared to coating with a 'natural' wax which did not contain polyethylene (data not shown).

Development of decay during storage, and particularly the development of mold rot on the sites of CI, was increased by the cold treatments. Thus, after 12 weeks of storage at 11°C and 2 additional weeks of simulated shelf life at 17°, the incidence of decay increased from 1.7% (± 0.4) of the control fruit to 3.5% (± 1.0) of the cold-treated fruit.

Whereas these results agree with data obtained with Florida grapefruit as to the effect of TBZ and delayed cooling on the reduction of CI (5, 7, 8, 14), they differ in the effect of the treatments on the development of decay. With Florida grapefruit, CI did not seem to affect the incidence of decay under the experimental conditions reported recently (7, 8). In contrast, our data indicate clearly that the fruit did develop CI following the relatively short exposure to the chilling-inducing temperatures of cold treatments, and that under these conditions, the incidence of decay increased. The differences could result from the different forms of CI which developed on the fruit — mostly brown-staining of the rind in Florida (7, 8), and mostly rind pitting in Israel — which developed even at the low temperatures of 0° to 2°C. In addition, in the current investigation decay development was evaluated after 14 weeks of storage, whereas in the recent reports from Florida (7, 8) it was evaluated 7 and 14 days after the cold treatment. Since prolongation of the treatment by only 4 days may result in an increase in CI (Table 3), the cold treatments may be close to the threshold of susceptibility of the Israeli fruit. For this reason, the use of TBZ in the wax to reduce CI seems particularly important, and its beneficial effect becomes pronounced with the increased susceptibility of the fruit to CI, due to factors such as the season (Table 1). Moreover, conditioning of the fruit to CI (7, 8) or delayed cooling (Table 2) together with the use of a polyethylene-containing wax may afford added protection to a CI-sensitive fruit, and may allow cold treatment of grapefruit to be used without adversely affecting the quality of the fruit.

Table 2. Effect of the combined treatment of waxing with TBZ and delayed cooling on incidence of chilling injury (CI) in cold-treated grapefruit.

Treatment	Incidence of CI[z] (%)
Non-waxed control	38.5 ± 4.2
Waxed only	9.5 ± 1.5
Waxed and delayed cooling	4.5 ± 1.1
Waxed with TBZ (0.4%)	3.8 ± 1.4
Waxed with TBZ (0.4%) and delayed cooling	1.4 ± 0.4

[z]Cold treatment was at 0°C for 10 days. The incidence of CI was determined after 4 weeks of subsequent storage at 11°. Statistical analysis was performed on percentages after an arcsin transformation. Other details are similar to those described in Table 1.

Table 3. Effect of prolonging the cold treatment by 4 days on incidence of chilling injury (CI).

Storage conditions	Incidence of CI[z] (%)
Storage at 0°C for 10 days	3.0 ± 0.4
14 days	3.8 ± 0.6
Storage at 2.2°C for 16 days	2.6 ± 0.3
20 days	3.4 ± 0.4
Storage at 11°C (control)	0.4 ± 0.3

[z]Values in the table represent an average (± SE) of values obtained from several semi-commercial tests in which the fruit was coated in the packinghouse with TBZ-containing wax. Most of the CI was in the form of slight pitting and only approximately 25% of the values in the table represent medium or severe pitting. The incidence of brown-staining of the rind was negligible. CI was determined after 4 weeks of storage at 11°. Statistical analysis was performed on percentages after an arcsin transformation.

Literature Cited

1. Chalutz, E., M. Schiffmann-Nadel, J. Waks, E. Alumot, Y. Carmi, and Y. Bussel. 1971. Peel injury to citrus fruit fumigated with ethylene dibromide. J. Amer. Soc. Hort. Sci. 96(6):782–785.
2. Chalutz, E., S. Biron, and E. Alumot. 1973. Thiabendazole reduction of ethylene dibromide peel injury on citrus fruit. Proc. Symp. Int. Inst. Refrig. Comm. C2:205–209.
3. Chalutz, E., M. Schiffmann-Nadel, J. Waks, and F.S. Lattar. 1974. Precooling of citrus fruits prior to simulated transport in ventilated ships. J. Amer. Soc. Hort. Sci. 99(4):368–370.

4. Chalutz, E., J. Waks, and M. Schiffmann-Nadel. 1981. The different responses of several citrus fruit cultivars to low storage temperature. Proc. Intl. Citrus Congr. 773–774.
5. Grierson, W. 1974. Chilling injury in tropical and subtropical fruit: V. Effect of harvest date, degreening, delayed storage and peel color on chilling injury of grapefruit. Proc. Trop. Reg. Amer. Soc. Hort. Sci. 18(1):66–73.
6. Hatton, T.T. and R.H. Cubbedge. 1982. Reducing chilling injury in grapefruit by prestorage conditions. Adv. Agr. Technol. ARS Southern Ser. No. 25:1–6.
7. Hatton, T.T. and R.H. Cubbedge. 1982. Conditioning Florida grapefruit to reduce chilling injury during low-temperature storage. J. Amer. Soc. Hort. Sci. 107(1):57–60.
8. Hatton, T.T. and R.H. Cubbedge. 1983. Preferred temperature for prestorage conditioning of 'Marsh' grapefruit to prevent chilling injury at low temperatures. HortScience 18(5):721–722.
9. Purvis, A.C. 1980. Influence of canopy depth on susceptibility of 'Marsh' grapefruit to chilling injury. HortScience 15(6):731–733.
10. Schiffmann-Nadel, M., F.S. Lattar, and J. Waks. 1971. The response of grapefruit to different storage temperatures. J. Amer. Soc. Hort. Sci. 96(1):87–90.
11. Schiffmann-Nadel, M., E. Chalutz, J. Waks, and F.S. Lattar. 1972. Reduction of pitting of grapefruit by thiabendazole during long-term cold storage. HortScience 7(4):394–395.
12. Schiffmann-Nadel, M., E. Chalutz, J. Waks, and M. Dagan. 1975. Reduction of chilling injury in grapefruit by thiabendazole and benomyl during long-term storage. J. Amer. Soc. Hort. Sci. 100(3):270–272.
13. USDA. 1982. Plant quarantine treatment manual. Animal and Plant Health Inspection Ser. PPQ, Sec. VI, T107, Washington D.C.
14. Wardowski, W.F., W. Grierson, and G.J. Edwards. 1973. Chilling injury of stored limes and grapefruit as affected by differentially permeable packaging films: HortScience 8(3):173–175.

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Reducing Decay in Fresh Blueberries with Controlled Atmospheres

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Additional index words. carbon dioxide, oxygen

Abstract. **Freshly harvested blueberry fruit (*Vaccinium corymbosum* L.) were held for 7 or 14 days at 2°C under constant atmospheres of CO_2 in air or with 2% O_2, under 2% O_2 alone or in normal atmosphere. When the berries were removed from the controlled atmospheres and held for 3 days at 21°, the CO_2-enriched atmospheres of 10%, 15%, or 20% significantly inhibited decay development for 1–2 days. The higher CO_2-enriched atmospheres generally were more effective. The 2% O_2 atmosphere alone was ineffective and did not enhance the CO_2 treatment.**

Blueberry fruit shelf life is limited by decay, principally gray mold rot (*Botrytis cinerea* Pers. ex Fr.), alternaria rot (*Alternaria* sp.), and anthracnose (*Colletotrichum* sp.), with the loci of infections primarily at the stem scar (1, 2, 3, 6). The foreign market potential for blueberries can be enhanced greatly if their shelf life can be extended sufficiently to cover the 12 to 14 days normally required for surface transport to European ports from the east coast of the United States (7). Effective control of decay in fresh blueberries was obtained with a combination of rapid precooling, a fungicidal dip, and modified atmospheres during cold storage (4). However, the use of dips is resisted by grower-shippers because of the extra cost of handling and drying the berries.

Atmospheres enriched with CO_2 were found fairly effective in inhibiting blueberry postharvest decay without a fungicide treatment (5). Various atmospheres of CO_2 in air were applied to film-packaged blueberries which then were cooled at different rates to 2°C. In that study, berry respiration and film leaks caused fluctuations in the package atmospheres during cooling and subsequent cold storage periods (5).

To determine more precisely the best atmosphere for disease control, we subjected fresh blueberries to several controlled atmospheres of CO_2 and O_2 during cold storage periods of 7 and 14 days in 1982 and 1983. Field trays, each with 12 uncovered, 1-pint (473 cm^3) pulpboard containers of commercially hand-picked or mixtures of hand-picked and machine-picked freshly harvested blueberries were obtained from New Jersey growers. Pints were randomized in every test, capped with a plastic film and, in sublots of 6 pints each, inserted into a 4-ml thick polyethylene film envelope (32 × 44 cm) which was heat-sealed. The air in each envelope was evacuated and replaced with a prescribed atmosphere. Test atmospheres consisted of 10%, 15%, and 20% CO_2 in air or with 2% O_2 and residual N_2; and 2% O_2 with 98% N_2 (Tables 1, 2, 3). Two envelopes with berries were connected serially to a cylinder (5.6–6.0 m^3 gas) of each of 7 test atmospheres. A gas flow rate of about 3 liters/hr was maintained during storage of the berries at 2°C. Controls consisted of berries held in a normal atmosphere within unsealed film envelopes.

After 7 or 14 days, the 12 pints of berries were removed from the 2 envelopes of each test treatment. Three pints of each test treatment were examined for market quality immediately after cold storage and 3 pints each were examined after 1, 2, and 3 days at 21°C and 85% RH. Four tests of 14 days duration were completed in 1982 and 6 tests of 7 days and 4 tests of 14 days duration were completed in 1983.

The combined results of the 6 blueberry storage tests replicated during the 1983 harvesting season are presented in Table 1. There were no significant differences in decay among any of the treatments when the ber-

Table 1. Effect of CO_2-enriched atmospheres on blueberry decay following 7 days of storage at 2°C, 1983.

Treatments	Decay[z] (%)				
	Initial storage period 7 days at 2°C	Subsequent holding period			
		1 day at 21°C	2 days at 21°C	3 days at 21°C	Total[y]
Storage air	0.3 a[x]	2.5 a	11.1 a	20.0 a	8.4
10% CO_2 + 90% air	0.1 a	1.0 c	5.0 bc	14.3 abc	5.1
15% CO_2 + 85% air	0.1 a	0.7 c	4.0 c	8.4 c	3.4
20% CO_2 + 80% air	0.0 a	0.9 c	3.4 c	10.5 bc	3.7
10% CO_2 + 2% O_2[w]	0.1 a	1.2 bc	5.0 bc	14.1 abc	5.0
15% CO_2 + 2% O_2	0.1 a	0.8 c	3.8 c	9.5 c	3.6
20% CO_2 + 2% O_2	0.0 a	0.9 c	3.6 c	11.5 bc	4.0
2% O_2	0.1 a	2.1 ab	8.9 ab	17.9 ab	7.2

[z]Principally gray mold and alternaria rots. Data derived from evaluation of all berries in 72 pints (avg. 242/pint) for each treatment in 6 tests.
[y]Based on total decay in all examinations.
[x]Mean separation within columns by Duncan's multiple range test, 5% level.
[w]Last 4 atmospheres in N_2.

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