the cell-pack box. The stowage factor for both containers included an additional 20% stowage allowance. The transport cost also included the truck transport charge from Vero Beach, Florida, to the port of Tampa, and the fumigation charge per trailerload of fruit.

The combined costs for packaging materials, direct labor, and transport for packing and shipping grapefruit to Tokyo, Japan, were $0.03 more/fruit for the cell-pack boxes than for the standard box (Table 4). For each standard box equivalent of 32 fruit, the additional packaging materials, direct labor, and transport costs to Tokyo amounted to $0.96 more (32 x $0.03) for fruit in the cell-pack box than for fruit in the standard box.

Trade reaction to commercial cell-pack boxes. The observations of grapefruit in cell-pack boxes from the first commercial shipment at the Kanda and Tsukiji wholesale fruit markets in Tokyo were made on March 27, 55 days after the fruit were packed at Vero Beach, Florida. Examinations of 17 cell-pack boxes selected at random at three wholesalers revealed that serious deformation averaged 1.4% and decay averaged about 3%. All of the Japanese wholesalers interviewed indicated that the cell-pack boxes delivered the fruit in near-perfect shape. The receivers agreed that a premium of about 270 yen ($1.08 when based on an exchange rate of 250 yen/U.S. dollar) would not be a problem for cell-pack boxes of fruit, provided that all fruit were of premium quality, in good shape, and without decay. Because the jobbers at the Kanda and Tsukiji markets examine and repack all of the grapefruit, thus guaranteeing their respective retailers 100% packout/box, they requested extra chipboard cell partitions and fiberboard layer dividers so that they could replace those soiled from decayed fruit. One jobber said that red or white chipboard cell partitions would complement the grapefruit more than the color of the kraft chipboard cell partitions used in these tests. Another jobber liked the vertical chipboard partitions because they permitted higher stacking of the boxes in the wholesale market stalls, where the cost of space is at a premium, than is possible with boxes not so equipped. A retailer stated that the chipboard cell partitions and fiberboard layer dividers should be kept in the cell-pack boxes, when repacking, to ensure quality at delivery into the retail stores from the wholesale markets.

Discussion

These tests demonstrated that Florida grapefruit packed in cell-pack boxes commercially with automatic equipment arrived in Tokyo, Japan in a better condition and with a better appearance than those shipped in standard 4/5-bu export boxes. The cell-pack boxes protected the grapefruit from deformation, and the reaction of the Japanese receivers to the use of the cell-packed boxes for large grapefruit was generally favorable. Although, at the time of our tests, it cost about $0.03 more/fruit to market Florida grapefruit in cell-pack boxes than in standard 4/5-bu export boxes in Tokyo, Japan, it appears that the cell-pack boxes are the best means currently available to ensure maintenance of quality, particularly avoidance of excessive deformation to grapefruit, during extended overseas shipments to Tokyo, Japan, which average 4 weeks or longer.

Literature Cited

1. Hale, P. W. 1973. Which grapefruit pack: bulge, flat, or slack? *Citrus and Veg. Mag.* 36(12):8, 11.
2. ———, and J. J. Smoot. 1973. Exporting Florida grapefruit to Japan. *Citrus and Veg. Mag.* 37(3):20-23, 45.
3. ———. 1980. Exporting large grapefruit in honeycomb cell-pack boxes. *Citrus and Veg. Mag.* 43(5):8, 28, 29, 32.
4. Hooks, R. C., and R. O. Kilmer. 1979. Estimated costs of packing and selling Florida citrus, 1977-78 season. *Univ. Fla. Econom. Infor. Rept.* 118, 18 pp.
5. Smoot, J. J., and P. W. Hale. 1977. Evaluation of decay control treatments and shipping containers for export of grapefruit to Japan. *Proc. Fla. State Hort. Soc.* 90:152-154.

Proc. Fla. State Hort. Soc. 93:319-323. 1980.

EFFECT OF INDIVIDUAL FILM WRAPPING AND RELATIVE HUMIDITY ON QUALITY OF FLORIDA GRAPEFRUT AND CONDITION OF FIBERBOARD BOXES IN SIMULATED EXPORT TESTS[1]

Kazuhide Kawada[2]
University of Florida, IFAS,
Agricultural Research and Education Center,
P. O. Box 1088, Lake Alfred, FL 33850

Philip W. Hale
USDA—SEA/AR,
2120 Camden Road, Orlando, FL 32803

[1]Florida Agricultural Experiment Stations Journal Series No. 2791. Mention of a trade name, proprietary product, or vendor is for specific information, only, and does not constitute a guarantee by the U.S. Department of Agriculture or imply its approval to the exclusion of other products that may also be suitable.

The authors are indebted to W. Grierson, J. J. Smoot, H. Kitagawa, and M. Iwamoto for their advice, to R. H. Cubbedge and P. D. Cooper for their technical assistance, and to Sea-Land Service, Inc., Elizabeth, NJ, for financial assistance in the form of a assistantship to K. Kawada.

[2]Permanent address: 709-4 Kamifukuoka-cho, Takamatsu-shi, Kagawa-ken, 760 Japan.

Additional index words. Citrus paradisi Macf., fruit deformation, nonrefrigerated shipping, packaging, packing, postharvest losses.

Abstract. **The effect of individual film wrapping with a low-density polyethylene bag and of in-transit relative humidity (RH) on the keeping quality of grapefruit and on the strength of fiberboard boxes were investigated. Florida 'Marsh' grapefruit harvested 3 times in 1979-80 were individually film wrapped or nonwrapped then stored to simulate a 4-week export period at 85% to 90% RH and 70°F (21°C) or 50% to 60% RH and 70°F, plus a 2-week marketing period at ambient conditions. Results indicated that if grapefruit were shipped in film wrapping, in-transit RH could be lowered below the currently recommended 85% to 90% RH without causing additional increase in weight loss, deformation, and decay. Reduced RH kept corrugated fiberboard drier than the 85% to 90% RH and thus, maintained its**

strength and minimized box distortion—results that would be beneficial in handling fiberboard boxes. The maintenance of shipping-box strength at low RH, however, did not reduce fruit deformation. In addition to overhead pressure and box failure, the current general practice of excessively tight place packing of grapefruit seems to be another major cause of severe fruit deformation. Results also indicated that if fruit are individually film wrapped, they might be shipped without refrigeration or humidity control, thereby saving energy, and still maintain their keeping quality.

Sharply increasing grapefruit production in Florida (6) requires further development of overseas markets, currently largely to Japan (17). Hale and Smoot in 1973 (12) reported that severe fruit deformation was one of the most serious problems in exporting grapefruit to Japan. Fruit deformation during transit usually relates to several factors such as: 1) Weight of overhead containers and their fruit content on lower boxes within box stacks, 2) pressure caused by the upper layers of fruit within each box on the lower layers of fruit within the box, 3) bulge packing (overfilling), 4) box strength and design, 5) vibration, and 6) any reduction in fruits' elasticity—its inherent resistance to deformation.

Hale and Smoot (12) evaluated 15 types of shipping containers. Results indicated that regardless of container type, the amount of fruit deformation was in the same range, and the deformation was attributed to bulge packing rather than to box failure. In subsequent, controlled laboratory tests conducted by Hale (7), the overall deformation of grapefruit was related to fruitpack height. The higher the fruit was packed, the more serious the deformation. In followup commercial export tests to Japan, Smoot and Hale (19) found that deformation was significantly reduced when grapefruit were packed flat, without over-top-bulge, in shipping boxes 0.5 inch (1.3 cm) deeper than the conventional, full-telescope corrugated-fiberboard boxes (so-called "cartons" in the produce industry). Some shippers are using fiberboard boxes, "Super-X," that are not only deeper than the conventional boxes, but also stronger, to protect fruit from overhead weight and, thus, from deformation. Tray-pack containers (8) and honeycomb cell-pack boxes (9, 13) have been field tested as means of providing additional protection to fruit during extended overseas shipments.

The resistance of grapefruit to deformation can be maintained by minimizing postharvest weight loss (14, 18). Very high RH (greater than 95%), however, cannot be used unless expensive, moisture-resistant boxes or bins (10) are used to prevent moisture absorption by the container materials and subsequent container failure. Corrugated fiberboard boxes lose about 9% of their compression strength with every 1% increase in moisture content up to 14% (5). Thus, a rather low RH would be beneficial in maintaining fiberboard box strength but it would accelerate the weight loss of grapefruit and results in deterioration of fruit quality (14, 18). Current commercial shipping RH is from 85% to 90%, and it often reaches 95% (11, 12, 18).

In a previous report to this Society by Kawada and Albrigo (14), individual film wrapping, referred to as "Uni-Pack," in a low-density polyethylene bag was the best treatment for maintaining the keeping quality of Florida grapefruit. Unipackaging not only minimizes weight loss, maintains fruit firmness, and reduces deformation (14, 15), but also reduces chilling injury (K. Kawada and W. Grierson, Agricultural Research and Education Center, University of Florida, Lake Alfred, FL, unpublished data). In addition, unipackaging reduces decay problems by preventing contact cross infection and "soilage" (blemishing of sound fruit by mold spores) among fruit packed in the same box and by facilitating the discard of spoiled fruit (14, 15). It also lends itself to an attractive wrap that could be imprinted with a packer's brand name (15). The beneficial effects of such packaging were confirmed in export tests from Florida to Japan and in simulated laboratory tests (1). The storage of citrus fruits individually wrapped with polyethylene film was also reported by scientists from Japan (16) and Israel (2). In both countries, equipment has been developed to wrap individual fruit mechanically.

The objective of this study was to determine whether the individual film wrapping of grapefruit would allow a reduction in in-transit RH without causing additional increase in weight loss and deformation of the grapefruit. Such RH reduction would reduce moisture absorption by the fiberboard boxes and permit the maintenance of box strength. Box-strength maintenance would allow boxes in lower layers in a stack to better withstand the pressure exerted on them by boxes in upper layers in the stack and, thus, allow less fruit deformation.

Materials and Methods

'Marsh' grapefruit were obtained from the Lake Alfred Agricultural Research and Education Center's Davenport grove, which was planted in 1960. The rootstock was rough lemon (*C. jambhiri* Lush.) and the soil type, Astatula fine sand. Fruit were harvested on November 14, 1979, and on January 7 and June 16, 1980. They were washed with FMC Fruit Cleaner 200 over brushes, treated with 1,000 ppm thiabendazole (TBZ) and Flavorseal No. 93 solvent wax, graded, and sized. Then they were "flat-packed" (19) in export fiberboard boxes 0.5 inch (1.3 cm) deeper than the domestic shipping boxes. The export container is a 4/5-bu (28.2 liter), full-telescope, single-wall corrugated fiberboard box with inside dimensions of 17 x 10 5/8 x 10 1/8 inches (43.2 x 27.0 x 25.7 cm). Each side of the box has two 5/8- x 3-inch (1.6- x 7.6-cm) ventilation slots. The gaps in the outer flaps of the cover and body measure 5/8 x 7 inches (1.6 x 17.8 cm). The cover is fabricated from 200-lb-test fiberboard and body from 350-lb-test fiberboard. No biphenyl pad was placed in the boxes.

The experimental design was 2^2 x 3 factorial, with film wrapping and RH as the factors and the 3 harvesting seasons as the blocks. Fruit were individually wrapped tightly in a low-density (0.923 g/cc) polyethylene bag (BAGGIES®, 6-3/4 x 8-1/4 inches, 0.6 mil thick, Colgate-Palmolive Co.) or left unwrapped as the control. The non-perforated bags were not sealed, but the open ends of the bags were tightly twisted so that the bag conformed to the shape of each fruit. Two boxes each of bagged and non-bagged fruit were stacked in vertical alignment. Weights totaling 200 lb. (91 kg) were then placed on the top of each stack to simulate overhead box-stacking (7-high) weights under commercial conditions (Fig. 1). One set of 4 fiberboard boxes was held at 85% to 90% RH and 70°F (21°C), and another set was held at 50% to 60% RH and 70°F.

After a 4-week storage period, the boxes were measured to determine changes in size or configuration. The moisture content of the fiberboard was calculated by weighing samples before and after drying at 158°F (70°C) for 2 days. The grapefruit were examined for weight loss, for deformation by the method of Hale (9), for decay, for firmness by the method of Rivero et al. (18), and for taste by the first author and a few other personnel in Lake Alfred. Firmness, decay, and taste were checked again after an additional 2-week "marketing period" at ambient conditions (average 70°F and 70% RH). Six fruit per box were used for weight loss evaluation, 2 samples of 5 fruit each for firmness evaluation, 32 to 40 for deformation and decay evaluation, and a few for taste evaluations. Data were then statistically analyzed for significance of the block (harvesting season) and factorial (wrapping and RH) treatments by using the analysis of variance for a factorial experiment. For the latter, simple effects rather than main effects were studied when the interaction of the 2 factors was significant.

Results and Discussion

Fiberboard Shipping Box

Physical damage. The fiberboard boxes held at 85% to 90% RH were distorted even more than those in previously reported commercial export studies (9, 19) (Fig. 1A, Table 1), but those held at 50% to 60% RH maintained their original size and shape with negligible box distortion (Fig. 1B). Boxes held at the high RH required careful handling when they were lifted to prevent the fruit from falling through the bottom flaps of the box body. However, boxes held at the low RH were still strong enough that they did not require such care in handling. Thus, it is apparent that the low RH during storage and transit would aid in keeping palletized boxes together as a unit (11). The humidity factor was statistically significant for all measurements, whereas the block, film wrapping, and humidity x wrapping interaction were not significant (Table 1). Unipackaging appeared to decrease box distortion at the high RH (Fig. 1A), possibly by decreasing moisture absorption by fiberboard in the initial periods, as discussed below, and by maintaining fruit firmness. However, the effects were not statistically significant (Table 1).

Moisture content. The moisture content of fiberboard increased from 6.4% to 12.4% in 4 weeks at 85% to 90% RH, but did not appreciably increase at 50% to 60% RH. The increase in moisture content at the high RH indicated that those boxes may have lost more than half of their original top-to-bottom compression strength, as corrugated fiberboard boxes lose as much as 9% of their compression strength with every 1% increase in moisture content (5). Hale and Smoot's data (12) suggested that the moisture content of grapefruit boxes would increase as much as 10% during export to Japan. Individual wrapping of fruit did not affect moisture content of fiberboard boxes at the end of 4-week tests (data not shown). However, it might have decreased moisture absorption by fiberboard in the initial portion of the 4-week period, for even waxing, alone, decreased moisture absorption by fiberboard during 5-day tests by Chuma (4).

Table 1. Physical damage to fiberboard shipping boxes packed with grapefruit during simulated 4-week export tests at 70°F (21°C) as affected by individual film wrapping and relative humidity.

Treatment or source	Distortion (cm) Side bulge	End bulge	Bottom sag	Compression
High (85-90%) RH				
Nonwrapped-fruit control	3.7	2.6	2.4	0.9
Wrapped fruit	2.8	2.3	2.0	0.5
Low (50-60%) RH				
Nonwrapped-fruit control	0.3	0.0	1.4	0.3
Wrapped fruit	0.2	0.2	1.4	0.2
Relative humidity[z]	**	**	**	*

[z]Mean effects of the humidity factor were significant at 1% (**) or 5% (*) levels. Block (harvesting season), film wrapping, and the humidity x wrapping interaction were not significant for any measurements. Data based on 6 boxes per treatment.

Grapefruit Condition

Weight loss. The amount of weight loss after 4 weeks at 85% to 90% RH (Table 2) was in the same range as that found in the export tests to Japan (1). Fruit wrapping significantly reduced weight loss at both high and low RH levels. The higher RH reduced weight loss for unwrapped fruit but not for wrapped fruit (Table 2). Fruit not wrapped and held at the low RH lost an average of 12.7% of their original weight and were not in salable condition after the simulated 4-week "export" period (Table 2). Fruit not wrapped but held at the high RH had a good appearance after the simulated export period, but after an additional 2-week "marketing" period they were considered of marginal quality and salable only at discounted prices. Unipackaged

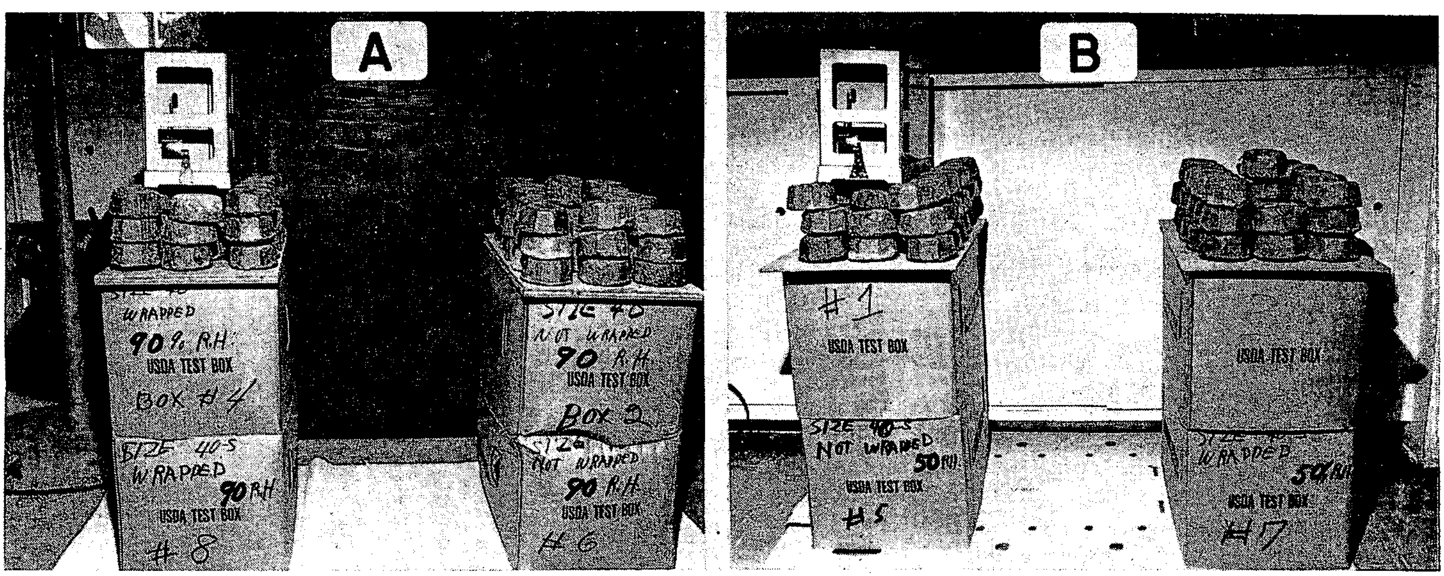

Fig. 1. Fiberboard shipping boxes held under 200 lb. (91 kg) weights to simulate export of Florida grapefruit. A: Boxes packed with Uni-Packed (L) or non-wrap control (R) fruit, and held at 85 to 90% RH and 70°F (21°C). B: Boxes packed with Uni-Packed (R) or non-wrap control (L) fruit, and held at 50 to 60% RH and 70°F.
Note the definite effect of the low-RH (B) and the noticeable effect of Uni-Pack at the high-RH (A) on maintaining the strength of fiberboard shipping boxes.

Table 2. Effect of harvesting season and of individual film wrapping and relative humidity (RH) during simulated 4-week export tests at 70°F (21°C) on the keeping quality of Florida 'Marsh' grapefruit in 1979-80.

Block, treatments or sources	Weight loss (%)	Deformation[z] Slight	Serious (%)	Total	Firmness[y] (%)	Decay[x] (%)
Block (harvesting season)						
Early	3.8	18.5	8.9	27.3	60.0/ 3.2	4.9/ 7.5
Mid	3.8	23.2	17.1	40.3	59.5/ 3.3	4.2/ 5.3
Late	5.7	22.2	30.0	52.2	51.4/ 6.0	10.9/26.0
High (85-90%) RH						
Nonwrapped-fruit control	3.0 b[w]	22.0	16.3 b	38.2 b	56.5 b / 4.2 b	8.8/14.7
Wrapped fruit	0.7 c	12.2	7.1 b	19.3 c	65.7 a / 2.7 c	8.0/12.3
Low (50-60%) RH						
Nonwrapped-fruit control	12.7 a	34.4	44.6 a	79.0 a	45.1 c / 6.6 a	6.4/19.1
Wrapped fruit	1.5 c	16.6	6.7 b	23.3 c	60.6 b / 3.1 c	3.5/ 5.2
Harvesting season	NS[w]	NS	**	**	** **	* **
Relative humidity	(**)[w]	NS	(**)	(**)	(**) (**)	NS NS
Film wrapping	(**)	**	(**)	(**)	(**) (**)	NS *
RH x film wrapping	**[w]	NS	**	**	* **	NS NS

[z]Slight deformation = total aggregate flattened or indented surface area 1 to 2 inches (2.5 to 5.1 cm) in diameter; serious deformation = total aggregate flattened or indented surface area more than 2 inches in diameter. Fruit with deformed area totaling less than 1 inch in diameter were classified as sound (9).
[y]Fruit firmness measured by the Grierson creep tester (18); elasticity / permanent deformation (%).
[x]Total decay % after a 4-week export period/plus a 2-week marketing period.
[w]Significant at 1% level (**), 5% level (*) or nonsignificant (NS). When the interaction was significant, significance of simple effects were studied and the results are indicated by letters adjacent to each treatment means. Unlike letters between appropriate 4 pairs within a column indicate significance of the simple effects at a level of at least 5%. Letters, however, do NOT indicate results of multiple comparison tests among treatment means. Data based on 8 boxes per block, or 6 boxes per treatment; 6 fruit per box were used for weight loss, 2 sets of 5 fruit for firmness, and 32 to 40 for deformation and decay evaluations.

fruit, on the other hand, held at either high or low RH were in excellent condition even after the marketing period. These data and observations confirm the importance of controlling weight loss in maintaining the keeping quality of freshly harvested grapefruit (1, 2, 14, 16, 18).

Deformation and firmness. The amount of deformed fruit found in this study was higher than that reported in studies of actual export shipments (9, 19). The average serious deformation of unwrapped fruit in boxes held at 85% to 90% RH in this study was 16.3%, whereas serious deformation in the commercial studies was 12.1% in 1976-77 (19) and 11.4% in 1978-79 (9). The difference between the temperature used in these studies, 70°F (21°C), and those used in the commercial export shipments, 50° to 52°F (10° to 11°C), might have been a factor in the additional amounts of deformation found in our studies. This view is supported by Kawada and Albrigo (14), who reported that grapefruit stored at lower temperatures were more resistant to deformation than those held at higher temperatures, even at the same weight-loss levels. Our data indicated that the later the fruit were harvested, the more seriously the fruit were deformed. Fruit firmness also followed the same seasonal trend (Table 2). The fruit firmness result agreed with the findings of Rivero et al. (18) that loss of grapefruit elasticity, and hence susceptibility to permanent deformation, increased with advancing season.

In general, both unipackaging and the higher RH were effective in maintaining fruit elasticity, thus reducing deformation (Table 2). However, statistical analysis indicated an interaction between film wrapping and RH. Wrapping was effective regardless of RH for all measurements except serious deformation, which was significantly reduced by wrapping only at the low RH. In contrast, humidity effects were dependent on whether fruit were wrapped or nonwrapped. The percentage of deformation in nonwrapped fruit was much less at the high RH than at the low RH, but the percentage of deformation in wrapped fruit did not differ significantly between the low and high RH levels. These data corroborate the importance of controlling weight loss in minimizing fruit deformation (18) and the striking effects of fruit wrapping in this regard (1, 14, 15).

The percentage of deformation was greater at the low RH than at the high RH (Table 2), in spite of negligible side and end bulge of flat-packed fiberboard boxes (Table 1). This result indicated that another important physical factor, or factors, in addition to top-to-bottom compression strength of shipping containers, bulge-packing (7), and overhead pressure, causes deformation of grapefruit. The constant demand for "a good full pack" results in the forcing of too much fruit into the container. Fruit so packed distort during transit. Shippers should negotiate with buyers to avoid excessively tight place packing of grapefruit because of the severe fruit deformation it causes. Container and fruit-size standards should be reconsidered to avoid packing fruit too tightly. Although the height of shipping containers for export markets has been increased by 0.5 inch to avoid bulge-packing (7, 19), side and end dimensions have not changed. The striking effects of tray-pack (8) and cell-pack (9, 13) boxes in minimizing fruit deformation are achieved by protecting fruit from overhead, side-to-side, and end-to-end pressures. Our results and observations also indicated that the overhead weight of fruit in upper boxes within in-register stacks exerts pressure causing bottom and top sag of lower boxes and deformation of fruit therein.

Decay and taste. The late-season fruit were more susceptible to decay than the early or midseason fruit (Table 2), as reported by Chace et al. (3). Decay percentages after the additional 2-week marketing period for early and midseason fruit were only slightly higher than the percentage observed in commercial export shipments (19), even though these simulated export tests were conducted at a much higher temperature, 70°F (20°C), than those in the commercial export shipments, 50° to 52° (10 to 11°C). One of the reasons for the low level of decay in our study could be the more careful harvesting and handling of the fruit used than is common in commercial practice. Humidity did not affect the percentage of decay in this study. Individual wrapping reduced decay in the 2-week marketing period (Table 2). Thus, the percentages of decay in fruit wrapped and held for 6 weeks at 70°F (21°C) were in the same range as was found in commercial export shipments at 50 to 52°F (10 to 11°C) (19), except in the fruit harvested very late in the season (June 16). Severe seed germination was also observed in the late-season fruit (data not shown).

Taste did not differ between treatments. No off-flavor was noticed, even for the fruit wrapped and held at 70°F (21°C) for 6 weeks (data not shown).

Conclusions

If grapefruit were individually wrapped in film, in-transit RH could be lowered below the currently recommended 85% to 90% to preserve the strength of fiberboard shipping boxes without causing additional increase in weight loss, fruit deformation, and decay. The current general practice of excessively tight packing or overfilling should be avoided to prevent severe deformation of grapefruit. Grapefruit should not be exported too late in the season because of excessive decay, seed germination, and deformation. Results also indicated that if grapefruit are individually film wrapped they might be shipped without refrigeration or humidity control, thereby saving energy. However, for successful shipment without refrigeration, proper harvesting, handling, and decay control will be required.

Literature Cited

1. Albrigo, L. G., K. Kawada, P. W. Hale, J. J. Smoot, and T. T. Hatton, Jr. 1980. Effect of harvest date and preharvest and postharvest treatments on Florida grapefruit condition in export to Japan. *Proc. Fla. State Hort. Soc.* (in press).
2. Ben-Yehoshua, S., I. Kobiler, and B. Shapiro. 1979. Some physiological effects of delaying deterioration of citrus fruits by individual seal packaging in high density polyethylene film. *J. Amer. Soc. Hort. Sci.* 104:868-872.
3. Chace, W. G., P. L. Harding, J. J. Smoot, and R. H. Cubbedge. 1966. Factors affecting the quality of grapefruit exported from Florida. *U.S. Dept. Agr. Mrktg. Res. Rept.* 739.
4. Chuma, Y. 1972. Up-to-date on the degreening of Satsuma and its effects on transportation, *Kajitsu Nippon* 27(12):20-25 (In Japanese).
5. ———, H. Kato, and M. Iwamoto. 1970. Studies on the deterioration and preserve-ability of cartons in the cold storage of Ama-natus. *Nogyo Kikai Gakkai-shi,* (*J. Jap. Agr. Eng.*) 32:225-231 (in Japanese, abst. in English).
6. Fairchild, G. F. 1979. Estimated Florida orange, 'Temple' and grapefruit production, 1979-80 through 1948-85. *Economic Res. Dept. Rept. Cir.* 79-1, Fla. Dept. Citrus.
7. Hale, P. W. 1973. Which grapefruit pack: bulge, flat, or slack? *Citrus and Veg. Mag.* 36(12):8, 11.
8. ———. 1976. New tray-pack containers for exporting Florida grapefruit. *Citrus and Veg. Mag.* 40(2):12-13, 16, 30.
9. ———. 1980. Exporting large grapefruit in honeycomb cell-pack boxes. *Citrus and Veg. Meg.* 43(5):8, 28-29, 32.
10. ———, W. R. Miller, and R. Egan. 1980. Bulk bins for exporting Florida grapefruit: Update on use of. *Citrus and Veg. Mag.* (in press).
11. ———, L. A. Risse, R. Moffitt, R. Cubbedge, and D. L. von Windeguth. 1979. Effect of pallet-stacking patterns on transit temperatures, fumigation, and arrival condition of grapefruit exported to Japan. *Proc. Fla. State Hort. Soc.* 92:203-208.
12. ———, and J. J. Smoot. 1973. Exporting Florida grapefruit to Japan. *Citrus and Veg. Mag.* 37(3):20-23, 45.
13. ———, ———, and T. T. Hatton. 1980. Cell-pack boxes for exporting large grapefruit. *Proc. Fla. State Hort. Soc.* (in press).
14. Kawada, K., and L. G. Albrigo. 1979. Effects of film packaging, in-carton air filters, and storage temperatures on the keeping quality of Florida grapefruit. *Proc. Fla. State Hort. Soc.* 92:209-212.
15. ———, and ———. 1980. "Uni-Pack" individually wrapped storage of grapefruit. Univ. Fla., IFAS, *Packinghouse Newsletter* 114:1. Lake Alfred, FL.
16. Kitagawa, H. 1970. Storage and quality of Ama-natsu. *Kajitsu Nippon* 25(4):22-25 (in Japanese).
17. ———, and K. Kawada. 1979. Marketing of Florida grapefruit in Japan. *Proc. Fla. State Hort. Soc.* 92:241-245.
18. Rivero, L. G., W. Grierson, and J. Soule. 1979. Resistance of 'Marsh' grapefruit to deformation as affected by picking and handling methods. *J. Amer. Soc. Hort. Sci.* 104:868-872.
19. Smoot, J. J., and P. W. Hale. 1977. Evaluation of decay control treatments and shipping containers for export of grapefruit to Japan. *Proc. Fla. State Hort. Soc.* 90:152-154.

Proc. Fla. State Hort. Soc. 93:323-327. 1980.

EFFECT OF HARVEST DATE AND PREHARVEST AND POSTHARVEST TREATMENTS ON FLORIDA GRAPEFRUIT CONDITION IN EXPORT TO JAPAN[1]

L. G. ALBRIGO AND K. KAWADA
University of Florida, IFAS,
Agricultural Research and Education Center,
P. O. Box 1088, Lake Alfred, FL 33850

P. W. HALE, J. J. SMOOT AND T. T. HATTON, JR.
USDA–SEA/AR,
2120 Camden Road, Orlando, FL 32802

Additional index words. antitranspirants, growth regulators, polyethylene wrapping, waxing.

Abstract. **Florida seedless grapefruit, both red and white fleshed, were harvested at midseason and late spring during the 1978-79 and 1979-80 seasons for shipping tests. Plots in each grove received antitranspirant (AT), gibberellic acid (GA) and 2,4-dichlorophenoxyacetic acid (2,4-D) sprays before harvest for comparison to nontreated fruit. Double and single waxing with a solvent wax and "Uni-Pack" (wrapping individually with polyethylene bags) were evaluated for fruit color development, gloss, weight loss and peel breakdown. Simulated shipment studies involving comparable holding times and temperatures were made locally and evaluated in addition to actual shipments to Japan. For 4 test shipments, harvest to market times were 7 to 8 weeks. Some undesirable orange peel color developed when nontreated midseason harvested fruit were held for extended periods at 10 to 13.4°C (50 to 55°F). Gloss was not maintained with a single waxing when weight loss during shipment exceeded 5% of original weight. Double waxing reduced weight loss 23% from the single waxed fruit and uni-packing reduced weight loss to <2% of original weight. Peel breakdown only occurred on fruit harvested late and only on fruit from some**

[1]Florida Agricultural Experiment Stations Journal Series No. 2729.