EXPORTING INDIVIDUALLY PACKAGED GRAPEFRUIT IN BULK BINS AND NONPACKAGED GRAPEFRUIT IN BULK BINS WITH FILM LINERS[1]

By

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The authors are attempting to evaluate additional viable alternatives for shipping fresh citrus.

Introduction

Shipping fresh citrus jumble packed in bulk bins as a means of reducing total marketing costs has been under study by USDA scientists for several years. In a report on 1976 shipping tests with four types of bins, stacked two-high, from Brownsville, Texas, to Le Havre, France, Miller and Carter (9) found that arrival condition of grapefruit in bulk bins was comparable to that of fruit in conventional 7/10-bu. (0.025 m^3) export boxes, but that the fiberboard bins suffered excessive compression, and crushing and total deformation of grapefruit in these bins were higher than for the wooden and wirebound bins tested.

In a series of export shipments from Florida to Japan, Hale et al. (4) reported that grapefruit in 20-box equivalent wirebound bins arrived with less deformation and decay than those shipped in wirebound bins which held 30-box equivalents of fruit. As the grapefruit were examined, it was noted that deformed fruit were most prevalent in the lower layers of the bins, and that this damage was attributed to the overhead weight of fruit within these bins. Other studies indicated that the resistance of grapefruit to deformation can be maintained by minimizing postharvest weight loss (5, 10). In studies conducted in 1979 and 1980 (5, 6, 7), the film wrapping of individual grapefruit in a low-density polyethylene bag provided the best treatment for maintaining the keeping quality of Florida grapefruit. Individual packaging of grapefruit before packing in 4/5-bu (0.028 m^3) standard boxes resulted in minimum weight loss, maintained fruit firmness, and reduced deformation.

The beneficial effects of such packaging were confirmed in export tests from Florida to Japan and in simulated

[1]The able technical assistance of Randall H. Cubbedge and Alice T. Dow is gratefully acknowledged.

laboratory tests (1, 7). The storage of citrus fruits individually wrapped with polyethylene film was also reported by scientists from Japan (8) and Israel (2, 3). In both countries, equipment has been developed to wrap individual fruit.

Objectives

The objective of this study was to determine whether individual polyethylene-bagged fruit shipped in 20 4/5-bu-box capacity bulk bins and nonpackaged grapefruit shipped in the same bins, but lined with polyethylene film would prevent weight loss of grapefruit in export shipments averaging 5 to 7 weeks in transit, and thus reduce deformation of grapefruit, especially deformation of fruit located in the lower layers of the bins.

This research is part of an ongoing effort by the Agricultural Research Service to evaluate new packages, shipping containers, and packing methods to reduce costs and improve arrival condition of agricultural products at overseas markets.

Materials and Methods

Four test shipments of grapefruit packed in wirebound bins were made from Florida to Tokyo, Japan: two in February 1981 and two in April 1981. The bulk wirebound bins were assembled manually at packinghouses in the Indian River area of Florida. 'Marsh' grapefruit (Citrus paradisi Macf.) harvested locally and washed commercially, treated with thiabendazole (TBZ) and an export-type solvent wax, graded, and sized, were conveyed directly into the bins. During the bin-filling operation, 40 biphenyl pads were placed between layers of fruit at random inside each bin; two pads for each equivalent 4/5 bu of fruit. For all shipments, the test bins were packed with an equivalent of 20 4/5-bu boxes of size 32 grapefruit with an average diameter of 4 1/4 inches (8.0 cm). The bins were constructed of 3/8-inch-thick (1.0 cm) southern hardwood and 1/16-inch-thick (0.4 cm) veneer slats. The inside dimensions were 43 1/2 x 42 inches (110.5 x 106.7 cm), and inside depth was 21 inches (53.3 cm). The wirebound bin had a self-contained, two-way-entry, wooden pallet base 3 5/8 inches (9.2 cm) high. The open bin top and spaces between the deckboards of the pallet base provided vertical ventilation through the bin. Spaces are also provided between the vertical wooden slats that form each of the four sides of the bin. For assembly and added peripheral strength, two 3/4-inch (1.9 cm) metal straps were placed around the top and bottom edges of the bin. The tare weight of the bins averaged 96.4 lb (43.7 kg).

As required by the Japanese government, all bulk bins were fumigated with ethylene dibromide at the Florida Division of Plant Industry fumigation stations and then loaded with commercial fruit in the refrigerated holds of ships. In all tests, the bins were stacked in interlocking sets of three bins for an overall outside dimension of 44 1/2 x 48 x 79 inches (113 x 121.9 x 200.7 cm) or 97.65 ft^3.

For the two shipments made in February, the fruit in the bins were delivered into port storage, and then all fruit for one test bin in each shipment were individually packaged in low-density, gusseted, polyethylene bags of 1 ml (0.001 inch) film that measured 5 x 4 x 10 inches (12.7 x 10.2 x 25.4 cm). Fruit in the control bin were left unbagged. The nonperforated bags were not sealed, but the open ends of the bags were twisted so that the bag conformed to the shape of each fruit. A sample of 150 fruit for each test bin was used to obtain net weight loss of the grapefruit. Each sample was divided into three 50-count lots and

placed in the bottom, middle, and top layer locations of each test and control bin for deformation evaluation.

For the two shipments made in April, the fruit in the bins were delivered into port storage, and on the following day, all fruit for one test bin were repacked into a bin lined with two sheets of low-density, polyethylene, 1 ml film that measured 16 x 5 ft (4.9 x 1.5 m). The film was lapped over the fruit at the top of the bin and not sealed. The control bin was unlined. For each bin, fruit samples of 150 fruit were used to obtain weight loss and deformation data as in the February test shipments.

For each test, single-point recording instruments were placed inside one test bin and inside one control bin in the middle of the load of fruit to record air temperatures continuously during transit.

Upon arrival in Japan, all citrus fruit were fumigated with cyanide gas for the eradication of possible insect pests. Regulations of the Plant Protection Division of Japan's Ministry of Agriculture and Forestry required that all polyethylene bags used to package the fruit individually in the February shipments be removed from the fruit by researchers before fumigation and subsequent Customs clearance. After fumigation the fruit were not repackaged into the polyethylene bags.

The polyethylene film used to line the inside of the bins for the April test shipments was not removed by the Japanese, but the film was folded back at the top of the bins prior to fumigation, thus exposing the fruit to the cyanide gas during the fumigation process.

After Customs clearance, the grapefruit were transported to the American Embassy in Tokyo and immediately reweighed to determine weight loss, and examined for serious deformation. In the rating scale used, a grapefruit that contained a total (aggregate) flattened or indented surface of 2 inches (5.08 cm) or more in diameter was to be classified as seriously deformed. The test fruit from the bins were then held at about 75°F (24°C) to simulate marketing conditions and reweighed after 2 weeks. The elapsed time from the packing and weighing of the fruit in the bins at shipping point until examination of their arrival condition and reweighing in Tokyo, Japan, ranged from 35 to 48 days for the four shipments (Table 1). The Student's *t* test for paired differences was used to analyze deformation and weight loss data between treatments.

Results

Packaged Grapefruit

The weight loss for the two test shipments of bins of packaged fruit (February shipments) averaged 0.6% upon arrival as compared to 2.6% weight loss for the control fruit after an average of 4 1/2 weeks in transit (Table 2). This difference was significant at the 1.0% level. Although fruit in the top of the control bin showed slightly more weight loss than fruit in the middle and bottom layers of the control bins, these differences were not significant. There was no difference in weight loss for the packaged fruit by layer location in the bins upon arrival. Differences after 2 weeks in total weight loss for all test fruit previously packaged were 2.1% less than for the control fruit. This difference was significant at the 1.0% level (Table 2).

Results of the two tests show that the total amount of serious deformation averaged 5.0% for the packaged fruit in bins as compared to 20.3% serious deformation for the control fruit in bins (nonpackaged) (Table 3). More seriously

TABLE 1. Log of four bulk-bin test shipments of Florida grapefruit to Tokyo, Japan, 1981

Test No.	Date fruit packed in bins at packinghouse	Test treatments	Date test treatment prepared at port	Date bins loaded on ship	Date ship sailed	Date of arrival inspection	Days elapsed
1	Feb. 2	Polyethylene-bagged vs. control	Feb. 4	Feb. 5	Feb. 9	Mar. 10	36
2	Feb. 19	Polyethylene-bagged vs. control	Feb. 20	Feb. 22	Feb. 24	Mar. 26	35
3	Mar. 30	Polyethylene-lined bin vs. control	Apr. 1	Apr. 3	Apr. 5	May 19	48
4	Mar. 31	Polyethylene-lined bin vs. control	Mar. 31	Apr. 6	Apr. 8	May 14	44

TABLE 2. Weight loss of packaged grapefruit in bins and control grapefruit (nonpackaged) in bins upon arrival, after 2 weeks in storage at 75°F (24°C), and total weight loss, average of 2 tests, Florida to Japan, 1981.

Treatment		Layer location of fruit			Average (%)
		Top	Middle (%)	Bottom	
Packaged fruit in bins					
Upon arrival[Y]		0.6	0.6	0.6	0.6
Plus 2 weeks		6.7	6.2	5.7	6.2
	TOTAL[Z]	7.3	6.8	6.3	6.8
Control fruit in bins (nonpackaged)					
Upon arrival[Y]		3.0	2.3	2.5	2.6
Plus 2 weeks		6.2	6.0	6.8	6.3
	TOTAL[Z]	9.2	8.3	9.3	8.9

[YZ]Difference in the amount of weight loss between the packaged fruit in bins and control fruit in bins (nonpackaged) upon arrival and difference in total weight loss between the packaged fruit in bins and control fruit in bins after 2 weeks' storage is statistically significant at the 1% level according to the t test for paired differences.

TABLE 3. Serious deformation of packaged grapefruit in bins and control grapefruit in bins (nonpackaged) upon arrival, average of 2 tests, Florida to Japan, 1981.

Layer location		Packaged fruit in bins (%)	Control fruit in bins (nonpackaged) (%)
Top		1.7	4.3[X]
Middle		1.6	5.4
Bottom[Y]		1.7	10.6[X]
	TOTAL[Z]	5.0	20.3

[X]The difference between the amounts of seriously deformed fruit in the top and bottom layers of the control bin (nonpackaged) was statistically significant at the 5% level according to the t test for paired differences.

[Y]Difference between the amounts of seriously deformed fruit in the packaged grapefruit in bins and control grapefruit in the bottom location of bins was statistically significant at the 5% level according to the t test for paired differences.

[Z]Difference between total amounts of seriously deformed packaged grapefruit in bins and control grapefruit in bins was statistically significant at the 5% level according to the t test for paired differences.

deformed fruit were found in the bottom of the control bin than in the bottom of the bin of packaged fruit (Table 3). In the control bin, more deformed fruit were found in the bottom layer than in the top layer of fruit. These differences were significant at the 5.0% level (Table 3). In contrast, the amount of serious fruit deformation in the bins containing packaged fruit did not differ significantly between layer location in the bins (Table 3).

Fruit in Bins with Film Liners

The weight loss for the two test shipments of grapefruit in bins with film liners (April shipments) averaged 2.0% upon arrival as compared to 3.4% weight loss for the control fruit after an average of 6 1/2 weeks in transit (Table 4). This difference was significant at the 1.0% level. Fruit in the top of the control bins showed slightly more weight loss than fruit in the other layer locations of the control bins. Upon arrival, there was no significant difference in weight loss for the fruit in bins with film liners by layer location in the bins. Differences in total weight loss for all test fruit after 2 weeks in the bins lined with film were 1.4% less than for the control fruit. This difference was significant at the 1.0% level (Table 4).

Results of the two tests show that the total amount of serious deformation averaged 2.5% for fruit in bins with film liners as compared to 15.5% serious deformation for the control fruit in bins (without film liners) (Table 5). More seriously deformed fruit were found in the bottom of the control bin than in the bottom of the film lined bins. In the control bin, more deformed fruit were found in the bottom layer than in the top and middle layers of fruit. These differences were significant at the 5.0% level. In contrast, the amount of serious deformation of fruit in the film lined bins did not differ significantly among fruit layer locations in the bins (Table 5).

Temperatures

The temperatures in the middle of the packaged grapefruit bins and in the middle of the grapefruit bins with film liners were satisfactory during transit, although they required about two additional days to reach the ships' thermostat setting of 50°F (10°C) as compared to the bins packed with control fruit (nonpackaged or in bins without liners).

Discussion

These tests indicate that Florida grapefruit individually packaged in polyethylene bags and shipped in 20 4/5-bu-box-capacity bins and grapefruit shipped in 20 4/5-bu-box-capacity bins with polyethylene liners that overlap the fruit at the top of the bins arrived in better condition and with a better appearance than those shipped nonpackaged in 20 4/5-bu-box-capacity bins or in bins without film liners. Packaging of fruit individually in polyethylene bags and shipping of fruit in bins lined with polyethylene film were significantly more effective in reducing weight loss of fruit upon arrival than were the control treatments (nonpackaged or in bins without liners). For the four export test shipments, serious deformation was less for fruit packaged in individual bags and shipped in bins or fruit shipped in bins with polyethylene liners, especially for fruit located in the bottom layers of the bins, than those shipped unpackaged and without film liners in bins. Thus, data from these commercial shipments confirm the importance of controlling weight loss in minimizing fruit deformation (10). At the time of our tests, Japanese governmental regulations did not allow acceptance of fruit for cyanide fumigation when fruit were individually film wrapped. It appears that bins with film liners may be used and are currently the

TABLE 4. Weight loss of grapefruit in bins with film liners and control grapefruit (in bins without liners) upon arrival, after 2 weeks in storage at 75°F (24°C), and total weight loss, average of 2 tests, Florida to Japan, 1981.

Treatment		Layer location of fruit			Average (%)
		Top	Middle (%)	Bottom	
Fruit in bins with film liners:					
Upon arrival[y]		2.2	2.2	1.6	2.0
Plus 2 weeks		3.2	3.7	3.8	3.6
	TOTAL[z]	5.4	5.9	5.4	5.6
Control fruit in bins without liners:					
Upon arrival[y]		3.7	3.2	3.4	3.4
Plus 2 weeks		3.6	3.5	3.6	3.6
	TOTAL[z]	7.3	6.7	7.0	7.0

[yz]The difference between the amount of weight loss in the fruit in bins with film liners and in control fruit in bins without liners upon arrival and the difference in total weight loss between the fruit in bins with film liners and control fruit in bins without liners after 2 weeks of storage are statistically significant at the 1% level according to the t test for paired differences.

TABLE 5. Serious deformation of grapefruit in bins with film liners and control grapefruit (in bins without liners) upon arrival, average of 2 tests, Florida to Japan, 1981.

Layer location	Fruit in bins with film liners (%)	Control fruit in bins (without film liners)
Top	0.5	1.0[w]
Middle	0.5	1.5[x]
Bottom[y]	1.5	13.0[wx]
TOTAL[z]	2.5	15.5

[w]The difference between amounts of seriously deformed fruit in the top layer and in the bottom layer of the control bin was statistically significant at the 5% level according to the t test for paired differences.

[x]The difference between amounts of seriously deformed fruit in the middle layer and in the bottom layer of the control bin was statistically significant at the 5% level according to the t test for paired differences.

[y]In the bottom of the bins, the difference between amounts of seriously deformed fruit in the grapefruit in bins with film liners and in control grapefruit was statistically significant at the 5% level according to the t test for paired differences.

[z]The difference between total amounts of seriously deformed fruit in the grapefruit in bins with film liners and in control grapefruit was statistically significant at the 5% level according to the t test for paired differences.

best means available to avoid excessive weight loss and serious deformation to grapefruit located in the lower layers of bins during extended overseas shipments to Tokyo, Japan, which average 4 weeks or longer. However, the use of bins with packaged fruit or with liners will still depend on the development of dual-purpose bins with a reuse salvage value to help offset the high material costs of the 20-box capacity wirebound bins as reported by Hale et al. in 1980.

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