mercial 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.

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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]

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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.

groves. AT sprays reduced weight loss of fruit from some groves and GA delayed color development in some groves but did not reduce seed sprouting in late harvested fruit.

Approximately 100,000 metric tons of Florida grapefruit are shipped to Japan annually with the bulk of the shipments marketed between January and July (6). Reduction in the tariff after June 1 results in large shipments scheduled to arrive after this date each year. Grapefruit in these shipments are harvested late, and are less likely to have good internal quality or acceptable peel condition upon arrival (6). Excessive weight loss during shipment (6) contributes to deformation and loss of gloss (5). A preliminary late season shipping test to Japan in 1978 (Albrigo and Hale, unpublished) further confirmed these problems and orange color development during prolonged cool shipment. Previous work on oranges showed that use of antitranspirant (AT) films and better handling methods decreased weight loss and aging (1, 2). Individual film wrapping has been shown to effectively reduce weight loss and other long-term holding problems of citrus including grapefruit (4, 5, 8). Growth regulators (GA and 2,4-D) have been reported to improve peel firmness and reduce preharvest drop of grapefruit (3). In grapefruit shipments to Japan and simulated export tests at Lake Alfred, Florida, harvest date, preharvest AT or growth regulator (GR) sprays and postharvest waxing or polyethylene film wraps were studied for effects on weight loss, peel color, gloss and peel condition during 1978-79 and 1979-80.

Materials and Methods

Groves of mature, 'Ruby Red' or 'Marsh' grapefruit trees were selected in the Indian River and Ridge districts for export tests in 1978-79 and 1979-80. Three plots of 3 trees each were selected for treatments. Treatments, groves, harvest dates, postharvest treatments and shipping periods for each season are summarized in Table 1.

At each harvest in 1978-79, fruit were transported, washed, treated with a 600 ppm benomyl [methyl 1-(butylcarbamoyl)-2-benzimidazole-carbamate] spray, dried and waxed with solvent wax. A second waxing was used as a postharvest treatment. One carton of single waxed and 1 carton of double waxed fruit for both export and simulated shipment were prepared per plot. Five fruit per carton were weighed before shipment or storage, on arrival in Japan, or after an equivalent time in storage and again after 2 additional weeks to simulate a marketing period. Shipping and storage temperatures were from 10°C (50°F) to 13.4°C (55°F) and the 2-week marketing period temperatures were 21°C (70°F) for fruit held locally and the prevailing temperature in the basement of the United States Embassy in Tokyo for shipped fruit. Fruit were weighed and evaluated visually for peel color (green, yellow green, yellow, yellow orange, orange), gloss (bright, lustrous, dull), aging, stem end rind breakdown, and decay and by touch for softness by one of the USDA authors for actual exports or by University of Florida personnel for local simulated shipments.

Similar procedures were followed in the 1979-80 season, except that 1 or 2 boxes of fruit were prepared per plot for simulated shipment and 1 for export shipment. In 1979-80, fruit were wrapped in uni-pack wraps (Baggies®, sandwich size, 15 μ, Colgate-Palmolive Co.) after harvest. Five to 10 uni-packed fruit were weighed and included in each box of fruit. Uni-packaging was compared with and without corner holes in the early shipment and without holes in the late shipment. Fruit from the late harvest were evaluated for peel color with a Hunter D 25D color and color-difference meter (10). Values for green (negative a/b), yellow (zero a/b) and orange (positive a/b) were read on 2 marked areas per fruit of at least 12 treated and 12 control fruit on June 9, June 27 and July 16, 1980.

In each year after the simulated shipping test, the fruit were returned to 10°C storage and evaluated on the first week of September for condition and taste. Weight loss data were analyzed by analysis of variance and Duncan's multiple range test.

Results and Discussion

Fruit from all treatments shipped to Japan or held locally from a December harvest in 1978 lost approximately 2.4 and 2.7%, respectively, of their original weight during a 5-week period at 13.4°C (Table 2). An additional weight loss of 0.8% occurred in fruit in the simulation test for 2 weeks at 21°C, whereas the additional weight loss was 3.3% for fruit held for 2 weeks under ambient conditions in Japan. Double waxing reduced weight loss 0.8 to 2.0% (average = 1%) of original weight when compared to single waxing.

A greater final gloss of the fruit was observed when weight losses were retarded (simulated test > export test, double waxed fruit > single waxed) (data not shown). The GR spray in early December resulted in less color change (greener fruit) by the end of the shipment or storage period. There was a slight loss of green in GR-treated fruit during the 2-week marketing period. The

Table 1. Groves, treatments and harvest dates for export tests in 2 shipping seasons.

Year	Groves[z]	Treatments and dates[y]	Harvest dates[x]	Postharvest treatments	Shipment time (wks)[x]
1978-79	1 IR (Ruby Red)	Controls	12/26/78	Single wax	5
		GR (12/06/78) AT (02/18/79)	04/25/79	Double wax	5½
1979-80	1 IR (Ruby Red)	Controls	Groves 1, 2, 3, 4 01/30/80	Single wax	6
	2 IR (Marsh)	GR + AT (01/30/80) groves 1, 2	Grove 5 02/22/80	Uni-Pack	6
	3 R (Red)	GR + AT (02/22/80) grove 5	Groves 1, 2, 5 05/08/80		5
	4 R (Red)				
	5 R (Marsh)				

[z]IR = Indian River, R = Ridge.
[y]GR = growth regulators: GA = gibberellic acid (20 ppm), 2,4-D = 2,4-dichlorophenoxyacetic acid (10 ppm), AT = antitranspirant (vapor gard), 1% v/v; GR and AT applied separately and also to same plots in 1978-79.
[x]Shipping times correspond to harvest dates in same row.

Table 2. Weight loss of grapefruit in a 1978-79 export test—harvested December 26, 1978, arrived in Japan January 31, 1979 (5 weeks).

Treatment[z]	Weight loss (%)—Japan			Weight loss (%)—local		
	Arrival[y]	+ 2 wks	Total	5 wks[y]	+ 2 wks	Total
Single wax	2.6 b	3.8 b	6.4 b	3.0 b	0.9 a	3.9 b
Double wax	2.1 a	2.8 a	4.9 a	2.3 a	0.7 a	3.0 a
Average	2.4	3.3	5.7	2.7	0.8	3.5

[z]Postharvest waxing applied with solvent wax.
[y]Five weeks of local holding compares to 5 weeks to arrival in Japan. Values with unlike letters within a column are significantly different at the 5% level.

control fruit were yellow to yellow-orange. Part of the orange color was due to the lycopenes (9) and yellow pigments in the peel of red grapefruit. Since Japanese tend to prefer citrus fruits with orange colored peel, the orange color development during transit and storage of winter harvested Florida grapefruit is probably not objectionable to Japanese consumers.

The 1978-79 late shipment weight loss for all treatments averaged 3.7% on arrival, 1.3% above the early shipment from the same grove. Total weight loss was 5% after 2 additional weeks, 0.7% less total weight loss than for the early shipment (Table 3). Total weight loss of fruit held locally, on the other hand, was 4.1% compared to 3.5% in the early shipment. The slightly lower weight losses during the late shipment to Japan resulted in fewer dull fruit than in the early shipment. The fruit held locally had good gloss in both early and late shipments. Color of all lots was judged to be yellow on arrival and after an additional 2-week holding period (not shown). The earlier delay in color development caused by GA had apparently dissipated.

After the local simulated shipping and holding period, the decayed fruit were removed and the remaining fruit were returned to 10°C storage until September. The decay loss was less than 1%, probably reflecting the gentler handling in picking for the research test over commercial harvesting. The AT + GR treated fruit were in excellent condition (color and gloss) in September with good flavor in the opinion of several tasters. The double waxed fruit were in noticeably better condition than the single waxed fruit.

In the early harvest of the 1979-80 season, the control fruit had nearly equal weight loss on arrival for the actual and simulated shipments (Table 4). During the following 2 weeks, the fruit in Japan lost an additional 5.6% of their original weight, whereas fruit in the simulated shipping test (21°C and 85 to 90% RH) lost only an additional 1.2% of their weight. The uni-packed fruit had lost only 1.7% of their weight in the Japanese export test compared to 8.5% for the control fruit. In the locally *held fruit, uni*-packed fruit lost only 1.1% of their weight or 2.8 percentage points less than the controls (Table 4).

Table 4. Weight loss of grapefruit in a 1979-80 export test—harvested January 30, 1980, arrived in Japan on March 12 (6 weeks).

Treatment[z]	Weight loss (%)—Japan			Weight loss (%)—local		
	Arrival	+ 2 wks	Total	6 wks	+ 2 wks	Total
Control	2.9 b[y]	5.6 b	8.5 b	2.7 b	1.2 b	3.9 b
Uni-pack	0.7 a	1.0 a	1.7 a	0.9 a	0.2 a	1.1 a

[z]Averages of 5 groves.
[y]Values with unlike letters within a column are significantly different at the 5% level.

Fruit lost gloss during the actual or simulated shipments but were judged to be brighter in Japan than when held locally (not shown). These ratings were contradictory to the weight loss data in Table 4, probably because different people rated the fruit at the 2 locations and lighting conditions were different. The uni-packed fruit were firmer and brighter than the control fruit in both the actual and simulated shipments. No uni-packed fruit were deformed from compression on arrival in Japan, whereas 38% of the control fruit were deformed. Firm fruit were previously shown to deform less and handle better than soft fruit (5, 7). Fruit color varied among groves with fruit from 2 of the red grapefruit groves having the most orange color (Table 5). Some color change occurred during the test with some control fruit changing from yellow to yellow-orange. The uni-packaging retarded this color change in 3 of the 5 groves (Table 5).

In the 1979-80 late harvest, control plus treated fruit averaged losses of 5.1 and 5.4%, respectively, of their weight during the export and local simulated tests (Table 6). The reduced weight loss for the Japan late shipment over the earlier one as in the previous year was related to holding conditions in Japan. The holding room in Japan was heated to 26.6°C in January, resulting in low relative humidity; the holding room for the late harvest and marketing simulation in June was at a temperature of 24.3°C (without heating). The control fruit lost significantly more weight than the AT + GR treated fruit in the local simulated test but not in the export shipment (Table 6). Uni-packs were more effective than the field treatments. The difference in early

Table 3. Weight loss and final gloss of grapefruit in a 1978-79 export test—late harvest on April 25, 1979, arrived in Japan on June 4 (5½ weeks).

Treatment[z]	Weight loss (%)—Japan			Gloss[x] Japan	Weight loss (%)—local			Gloss[x] local
	Arrival	+ 2 weeks	Total		Arrival 5½ weeks	+ 2 weeks	Total	
Control—SW	3.8 bc	1.5	5.3 bc[y]	L	3.3 b	2.3	5.6 b	L-D
Control—DW	3.7 ab	1.2	4.9 ab	B-L	2.6 a	1.5	4.1 a	B-L
AT—SW	3.7 ab	1.1	4.8 ab	L	2.6 a	1.5	4.1 a	L
AT—DW	3.9 bc	1.3	5.2 bc	B-L	2.3 a	1.3	3.6 a	B-L
GR—SW	4.5 c	1.2	5.7 c	L	2.4 a	1.7	4.1 a	L
GR—DW	3.4 ab	1.4	4.8 ab	B-L	2.6 a	1.6	4.2 a	L
GR + AT—SW	3.5 ab	1.2	4.7 ab	L	2.4 a	1.7	4.1 a	L
GR + AT—DW	3.0 a	1.3	4.3 a	B-L	2.0 a	1.2	3.2 a	B-L
Average	3.7	1.3	5.0		2.5	1.6	4.1	

[z]GR = growth regulators (GA 20 ppm and 2,4-D 10 ppm) applied Dec. 6, 1978. AT = antitranspirant applied Feb. 18, 1979 at 1% (v/v); SW = single wax; DW = double wax.
[y]Values with unlike letters within a column are significantly different at the 5% level.
[x]Gloss was evaluated visually; B = bright; L = lustrous;; D = dull.

Table 5. Hunter color and color difference a/b values after 10 weeks of storage for control and uni-pack grapefruit from the first harvest in 1979-80.

Grove	Color (a/b) Control	Uni-Pack
1 IR (Red)	+0.12 d[z]	+0.06 c
2 IR (Marsh)	−0.08 a	−0.02 a
3 R (Red)	+0.04 b	−0.03 a
4 R (Red)	+0.13 d	+0.11 d
5 R (Marsh)	+0.08 c	+0.04 b

[z]Averages of 30 fruit, negative = green, zero = yellow, positive = orange. Values in a column followed by a different letter are significantly different at the 5% level. Uni-packs significantly less orange than controls from groves 1 and 5 and more green from grove 3; in grove 2 uni-packs yellower.

shipment weight loss between export and simulated shipments and the AT + GR effect in the local test demonstrated that simulated shipping tests could not always duplicate export test conditions.

Two of 3 groves showed color changes during the late shipment to Japan in 1979-80, but no change was detected in the simulated shipping test fruit. The evaluation of the simulated test may have been less critical. None of the final colors were objectionable. Color of the GR treated uni-packed fruit from grove No. 5 were almost green (Table 7). These fruit received a later GA spray than the other groves. Uni-packaging significantly retarded the loss of this green color. Although the late GR spray, with 2,4-D included, applied to grove No. 5 did not noticeably improve peel condition, we observed that it reduced the amount of fruit drop before the late harvest, a finding similar to results reported by Ali Dinar et al. (3).

Table 7. Hunter color and color difference a/b values for control and pre- and postharvest treated grapefruit from the late harvest of grove 5 in 1979-80.

Main treatment effects	Color a/b Harvest + 22 days[z]	+ 41 days[z]
Non-sprayed		
Non-wrap control	0.06	0.08
Uni-pack	0.03	0.04
AT + GR		
Non-wrap control	0.04	0.05
Uni-pack	0.01	0.01
Spray[z]	*	*
Wrapping[z]	*	**

[z]Significant differences in treatment groups are indicated at the 1% level by ** and the 5% level by *.

Preharvest sprays with AT improved shine and condition of fruit from some groves, but uni-packaging was more effective. Small amounts of aging and stem end rind breakdown were observed in some control lots.

Fruit from grove No. 5 had severe seed sprouting (Table 8). Fruit from grove No. 2 had considerable sprouting, but the sprouts had not grown much nor had the few seeds which were sprouted in fruit from grove No. 1. In contrast to an early report (3), GR sprays did not appear to reduce seed sprouting. Roots of sprouting seeds were observed coming through the peel of a few uni-packed fruit in both actual and simulated shipments. The high humidity in the wraps may have promoted the rooting through the peel. Another serious internal problem in the late harvested fruit from grove No. 5 was the extent of section drying, granulation (Table 8). Most of the drying found in equatorially cut fruit from grove Nos. 1 and 2 was only a few juice vesicles in 1 or 2 segments. After evaluation, the remaining uncut fruit were returned to 10°C storage and held until early September. The AT + GR treated fruit and especially the uni-packed fruit from the Indian River groves had excellent color and gloss and good taste after this extended holding period (data not shown).

Table 8. Seed sprouting and section drying of late harvested grapefruit in the 1979-80 season—harvested May 8, 1980, examined July 2 after 7 weeks of local storage.

Grove	Fruit/w seed sprouts (%)	Fruit/w dry sections (%)	Degree of drying
1	8[z]	32	Slight
2	21	39	Slight
5	56	60	Severe

[z]Average of control and growth-regulator treated plots in each grove since treatments not significantly different.

Double waxing is not practical due to equipment clogging and uni-packaging must be applied after fumigation. Preharvest AT sprays are expensive but this cost could be recovered in shipments of prime fruit. The AT sprays had a greater effect beyond the 7- to 8-week holding period required to market in Japan. The use of GA applied in early December resulted in fruit marginally green when harvested in late December but prevented the typical orange cast from developing during shipment. Addition of GA to a spring spray did not produce any observed benefit in 1979-80, but the 2,4-D appeared to reduce fruit drop.

These tests demonstrated that good quality fruit could be delivered to Japan even into early August. This would require some additional treatment for weight loss and seed sprouting control. Fruit harvested later than mid-May probably will have peel and internal condition problems (excessive

Table 6. Weight loss of grapefruit in a 1979-80 season export test—late harvest on May 8, 1980; arrived in Japan on June 18 (5 weeks).

Treatment[z]	Weight loss (%)—Japan Arrival	+ 2 wks	Total	Weight loss (%)—local 5 weeks	+ 2 wks	Total
Control	3.0 b[y]	2.1 b	5.1 b	2.9 b	3.0 b	5.9 c
Control, uni-pack	1.1 a	0.5 a	1.6 a	0.4 a	0.3 a	0.7 a
Treated	2.8 b	2.2 b	5.0 b	2.6 b	2.3 b	4.9 b
Treated, uni-pack	1.0 a	0.7 a	1.7 a	0.5 a	0.3 a	0.8 a
Non-unipack average	2.9	2.2	5.1	2.7	2.7	5.4

[z]Treated fruit received antitranspirant (1% v/v), GA (20 ppm) and 2,4-D (10 ppm) as a preharvest spray on Jan. 30, 1980 in 2 groves and on Feb. 22 in grove 3; uni-pack, polyethylene wraps applied after washing and waxing.
[y]Values with unlike letters within a column are significantly different at the 5% level. Averages of tests from 3 groves.

softening, seed sprouting and section drying) as well as high decay. Careful harvesting in April to early May followed by proper handling and storage resulted in grapefruit that had excellent quality for marketing later than mid-July. According to Kitigawa and Kawada (6), only a small amount of grapefruit is presently being marketed after early July in Japan. Thus, there is an opportunity to expand the Japanese market with shipments for sale in July or August, but only with appropriate treatments as discussed above.

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Proc. Fla. State Hort. Soc. 93:327-331. 1980.

RETAIL TRADE IN FLORIDA GRAPEFRUIT IN JAPAN[1]

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Additional index words. Citrus paradisi, export, statistics.

Abstract. **A survey was sent to 1,526 large scale retailers handling grapefruit in Japan. A total of 637 companies answered and these between them owned 3,134 retail outlets which handled about 20% of the total Japanese grapefruit imports from Florida in 1979-80. From these answers, data are presented on the effects on sales of Florida grapefruit of such factors as: price, external and internal quality, decay and injury, competition, promotion, and type of retailer. Total quality improvement and its control appeared to be the most important factor for the retail trade in Florida grapefruit in Japan.**

Imports of Florida grapefruit into Japan increased rapidly after the trade liberalization in July 1971, exceeding 6 million cartons in 1973-74 after only 3 seasons. Imports, however, have not increased much thereafter, the record being 6.9 million cartons in 1978-79. Only about 5.9 million cartons were imported last season, 1979-80 (Table 1). We described the marketing system for grapefruit in Japan and discussed competition and problems, as well as ways to increase Florida grapefruit exports to Japan in our previous report to this Society (3). In this report, we discuss the results of a survey conducted with 1,526 retailers in Japanese principal cities. Data and opinions from the questionnaire include the present situation, problems, and future of retail trade in Florida grapefruit in Japan.

Table 1. Japanese imports of fresh grapefruit from various countries in the last 2 seasons.

Country	Season (Oct.-Sept.) 1978-79	1979-80	'79-80 '78-79 (%)
	.....1,000 cartons.....		
U.S.A.	9,619[z] (92)	7,654 (93)	80
Florida	6,875 (66)	5,907 (72)	86
California	2,285 (22)	1,296 (16)	57
Arizona	341 (3)	421 (5)	123
Texas	118 (1)	29 (—)	25
Africa	356 (3)	231 (3)	65
Israel	323 (3)	221 (3)	68
Mexico	103 (1)	47 (—)	49
Cuba	3 (—)	66 (1)	2368
New Zealand	3 (—)	4 (—)	168
Total	10,407 (100)	8,223 (100)	79

[z]Source: Japan Fresh Fruit and Vegetables Imports Managerial Association, Tokyo, Japan.

Methods

A 10-page questionnaire consisting of 4 chapters, 25 sections and 40 questions was prepared for this study. The 4 chapters were: 1) general background and handling experiences of the retailer; 2) purchase and sales practices for Florida grapefruit; 3) advertising and promotion; and 4) miscellaneous e.g. consumers' resistance to use of fungicides, future trade in Florida oranges. Due to space limitation, only part of the results are presented herein.

There are 3 types of retail fruit outlets in Japan: 1) specialty fruit shops (about 24,000 companies including about 6,000 "quality fruit stores"); 2) "greengroceries" (about 45,000 companies excluding small "mama and papa" stores); 3) supermarkets, other types of chain store and department store (about 1,200 companies). Often, however, fruit counters in department stores are leased to fruit shops

[1]The authors are indebted to Dr. W. Grierson, University of Florida, for his advice in reviewing this manuscript, to the Japan Fresh Fruits and Vegetables Imports Managerial Association for useful statistical information, and to the Nippon Fruiterers' Cooperative Union and the Japan Selfservice Association for their cooperation in conducting this survey.

This study was financially supported by the Florida Department of Citrus, Lakeland, Florida 33802.