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CONSUMER PACKAGES FOR FLORIDA CITRUS FRUITS

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ABSTRACT

The rapid increase in the marketing of fresh produce in consumer packages is presenting a new challenge to the fresh citrus trade. Comparatively minor percentages of decayed fruits can mean severe losses in terms of packages rendered unsalable due to 1 or more rots. Simulated shipping and marketing tests were carried out with oranges, grapefruit, tangerines, tangelos, and 'Temples' using perforated polyethylene ("poly") bags, mesh ("Vexar") bags, perforated and nonperforated shrinkfilm packs. Two vapor-phase fungicides were used: diphenyl and 2-aminobutane. Mesh bags and perforated films tended to result in lower decay levels than did perforated "poly" bags and intact shrinkfilms. The new fungicide, 2-aminobutane, was more effective as the carbonated form applied to the fruit cup as a dip than as the free amine used as a vapor-phase fungicide applied to the shrink-film trays. Diphenyl and 2-aminobutane were comparable as vapor-phase fungicides, but diphenyl was easier to use.

INTRODUCTION

Current trends in retail marketing of produce move steadily towards more and more consumer packaging (2, 14, 15). This tendency has been so marked that estimates of the proportion of citrus fruits sold at retail in consumer packages have risen from approximately 20% 5 years ago (15) to a recent estimate that approximately 88% of oranges, grapefruit, and lemons and 68% of tangerines were sold in prepackaged form last year (17). This tendency is encouraged, not only by the shortage of labor in the supermarkets, but also by studies showing that the use of consumer packages increases retail sales volume (1) and net returns (15) in the produce departments. Typical packages such as have been used in this study are shown in Figure 1.

This trend considerably complicates the marketing of decay-prone fruits as Florida citrus. It is no new observation that, because "reworking" of packages is uneconomic and at times impossible, the importance of decay losses is multiplied by the number of fruit in the package (4). It has been estimated that one-fifth of all fresh produce is lost in marketing, (13) and this proportion is apt to increase when intact consumer packages have to be discarded or sold at a loss because of 1 or more decayed fruit in the package.

Shipping point prepackaging of Florida citrus has been almost entirely confined to oranges and grapefruit in mesh and polyethylene bags, and considerable research has been done on the problems involved (3, 6, 7, 8, 9, 10, 11) "Poly" bags have been associated with increased decay ever since they were introduced for use with Florida citrus (3). Originally, these bags had as few as eight ¼-inch holes (11). Increasing the number of holes helps to reduce decay (9), but even after standardization on seventy-two

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Fig. 1.—Typical consumer packages for Florida citrus. From left to right, front row: cotton mesh 8-pound bag; draw-string-type 8-pound polyethylene bag; two "Vexar" polyethylene net bags; printed "poly" 5-pound draw-string bag; clear "poly" bags; cotton net bag; top row; all shrinkfilm trays of various sizes.

¼-inch holes per 5-pound bag (18), decay troubles have persisted. The effect can be economically drastic without necessarily being statistically significant since it occurs not as a general increase in decay levels, but as an aggravation of the abnormal decay levels associated with "weak" crops (5). Fungicides, either applied directly to the fruit (3, 6, 7, 10, 16) or as diphenyl in the vapor-phase in the master container (6, 7, 8) afford practical control measures for citrus bagged at shipping point. However, this is usually not possible for citrus bagged at terminal markets, supermarkets warehouses, or other distribution points where merchandising is increasingly turning to "fancier" packages such as shrinkfilm trays (14, 15, 17). Moreover, recent studies have shown that for tender fruit, such as tangerines, diphenyl may be phytotoxic in anything above very moderate amounts (8). Initial studies have indicated that decay in shrinkfilm packages of citrus is apt to be comparable to that in "poly" bags (8).

However, little information is available on the effect of such consumer packaging on the specialty citrus varieties such as tangerines, tangelos, 'Murcotts,' 'Temples,' etc. A program was, therefore, initiated to study the effect of such packaging methods on decay in these varieties and to seek decay control measures that might be applicable in out-of-state packaging centers where treatment of the fruit with dips or waxes is not practical.

The work reported here was preceded by exploratory experiments in 1963-64 and 1964-65 involving storage tests, simulated shipping tsets, small scale cooperative marketing experiments in a local supermarket, and diphenyl residue analyses The experimental design for the 1965-66 season compared several types of consumer packages and 2 vapor-phase fungicides that could be applied to the package rather than to the fruit. The program, which was intended to run through the season with specialty varieties, was severely curtailed by the freeze of January 31, 1965 ('Valencia' oranges and 'Duncan' grapefruit were used as partial substitutes). Despite this unscheduled change of plan, the results obtained confirm those noted in exploratory studies and establish a new technique for experimenting with the use of vapor-phase fungicides for consumer packages.

Materials and Methods

Fruit.—'Dancy' tangerines were picked from a commercial grove near Orlando as part of harvesting experiments which are to be reported elsewhere. Lots harvested by different methods and hauled separately were treated as replications. 'Orlando' tangelos were obtained from a commercial grove near Lutz. 'Temples' were from the groves of the Indian River Field Laboratory at Fort Pierce, picked 1 day and prepared the next. 'Valencia' oranges and 'Duncan' grapefruit were from the Citrus Experiment Station groves and prepared the day that they were picked.

Fruit Preparation.—Standard packinghouse equipment was used. The tangelos were degreened for 48 hours with ethylene The other varieties did not need degreening. All fruit was washed, dried on slat conveyors without brushing, waxed with "Flavorseal," graded, and sized. Inasmuch as possible, a single size was used in any particular comparison. When this was not possible, the sizes were distributed equally among the treatments being compared. When the 2-aminobutane fungicide was applied to the fruit, the methods of McCornack and Brown were used (12).

Packaging (see Figure 1).—Polyethylene bags were standard 72-hole, draw-string type, 1½ mil 5-pound "poly" bags (18). Mesh bags were "Vexar" polyethylene net, closed with a twisted paper-covered wire tie.

Trays used in shrinkfilm packaging were molded fibreboard, size and shape being selected to fit the number and type of fruit being packaged. Intact shrinkfilm was oriented polyethylene applied as a loose sleeve so that the ends of the package were always open after the heat-shrink treatment. Perforated film was similar except that it had 576 perforations per square foot, each tear-drop shaped *ca.* 3 mm X 1:5 mm prior to heat shrinking.

Grapefruit had to be picked ahead of schedule to avoid a storm. In consequence, half were packaged the day they were picked and the other half precooled to 40° F overnight and packaged the next day. These 2 lots were treat-as separate subtreatments: "Packaged then cooled" and "Precooled then packaged."

The number of fruit per package and number of packages per treatment varied with the type of fruit and size of package and are indicated in the tables. When the number of fruit per package had to be low, the number of packages per treatment was increased. All consumer packages were placed in fibreboard master containers immediately after packing.

Use of Fungicides

Fungicides applied to fruit.—In a single trial with 'Orlando' tangelos, the new fungicide, 2-aminobutane, was used both as a dip and as the aqueous solution applied to the trays. Thirty-six trays of 4 fruit each were packed with size 100 tangelo treated with 1% 2-aminobutane (carbonated) dip (12). An equal number of trays were packed with untreated fruit.

Fungicides applied to trays.—Diphenyl paper was inserted in the trays before filling them with fruit. Two quantities were tried, 1/50 and 2/50 of a pad per fruit. (These diphenyl pads are a standard commercial product, each of 1,032 square cm. containing 2.35 grams of diphenyl.)

2-aminobutane was used in the free amine form. Originally a 10% aqueous solution was pipetted into each tray to give the required amount of active material and then brushed in immediately before adding the fruit. Later this concentration was raised to 25%. Full strength (98%) and 50% 2-aminobutane (free amine) were also used as noted.

Tests

Storage tests involved holding at 70° F, with weekly examinations for decay for 3 weeks. Bags were opened at each examination. Decayed fruit in shrinkfilm packs were marked on the outside of the package, and the film was not broken until the last examination.

Simulated shipping and marketing tests were more elaborate and sought to reproduce the conditions encountered in actual practice. Immediately after packaging, the samples were transferred to 40° F to simulate shipping in iced cars or trucks. On the fourth day, they were transferred to 70° F to simulate opening the freight car or truck and transferring, through warehousing, to the retail store. On the sixth day (simulating retail purchase), master containers were discarded, the packages opened for examination, and wooden crates used thereafter to simulate "fruit-bowl" conditions at 70° F. Bags were set in these crates, upright, with tops open.

Fruit from shrinkfilm packages were transferred to open top kraft paperbags After 1 week (simulating conditions in the customer's home), another decay count was made and the samples were discarded.

Results and Discussion

Container Comparisons.—The comparison between types of containers was repeated with 5 types of citrus as shown in Table 1. Only the results of the first decay count (at "retail sale") are shown in detail, but these are expressed both as percentage of decayed fruit and also the more important "percentage of spoiled packages" (i.e. those having 1 or more rots). Losses in the week after "simulated retail purchase" are summarized briefly in Table 3. In the single experiments on tangelos and oranges, losses at "retail sale" were not related to degree of ventilation of containers. However, differences in favor of the most highly ventilated containers showed up in the second week. Grapefruit showed no response to increased ventilation of consumer packages.

In the comparison between mesh and "poly" bags for tangerines and 'Temples,' minor differences in terms of percentage of decayed fruit became differences in favor of mesh over "poly" of 55% versus 35% for tangerines and 10% versus 3.3% for 'Temples' when considered in terms of spoiled packages. The use of perforated shrinkfilm showed no advantage up to the "retail sale" examination for tangerines, but with 'Temples' resulted in zero loss at "retail sale" in each of the experiments. Since decay levels were low and the ends of the shrinkfilm tray packs are open, it was considered surprising to observe any benefit from the use of the perforated film.

Use of Fungicides

Fungicides applied to fruit.—In the initial storage test with 'Orlando' tangelos, decay was sharply reduced during the first week at 70° F by the 2-aminobutane dip treatment (Figure 2A).

Table 1.--Percentage decay and percentage spoiled packages of 'Orlando' tangelos, 'Dancy' tangerines, 'Valencia' oranges, and 'Duncan' grapefruit in 4 types of packages. Tangelos held for 1 week at 70° F. For other varieties, losses are at "retail sale" in simulated shipping tests.

		Quantities		% decay				% spoiled packages			
				Bags*		Shrinkfilm		Bags*		Shrinkfilm	
Picking date	Type of fruit	Fruit per pack	Pack per sample	"Poly"	Mesh	Non-perf.	Perf.**	"Poly"	Mesh	Non-perf.	Perf.**
11/19/65	Tangelos	6-8	20	11.0	10.2	7.7	--***	60	60	35	--***
12/14/66	Tangerines										
	Replicate I	10-12	10	6.7	3.3	2.0	1.0	60	40	20	10
	Replicate II	14	10	12.1	5.0	10.7	7.8	90	50	80	80
1/5/66	Replicate III	10	10	6.0	4.0	9.0	10.0	50	30	60	60
	Replicate IV	10	10	2.0	2.0	1.0	4.0	20	20	10	30
	Averages			6.7	3.6	5.8	5.7	55	35	42.5	45
2/15/66	'Temples'	6	10	1.7	0.0	1.7	0.0	10	0	10	0
2/22/66	'Temples'	6	10	1.7	1.7	3.3	0.0	10	10	20	0
3/1/66	'Temples'	6	10	1.7	0.0	0.0	0.0	10	0	0	0
	Averages			1.7	0.6	1.7	0.0	10	3.3	10	0
5/26/66	'Duncan' grapefruit	10 (bags) 2 (trays)	5 30								
	I packed then cooled			2.0	4.0	1.7	1.7	20	40	3.3	3.3
	II pre-cooled then packed			6.0	2.0	1.7	1.7	40	20	3.3	3.3
	Averages			3.0	3.0	1.7	1.7	30	30	3.3	3.3
6/13/66	'Valencias'	6 (trays) 10 (bags)	10 15	1.3	1.3	0.8	0.0	13.3	13.3	5.0	0.0

*"Poly" bags were 72-hole, 1-1/2 mil polyethylene film: Mesh bags were "Vexar" polyethylene net.
**Perforated
***Data not available.

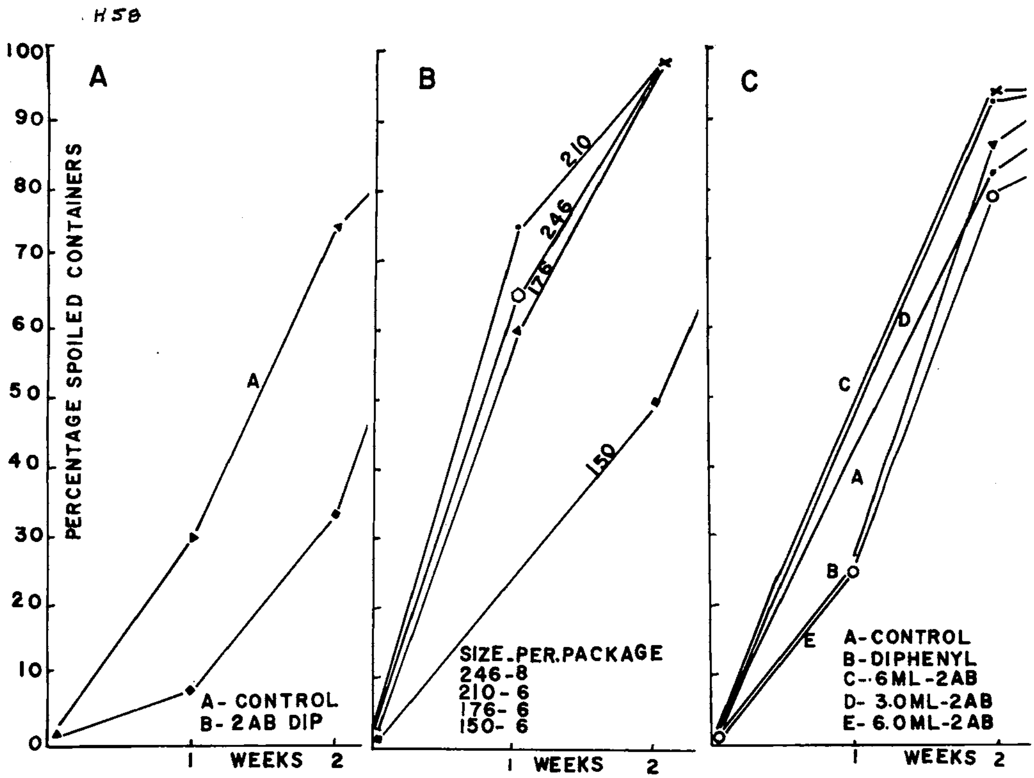

Fig. 2.—Packaging experiments with a single picking of 'Orlando' tangelos, holding test at 70° F. A-Size 100 packed 4 per package and 36 packages per treatment, comparing untreated fruit and fruit dipped in 1% 2-aminobutane (2-AB) solution. B—Fruit size as related to keeping quality. C—Effect of fungicides applied to shrinkfilm trays, 24 packages per treatment, 6-8 fruit per package. (Tests were continued for 3 weeks: only first 15 days shown here.)

Fungicides applied to trays.—Sizes 120, 150, and 176 were equally distributed between 5 treatments: control; diphenyl paper at one-fiftieth of a pad per fruit; and 10% 2-aminobutane at 0.6, 3.0, and 6.0 ml per tray. Sizes were kept separate with 6 or 8 fruit per tray and 24 trays per treatment. The importance of this is shown in Figure 2B which shows the percentage of spoiled containers within the control treatment separated by sizes. The tendency of the larger size (size 150) to keep better than the smaller sizes is notable. Some success was obtained with diphenyl and with 2-aminobutane at 6 ml rate (Figure 2C). Both diphenyl and 6 ml of 10% 2-aminobutane reduced the percentage of spoiled packages at 1 week from 43% to 25%.

This was considered encouraging enough to proceed with a series of simulated shipping tests with specialty fruits. In the first such test, diphenyl was used at 1/50 and 2/50 of a pad per fruit without evidence of the phytotoxicity found with diphenyl levels in previous experiments with tangerines (8). Thereafter, the two-fiftieth quantity was used. The 10% aqueous solution of 2-aminobutane caused undesirable wetting of the paper trays, and the concentration was raised, first to 25% and then to 98% (full strength). The latter caused epidermal injury to grapefruit, and concentration was reduced to 50% for 'Valencia' oranges.

Results of the first examination (at simulated "retail sale") are shown in some detail in Tables 1 and 2. Results of the second examination (after a simulated "week in the customer's home") are presented in summary form in Table 3. This brief table illustrates the magnitude of the decay problem with regard to

Table 2.--Fungicides in shrinkfilm trays: loss at "retail sale" in simulated shipping tests with 'Dancy' tangerines, 'Temples,' 'Duncan' grapefruit, and 'Valencia' oranges.

Fruit variety & size		Quantities: Fruit per tray	Quantities: Trays per sample	% decayed fruit: Control	% decayed fruit: Diphenyl Amount ml/fruit	% decayed fruit: Diphenyl % loss	% decayed fruit: 2-aminobutane Amount ml/tray	% decayed fruit: 2-aminobutane % loss	% spoiled packages: Control	% spoiled packages: Diphenyl Amount ml/fruit	% spoiled packages: Diphenyl % loss	% spoiled packages: 2-aminobutane Amount ml/tray	% spoiled packages: 2-aminobutane % loss
Tangerines													
Size 150	I	10	8	1.25	1/50	1.25	0.6+	2.5	12.5	1/50	12.5	0.6+	25.0
					2/50	0.0	1.2*	5.0		2/50	50.0	1.2*	50.0
	II	10	8	6.25	1/50	5.0	0.6+	1.25	50.0	1/50	37.5	0.6+	12.5
					2/50	2.5	1.2*	3.75		2/50	25.0	1.2*	25.0
	III	10	6	6.7	2/50	1.7	4.8	5.0	67.0	2/50	17.0	4.8	50.0
	IV	10	6	5.0	2/50	3.3	4.8	0.0	50.0	2/50	33.3	4.8	0.0
Averages				4.8		2.3		2.9	45.0		29.0		27.0
'Temples'													
Size 200		8	6	0.0	2/50	0.0	1.2*	2.1	0.0	2/50	0.0	1.2*	16.7
Size 200		8	6	2.1	2/50	0.0	1.2*	0.0	16.7	2/50	0.0	1.2*	0.0
Size 200		8	6	0.0	2/50	0.0	1.2*	0.0	0.0	2/50	0.0	1.2*	0.0
Averages				0.7		0.0		0.7	5.6		0.0		5.6
'Duncan' grapefruit Size 64		2	120	2.1	--	--	Conc.‡	1.7	4.2	Conc.‡	--	--	3.3
'Valencia' oranges size 163		6	40	0.4	--	--	Conc.‡	0.0	2.5	Conc.‡	--	--	0.0

+2-aminobutane as 10% solution
*2-aminobutane as 25% solution
‡1 stroke with a 2-inch brush using 98% 2-aminobutane
Ø1 stroke with a 2-inch brush using 50% 2-aminobutane

Table 3.--Summary of losses, as percentage of decayed fruits, after a week simulating fruit bowl conditions "in the customer's home." From the same simulated marketing experiments as in Tables 1 and 2, presented as averages for each variety.

Variety	Container comparison: Bags "Poly"	Container comparison: Bags Mesh	Container comparison: Shrinkfilm Non-perf.	Container comparison: Shrinkfilm Perf.	Fungicides in Shrinkfilm trays: Control	Fungicides in Shrinkfilm trays: Fungicide 2-AB	Fungicides in Shrinkfilm trays: Fungicide Diphenyl
Tangelos	31.4	22.7	33.4	---	32.2	20.9	23.5
Tangerines	42.6	20.2	25.5	19.7	27.2	21.4	25.0
'Temples'	11.7	9.4	5.6	3.3	11.1	4.9	4.9
Grapefruit	12.0	12.0	5.9	6.7	8.8	3.8	---
Oranges	28.7	16.4	19.0	12.7	8.6	1.3	---
Averages*	25.3	16.1	14.0	10.6	23.5	15.4	17.8

*For comparable samples as indicated by brackets.

Florida citrus and the degree to which differences at time of simulated "retail sale" persist during a subsequent week of "fruit bowl conditions" at 70° F.

Decay in tangerines was approximately halved by the use of the diphenyl inserts at the "two-fiftieth" amount. Two-aminobutane was slightly less effective in terms of percentage of decayed fruit, but slightly more effective in terms of spoiled packages and the effect persisted well into the second week.

Decay in 'Temples' was so low at the "retail sale" examination shown in Table 2 as to make differences between treatments appear to be almost meaningless. However, in the "week after sale" the control averaged 51.2% spoiled packages, reduced to 25.9% and 33.3% by diphenyl and 2-aminobutane, respectively.

'Duncan' grapefruit did not decay in the first week despite epidermal injury due to the use of full-strength 2-aminobutane. In the second week, the percentage of spoiled packages was reduced from 15% to 6.7% by the use of 2-aminobutane; a very small difference, but in the right direction.

2-Aminobutane was more effective with 'Valencia' oranges, which also suffered negligible loss in the first examination. In the "week after sale" loss in terms of decayed fruit was reduced from 8.6% to 1.3% and the percentage of spoiled packages was reduced from 50% to 5%.

Conclusions

The comparisons between "poly" and mesh bags confirm observations with oranges going back many years (, 5, 6, 7, 8, 9, 11, 16) and are therefore considered reliable. The results uing fungicides in shrinkfilm trays must be considered exploratory in view of the necessary changes in the technique as the work progressed and the freeze-enforced curtailment of supplies of the specialty varieties now being marketed in this type of package.

Losses in terms of percentage of spoiled packages were so high, particularly with tangelos and tangerines, as to indicate an urgent need for continued research on decay control for citrus fruits in consumer packages. In particular, automated methods for application of fungicides to the trays are needed. Preliminary discussions with equipment manufacturers have indicated that this may be achievable.

As long as packaging is done at the shipping point, it would appear to be preferable to treat the fruit by conventional methods rather than to treat the package, although combinations of the 2 methods are obviously possible.

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