percent of the high budded trees and only 27% of the low budded trees had trunk lesions. Sixty-nine percent of the trees with virus symptoms had trunk lesions and 34% of those without virus had lesions.

Taking into consideration only the bearing groves, of a total of 844 trees in 18 groves 38.5% had trunk lesions and 31.5% showed virus symptoms. The prevalence of lime bark disease increased sharply with the age of the groves up to 15 years. At the same time the percentage of virus symptoms decreased in groves over 10 years old.

The percentage of trees with no virus symptoms but with trunk lesions increased with age at about the same rate as the percent total lesions. The percentage of trees with virus symptoms that had trunk lesions increased with age more rapidly and was consistently higher. This indicates that the presumed virus disease is a contributing factor to the prevalence of lime bark disease. Whether or not the virus disease is a predisposing factor for *Diplodia* bark rot, the losses accrued through reduced quality of the fruit and the general unthriftiness of the diseased trees may be serious.

The height of the bud union seemed to be more of an important factor in lime bark disease in trees under ten years old. In the younger groves the low budded trees had consistently more trunk lesions than the high budded trees. In some of the older groves there was as much or more bark disease among the trees with high buds.

This survey did not indicate that there is any difference between the Idemor and the common Tahiti varieties of limes as far as susceptibility to lime bark disease is concerned.

Factors which should be studied as to their possible contribution to the disease are stock scion compatibility, planting depth, budding procedures, and fertilized and cultural practices.

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PACKAGING AND STORAGE OF PERSIAN LIMES[1]

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During the past twenty years, the commercial production of Persian limes has rapidly increased in Florida. In 1929 only 8,000 boxes (1-3/5 bushels) were produced in the entire state, whereas, in 1949 there were 250,000 boxes produced (6). The rapid growth of this industry has increased the competition for existing and potential markets, thus focusing attention upon the need for additional information pertaining to the handling and storage of this fruit. The following investigation was undertaken to determine the effect of packaging, surface treatments, and storage temperature upon the period of marketability of Persian limes.

The selection of materials for packaging and surface treating the fruit as well as the storage temperature was directed toward reducing the rate of respiration and subsequent ripening, decreasing moisture loss, and minimizing pathologi-

[1] The material for this paper was taken from the thesis of the author presented to the Graduate School of the University of Miami in partial fulfillment of the requirements for the degree of Master of Science.

cal and physiological breakdown which occurs during the storage of Persian limes.

Forty-eight degrees F. was selected as the refrigerated storage temperature. This is within the range recommended by Rose and his associates (5) for the prevention of rind breakdown in Persian limes, within a few degrees of that found most satisfactory of those tested by Stahl and Vaughan (7), and approximately the recommended shipping temperature for avocados which are frequently transported with limes (2). The following three storage periods were selected as they duplicate in as far as possible, conditions under which limes might be marketed:

(1) Simulated refrigerated shipment and storage and unrefrigerated retail sale—fruit stored for four weeks at 48 degrees F. and then transferred to room temperature.
(2) Simulated refrigerated shipment followed by unrefrigerated retail sale—fruit stored for one week at 48 degrees F. and then transferred to room temperature.
(3) Simulated unrefrigerated shipment and retail sale or local, unrefrigerated retail sale—fruit stored at room temperature throughout storage period.

The selection of packaging materials was based upon a preliminary investigation reported elsewhere (3). This investigation showed that some of the materials which had proved satisfactory as individual wraps on Persian limes (7) are not satisfactory when used as tightly closed bags for packaging this fruit. The packaging materials used are designated by the code identifications of the manufacturers. Good-rite Latex VL-600 was used as a surface coating in the following tests. It was found that a 25 percent aqueous solution of this material containing 0.15 percent Triton was superior to either a 50 or 75 percent solution of latex containing 0.15 percent Triton as a surface coating for Persian limes (3). The latex was applied as a dip and allowed to dry at room temperature before placing the fruits under refrigeration.

The color of the fruit was determined by comparison of the individual fruits with Plate XVII in Ridgeway (4). Those fruits which had ripened to the extent that the skin had turned dull green yellow were considered no longer marketable.

Moisture loss was determined by weighing the individual samples to the nearest one-hundredth of a gram and comparing this figure with the original weight.

The percentage of marketable fruit was periodically determined and used in conjunction with moisture loss as criteria for determining the effectiveness of the respective treatment. It will be noted in the data which follows that the factors contributing to the unmarketability of the fruit are listed separately to afford a clearer conception of the effect of each treatment upon the fruit during storage.

All types of pathological and physiological breakdown other than stylar-end rot were recorded simply as "miscellaneous types of breakdown."

Freshly picked and graded limes were taken directly from the packing house to the laboratory where they were utilized within twenty-four hours. The fruit sizes are the same as those used commercially and run 48's ("jumbo"), 54's (large), 60's and 70's (medium), 80's and 90's (small), and 100's and 110's ("bar").

Medium Sized Fruit

Approximately 800 limes of sizes 54 and 60 were obtained, all of which had been commercially waxed with the exception of those to be dipped in Latex

VL-600. Five samples consisting of ten limes each were treated as indicated in Table 1. The bags, constructed of the five films listed, were tightly closed with double folds. The results of this investigation are summarized in Table 1 and 2.

It is clearly evident from the results in the accompanying tables that refrigeration materially extended the period of marketability and decreased the moisture loss of all the samples. After three weeks of storage at 48 degrees F., approximately 99 percent of both the packaged and surface treated limes remained marketable, whereas, only approximately 62 percent of those stored for one week at 48 degrees F. and 49 percent of those stored at room temperature still remained marketable.

The data indicate that perforated pliofilm and perforated cellophane are slightly superior to the other packaging materials tested when considered both from the aspect of moisture retention and percentage of marketable fruit. Polyethylene is also a promising packaging material for medium sized Persian limes providing the limes are marketed soon after they are removed from refrigerated storage. Vinylite, of the gauge tested, is not recommended as a bag material due to its lack of strength. The higher percentage of moisture loss from limes packaged in LSAT cellophane as compared to perforated cellophane favors the use of the perforated material for packaging Persian limes. Latex VL-600 compared favorably with wax as a surface coating for Persian limes. Fruits treated with this material and initially refrigerated were found to retain their green color for a longer period than the waxed fruit. The latex treated fruit, however, lost a slightly higher percentage of moisture than the waxed samples.

"Jumbo" and "Bar" Limes

It was felt by some engaged in the sale of limes that the "jumbo" and "bar" sizes could be more readily marketed if packaged in protective, attractive, and convenient containers.

This investigation with "jumbo" limes was confined to the use of semi-moisture-proof and perforated films due to the greater tendency of large limes to develop stylar-end rot (1) and the association of this breakdown with high humidity. Perforated 75 FF pliofilm and perforated 300 LSAT cellophane were used for the bags and perforated and nonperforated 300 LSAT cellophane were used for overwrapping the trays. It will be noted in Table 3 that one set of samples was dipped in 25 percent Latex VL-600 prior to packaging. Since the packaged "jumbo" limes must be sold in competition to bulk limes, packages were selected which would hold four of these large limes so that the price per packaged unit would be comparable with that of a half dozen of the bulk, medium sized fruit. It was found that a bag 6½ inches wide and approximately 8 inches deep could be used conveniently for the packaging of four "jumbo" limes. Three limes per sample were packed in the overwrapped trays as no trays that would hold four limes were available.

Perforated bags 8-1/3 inches wide and approximately 13 inches deep constructed of perforated 120 gauge pliofilm and perforated 300 gauge LSAT cellophane were used for packaging the "bar" sized limes. Bags of these dimensions were selected as they hold three dozen of the small limes which are usually sold to the individual purchaser in considerably larger quantities than the other sizes of fruit.

All of the limes were commercially waxed with the exception of those to be dipped in Latex VL-600.

TABLE 1.
EFFECT OF VARIOUS FACTORS UPON THE MARKETABILITY OF MEDIUM SIZED LIMES.

TREATMENT[1]	Number of Samples	Number of Limes	1st Week				2nd Week				3rd Week				4th Week				5th Week				6th Week			
			Percentage Marketable	Percent Unmarketable Due to			Percentage Marketable	Percent Unmarketable Due to			Percentage Marketable	Percent Unmarketable Due to			Percentage Marketable	Percent Unmarketable Due to			Percentage Marketable	Percent Unmarketable Due to			Percentage Marketable	Percent Unmarketable Due to		
				Stylar-end Rot	Misc. Breakdown	Color		Stylar-end Rot	Misc. Breakdown	Color		Stylar-end Rot	Misc. Breakdown	Color		Stylar-end Rot	Misc. Breakdown	Color		Stylar-end Rot	Misc. Breakdown	Color		Stylar-end Rot	Misc. Breakdown	Color
48° F.—Room Temperature (67°-80° F.)[2]																										
Waxed	5	50	100	0	0	0	100	0	0	0	98	0	2	0	72	0	2	26	57	0	9	34	20	4	16	60
25% Latex VL-600	5	50	100	0	0	0	100	0	0	0	100	0	0	0	96	0	4	0	73	0	25	2	37	2	45	16
Vinylite	5	50	100	0	0	0	100	0	0	0	98	0	0	2	54	0	8	38	20	0	12	68	12	0	16	72
Cellophane	5	50	100	0	0	0	100	0	0	0	98	0	0	2	70	0	4	26	39	0	9	52	18	0	16	66
Polyethylene	5	50	100	0	0	0	100	0	0	0	100	0	0	0	94	0	2	4	65	0	7	28	20	0	20	60
Perforated Pliofilm	5	50	100	0	0	0	100	0	0	0	98	0	2	0	70	0	2	28	41	2	7	50	14	4	8	74
Perforated Cellophane	5	50	100	0	0	0	100	0	0	0	100	0	0	0	54	0	2	44	39	2	5	54	18	2	8	72
48° F.—Room Temperature (67°-80° F.)[3]																										
Waxed	5	50	100	0	0	0	96	2	2	0	68	2	16	14	38	2	20	40								
25% Latex VL-600	5	50	100	0	0	0	100	0	0	0	56	0	40	4	18	0	76	6								
Vinylite	5	50	100	0	0	0	98	2	0	0	54	6	16	24	14	6	52	28								
Cellophane	5	50	100	0	0	0	98	0	2	0	56	4	18	22	8	4	54	34								
Polyethylene	5	50	100	0	0	0	94	2	4	0	68	8	16	8	0	8	82	10								
Perforated Pliofilm	5	50	100	0	0	0	96	0	4	0	72	2	4	22	10	2	60	28								
Perforated Cellophane	5	50	100	0	0	0	94	0	6	0	64	2	12	22	10	2	66	22								
Room Temperature (67°-80° F.)																										
Waxed	5	50	100	0	0	0	90	4	4	2	44	6	18	32	6	6	56	32								
25% Latex VL-600	5	50	100	0	0	0	94	4	2	0	54	4	18	24	12	4	52	32								

[1] Vinylite P9V (chemically treated), Cellophane 300 LSAT, polyethylene (Visqueen) 0.002 inch, Perforated pliofilm P 1206, Perforated cellophane 300 MSAT.
[2] Stored at 48° F. for 4 weeks then transferred to room temperature.
[3] Stored at 48° F. for 1 week then transferred to room temperature.

Packages of the "jumbo" and "bar" limes were placed under two combinations of storage conditions. One group of packages were refrigerated at 48 degrees F. for one week followed by transfer to room temperature (69-83 degrees F.), simulating refrigerated shipment followed by unrefrigerated sale. The second group of packages were stored throughout the three weeks period at room temperature, simulating unrefrigerated shipment and sale.

The results of this investigation are summarized in Tables 3 and 4.

These results show that the storage life of packaged "jumbo" limes can be extended somewhat by storing them initially for one week at 48 degrees F., although the difference in marketability at the end of the third week of storage was only 82 percent significant instead of 95 percent which is the generally accepted value for conclusive significance. Initial refrigeration did not seem to be as important for the storage of packaged "bar" limes as for packaged "jumbo" limes. At the end of three weeks of storage, the difference in marketability between the initially refrigerated and unrefrigerated packaged "bar" limes was only 27 percent significant as compared to the 82 percent significance for the "jumbo" size. Refrigeration decreased the percentage of moisture loss of all samples with the exception of unpackaged "jumbo" limes.

The data in Tables 3 and 4 indicate that although packaging did not increase the period of marketability of "jumbo" and "bar" limes it did decrease the percentage of moisture loss from the fruit during storage. The differ-

TABLE 2.

EFFECT OF VARIOUS FACTORS UPON THE PERCENTAGE MOISTURE LOSS OF MEDIUM SIZED LIMES

Temperature	Treatment[1]	Moisture Loss after					
		1 week	2 weeks	3 weeks	4 weeks	5 weeks	6 weeks
48° F.-R.T.[2]	Waxed	1.81	2.23	2.59	3.11	5.37	7.45
	Latex VL-600	1.89	2.46	2.86	3.41	5.40	8.48
	Vinylite	1.78	2.03	2.10	2.51	4.96	9.83
	Cellophane	1.56	1.91	2.23	2.54	4.70	8.00
	Polyethylene	1.31	1.37	1.38	1.42	3.41	6.14
	Per. Pliofilm	1.55	1.60	1.80	2.04	4.18	6.35
	Per. Cellophane	1.47	1.50	1.69	1.95	4.47	6.46
48° F.-R.T[3]	Waxed	1.78	3.69	5.55	7.23		
	Latex VL-600	1.98	3.88	6.08	9.18		
	Vinylite	1.63	2.95	4.01	8.30		
	Cellophane	1.61	3.47	5.04	7.62		
	Polyethylene	1.58	2.12	2.51	3.33		
	Per. Pliofilm	1.61	2.86	3.63	4.72		
	Per. Cellophane	1.45	2.22	3.33	4.20		
R.T.[4]	Waxed	3.67	5.32	7.04	8.80		
	Latex VL-600	4.13	5.94	7.90	10.02		

[1] Commercially waxed; Good-Rite Latex VL-600 25 percent; Vinylite P9V (chemically treated) 20 ga.; Cellophane LSAT 300 ga; Polyethylene (Visqueen) 0.002 in.; Pliofilm perforated P1206; Cellophane perforated MSAT 300 ga.

[2] Stored at 48 degrees F. for 4 weeks and then transferred to room temperature

[3] Stored at 48 degrees F. for 1 week and then transferred to room temperature

[4] Stored at room temperature (67-80 degrees F.).

TABLE 3.
EFFECT OF VARIOUS FACTORS UPON THE MARKETABILITY OF "JUMBO" AND "BAR" LIMES.

TREATMENT[1]	Number of Samples	Number of Limes	1st Week				2nd Week				3rd Week			
			Percent Marketable	Percent Unmarketable Due to			Percent Marketable	Percent Unmarketable Due to			Percent Marketable	Percent Unmarketable Due to		
				Stylar-end Rot	Misc. Breakdown	Color		Stylar-end Rot	Misc. Breakdown	Color		Stylar-end Rot	Misc. Breakdown	Color
48° F.—Room Temperature[2]														
Jumbo														
Pliofilm Bag	5	20	100	0	0	0	100	0	0	0	75	15	10	0
Cellophane Bag	5	20	100	0	0	0	90	0	10	0	75	5	10	10
Pliofilm and Latex	5	20	100	0	0	0	95	5	0	0	70	10	15	5
Cellophane Wrap	5	15	100	0	0	0	93	0	7	0	33	7	20	40
Cellophane P. Wrap	5	15	100	0	0	0	100	0	0	0	67	0	13	20
Check	1	20	100	0	0	0	100	0	0	0	75	0	20	5
Bar														
Pliofilm Bag	2	72	100	0	0	0	96	1	1	2	81	1	7	11
Cellophane Bag	2	60	98	2	0	0	90	2	5	3	57	3	7	33
Check	1	18	100	0	0	0	94	0	6	0	78	0	6	16
Room Temperature[3]														
Jumbo														
Pliofilm Bag	5	20	100	0	0	0	70	15	15	0	40	15	40	5
Cellophane Bag	5	20	100	0	0	0	80	5	15	0	30	10	25	35
Pliofilm and Latex	5	20	100	0	0	0	80	10	10	0	70	10	15	5
Cellophane Wrap	5	15	100	0	0	0	73	0	20	7	47	7	20	26

TABLE 3—Continued on next page

TABLE 3—Continued

Cellophane P. Wrap	5	15	100	0	0	0	87	0	7	6	53	7	13	27
Check	1	20	100	0	0	0	90	0	5	5	80	0	6	14
Bar														
Pliofilm Bag	2	72	97	0	3	0	89	0	6	5	74	0	7	19
Cellophane Bag	2	48	100	0	0	0	90	0	10	0	75	0	10	15
Check	1	18	100	0	0	0	100	0	0	0	78	0	6	16

[1] Jumbo-Perforated pliofilm 75 FF bag, Perforated cellophane 300 LSAT bag, Perforated pliofilm 75 FF bag and limes treated with 25% VL-600 Latex, Cellophane 300 LSAT overwrap, Perforated cellophane 300 LSAT overwrap, and waxed check. Bar-Perforated pliofilm 120 FF bag, Perforated cellophane 300 LSAT bag, and waxed check.

[2] Limes stored for one week at 48 degrees F. then transferred to room temperature (69-83 degrees F.).

[3] Limes stored at room temperature throughout the experiment.

ence in moisture loss under the two storage temperatures was found to be 83 percent significant for the "jumbo" and 42 percent significant for the "bar" limes. Perforated cellophane and perforated pliofilm proved to be superior to nonperforated cellophane for the packaging of "jumbo" limes held under initial refrigeration. None of the packaging material can be recommended for the packaging of unrefrigerated, waxed, "jumbo" limes. It was found that "jumbo" limes dipped in Latex VL-600 prior to packaging in perforated pliofilm bags remained marketable for a longer period than did any of the other unrefrigerated samples. Caution is advised in selecting bags for the packaging of "jumbo" limes to be sure that the location of the perforation in the bags is such that they will not be blocked by the fruit after packaging. The higher percentage of pathological and physiological breakdown, particularly stylar-end rot, observed in the "jumbo" limes stored in bags as compared to that observed in overwrapped cartons can be partially attributed to the location of the perforations in the bags. It was noted during the investigation that many of the perforations in the bags were completely blocked by the limes.

Perforated pliofilm was found to be slightly superior to perforated cellophane for the packaging of "bar" limes when considered both from the aspect of period of marketability and decrease in moisture loss of initially refrigerated and unrefrigerated samples.

Summary

The results of this investigation show that initial refrigeration extended the period of marketability and decreased the moisture loss of packaged and surface treated medium sized Persian limes. Initial refrigeration was found to be more important for the storage of

TABLE 4.

EFFECT OF VARIOUS FACTORS UPON THE PERCENTAGE MOISTURE LOSS OF MARKETABLE "JUMBO" AND "BAR" LIMES.

Temperature	Treatment[1]	Moisture Loss After		
		1 Week	2 Weeks	3 Weeks
	Jumbo			
	Pliofilm Bag	0.20	1.77	2.79
	Cellophane Bag	0.42	3.39	5.65
48° F.-R.T.[2]	Pliofilm and Latex	0.27	1.83	2.95
	Cellophane Wrap	0.12	2.30	3.63
	Cellophane P. Wrap	0.23	3.04	4.75
	Check	4.17	7.79	10.16
	Bar			
	Pliofilm Bag	0.34	2.20	4.05
48° F.-R.T.	Cellophane Bag	0.48	3.40	5.90
	Check	0.70	4.37	7.01
	Jumbo			
	Pliofilm Bag	1.02	2.38	3.94
	Cellophane Bag	2.25	4.67	6.82
R. T.[3]	Pliofilm and Latex	1.23	2.64	4.01
	Cellophane Wrap	1.51	3.24	4.84
	Cellophane P. Wrap	1.73	3.58	5.34
	Check	3.28	6.38	8.82
	Bar			
	Pliofilm Bag	1.97	2.81	4.52
R. T.	Cellophane Bag	2.51	4.94	7.32
	Check	3.28	6.42	8.96

[1] Jumbo—Perforated 75 FF pliofilm bag; Perforated 300 LSAT cellophane bag; Perforated 75 FF pliofilm bag and limes treated with 25% Latex Vl-600; 300 LSAT cellophane overwrap; 300 LSAT perforated cellophane overwrap; and waxed check.

Bar-120 FF perforated pliofilm bag; 300 LSAT perforated cellophane bag; and waxed check.

[2] Limes stored for one week at 48 degrees F. then transferred to room temperature (69-83 degrees F.).

[3] Room temperature (69-83 degrees F.).

packaged "jumbo" limes than for packaged "bar" limes. Perforated pliofilm and perforated cellophane proved to be superior to the other materials tested for the packaging of medium and "jumbo" size fruit. Perforated pliofilm was found to be slightly superior to perforated cellophane for packaging "bar" size limes. Latex VL-600 compared favorably to wax as a surface coating for medium sized fruit.

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STUDIES OF STYLAR END ROT OF TAHITI LIMES

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Stylar end rot probably causes greater losses than any other type of breakdown affecting fruits of the Tahiti lime. It may occur on fruits before they are harvested, in the interval between harvesting and packing or in transit. Observations indicate that most of the breakdown develops during July, August, and September but within this period wide variation in its incidence may occur. What factor or combinations of factors is responsible for such variation is not known, but variations in climatic conditions, cultural practices or harvesting, packing and marketing operations could conceivably have a bearing on the problem. Since little is known concerning stylar end rot or of the factors that influence its expression, a general investigation of the problem was begun in 1949. This paper is a report of a study on the possible relationship between the development of stylar end rot, fruit size and percent juice content in lots of fruit from different sources.

The usual method of obtaining samples was to select the desired fruit from the appropriate bins in commercial packing houses after routine grading and sizing had been done. The samples were selected to cover sizes and juice percentages commonly marketed during the summer. In some cases several sizes of limes were selected from one lot. The fruit from these sizes were occasionally divided into samples of different juice percentages. Ten fruit were selected at random from each sample for determination of size and juice percentage. The average fruit size was determined from the volume of water displaced by ten fruit. The juice percentage was detemined by the method used by inspectors in the industry, i.e., the amount of extracted juice from ten fruit was divided by their volume. The sample was then stored from three to five days under various conditions to permit the development of stylar end rot.

Some mention should be made concerning the variability of the samples used. Preliminary investigation revealed that often considerable variation existed in the percent juice content of fruits that appeared to be identical in all other respects, and that it was impossible to separate limes with any certainty so