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TEXAS AGRICULTURAL EXPERIMENT STATION

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COLLEGE STATION, BRAZOS COUNTY, TEXAS

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DIVISION OF HORTICULTURE

STORAGE EXPERIMENTS WITH TEXAS CITRUS FRUIT

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**In cooperation with U. S. Department of Agriculture.

During the season of 1930-31, experiments were initiated to determine the most favorable conditions for holding Texas citrus fruit in cold storage. The object of this work was to determine the principal causes of loss of grapefruit in cold storage under Valley conditions, and to study the effect of certain factors on the keeping quality of fruit.

It is evident that pitting, scald, and stem-end rot are the principal causes of loss in the cold storage of Texas citrus fruit; blue mold, blossom-end rot, and bruising being of minor importance. The most serious problem the cold-storage plant operator has to contend with is physiological breakdown of the rind of the fruit, such as pitting and scald. Blue mold was not a factor of importance in these experiments, largely because the greater part of the fruit used had been treated with a fungicidal wash. Bruising was more important in some lots than in others, but is a factor which can be almost eliminated by proper handling of the fruit.

A temperature of 44-45°F. was the one which gave the best results during the longer periods of storage. The loss from scald was greatest at the low temperature (31-32°F.). The temperature of 36-37°F. was not a satisfactory temperature for the storage of grapefruit under the conditions of these experiments. Environmental influences, especially rain during the maturation period, apparently exert a greater influence on keeping quality than does age or ripeness of the fruit.

Pre-storage treatments such as wrapping the fruit in waxed paper and curing the fruit at 70°F. for ten days, prolonged the life of the fruit in cold storage. The fruit which was wrapped in waxed paper also held up much better after it was removed from cold storage. These waxed wrappers materially reduce the possibility of decay spreading from one fruit to another.

There was a rather marked difference in the way fruit of the different varieties kept in storage. Duncan grapefruit retained its original flavor much better than did that of the Marsh Seedless variety, and was not as susceptible to physiological breakdown of the rind as was the Marsh fruit. Valencia oranges were not seriously affected by physiological breakdown of the rind and retained their original flavor and freshness in a most satisfactory manner.

Grapefruit from trees which had received applications of fertilizer containing a high percentage of potash showed much more physiological breakdown (scald) while in cold storage, than did fruit from unfertilized trees. Fertilization did not have any detrimental effect on the keeping quality of Valencia oranges.

Recommendations for the storage of Valley citrus fruit are suggested.

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STORAGE EXPERIMENTS WITH TEXAS CITRUS FRUIT

W. H. FRIEND AND WALTER J. BACH

The steady expansion of the citrus industry in the Lower Rio Grande Valley will inevitably lead to marketing problems of increasing importance. Under present conditions, most of the crop must be marketed during a relatively short period of time. The beginning of the marketing season is rather definitely fixed by the maturity of the fruit and the regulatory measures pertaining to the movement of green or immature fruit, while the end of the season is definitely fixed by Federal quarantine regulations. The bulk of the fruit crop must move between December 1 and March 1, owing to the natural maturity of the greater part of the crop during this period.

The storage of a portion of the crop for movement to consuming centers after the normal shipping season would eliminate much of the costly dumping of fruit on oversupplied markets. This extension of the period of consumption for Valley citrus fruit should result in a saving of thousands of dollars annually, and the saving should increase with the expansion of the industry. Common storage can not be relied upon to keep fruit for periods longer than three or four weeks. Cold storage, therefore, offers a promising means of solving the problem of extending the period of consumption of Valley fruit.

Small quantities of Texas citrus fruit are placed in cold storage each season. Some of this fruit is stored in local cold storage plants, but the greater part of it is stored in Houston and San Antonio. Several growers who have their own cold storage plants, have met with considerable success in storing grapefruit. Some growers place the unwashed, unbrushed, and unwrapped fruit, packed loosely in baskets or field boxes, in a 31°-32°F. storage room. Others follow much this same procedure, but use a much higher storage-room temperature (50°F.). These small operators seem to be more successful, in general, in holding fruit in cold storage than the large-scale operators who store by the carload each season. These large operators, however, deal only in commercial packs of fruit and this may account, at least in part, for the difference in the results obtained.

The officials of the Central Power and Light Company, realizing the need for more exact information concerning the cold storage of Texas citrus fruits, invited the Texas Experiment Station to co-operate with them in the organization of a program of investigations in connection with the storage of citrus fruits, produced under Valley conditions. The experimental work, initiated by the Division of Horticulture, is being conducted in co-operation with the Division of Plant Pathology and Physiology, Texas Agricultural Experiment Station.

PREVIOUS WORK

Experiments conducted by Hawkins and Magness (4) in 1920 showed that the difficulties in the successful storage of citrus fruits are not insurmountable. Their work showed that "pitting", probably the most serious problem to be met in the cold storage of citrus, was made less serious at relatively high cold-storage temperatures (about 45°F.). More recent work by Hawkins and Barger (5) indicates that under certain conditions at least, relatively low cold-storage temperatures (31° - 32°F.) may be expected to give the best results. They also point out the fact that "curing" the fruit at about 70°F. for ten days materially reduces the amount of "pitting" which shows up in the stored fruit. The comment is also made that Marsh grapefruit is not adapted for holding in cold storage. These investigations were conducted with Florida fruit.

Young and Read (10), working in Australia with Washington Navel and Valencia oranges, found that fruit which had not been through a commercial packing plant kept in cold storage much better than commercial fruit. They found that carefully handled fruit kept better than fruit handled in the ordinary way. It was also thought that sweating which took place during transportation added to the keeping qualities of the unwrapped fruit. Fruit transported loose in boxes, and stored in that condition, held up better than packed fruit. This would indicate that even the most careful packing damages the fruit somewhat. These investigators report that relatively high cold-storage temperatures (45°) gave the most satisfactory results. They also reported little change in the sugar content of the juice during storage.

Overholser (9), working on marine refrigeration of California oranges, found that temperatures of 36° to 38°F. were most satisfactory. Lower temperatures resulted in deterioration of the rind and higher temperatures resulted in wilting of the fruit and excessive losses from blue mold.

The results obtained in the cold storage of fruit grown in other localities may not apply to fruit grown in Texas. The difference in conditions make it desirable to conduct similar tests in this State.

PLAN OF EXPERIMENT

Since citrus fruit is grown on several distinct soil types in the Valley, it was deemed best to have a portion of the fruit for some of the tests to come from the La Feria district, in the lower section of the citrus region, where a clay loam type of soil predominates (2), and another portion of fruit of the same variety, from the Mission district, farther up the Valley, where a sandy loam type of soil predominates (7). The two localities are about thirty-five miles apart.

Comparable lots of fruit were placed in each of three storage rooms where the temperature was maintained at 31°-32°F., 36°-37°F., and 44°-45°F., respectively. In order to study the effect of maturity of the fruit on its keeping quality, fruit was packed and stored at different times during the harvesting season. Lots were placed in storage at intervals of two weeks, beginning on December 22, 1930 and ending February 20, 1931.

In order to determine the length of time citrus fruit will hold up in storage at the three different temperatures, lots of five boxes each, from all of the test lots in each of the three storage rooms, were removed at intervals of two weeks, starting ten weeks after the first fruit was placed in storage. This fruit was examined and records made of the amount of deterioration. Most of the fruit used in the maturity and length of storage tests was treated with borax and paraffin, according to the "Brogdex" method, and was the first-grade fruit from the packing plants in the two localities.

Certain lots of comparable fruit which had not previously received any treatment were given different pre-storage treatments, such as dipping in various fungicidal washes, curing, wrapping, and packing in different ways. The treatments given the fruit utilized in this part of the experiment were as follows:

Fruits used in the fungicidal wash tests were unbrushed and were packed in commercial boxes without wrapping, except in the case of the lots treated with the hypochlorite wash. This fruit was from a different source from that used in the other tests and was put through a commercial packing plant. It is, therefore, not strictly comparable with the other lots of fruit in this test. The washes used to determine their effect on the keeping quality of the fruit were water and solutions of borax, sodium hypochlorite (Slater process), sodium sulphide, 1 per cent, and sodium bicarbonate, 3 per cent.

Ten boxes of fruit were used in the tests, to determine the effect of wrapping on keeping quality of the fruit. Five of these were wrapped in the usual manner with ordinary grapefruit paper, while the other five boxes, of similar fruit, were wrapped in medium-weight waxed paper.

Only two methods of packing were used in the tests to determine the effect of this operation on the percentage of loss while the fruit was in cold storage. All of the fruit used was from the same orchard and was unwashed, unbrushed, and was packed without wrapping. Standard packs were used in arranging the fruit in the boxes but in one lot of five boxes the last tier of fruit was left off so as to avoid the crushing effect of the bulge. The other five-box lot was packed so as to have the standard amount of bulge. Both of these lots were held under identical storage conditions.

Fifteen boxes of fruit were used in the tests to determine the effect of "curing," coloring with ethylene gas, and coloring with stove gas on the keeping quality of grapefruit in cold storage. The lot treated with ethylene gas is not strictly comparable with the other two lots ,as the fruit came from a different orchard. The "gassed" fruit was treated according to the usual method followed by commercial packers in the coloring of citrus fruit. The "cured" fruit was untreated, except that it was held at ordinary room temperatures for a period of ten days before being placed in cold storage along with the other lots in this test. None of this fruit was washed, brushed, or wrapped. It was held in the 31° - 32°F. storage room, samples being removed for examination after the tenth and twelfth weeks.

Five-box lots of Marsh and Duncan grapefruit, and of Valencia oranges were placed in cold storage, to furnish information concerning the keeping quality of these varieties. The fruit was uncolored, unwashed, and unbrushed, but was wrapped. All lots were stored in the 31° - 32° F. room, sample lots being withdrawn for examination after the tenth and twelfth weeks.

The effect of fertilizer high in potash on the keeping quality of grapefruit was determined by comparing lots of both Marsh and Duncan grapefruit from fertilized and unfertilized trees. These comparisons were made after the fruit had been held in cold storage for ten and twelve weeks. The fruit used in these tests was treated in the same manner as that used in the work relating to varietal influences, and was stored in the same storage room (31° - 32° F.).

The sugar and acid content of respresentative lots of fruit of the different varieties in this experiment was determined at the time the fruit was stored and at the end of the tenth and the twelfth weeks. The usual method followed by State inspectors in the enforcement of the Citrus Fruit Maturity Law was used in determining the sugar and the acid content of of the juice.

Shrinkage, or loss in weight during storage, was determined by weighing samples from each lot of fruit, both when it was placed in cold storage and when it was removed from storage.

After the fruit was removed from storage, it was unwrapped, graded, and placed loose in boxes, and was allowed to stand at room temperatures for seven to fifteen days. The amount of loss occurring, after removal from cold storage, was determined by re-examination and re-grading of those portions of the different lots that were considered to be marketable at the first examination.

The principal causes of loss of citrus fruit in cold storage were determined by examining every fruit, in each of the lots, as it was removed from storage, and grading it as to the kind and amount of injury present. The grading was done by the same men in every case. Since the same number of fruits were not included in each test, the results are expressed on a percentage basis. The summarized data from these tests reveal the more important factors which are responsible for loss in cold storage of citrus fruits.

CONDITIONS OF THE EXPERIMENTS

Storage-plant facilities for these tests were provided at the Harlingen cold storage plant of the Central Power and Light Company. Space was made available in three rooms where the temperatures were maintained at 31°-32°F., 36°-37°F., and 44°-45°F., respectively. The equipment of this plant was of such nature that temperatures could be maintained to within one degree of the desired point. Temperatures in these rooms were checked at regular intervals, and in addition, charts of the temperature were made with recording thermometers. In checking the temperature variations, readings were taken at the bottom of the stacks; and at both the front and the back of the rooms. These records show that temperatures in all parts of every room were maintained within a very small range, and the variation did not exceed 1°F., except in a very few instances. Air circulation in the rooms was provided by the use of oscillating, electric fans.

Humidity within the storage rooms showed considerably more variation than did temperature. The relative humidity was determined at regular intervals, with a sling psychrometer, and the records charted. These records show that there was considerable variation in the humidity of the different rooms and in the various parts of the rooms. The fluctuations were of rather short duration and, in most instances, were within a fairly narrow range. An effort was made to maintain the humidity in all rooms used in this work at about 85 per cent. When the humidity exceeded this figure, the moisture content of the rooms was lowered by placing hoppers of calcium chloride in front of the electric fans. These desiccators were removed from the rooms when it was found that the moisture content of the air had been lowered to the proper point. The tabulated data in regard to humidity show that a relative humidity of approximately 85 per cent was maintained in the 31° - 32°F. room. The extremes in the case of this room were 78 minimum and 100 maximum. The periods of time when extreme variations from the normal prevailed, were of relatively short duration, however, and of rather infrequent occurrence. Humidity in the 36° - 37°F. room showed less variation than did either of the other two rooms, remaining fairly constant at about 83 per cent. The extremes in this case were 75 and 91; the humidity remaining at about 80 per cent for a short period of time. The 44° - 45° F. room showed a considerable amount of irregularity in regard to the maintenance of the humidity at a fixed point. The humidity in this did not rise above 95 per cent or drop below 78 per cent, but stood at 82 to 89 per cent during the greater part of the time.

The size of the storage rooms varied from about 16 x 16 feet in the case of the 44° - 45°F. roomto 48 x 48 feet in the case of the 36°-37°F. room, The 31° - 32° F. room was about 16 x 48 feet in size.

Each of the storage rooms was provided with an inlet for fresh air and an outlet for the withdrawal of stale air. Fresh air was forced into the rooms through a modern, ozone replacement system. The amount of ventilation allowed in the different rooms was approximately the same, the duration of the ventilation period being based on the size and contents of the rooms.

Since varying amounts of other commodities, such as potatoes, budwood, and other fruit were stored in the same rooms with the experimental fruit, it is likely that some of these commodities may have had something to do with the fluctuations in humidity.

The season of 1930-31 was a rather unfavorable season for the storage of citrus fruit, because of the unusual amount of rain which fell during the month of January. Mean temperatures were below normal during the fruit-ripening season, and probably had some effect on the maturation of the fruit. There was a marked decline in the quality of the fruit, as indicated by the flavor of the juice and by the low total-solids content, in the case of the fruit harvested late in the season.

EXPLANATION OF TERMS

Every fruit in these tests was examined within a few hours after it was removed from storage and classified as the condition of the fruit justified. Certain descriptive terms were used in the tabulation of the data, to designate the different classifications.

Pitted refers to fruit showing light-colored to brown sunken spots in the rind, which develop in cold storage. Pitting first appears as small discolored, slightly sunken spots, which increase in size and may coalesce forming irregular-shaped patches.

Mild as a subclassification under pitted refers to fruit which showed only a few small discolored spots involving less than 5 per cent of the surface area.

Severe as a subclassification under pitted refers to fruit which showed conspicuous spotting, involving 5 per cent or more of the surface area of the rind.

Scald is a term applied to fruit showing a slight to distinct brownish discoloration of different areas of the surface of the rind. There is usually little or no sunken margin between the discolored and normal tissue. Although scald may present a spotted appearance, usually a large portion of the surface of the fruit is involved.

Stem-end rot has been applied to fruit showing a buff to brown colored, leathery, pliable decayed area on the stem-end of the fruit. Occasionally the discoloration may be dark-brown or almost black.

Blue mold is a soft, watery decay which starts as a discoloration on the surface of the fruit and later involves the entire fruit, becoming a soft shrunken mass covered with a layer of blue or green powdery spores. No attempt was made to differentiate between the common green mold, *Pencilliam digatatum*, and the blue contact mold, *Pencilliam italicum*, and both have been classed as blue mold.

Blossom-end rot is usually a firm, dry, slow form of decay, brown to black in color, prominent on the blossom end and central core of the fruit.

Bruised is a term applied to fruit which showed no decay but which had been bruised in handling or packing.

Good is a term used to designate the fruit which showed no evidence of disease or breakdown. There was no visible evidence that this class of fruit had been changed by the cold-storage treatment.

Marketable is a term applied to those fruit which were classed as good and those which showed mild pitting, and represents the salable fruit at the time of the examinations.

No attempt was made to give any of the fruits a double or triple classification. The classifications were made on the basis of the most prominent condition responsible for the rejection of the fruit.

DISCUSSION OF RESULTS

The general purposes of placing citrus fruit in cold storage are to prevent the development of decay and to delay deterioration in order to lengthen the period of time the fruit will retain its freshness. The fungus diseases that affect stored citrus fruit can best be controlled by storing the fruit at the lowest possible temperatures without freezing it.[1] However, there are certain physiological disturbances which arise at low temperature, chief among which are pitting and scald. The causes of these diseases are not fully understood but appear to be closely connected with interferences with the normal respiration process and enzyme activity of the fruit at low temperatures (3).

Pitting is one of the most serious diseases encountered in holding citrus fruit in cold storage and is one of the most difficult to control. These spots are confined to the layer of rind containing the oil vesicles and are formed by the breaking down of this tissue. Upon exposure to warmer temperatures, the spots gradually turn brown. Pitting not only detracts from the appearance (Fig. 1), keeping quality, and marketability of citrus fruit, but also serves as an entrance for decay-producing fungi.

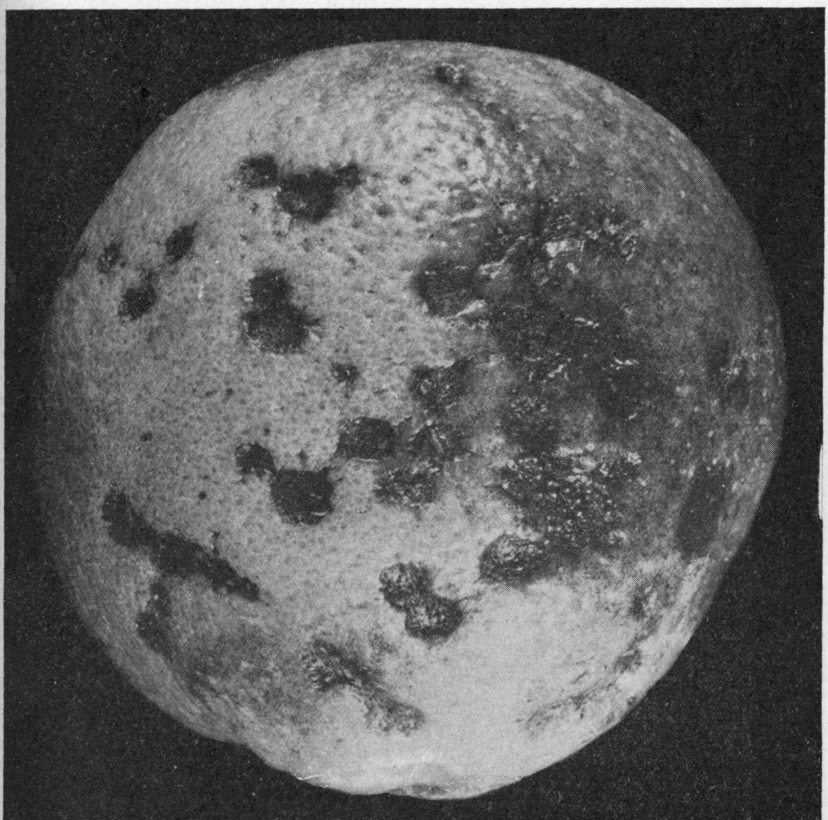

Figure 1. "Pitting" or Cold-Storage Spot on Grapefruit.

Severely-pitted fruit presents an unattractive appearance and is unmarketable (Fig. 2). Fruit which showed only mild pitting was marketable at the time of examination but deteriorated rather rapidly, as a rule, upon exposure to warmer temperatures. The appearance perhaps detracts more from the marketability of the fruit after a period of a few days than the actual reduction in the quality of the product as influenced by the mild pitting.

The storage temperature of 44° - 45°F. caused less pitting on the fruit than the lower temperatures (Tables 1 and 2) and no pitting occurred on the fruit held in common storage (Table 9). This agrees with the work of Hawkins and Magness (6), who found pitting to be severe on grapefruit at 40°F. and lower, but absent in ordinary storage. According to Fawcett and Lee (3), the temperatures that have given most trouble with spotting on citrus fruits are between 32° and 38°F. The maximum percentage of pitting was reached soon after the tenth week in storage, as shown in Tables

Figure 2. Severe Pitting on Cold-Storage Grapefruit.

1 and 2. Lengthening the storage period to exceed ten weeks did not significantly increase the proportion of fruits showing pitting, but did cause an increase in the degree of severity of pitting.

Pitting was greatly reduced and the per cent of marketable fruit increased by curing the fruit for ten days at 70°F. prior to storing (Table 3). Hawkins (4) showed that pitting could be greatly reduced by holding the fruit for one to three weeks at 70°F. before placing it in cold storage. The results

Table 1. Effect of Storage Temperatures, Date of Storage, and Length of Storage Period on the Keeping Quality of Marsh Grapefruit Grown at Mission, Texas.

Date Stored	Length of Storage Period	Storage Temperature	Condition of Fruit after Storage: % Pitted									
			Mild	Severe	% Stem-End Rot	% Scald	% Blossom-End Rot	% Blue Mold	% Bruised	% Good	Total Fruit in Test	% Marketable
Dec. 22	10 weeks	31°–32°	24.67	16.70	2.31	7.74	0	0	4.11	44.47	389	69.14
		36°–37°	3.20	34.16	53.73	.35	0	.71	.74	7.11	281	10.51
		44°–45°	7.32	18.84	28.79	5.23	6.28	1.57	1.35	30.62	382	37.94
	12 weeks	31°–32°	16.11	56.16	7.81	3.35	2.60	0	2.84	11.13	422	27.24
		36°–37°	.98	26.88	58.36	0	0	.98	.35	12.45	305	13.43
		44°–45°	7.56	19.54	25.84	2.31	3.15	2.32	2.94	36.34	476	43.90
	14 weeks	31°–32°	2.57	43.22	9.34	37.38	3.50	.23	.73	3.03	428	5.60
		36°–37°	.65	38.95	49.83	.65	6.59	0	.32	3.09	307	3.74
		44°–45°	2.42	15.78	32.38	13.52	5.66	0	1.90	28.34	494	30.76
	16 weeks	31°–32°	4.67	61.15	8.99	17.98	1.79	0	3.95	1.43	278	6.10
		36°–37°	1.61	40.77	41.74	4.21	0	10.67	.64	.32	309	1.93
		44°–45°	3.12	21.97	25.00	6.77	.35	3.47	3.99	35.24	576	38.36
	18 weeks	31°–32°	4.20	51.14	27.85	12.00	.12	.24	1.80	2.64	833	6.84
		36°–37°	1.03	17.07	66.62	9.05	0	10.99	2.58	3.10	773	4.13
		44°–45°	1.77	11.09	42.28	7.32	0	8.21	3.99	25.41	901	27.18
	20 weeks											
		36°–37°	.24	26.93	45.63	.99	0	26.18	0	0	401	.24
		44°–45°	2.86	11.73	37.51	12.68	0	11.18	53.20	18.69	733	21.55
Jan. 7	8 weeks	31°–32°	9.27	2.50	0	.52	.50	0	5.51	81.70	399	90.97
	12 weeks	31°–32°	18.20	15.96	0	23.47	.49	0	8.97	32.91	401	41.11
	16 weeks	31°–32°	12.40	20.34	.49	16.87	.24	.24	25.36	24.06	403	36.46
Jan. 20	8 weeks	31°–32°	25.37	8.04	.25	1.25	2.01	.25	3.04	59.79	398	85.16
		36°–37°	7.53	71.98	3.92	0	0	.50	.50	15.57	382	23.10
		44°–45°	29.63	24.65	4.70	5.30	.55	2.77	3.04	29.36	361	58.99
	10 weeks	31°–32°	4.96	49.34	14.62	6.52	0	.55	3.13	20.88	383	25.84
		36°–37°	0	69.40	23.28	0	0	1.40	.45	5.47	219	5.47
		44°–45°	8.69	76.81	4.37	0	0	1.44	0	8.69	69	17.38

Table 1. Effect of Storage Temperatures, Date of Storage, and Length of Storage Period on the Keeping Quality of Marsh Grapefruit Grown at Mission, Texas—(Continued).

Date Stored	Length of Storage Period	Storage Temperature	Condition of Fruit after Storage									
			% Pitted		% Stem-End Rot	% Scald	% Blossom-End Rot	% Blue Mold	% Bruised	% Good	Total Fruit in Test	% Marketable
			Mild	Severe								
Feb. 5	8 weeks	31°–32°	19.70	17.10	0	21.56	.74	0	4.85	36.05	269	55.75
	12 weeks	31°–32°	2.93	54.94	.39	12.08	0	0	26.00	3.66	273	6.59
	8 weeks	31°–32°	10.13	20.26	.32	1.28	0	.37	17.32	50.32	306	60.45
		36°–37°	7.30	79.73	4.68	0	0	.99	4.65	2.65	301	9.95
		44°–45°	6.94	58.33	12.84	2.08	0	14.93	1.07	3.81	288	10.75
Feb. 20	12 weeks	31°–32°	8.93	23.65	2.13	41.34	0	2.94	10.96	10.05	985	10.98
		36°–37°	0	52.97	25.05	0	0	21.98	0	0	874	0
		44°–45°	4.30	24.22	37.41	1.38	0	29.60	.13	2.96	743	7.26

in Table 3 also show some indication of association between the type of fungicidal wash and the development of pitting.

The maturity of the fruit apparently had little effect on pitting. It should be pointed out, however, that environmental factors may have some influence on its development.

Scald is also due to physiological breakdown of the rind of cold-storage fruit. The injury to the cells appears similar to pitting but it is more superficial. Scald also renders the fruit unmarketable from the standpoint of

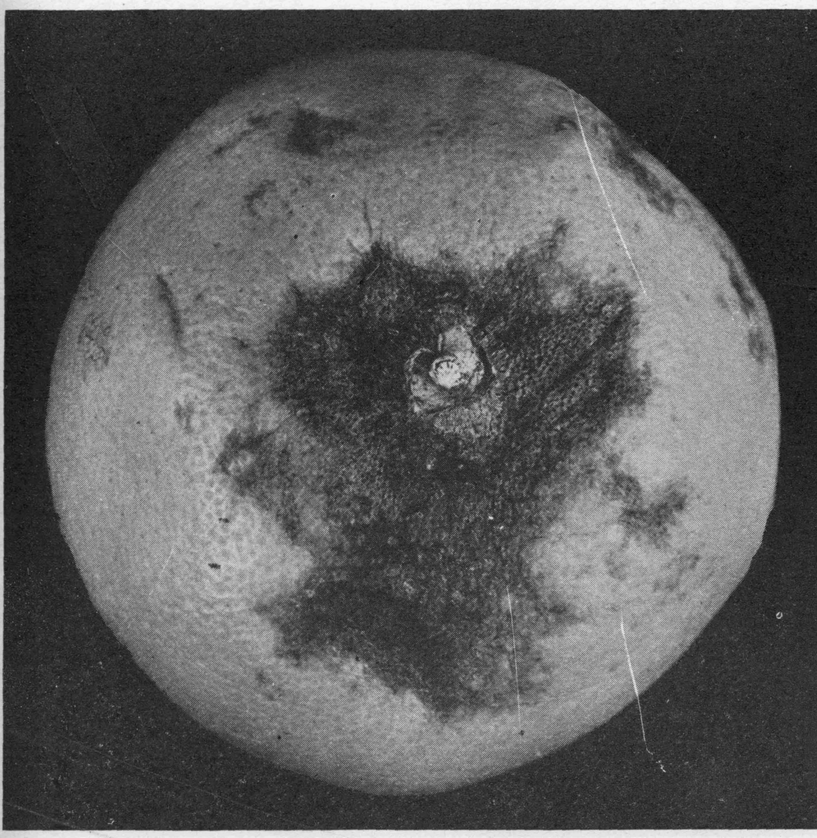

Figure 3. Stem-End Rot on Cold-Storage Grapefruit.

appearance and the physiological breakdown lowers the natural resistance of the fruit to decay. Scald may appear on fruit which are also pitted and in many respects the two troubles appear to be related. As shown in Tables 1 and 11, there was less scald at the 44°-45°F. temperature than at the two lower storage temperatures and it was most severe at 31°-32°F. Table 3 shows that scald was greatly reduced and the percentage of marketable fruit increased by curing the fruit at 70°F. for ten days before placing it in cold storage.

Under the conditions of this experiment, fruit which was treated with borax solution developed less scald than other comparable lots which received different treatments. However, excessive pitting developed in this lot (Table 3). An excessive amount of scald developed on fruit from trees which received an application of fertilizer high in potash, as compared to fruit from unfertilized trees (Table 4). Scald often became more prominent as the amount of pitting decreased (Table 3).

Since there was considerable variation in the amount of scald which de-

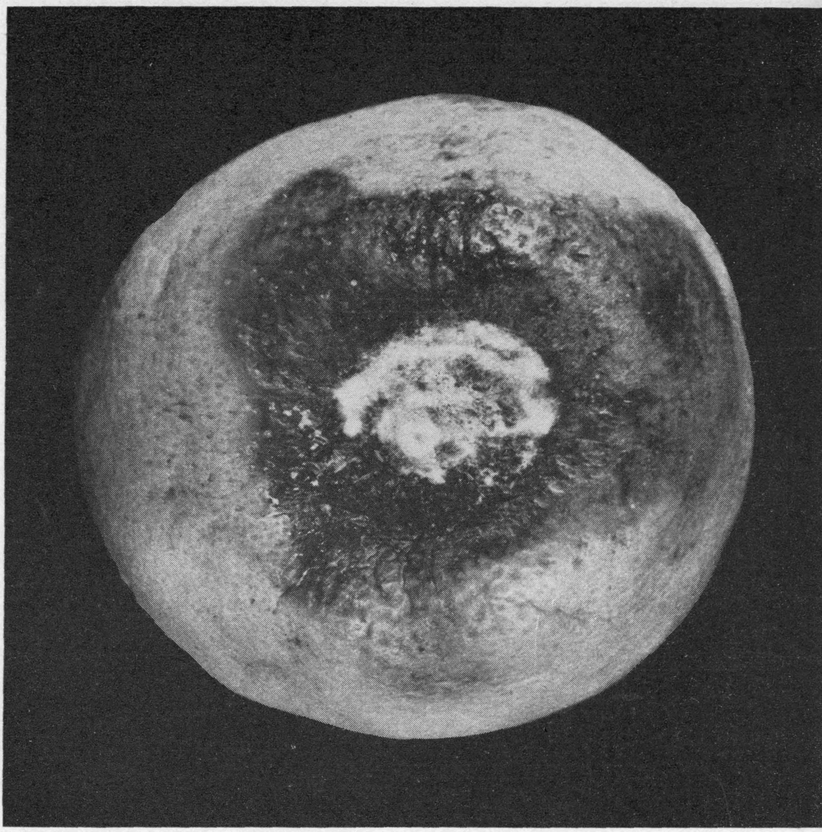

Figure 4. Stem-End Rot on Cold-Storage Grapefruit Showing Growth of Fungus on Surface.

veloped in fruit from different groves in the same community, it appears that certain environmental factors influence the occurrence of scald.

Stem-end rot may also cause serious losses after the fruit is placed in storage (Fig. 3 and 4). This disease may be caused by either of two organisms, *Phomopsis citri* Faw. or *Diplodia natalensis* Evans. Cultures of a limited number of typical specimens of fruit removed from cold storage indicated that this particular stem-end rot was caused by the Diplodia organism. Fruit may become infected with the stem-end rot fungus over a relatively long period of time during its development on the trees. Apparently a certain degree of physiological decline must take place in the fruit before its tissues are actually invaded and broken down, and this usually occurs some days after picking. With higher temperatures this interval is shortened to a few days, but with a lower temperature it is lengthened to several weeks. At 50°F. or below, very little stem-end rot of either type can develop for three or four weeks, or longer. However, the warm temperatures in coloring rooms offer ideal conditions for incubating this disease, especially that of the Diplodia type. Standard refrigeration, or pre-cooling when the fruit is carefully and properly handled after removal from the tree, readily prevents both types (3). Since dead wood harbors the stem-end rot organisms, all dead and weak branches should be removed. Little trouble should ordinarily be experienced in cold storage with stem-end rot unless the fruit grew on trees which had an excessive amount of dead wood in them.

Blue-mold may cause serious losses of fruit in cold storage, depending almost entirely upon such factors as maturity of fruit, care and promptness in handing, and storage conditions. The fungi causing this decay depends primarily upon injuries to the skin of the fruit for entrance. Losses from blue mold were almost negligible in these tests and Table 1 shows that the loss from blue mold was not excessive up to 16 to 20 weeks of storage at any of the temperatures. The loss was greater on fruit stored late in the season (Feb. 20). There was less loss from blue mold at 31°-32°F. than at 36° - 37°F. or 44° -45°F. Careful handling of the fruit from the time it leaves the tree through the entire process of handling, storage, and marketing has been found by research workers to reduce the loss from blue mold. Supplementary treatments of various fungicidal solutions have proved beneficial but cannot be expected to be a substitute for careful handling. Experience has shown that much of the bruised fruit would undoubtedly develop blue mold after removal from storage.

Blossom-end rot and other decays would, under ordinary conditions, not be expected to cause any appreciable loss of fruit in cold storage. Weather conditions, such as excessive rains, which influence splitting of the blossom-end, are largely responsible for the occurrence of blossom-end rot. In the experiment conducted it will be seen from the tables that the loss from blossom-end rot was small, except in the case of fruit held for fourteen weeks.

Bruising was responsible for a high percentage of loss in fruit held at all three temperatures in the cold-storage test. This loss could not be attributed to the cold storage, as it indicates lack of proper precautions in handling and packing the fruit. Bruised fruit is more subject to decay than sound fruit owing to the ease of entrance of fungus organisms. The amount of bruised fruit found in the experimental lots indicates that there is need for much improvement along this line. The use of modern methods of treating the fruit will do much to improve its appearance and prolong its life.

EFFECT OF THE STORAGE TEMPERATURES ON THE KEEPING QUALITY OF THE FRUIT

It can be seen from Tables 1, 2, and 12, that fruit held for comparatively short periods, such as eight weeks, and in some cases as long as eighteen weeks, held up best at 32°F. For the longer periods it is apparent that 44°-45°F. gave more satisfactory results. The loss from pitting and scald was less at the higher temperature than at either 31°-32°F. or the 36°-37°F. temperatures. This was not the case with stem-end rot or blue mold, both of these decays being held in check much better at 31°-32°F. However, there are other factors that are more important from the standpoint of decay, such as source of fruit and care in handling, which will be discussed under other heads. Pitting was more severe on fruit held at 36°-37°F., while scald was more severe on fruit held at the lowest temperature, 31°-32°F. In these tests, 36°-37°F. was an intermediate temperature which was not satisfactory, ranking below either of the other two temperatures. Pitting appeared earlier and was more severe at this temperature than at the 31°-32°F. or the 44°-45°F. temperature. While deterioration at 44°-45°F. was greater at eight weeks than at 31°-32°F., the development of subsequent loss was at a much slower rate at 44°-45°F. than at either of the other two temperatures.

EFFECT OF MATURITY (DATE OF STORAGE) ON THE KEEPING QUALITY OF THE FRUIT

The maturity or age of the fruit is apparently an important factor in determining the keeping quality of grapefruit in cold storage. Citrus fruit is usually considered at its prime, from the standpoint of maturity, during the latter part of January, but starts to decline in quality toward the end of the season. This change in composition may be influenced by both seasonal and weather conditions.

Table 1 shows that fruit stored on January 20 at 31°-32°F. held up in storage better than fruit of any other age when held for eight weeks. Fruit stored at the same temperature on February 20 held up fairly well for a period of eight weeks. Fruit which was harvested earlier in the season held up better over longer periods of time, especially at higher temperatures, 44°-45°F. This would indicate that fruit that is in good condition will hold up better in storage than fruit that is inclined to be over-mature. The composition of the fruit at any time during the year, as already indicated, would also depend upon seasonal and weather conditions.

EFFECT OF THE LENGTH OF THE STORAGE PERIOD ON THE KEEPING QUALITY OF THE FRUIT

Tables 1, 2, and 12 show that there is a limit to the time which grapefruit will hold up in cold storage, as the percentage of loss is in direct proportion to the time the fruit remains in storage. Prior to examination of the first lots, after the tenth week, individual boxes were examined at four, six, and eight-week intervals after being placed in storage. Up to eight weeks, all the fruit stored on December 22 appeared to be keeping well. There was very little indication of pitting even at 36°-37°F., and only a slight amount of blue mold. Fruit held in storage for 12 to 20 weeks, at 44°-45°F., showed less loss than at either of the other two temperatures. Lengthening of the storage period more than 8 or 10 weeks in the case of the 31°-32°F. temperature does not appear to be practical.

Blue mold spread more or less rapidly from fruit to fruit after gaining a foothold, as shown in Table 1. The most rapid spread was after the sixteenth week. Fruit from La Feria which was stored late in the season (February 20) also showed a heavy loss from blue mold after 12 weeks, at both 36°-37°F. and 4 4°-45°F. Stem-end rot showed a decided increase in fruit from La Feria, after ten weeks in storage (Table 2). This disease did not become a factor on Valencia oranges until after twelve weeks in storage, as shown in Table 4. There was also a decided increase in stem-end rot in the treated fruit after twelve weeks, as shown in Table 3.

The long period in storage also changed the appearance of pitted and scalded fruit to a slight extent. Pits became deeper and darker the longer the fruit remained in storage. Scald in its early stages (up to 8 weeks) was little more than a series of buff discolorations or blotches on the rind of the fruit. As the storage period progressed, these areas increased in size and the color changed from buff to light-brown. In some instances, the entire surface of the fruit became involved and the fruit had the general appearance of one that has been submerged in hot water and scalded.

EFFECT OF THE SOURCE OF FRUIT ON THE KEEPING QUALITY

A comparison of Table 1 with Table 2 shows that fruit from La Feria, stored on December 22 and held for sixteen weeks, kept better than that from Mission. At ten weeks, 55 per cent of the La Feria fruit stored at 44°-45°F. was marketable, while under the same conditions only 27 per cent of the fruit from Mission was marketable.

In making the examinations, it was noted that some lots of fruit showed different grower numbers, and that some of these lots held up much better than others from different sources and growers. This would indicate that fruit from certain groves will hold up in cold storage better than that from other groves (Tables 10, 11, and 12).

It should be pointed out that there are many factors which may affect the keeping quality of the fruit, such as environmental conditions, orchard management, method of handling and packing-house management.

Marked differences in the development of disease are apparently due to differences in the sources of fruit. There was more stem-end rot in fruit from Mission, as shown in Table 1, than in fruit from La Feria, as shown in Table 2. This difference was no doubt due to the presence of dead wood in the trees which harbor the Diplodia or Phomopsis stem-end-rot organisms. It was also observed that fruit which came from the same packing house, but from different groves, showed a marked difference in the amount of scald which developed when the fruit was stored under identical conditions (Table 11).

Table 2. Effect of Storage Temperatures, Date of Storage, and Length of Storage Period on the Keeping Quality of Marsh Grapefruit Grown at La Feria, Texas.

Date Stored	Length of Storage Period	Storage Temperature	Condition of Fruit after Storage									
			% Pitted		% Stem-End Rot	% Scald	% Blossom-End Rot	% Blue Mold	% Bruised	% Good	Total Fruit in Test	% Marketable
			Mild	Severe								
Dec. 22	16 weeks	31°–32°	1.41	15.69	5.63	74.70	.46	.23	1.65	.23	427	1.64
		36°–37°	5.79	22.04	27.03	6.04	0	26.77	2.89	9.44	381	15.23
		44°–45°	5.69	22.36	5.28	1.63	4.06	15.45	4.88	40.65	246	46.34
	18 weeks	31°–32°	0	5.32	8.14	85.64	0	.30	0	.60	320	.60
		36°–37°	4.80	16.53	29.13	0	0	41.14	.60	7.80	333	12.60
		44°–45°	5.70	7.19	14.38	4.54	0	16.68	1.89	49.62	264	55.32
Jan. 7	8 weeks	31°–32°	0	1.25	1.25	88.75	0	0	7.50	1.25	80	1.25
		36°–37°	11.25	15.00	5.00	0	0	0	6.25	62.50	80	73.75
		44°–45°	1.25	0	0	0	3.70	2.50	6.15	86.41	81	87.66
	12 weeks	31°–32°	5.93	5.93	1.56	5.00	.63	5.65	2.18	73.12	320	79.05
	20 weeks	31°–32°	0	.31	.32	99.37	0	0	0	0	319	0
		36°–37°	6.88	26.39	20.90	.47	0	42.51	0	2.85	421	9.73
Feb. 2	8 weeks	31°–32°	11.47	12.46	.75	7.50	1.50	0	4.23	62.09	401	83.56
	12 weeks	31°–32°	30.90	16.36	2.46	20.00	.60	.60	4.24	24.84	495	55.74

EFFECT OF PRE-STORAGE TREATMENTS ON KEEPING QUALITY OF FRUIT

Various lots of fruit were treated in different ways prior to being placed in cold storage, to obtain data concerning the effect of these treatments on keeping quality. Some of the treatments were decidedly beneficial, as is brought out in the discussion under each individual heading.

Effect of Washing or Dipping in Various Fungicides. The practice of passing fruit through a fungicidal wash or applying some similar treatment, in an effort to overcome fungus diseases and prolong the life of the fruit, offers some promise. The use of various washes such as borax and sodium bicarbonates, and patented methods such as "Brogdex" and the Slater hypochlorite process have become fairly common in the commercial packing of citrus fruits. A limited number of the most promising of these treatments were included in this experiment, and the results are recorded in Table 3.

The results presented in this table show that the use of the various fungicides had little or no effect on the amount of pitting or scald which occurred except in the case of the borax treatment, where less scald, but more pitting occurred. The amount of stem-end rot appears to have increased after twelve weeks of storage and consequently it appears that loss from this cause was not affected by the treatments. This is due to the nature of the disease, as infection is confined to the internal portion of the stem-end of the fruit.

Blue mold, the disease which most of these solutions are designed to control, was not a factor of importance in these experiments. Table 3 shows that after storage for ten weeks, there was no blue mold, and practically none after twelve weeks. Since blue mold was not a factor in these lots of fruit, no conclusion could be reached regarding the control of this disease with the fungicides used in these tests. However, with lots of fruit that show more or less blue mold, the value of fungicidal washes has been generally recognized and their use has been widely adopted commercially.

In addition to the use of materials of this nature for the control of disease such as blue mold, there are also certain processes designed to aid in preserving the freshness of the fruit. These processes make use of a thin coating of paraffin wax on the fruit in conjunction with other treatments.

Effect of Wrapping: Two types of wraps were used, one consisting of ordinary commercial wraps and the other waxed paper. There was no blue mold in either of these lots of fruit. Pitting was materially decreased by the use of waxed wraps, owing perhaps in part to the exclusion of the air by waxed paper. Scald was apparently not affected by the kind of wraps used.

Another point which is important, but which is not shown in the tables, is that fruit in the waxed wraps held up much better and was much more firm than that wrapped in ordinary grapefruit paper.

Effect of bulge pack and loose pack: Two methods of packing were tested, one in which the ordinary commercial bulge pack was used and the other in which the bulge was eliminated. The percentage of good and

Table 3. Effect of Pre-Storage Treatments on the Keeping Quality of Grapefruit in Cold Storage. Washing, Wrapping, Packing, and Curing

Length of Storage Period	Pre-Storage Treatment	Condition of Fruit after Storage									
		% Pitted		% Stem-End Rot	% Scald	% Blossom-End Rot	% Blue Mold	% Bruised	% Good	Total Fruit in Test	% Market-able
		Mild	Severe								
10 weeks	**Washing**[1]										
	Hot borax wash	27.12	59.32	1.69	5.09	0	0	1.69	5.09	59	32.21
	Sodium Hypochlorite wash	5.55	16.65	0	51.85	0	0	5.55	20.40	54	25.95
	Sodium Sulphide wash	28.12	31.25	0	17.20	0	0	0	23.43	64	51.55
	Water Wash only	27.69	15.38	0	6.17	0	0	7.69	43.07	65	70.76
	Sodium bicarbonate wash	48.38	14.53	0	6.45	0	0	12.90	17.74	62	66.12
	Wrapping[2]										
	Waxed Wraps (Light Wt.)	17.72	12.65	2.53	8.86	0	0	6.35	51.89	79	69.61
	Commercial Wraps	26.72	52.58	0	5.17	0	0	3.44	11.20	116	37.92
	Packing[3]										
	Standard Pack without bulge	12.96	7.44	0	3.70	1.85	0	14.80	59.25	54	72.21
	Standard Pack with bulge	23.18	30.43	1.50	0	0	0	5.76	39.13	69	62.31
	Curing[4]										
	Fruits colored with Ethylene gas	23.46	15.31	3.08	8.16	0	0	8.16	41.83	98	65.29
	Fruits colored with Stove gas	26.45	15.09	0	11.32	3.76	0	1.88	41.50	53	67.95
	Fruits uncolored ("cured" for 10 days at 70°)	0	5.97	1.49	1.49	0	1.49	7.48	82.08	67	82.08

[1]Fruit unbrushed; commercial pack, except Hypochlorite wash lot was brushed.
[2]Fruit unbrushed and unwashed; commercial pack.
[3]Fruit, unbrushed, unwashed, and unwrapped.
[4]Fruit unbrushed, unwashed, and unwrapped; commercial pack.
*Fruit not shriveled—condition good.

Table 3. Effect of Pre-Storage Treatments on the Keeping Quality of Grapefruit in Cold Storage—(Continued).
Washing, Wrapping, Packing and Curing

Length of Storage Period	Pre-Storage Treatment	Condition of Fruit after Storage									
		% Pitted		% Stem-End Rot	% Scald	% Blossom-End Rot	% Blue Mold	% Bruised	% Good	Total Fruit in Test	% Marketable
		Mild	Severe								
12 weeks	**Washing**[1]										
	Hot borax wash	26.66	50.98	8.09	2.85	.47	0	6.19	4.76	210	31.42
	Sodium Hypochlorite wash	6.19	16.52	.82	33.88	.41	0	.82	41.36	242	47.55
	Sodium Sulphide wash	10.18	27.27	8.02	38.50	0	0	2.67	13.36	187	23.54
	Water wash only	18.97	13.84	11.28	12.33	0	.51	4.61	38.46	195	57.43
	Sodium carbonate wash	22.74	24.64	11.37	11.87	.95	0	2.84	25.59	211	48.33
	Wrapping[2]										
	Waxed Wraps (Light Wt.)	10.19	29.20	0	17.69	0	0	0	42.92	226*	53.11
	Commercial Wraps	7.07	59.80	0	20.25	.64	.32	1.28	10.64	311	17.71
	Packing[3]										
	Standard Pack without bulge	17.67	10.49	5.54	8.29	2.20	0	6.07	49.74	181	67.41
	Standard Pack with bulge	20.00	30.00	3.80	10.00	0	0	4.30	31.90	210	51.90
	Curing[4]										
	Fruits Colored with Ethylene gas	6.56	49.03	2.33	26.64	0	0	.39	15.05	259	21.61
	Fruits Colored with Stove gas	8.43	15.66	3.61	15.66	1.20	0	5.44	50.00	166	58.43
	Fruits uncolored ("Cured" for 10 days at 70°)	8.82	8.91	5.13	16.03	1.10	0	8.84	51.17	170	59.99

[1]Fruit unbrushed; commercial pack, except Hypochlorite wash lot was brushed.
[2]Fruit unbrushed and unwashed; commercial pack.
[3]Fruit, unbrushed, unwashed, and unwrapped.
[4]Fruit unbrushed, unwashed, and unwrapped; commercial pack.
*Fruit not shriveled—condition good.

marketable fruit at the end of the storage period favors the elimination of the bulge pack, as shown in Table 3. There was less pitting in the box that was packed loosely, but, for some reason more bruised fruit were found in this lot. The results secured this season indicate that fruit which is loosely packed suffers less loss in storage than tightly packed or commercial fruit.

Effect of curing: As shown in Table 3, fruit which was "cured" at 70°F. temperature for ten days held up better than that treated with ethylene gas or stove gas. Although there was considerable shrinkage in this lot of fruit, it held up better than any lot in the test. There was a great reduction in the amount of pitting and scald that showed up in comparison with the lots treated with gas. There was no outstanding difference in regard to the amount of other diseases present.

VARIETAL DIFFERENCES AND FERTILIZER TREATMENTS AS RELATED TO KEEPING QUALITY

Table 4 deals with fruit of different varieties and fruit from trees receiving different fertilizer treatment. In general, the Duncan grapefruit held up in storage better than the Marsh fruit, and in addition, retained its flavor much better. It should also be noted that Valencia oranges held up in storage in a most satisfactory manner.

Fruit from trees which received a liberal quantity of fertilizer high in potash did not hold up as well in cold storage as fruit from unfertilized trees. It is possible that factors other than soil fertility may have been responsible for the differences in the keeping quality of these lots of fruit, since they were taken from different groves. The fruit from the trees which received the heavy application of potash was immature, as shown by the composition of the juice. It is likely that the factors responsible for the delayed maturity of the fruit were also responsible for its poor keeping quality.

In the case of the fertilized fruit, scald caused an excessive amount of loss, while pitting was severe on fruit from both fertilized and unfertilized trees.

CHANGES IN COMPOSITION OF CITRUS FRUIT JUICE DURING COLD STORAGE

The data concerning the composition of the juice from the various lots of fruit included in these tests are summarized in Table 5. It will be seen that the sugar and acid content of the juice of the fruits held at 31°-32°F. for periods of ten and sixteen weeks showed only slight changes. The Valencia oranges showed a slight increase in the percentage of acid present at the end of the experiment, but in general, the variations in composition were quite small.

The changes in the flavor of the juice were much more pronounced than were the changes in the sugar and the acid content. The relatively low acid grapefruit deteriorated somewhat in flavor, even by the end of the

Table 4. Effect of Varietal Differences, Fertilizers, and Source of Fruit on the Keeping Quality of Citrus Fruits in Cold Storage.

Length of Storage Period	Kind of Frruit	Location of Orchard	Fertilizer Treatment*	Condition of Fruit after Storage									
				% Pitted		% Stem-End Rot	% Scald	% Blossom-End Rot	% Blue Mold	% Br's'd	% Good	Total Fruit in Test	% Marketable
				Mild	Severe								
10 weeks	Duncan	Clark Groves La Feria	Fertilized	7.69	23.09	0	7.69	0	0	0	61.53	39	69.22
	Duncan	Commons Grove Mercedes	Unfertilized	20.45	11.37	0	43.18	0	0	0	25.00	44	45.45
	Marsh	Clark Groves La Feria	Fertilized	13.20	26.40	0	41.54	0	0	0	18.86	53	32.06
	Marsh	Station Grove Mercedes	Unfertilized	18.97	3.64	0	29.96	0	0	3.64	43.79	137	62.76
	Valencia Orange	Clark Groves La Feria	Fertilized	2.52	.70	0	29.70	0	0	1.40	94.68	176	97.20
12 weeks	Duncan	Clark Groves La Feria	Fertilized	5.00	18.46	0	54.63	0	0	.38	21.53	260	26.53
	Duncan	Commons Grove Mercedes	Unfertilized	6.40	24.40	0	16.80	.40	0	1.20	50.80	250	57.20
	Marsh	Clark Groves La Feria	Fertilized	.80	12.80	0	77.60	.40	0	.40	8.00	249	8.80
	Marsh	Station Grove Mercedes	Unfertilized	5.88	24.15	1.30	39.00	.30	.30	.90	28.17	323	30.05
	Valencia Orange (wrapped)	Clark Groves La Feria	Fertilized	2.00	.75	14.23	.18	0	0	5.29	77.55	548	79.55
	Valencia Orange (unwrapped)	Clark Groves La Feria	Fertilized	0	0	5.62	0	0	0	20.00	74.38	160	74.38

*Fifteen pounds per tree of a 5-5-15 formula.

ten-weeks storage period, and had deteriorated decidedly by the end of the sixteen-weeks period. Duncan grapefruit, however, retained a pleasing flavor for a much longer period than did the Marsh fruit. The differences were so outstanding as to warrant the conclusion that the more acid grapefruit of the Duncan type is best adapted for holding in cold storage. The flavor of the Valencia oranges was not materially affected, even by the longer periods of cold storage.

LOSS IN WEIGHT OF GRAPEFRUIT DURING COLD STORAGE

The losses due to actual shrinkage in the weight of the packed boxes of grapefruit are negligible when compared with the losses due to other causes. The most interesting point brought out by these data is in regard to the relatively greater losses in weight in the 44°-45°F. room and the 31°-32° room as compared with the weight losses in the 36°-37° room. These data indicate that the rate of dehydration was greater in the former rooms, but whether these differences are due to the fact that the 44°-45°F. room and the 31°-32°F. room were smaller than the 36°-37°F. room, and consequently less humid, or whether the temperature or ventilation of the rooms affected the transpiration rate of the fruit, is not known.

LOSSES AFTER REMOVAL FROM COLD STORAGE

There are numerous opinions held concerning the use of cold storage for agricultural products. It is generally considered that cold-storage grapefruit deteriorates very rapidly after removal from storage. Several lots of fruit, which had been stored at different dates and held for different lengths of time, were held at room temperatures for seven to fifteen days after removal from cold storage. The results of these examinations are recorded in Tables 7 and 8. In general, the fruit which kept best in cold storage held up best after removal from storage. There was no consistency in the amount of disease which appeared upon re-examination. Considerable stem-end rot occurred, due to exposure to temperatures more favorable for its development. There seemed to be an undue increase in the number of fruit showing "bruise" in some lots, at second examination. A portion of this bruising may have been present in initial stages, upon the first examination, but the greater part of it probably resulted from handling the fruit too soon after removal from cold storage.

The fruit stored on January 7, at 31°-32°F., and held in cold storage for eight weeks, held up best after removal from storage. There were 399 fruits in this lot, 90.97 per cent of which were marketable upon removal from cold storage. Of the remaining 365 fruits, 89.01 per cent were marketable after seven days of additional storage at room temperature, as shown in Table 7. Another lot of fruit also stored on January 7, but at 44°-45°F. temperature, held up fairly well.

The effect of waxed wraps on the keeping quality of the fruit, after removal from cold storage, was outstanding, as shown by the data in Table 8. The fruit which had been wrapped in waxed wraps was firmer and in better condition than any of the other fruit in this test.

Table 5. Changes in the Composition of Citrus Fruit Juice During Storage at 32° F.

Date of Test	Kind of Fruit*	Location of Orchard	Fertilizer Treatment	Total Solids %	Total Acid %	Ratio of Sugar to Acid	Flavor of Juice
Dec. 22 (when stored)	Duncan	Clark Groves La Feria	5-5-15*** (complete)	10.31	1.46	7.06 :1	Acid
	Duncan	Commons Grove Mercedes	None	11.41	1.64	6.95 :1	Acid
	Marsh	Shary Grove Mission	None	9.61	1.11	8.65 :1	Mildly Acid
	Marsh	Clark Groves La Feria	5-5-15*** (complete)	8.91	1.26	7.07 :1	Acid
	Marsh	Station Grove Mercedes	None	9.43	1.18	7.99 :1	Mildly Acid
	Valencia Orange	Clark Groves La Feria	5-5-30*** (complete)	9.81	0.96	10.02 :1	Sweet
March 7 (Stored 10 weeks)	Duncan	Clark Groves La Feria	5-5-15*** (complete)	9.15	1.38	6.5 :1	Acid—Slightly bitter
	Duncan	Commons Grove Mercedes	None	11.95	1.60	7.5 :1	Acid—Slightly bitter
	Marsh	Clark Groves La Feria	5-5-15*** (complete)	8.30	1.11	7.5 :1	Acid—Bitter
	Marsh	Station Grove Mercedes	None	8.90	1.18	7.5 :1	Acid—Bitter
	Valencia Orange	Clark Groves La Feria	5-5-30*** (complete)	9.10	1.04	8.9 :1	Sweet
April 21 (Stored 16 weeks)	Duncan	Clark Groves La Feria	5-5-15*** (complete)	10.45	1.46	7.0 :1	Acid—Slightly bitter
	Duncan	Commons Grove Mercedes	None	11.65	1.56	7.46 :1	Acid—Slightly bitter
	Marsh	Clark Groves La Feria	5-5-15*** (complete)	9.05	1.22	7.41 :1	Acid—Bitter
	Marsh**	Station Grove Mercedes	None	9.90	1.22	8.0 :1	Acid—Bitter
	Valencia Orange	Clark Groves La Feria	5-5-30*** (complete)	9.35	1.04	9.0 :1	Sweet

*Fruit harvested Dec. 20, 1930, Unwashed, unbrushed and untreated. Commercial wrapping and packing.
**Determination made March 21, 1931.
***15 lbs. per tree.

Table 6. Shrinkage During Storage.

Date Stored	Length of Storage Period	Variety	Treatment	Storage Temperature	Average Weight Pounds		Average Loss in Weight Pounds	Total No. Boxes in Test
					When Stored	When Removed		
Dec. 22	10 weeks	Marsh	Commercial pack	32	84.5	82.5	2.0	2
		Marsh	Unwrapped	32	82.0	78.83	3.16	3
		Marsh	Commercial pack	37	77.0	72.2	5.0	4
Dec. 22	12 weeks	Marsh	Cured 10 days	32	82.0	76.66	5.33	3
		Marsh	Unwrapped	32	83.0	79.8	3.2	5
		Marsh	Commercial pack	32	81.5	80.0	1.5	3
		Marsh	Commercial pack	37	79.0	75.0	4.0	2
Dec. 22	18 weeks	Marsh	Commercial pack	32	83.5	79.5	3.0	2
		Marsh	Commercial pack	37	78.5	75.0	3.5	2
		Marsh	Commercial pack	45	82.3	77.0	5.3	3
Dec. 22	20 weeks	Marsh	Commercial pack	37	83.5	79.0	4.5	15
Jan. 7	8 weeks	Marsh	Commercial pack	32	90.4	89.4	1.0	5
		Marsh	Commercial pack	45	89.0	87.0	2.0	2
Jan. 7	10 weeks	Marsh	Commercial pack	32	90.1	88.6	1.5	5
	14 weeks	Marsh	Commercial pack	32	89.5	87.8	1.7	3
Jan. 7	18 weeks	Marsh	Commercial pack	32	89.6	87.1	2.5	4
		Marsh	Commercial pack	37	89.6	83.2	6.4	4
Jan. 25	8 weeks	Marsh	Commercial pack	32	87.1	85.9	1.2	5
		Marsh	Commercial pack	37	87.2	85.4	1.8	5
		Marsh	Commercial pack	45	86.6	83.3	3.3	5
Jan. 25	10 weeks	Marsh	Commercial pack	32	84.0	80.75	3.25	2
		Marsh	Commercial pack	37	87.33	85.0	3.5	3
		Marsh	Commercial pack	45	90.62	87.5	3.62	4
Feb. 5	8 weeks	Marsh	Commercial pack	32	85.2	83.95	1.25	10
Feb. 5	12 weeks	Marsh	Commercial pack	32	85.63	82.98	2.65	8
Feb. 20	8 weeks	Marsh	Commercial pack	32	85.2	82.6	2.6	5
		Marsh	Commercial pack	37	82.1	79.4	2.7	5
		Marsh	Commercial pack	45	81.1	78.3	2.8	5
Feb. 20	12 weeks	Marsh	Commercial pack	32	81.66	79.06	2.6	15
		Marsh	Commercial pack	45	82.77	75.63	7.13	11

STORAGE OF GRAPEFRUIT AT ATMOSPHERIC TEMPERATURES

In order that there be some data collected in regard to the keeping quality of grapefruit held in common, ventilated storage, a portion of the fruit from some of the last lots to be placed in cold storage was graded, wrapped as commercial grapefruit, and stored loosely in field boxes. These boxes of fruit were stored on a concrete floor, in an inside room of a two-story barn. A window was kept slightly raised to insure proper ventilation. This window opening, together with a crack under the door, later proved to be too much ventilation, as shown by the shriveling and dehydration of the fruit. The data concerning this test are presented in Table 9. It should be noted that none of the diseases or breakdown were responsible for appreciable losses in the fruit held in common storage, for this relatively short period.

CONCLUSIONS AND RECOMMENDATIONS

The solution of the problems incident to the cold storage of Texas citrus fruits would be a material aid in the marketing of the increasing volume of fruit from this state.

It is a significant fact that seedy grapefruit of the Duncan type keep better in cold storage than do the more salable varieties of the Marsh Seedless type. Valencia oranges are more easily kept in cold storage than grapefruit.

The successful cold storage of citrus fruits is probably as directly dependent upon careful and skillful orchard management as it is upon the proper handling of the fruit after it is ready to be harvested and stored. The results obtained during the season 1930-31 indicate that the major portion of the losses of citrus fruit in cold storage are due to conditions which are directly affected by certain orchard practices. Losses due to stem-end rot can be minimized by pruning out the dead wood commonly found in the interior portions of citrus trees. Data recorded in connection with these experiments indicate that such practices as fertilization and irrigation have a decided influence on the keeping quality of the stored fruit. The environmental conditions under which the fruit grew and matured undoubtedly affect losses in storage due to such physiological conditions as scald and pitting. "Curing" the fruit has materially reduced the losses caused by these physiological diseases.

Careless handling increases the percentage of bruised fruit, and such fruit keeps poorly under any conditions. The use of fungicidal washes may reduce the initial infection of such diseases as blue mold but will not take the place of careful handling and packing of the fruit, or proper orchard management. The use of waxed wrappers may hinder the spread of certain diseases from one fruit to another and thus reduce losses.

Storage temperatures are quite important in preventing loss from scald and pitting. Low temperatures like 31°-32°F., when sustained for more than eight weeks, are more conducive to scald and pitting than are temperatures above 44 degrees.

Since pitting, scald, and stem-end rot are responsible for most of the losses in cold storage grapefruit, the factors affecting these diseases

Table 7. Effect of Varietal Differences, Fertilizers, Source of Fruit, and Temperatures Upon the Keeping Quality of Fruit After Removal From Cold Storage.

Date Stored	Lgth. of Storage Period Weeks	Variety	Source	Fertilizer Treatment	Storage Temperature	Condition of fruit when removed from cold storage									
						% Pitted		% Stem-End Rot	% Scald	% Blossom-End Rot	% Blue Mold	% Br's'd	% Good	Total Fruit in Test	% Marketable
						Mild	Severe								
Dec. 22	10	Marsh	Mission	None	31°–32°	24.67	16.70	2.31	7.74	0	0	4.11	44.47	389	69.14
Dec. 22	10	Marsh	Mission	None	36°–37°	3.20	34.16	53.73	.35	0	.71	.74	7.11	281	10.31
Dec. 22	10	Marsh	Mission	None	44°–45°	7.32	18.84	28.79	5.23	6.28	1.57	1.35	30.62	382	37.94
Dec. 22	10	Duncan	La Feria	5-5-15	31°–32°	20.45	11.37	0	43.18	0	0	0	25.00	44	45.45
Dec. 22	10	Duncan	Mercedes	None	31°–32°	7.69	23.09	0	7.69	0	0	0	61.53	39	69.22
Dec. 22	10	Marsh	La Feria	5-5-15	31°–32°	13.20	26.40	0	41.54	0	0	0	18.86	53	32.06
Dec. 22	10	Marsh	Mercedes	None	31°–32°	18.97	3.64	0	29.96	0	0	3.64	43.79	137	62.76
Dec. 22	10	Valencia	La Feria	5-5-30	31°–32°	2.52	.70	0	.70	0	0	1.40	94.68	176	97.20
Dec. 22	12	Duncan	Mercedes	None	31°–32°	6.40	24.40	0	16.80	.40	0	1.20	50.80	250	57.20
Jan. 7	8	Marsh	Mission	None	31°–32°	9.27	2.50	0	.52	.50	0	5.51	81.70	399	90.97
Jan. 7	8	Marsh	La Feria	5-5-15	31°–32°	0	1.25	1.25	88.75	0	0	7.50	1.25	80	1.25
Jan. 7	8	Marsh	La Feria	5-5-15	36°–37°	11.25	15.00	5.00	0	0	0	6.25	62.50	80	17.50
Jan. 7	8	Marsh	La Feria	5-5-15	44°–45°	1.25	0	0	0	2.70	2.50	6.15	86.41	81	87.66
Jan. 25	8	Marsh	Mission	None	31°–32°	25.37	8.04	.25	1.25	2.01	.25	3.04	59.79	398	75.16
Jan. 25	8	Marsh	Mission	None	36°–37°	7.53	71.98	3.92	0	0	.50	.50	15.57	382	23.10
Jan. 25	8	Marsh	Mission	None	44°–45°	29.63	24.65	4.70	5.30	.55	2.77	3.04	29.36	361	58.99

Table 7. Effect of Varietal Differences, Fertilizers, Source of Fruit, and Temperatures Upon the Keeping Quality of Fruit After Removal From Cold Storage—(Continued).

Date Stored	Lgth. of Storage Period Weeks	Variety	Source	Fertilizer Treatment	Storage Temperature	Condition of fruit 7 days after removal from cold storage* % Pitted									
						Mild	Severe	% Stem-End Rot	% Scald	% Blossom-End Rot	% Blue Mold	% Br's'd	% Good	Total Fruit in Test	% Marketable
Dec. 22	10	Marsh	Mission	None	31°–32°	13.40	12.68	10.50	4.10	2.88	.36	10.80	45.28	276	58.68
Dec. 22	10	Marsh	Mission	None	36°–37°	3.70	14.80	29.60	7.40	0	0	18.60	25.90	27	29.60
Dec. 22	10	Marsh	Mission	None	44°–45°	10.56	2.81	10.56	2.11	2.81	2.81	19.75	48.59	142	59.15
Dec. 22	10	Duncan	La Feria	5-5-15	31°–32°	30.00	0	0	10.00	0	0	0	60.00	10	90.00
Dec. 22	10	Duncan	Mercedes	None	31°–32°	5.88	0	0	5.88	0	0	17.66	70.58	17	76.46
Dec. 22	10	Marsh	La Feria	5-5-15	31°–32°	Too few good fruit remained for reexamination									
Dec. 22	10	Marsh	Mercedes	None	31°–32°	0	3.92	0	35.29	0	0	5.89	54.90	51	54.90
Dec. 22	10	Valencia	La Feria	5-5-30	31°–32°	2.73	0	9.58	0	0	0	15.06	72.63	146	75.36
Dec. 22	12	Duncan	Mercedes	None	31°–32°	9.21	21.05	7.89	5.28	0	0	0	56.57	76	65.78
Jan. 7	8	Marsh	Mission	None	31°–32°	1.80	2.08	0	2.16	.27	.54	5.94	87.21	365	89.01
Jan. 7	8	Marsh	La Feria	5-5-15	31°–32°	Too few good fruit remained for reexamination									
Jan. 7	8	Marsh	La Feria	5-5-15	36°–37°	1.69	1.69	6.76	0	0	5.07	6.76	78.03	59	79.72
Jan. 7	8	Marsh	La Feria	5-5-15	44°–45°	0	0	6.90	2.75	1.38	0	6.90	82.06	72	82.06
Jan. 25	8	Marsh	Mission	None	31°–32°	19.50	2.90	2.90	1.24	0	6.63	4.97	61.86	241	81.36
Jan. 25	8	Marsh	Mission	None	36°–37°	8.86	35.44	43.10	3.78	0	0	1.26	7.56	79	16.42
Jan. 25	8	Marsh	Mission	None	44°–45°	20.47	16.19	7.64	2.38	0	1.43	13.80	38.09	210	58.56

Table 7. Effect of Varietal Differences, Fertilizers, Source of Fruit, and Temperatures Upon the Keeping Quality of Fruit After Removal From Cold Storage—(Continued).

Date Stored	Lgth. of Storage Period Weeks	Variety	Source	Fertilizer Treatment	Storage Temperature	Condition of fruit 15 days after removal from cold storage**									
						% Pitted		% Stem-End Rot	% Scald	% Blossom-End Rot	% Blue Mold	% Br's'd	% Good	Total Fruit in Test	% Marketable
						Mild	Severe								
Dec. 22	10	Marsh	Mission	None	31°–32°	***	-------	-------	-------	-------	-------	-------	-------	-------	-------
Dec. 22	10	Marsh	Mission	None	36°–37°	***	-------	-------	-------	-------	-------	-------	-------	-------	-------
Dec. 22	10	Marsh	Mission	None	44°–45°	***	-------	-------	-------	-------	-------	-------	-------	-------	-------
Dec. 22	10	Duncan	La Feria	5-5-15	31°–32°	***	-------	-------	-------	-------	-------	-------	-------	-------	-------
Dec. 22	10	Duncan	Mercedes	None	31°–32°	***	-------	-------	-------	-------	-------	-------	-------	-------	-------
Dec. 22	10	Marsh	La Feria	5-5-15	31°–32°	***	-------	-------	-------	-------	-------	-------	-------	-------	-------
Dec. 22	10	Marsh	Mercedes	None	31°–32°	***	-------	-------	-------	-------	-------	-------	-------	-------	-------
Dec. 22	10	Valencia	La Feria	5-5-30	31°–32°	***	-------	-------	-------	-------	-------	-------	-------	-------	-------
Dec. 22	12	Duncan	Mercedes	None	31°–32°	***	-------	-------	-------	-------	-------	-------	-------	-------	-------
Jan. 7	8	Marsh	Mission	None	31°–32°	1.50	0	0	0	0	1.50	.30	96.70	328	98.20
Jan. 7	8	Marsh	La Feria	5-5-15	31°–32°	***	-------	-------	-------	-------	-------	-------	-------	-------	-------
Jan. 7	8	Marsh	La Feria	5-5-15	36°–37°	2.12	0	0	0	0	2.12	2.12	93.64	47	95.76
Jan. 7	8	Marsh	La Feria	5-5-15	44°–45°	0	0	0	0	1.69	3.38	0	94.93	59	94.93
Jan. 25	8	Marsh	Mission	None	31°–32°	***	-------	-------	-------	-------	-------	-------	-------	-------	-------
Jan. 25	8	Marsh	Mission	None	36°–37°	***	-------	-------	-------	-------	-------	-------	-------	-------	-------
Jan. 25	8	Marsh	Mission	None	44°–45°	***	-------	-------	-------	-------	-------	-------	-------	-------	-------

*Only the fruits of marketable grade on 3/5 included in this classification (3/12)
**Only fruits of marketable grade on 3/12 included in this classification (3/20)
***Not reexamined

Table 8. Effect of Different Pre-Storage Treatments on the Keeping Quality of Fruit After Removal From Cold Storage.

Length Storage Period Weeks		% Pitted		% Stem-End Rot	% Scald	% Blossom-End Rot	% Blue Mold	% Bruised	% Good	Total Fruit in Test	% Market-able
		Mild	Severe								
		Condition of fruit when removed from cold storage									
10	Hot Borax wash	27.12	59.32	1.69	5.09	0	0	1.69	5.09	59	32.28
	Sodium Hypochlorite wash	5.55	16.65	0	51.85	0	0	5.55	20.40	54	25.95
	Sodium bicarbonate wash	48.38	14.53	0	51.85	0	0	12.90	17.74	62	66.12
	Sodium Sulphide wash	28.12	31.25	0	17.20	0	0	0	23.43	64	51.55
	Water wash only	27.69	15.38	0	6.17	0	0	7.69	43.07	65	70.76
	Wax wrap	17.72	12.65	2.53	8.86	0	0	6.35	51.89	79	69.61
	Commercial wrap	26.72	52.58	0	5.17	0	0	3.44	11.20	116	37.92
	Standard pack without bulge	12.96	7.44	0	3.70	1.85	0	14.80	59.25	54	72.21
	Standard pack with bulge	23.18	30.43	1.50	0	0	0	5.76	39.13	69	62.31
	Fruit colored with Ethylene gas	23.46	15.31	3.08	8.16	0	0	8.16	41.83	98	65.29
	Fruit colored with Stove gas	26.45	15.09	0	11.32	3.76	0	1.88	41.50	53	67.95
	Fruit uncolored, cured for 10 days at 70°	0	5.97	1.49	1.49	0	1.49	7.48	82.08	67	82.08
		Condition of fruit 7 days after removal from cold storage									
10	Hot Borax wash	16.66	16.66	33.32	0	5.55	0	11.15	16.66	18	33.32
	Sodium Hypochlorite wash	21.42	0	7.18	28.56	0	0	0	42.84	14	64.26
	Sodium bicarbonate wash	18.41	21.04	5.26	18.47	0	0	28.93	7.89	38	26.30
	Sodium Sulphide wash	9.36	53.20	3.12	3.12	0	0	12.48	18.72	32	28.08
	Water wash only	6.66	42.28	4.44	2.22	2.22	4.44	19.98	17.76	45	24.42
	Wax wrap	20.51	27.03	0	6.36	0	3.17	7.95	34.98	63	54.49
	Commercial wrap	13.85	5.55	5.55	5.55	0	0	33.29	36.21	36	50.06
	Standard pack without bulge	9.52	40.46	9.52	11.90	4.76	0	2.38	21.46	42	30.98
	Standard pack with bulge	6.96	78.88	0	0	0	9.40	0	4.76	43	11.72
	Fruit colored with Ethylene gas	25.27	17.29	2.66	7.98	0	1.58	6.65	38.57	75	63.84
	Fruit colored with Stove gas	8.10	48.60	2.80	8.10	0	8.10	5.40	18.90	37	27.00
	Fruit uncolored, cured for 10 days at 70°	0	3.50	0	22.75	0	1.75	33.25	38.75	57	33.25

Table 8. Effect of Different Pre-Storage Treatments on the Keeping Quality of Fruit After Removal From Cold Storage—(Continued).

Length Storage Period Weeks		Condition of fruit when removed from cold storage									
		% Pitted		% Stem-End Rot	% Scald	% Blossom-End Rot	% Blue Mold	% Bruised	% Good	Total Fruit in Test	% Market-able
		Mild	Severe								
12	Hot Borax wash	26.66	50.98	8.09	2.85	.47	0	6.19	4.76	210	31.42
	Sodium Hypochlorite wash	6.19	16.52	.82	33.88	.41	0	.82	41.36	242	47.55
	Sodium bicarbonate wash	22.74	24.64	11.37	11.87	.95	0	2.84	25.59	211	48.33
	Sodium Sulphide wash	10.18	27.27	8.02	38.50	0	0	2.67	13.36	187	23.54
	Water wash only	18.97	13.84	11.28	12.33	0	.51	4.61	38.46	195	57.43
	Wax wrap	10.19	29.20	0	17.69	0	0	0	42.92	226	53.11
	Commercial wrap	7.07	59.80	0	20.25	.64	.32	1.28	10.64	311	17.71
	Standard pack without bulge	17.67	10.49	5.54	8.29	2.20	0	6.07	49.74	181	67.41
	Standard pack with bulge	20.00	30.00	3.80	10.00	0	0	4.30	31.90	210	51.90
	Fruit colored with Ethylene gas	6.56	49.03	2.33	24.64	0	0	.39	15.05	259	21.61
	Fruit colored with Stove gas	8.43	15.66	3.61	15.66	1.20	0	5.44	50.00	166	58.43
	Fruit uncolored, cured for 10 days at 70°	7.22	10.55	5.55	18.36	1.11	0	14.44	42.77	180	49.99

Length Storage Period Weeks		Condition of fruit 10 days after removal from cold storage									
		% Pitted		% Stem-End Rot	% Scald	% Blossom-End Rot	% Blue Mold	% Bruised	% Good	Total Fruit in Test	% Market-able
		Mild	Severe								
12	Hot Borax wash	0	39.39	43.93	4.56	0	6.06	6.06	0	66	0
	Sodium Hypochlorite wash	13.95	13.95	9.30	23.25	0	0	9.30	30.25	43	44.20
	Sodium bicarbonate wash	1.00	27.00	49.00	3.00	0	11.00	9.00	0	100	1.00
	Sodium Sulphide wash	4.44	46.66	31.14	4.44	0	4.44	8.88	0	45	4.44
	Water wash only	.88	36.85	30.70	6.14	0	19.29	6.14	0	114	.88
	Wax wrap	11.25	16.25	0	11.87	0	11.25	9.38	40.00	160	51.25
	Commercial wrap	14.54	21.81	3.64	10.92	0	7.28	16.36	25.45	55	39.99
	Standard pack without bulge	0	34.03	7.44	2.09	0	35.61	0	.83	121	.83
	Standard pack with bulge	0	34.90	23.58	3.77	0	26.41	10.37	.97	106	.97
	Fruit colored with Ethylene gas	1.78	21.36	5.34	37.38	0	3.56	7.12	23.16	56	24.94
	Fruit colored with Stove gas	1.02	35.70	10.20	6.12	0	40.80	3.06	3.10	98	4.12
	Fruit uncolored, cured for 10 days at 70°	1.08	11.88	10.80	4.92	0	45.36	16.20	9.76	92	10.84

should receive most careful consideration. The length of the storage life of the fruit and its keeping quality after it is removed from storage will depend largely upon the control of the factors affecting the development of pitting, scald, and stem-end rot.

In the light of present knowledge, it would seem practicable to store fruit of the Duncan type in the case of grapefruit, and Valencia oranges. The fruit should be taken from trees that are relatively free from dead wood and shoud be harvested during a period when the fruit is of good quality, preferably when the orchard soil is rather dry. Harvesting and handling of the fruit should be done in such a manner as to minimize bruising. From our present knowledge of the situation, the following method of storage is suggested: Pack unbrushed fruit loosely in boxes and cure in common, ventilated storage for approximately ten days, and then sort and wrap in waxed wrappers; pack without excessive bulge, and store in cold storage rooms where the temperature is maintained at about 45 degrees and the humidity at approximately 85 per cent. Unless waxed wrappers are used, the fruit should be stored without wrapping.

SUMMARY

1. A temperature of 45°F. was more satisfactory for the storage of grapefruit than were the lower temperatures, where the fruit was of good quality and not over-ripe.

2. The lower temperature (31°-32°F.) retarded the development of disease in the stored fruit, but marked increases in the losses due to pitting and scald occurred at this temperature.

3. It appears that 4 weeks is about the time limit for holding fruit at atmospheric temperatures, while 8 to 10 weeks appears to be a practical limit on the time Valley grapefruit should be held in cold storage.

4. Duncan grapefruit was superior to that of the Marsh variety for holding in cold storage, both from the standpoint of actual loss and retention of flavor during the period of storage.

5. The Valencia oranges included in this experiment held up at 32°F. in a most satisfactory manner, even for a relatively long period of time (20 weeks).

6. The maturity of the fruit, as influenced by its age, apparently had less effect on its keeping quality than did environmental factors such as soil type and rain during the harvesting period.

7. Fruit harvested relatively late in the season (late February), especially where it is slightly past its prime, kept poorly in storage. Low temperatures (31°) should be used in holding such fruit and the period of storage should be rather short (4 to 6 weeks).

8. Pre-storage treatments, such as curing the fruit prior to storage and the use of waxed wraps, reduced the amount of loss to a significant degree. The use of fungicidal washes was of no particular benefit, under the conditions of this experiment.

9. The use of rather heavy applications of fertilizer high in potash (5-5-15) had an unfavorable effect on the keeping quality of the fruit, as

Table 9. Common Storage of Grapefruit.*

Date Stored	Variety	Treatment	Condition of Fruit when Removed after 30 days.									
			% Pitted		% Stem-End Rot	% Scald	% Blue Mold	% Bruised (Soft)	% Shriv-eled	% Good	Total Fruit in Test	% Market-able
			Mild	Severe								
Feb. 20	Marsh	Commercial wraps—No washing or brushing	0	0	0	0	3.58	6.09	53.40	36.93	279	90.33

*This fruit was unwashed, unbrushed, and was wrapped and loosely packed in field boxes approximately 24 hours after it was removed from the trees.

Table 10. Effect of Source of Fruit, Date of Storage, and Storage Temperature on the Development of Pitting.

Percentage of Pitted Fruit after Eight Weeks' Storage

Storage Temperature	Mission Fruit, Stored:								La Feria Fruit, Stored:			
	Jan. 7		Jan. 20		Feb. 5		Feb. 20		Jan. 7		Feb. 5	
	Mild	Severe	Mild	Severe	Mild	Severe	Mild	Severe	Mild	Severe	Mild	Severe
31°-32°	9	3	25	8	20	17	10	20	0	1	11	12
36°-37°	0	0	8	72	0	0	7	80	11	15	0	0
44°-45°	0	0	30	25	0	0	7	58	1	0	0	0

Percentage of Pitted Fruit after Twelve Weeks' Storage

Storage Temperature	Mission Fruit, Stored:								La Feria Fruit, Stored:			
	Dec. 22		Jan. 7		Feb. 5		Feb. 20		Jan. 7		Feb. 5	
	Mild	Severe	Mild	Severe	Mild	Severe	Mild	Severe	Mild	Severe	Mild	Severe
31°-32°	16	56	18	16	3	55	9	24	6	6	31	16
36°-37°	0	27	0	0	0	0	0	53	0	0	0	0
44°-45°	8	20	0	0	0	0	4	24	0	0	0	0

Table 11. Effect of Source of Fruit, Date of Storage, and Storage Temperature on the Development of Scald.

Percentage of Fruit Showing Scald after Eight Weeks' Storage

Storage Temperature	Mission Fruit, Stored:				La Feria Fruit, stored:	
	Jan. 7	Jan. 20	Feb. 5	Feb. 20	Jan. 7	Feb. 5
31°-32°	1	1	22	1	89	8
36°-37°	0	0	0	0	0	0
44°-45°	0	5	0	2	0	0

Percentage of Fruit Showing Scald after Twelve Weeks' Storage

Storage Temperature	Mission Fruit, Stored:				La Feria Fruit, stored:	
	Dec. 22	Jan. 7	Feb. 5	Feb. 20	Jan. 7	Feb. 5
31°-32°	3	24	12	41	5	20
36°-37°	58	0	0	0	0	0
44°-45°	2	0	0	1	0	0

Table 12. Effect of Source of Fruit, Date of Storage, and Storage Temperature on Keeping Quality of Grapefruit.

Percentage of Marketable Fruit after Eight Weeks' Storage

Storage Temperature	Mission Fruit, Stored:				La Feria Fruit, stored:	
	Jan. 7	Jan. 20	Feb. 5	Feb. 20	Jan. 7	Feb. 2
31°-32°	91	85	56	60	1	84
36°-37°	0	23	0	10	74	0
44°-45°	0	59	0	11	88	0

Table 12. Effect of Source of Fruit, Date of Storage, and Storage Temperature on Keeping Quality of Grapefruit.—(Continued)

Percentage of Marketable Fruit after Twelve Weeks' Storage

Storage Temperature	Mission Fruit, Stored: Dec. 22	Mission Fruit, Stored: Jan. 7	Mission Fruit, Stored: Feb. 5	Mission Fruit, Stored: Feb. 20	La Feria Fruit, stored: Jan. 7	La Feria Fruit, stored: Feb. 5
31°-32°	27	41	7	11	80	56
36°-37°	13	0	0	6	0	0
44°-45°	44	0	0	7	0	0

Percentage of Marketable Fruit after Sixteen Weeks' Storage

Storage Temperature	Mission Fruit, stored: Dec. 22	Mission Fruit, stored: Jan. 7	La Feria Fruit, stored: Dec. 22
31°-32°	6	36	2
36°-37°	2	0	15
44°-45°	38	0	46

Percentage of Marketable Fruit after Twenty Weeks' Storage

Storage Temperature	Mission Fruit, stored: Dec. 22	La Feria Fruit, stored: Jan. 7
31°-32°	0	0
36°-37°	0	9
44°-45°	22	0

shown by the results secured with fruit from unfertilized trees.

10. There were only slight changes in the sugar and the acid content o the juice of the citrus fruits held for 16 weeks at 31°-32°F.

11. The rate of deterioration of the fruit after it was removed fron cold storage was not excessive. The lots of fruit which held up best ir cold storage showed less rapid deterioration after the fruit was removec from cold storage. Waxed wraps kept the fruit in better condition after it was removed from cold storage than did ordinary grapefruit wraps.

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