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Progress Report Of Prune Storage And Maturity Studies

By

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*In Co-operation with U. S. Department of Agriculture.

PROGRESS REPORT OF PRUNE STORAGE AND MATURITY STUDIES

By
C. C. Vincent, Leif Verner, and E. C. Blodgett*

INTRODUCTION

The principal fresh prune shipments of the United States originate in Idaho, Washington, Oregon and California. Idaho's fresh prune shipments vary from 1500 to 2000 cars annually. The industry in this state represents an investment of approximately $20,000,000, with an average annual crop value of about $2,000,000.

The increasing prune production of recent years, together with faulty methods of handling and marketing, has resulted in unstable market conditions and consequent losses to the fresh prune industry. In 1926, from 350 to 400 cars of prunes were left unpicked in Idaho orchards in order to avoid market gluts. The growers of the state, as a result of this, lost approximately $146,000, the railroads an equal amount, and the dealers about $25,000.

Hartman (1) in 1926 estimated that of the 57,000 acres of prune trees in Oregon not more than half were at that time of bearing age. In Idaho at the present time there are, in commercial orchards, approximately 500,000 prune trees, of which 100,000 are not yet in bearing. The most recent data available indicate a similar trend of production in Washington and California.

The consequent production increase to be faced in the near future will do much to aggravate the unfavorable market con-

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ditions of the immediate past. In the hope of finding some means of relieving this situation an attempt has been made in the following experiments to determine the possibilities of fresh prune storage for the purpose of extending the marketing season for this fruit and to make possible a more favorable seasonal distribution of the average crop. An effort has also been made to determine the stages of maturity and other conditions under which the fruit will carry best and give the best storage results.

For Idaho growers the storage of prunes offers perhaps greater possibilities than for the other large producing states. The normal ripening time for the Italian prune in Idaho is somewhat later than in the commercial sections of California, Oregon and Washington, with the result that stored prunes from Idaho, going on the market after the season for the unstored fruit is past, will not come into competition with the freshly picked product of a later section, as would be the case with all of the commercial sections of the other three states.

PLAN OF EXPERIMENT

The prune storage and maturity tests were started in the Boise Valley in the fall of 1927. The first season the fruit tested was all picked from nine trees in one block selected as representative of average orchard conditions throughout the locality. Pickings were made at 3-day intervals from August 31 to October 9 inclusive. A part of the fruit from each picking was placed in common storage, part in storage at 45° to 55° F., and part at 32°. Complete tests were run on each lot at the time of picking, after seven days in storage, after 11 days in storage, and at maturity. At the end of the 11-day period for each lot one basket was placed in a display window at room temperature and notes taken from time to time as to changes in condition and quality.

In 1928 the greater amount of fruit required made it necessary to secure the samples from the packing house rather than from selected trees, the results therefore being more variable than in 1927. Samples were taken at 3-day intervals all through the season, beginning on August 27. From each picking 32-5 lb. baskets were placed in storage and enough additional prunes taken to make complete tests of the fruit as picked. Beginning with the seventh day in storage for each picking; and following that, every fourth day for 43 days; three baskets of

fruit were removed from storage. The fruit of one of these baskets was tested at once. The other two baskets were placed in a display window at room temperature under conditions comparable to those that the fruit would be subjected to at the hands of the retail trade in the usual methods of marketing. One of these baskets was tested at the end of three days and the other at the end of six days.

Unfortunately, due to the earliness of the season, the tests were not begun in 1928 until the fruit was considerably farther advanced than at the beginning of the tests the previous season. In both years the following records were taken on the fruit of each basket tested: pressure resistance, flavor, flesh texture, firmness, skin color, flesh color, and the percentage of fruit that was shriveled, decayed, cracked, or breaking down internally. Sugar and acid determinations, and size and weight of fruit, were recorded for each lot at the time of picking.

RESULTS OF MATURITY TESTS

As a prune approaches mature size and ripeness it undergoes important changes of both a physical and a chemical nature. The principal change physically consists of a gradual softening of the flesh. Chemically there is an increase in the sugar content and a decrease in acid.

The tests used in this work were designed to measure quantitatively the stage of maturity of the fruit on the bases of these physical and chemical changes and so to avoid the personal element and consequent error in judgment in attempting to determine stage of maturity by pressure of thumb, by flesh texture, by size, or by casual color observation as so commonly practiced by growers. A further attempt has been made to correlate the stages of maturity, as determined by these quantitative tests, with the shipping, storage, and dessert qualities of the fruit.

Sugar Test

Under the conditions of this experiment the hydrometer reading or "sugar test" of the fruit juice proved subject to variation from so many sources as to be unreliable for maturity determinations. While on the whole there was a significant increase in the hydrometer readings as the fruit matured, both in the orchard and in storage, the increase was not uniform and

was occasionally broken by a sudden and often considerable decrease at a time when there was no apparent reason for the change. Two such decreases occur in the records of the tests made at picking times in 1927. Between lots 9 and 10 there was a drop of 1.7 per cent and between lots 11 and 12 a drop of 1.6 per cent. (Table I).

Most of the irregularities noted in the hydrometer readings can probably be accounted for on the basis of variations in juice temperature, pulp in suspension in the juice, increased concentration due to shriveling, or to other variables which might under the most careful laboratory conditions be kept under control. To eliminate all of these factors would, however, make the test so cumbersome as to be unsuited for practical field and storage conditions.

Acid Test

The per cent of acid in the juice of prunes parallels rather closely the maturity changes of the fruit, but to get an accurate acid reading is difficult. When the juice sample is turbid or very dark, as is sometimes the case, it is difficult to detect the neutral point. Also during titration the juice itself may give a color reaction sufficient to conceal the color change of the indicator (No. pH determinations were made).

The changes in acidity accompanying significant differences in maturity are sometimes so slight that they may be overshadowed by differences due simply to error in the readings or to random sampling. Comparable results were found in similar tests conducted in Oregon. (1). The acid test therefore, is without promise as a practical measure of prune maturity.

Color Changes

Skin color, after removal of the bloom, has some promise as a means of maturity determination in prunes. Color changes parallel closely the maturity changes of the fruit in the orchard. After picking, the correlation between color and maturity is less consistent. Skin color determinations were based on Ridgway's *"Color Standards and Nomenclature."*

It is doubtful if skin color will prove as satisfactory for practical purposes as the pressure test. Further observation will be necessary on this phase of the problem.

TABLE I

MATURITY READINGS ON PRUNES AT PICKING DATES AND AFTER 11 DAYS IN COLD AND COMMON STORAGE, 1927

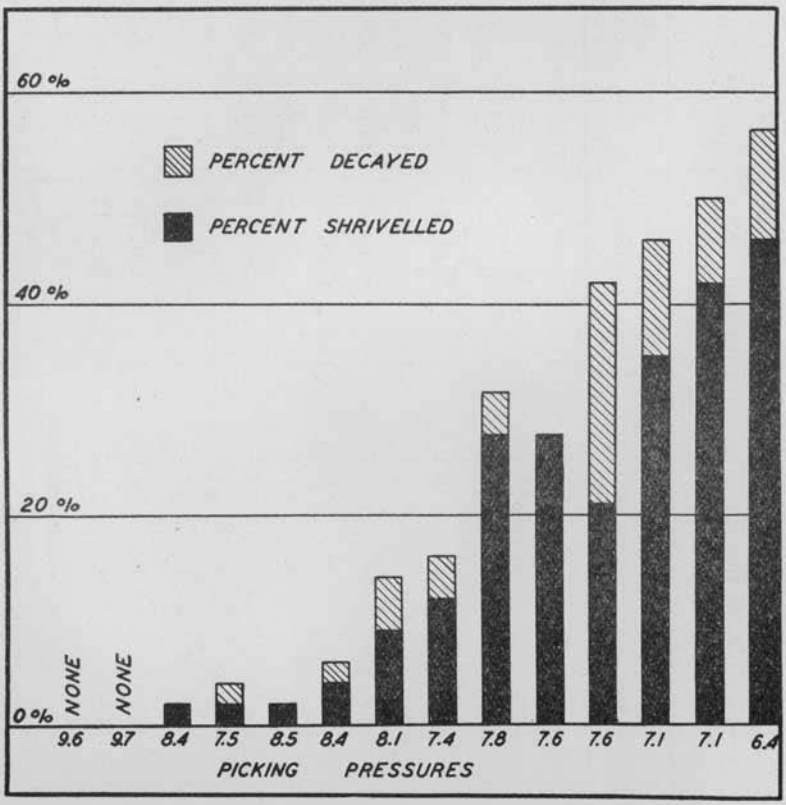
Lot No.	Date Picked	Pressure Lbs.	Sugar (Balling)	Acid Per Cent	11th Day Date	Cold Storage-32°			Common Storage		
						lbs. Pressure	Sugar Per cent	Acid percent	Lbs. Pressure	Sugar percent	Acid percent
1	Aug. 31	12.6	14.0	1.31	Sept. 11	12.7	13.9	1.31	9.6	14.9	1.30
2	Sept. 3	12.0	14.8	1.30	Sept. 14	12.2	13.7	1.16	9.6	14.6	1.10
3	Sept. 6	11.1	15.9	1.25	Sept. 17	11.5	15.0	1.23	6.9	18.4	.95
4	Sept. 9	10.2	16.1	1.25	Sept. 20	10.0	16.1	1.21	5.9	19.0	.75
5	Sept. 12	10.0	16.1	1.19	Sept. 23	10.1	17.3	.90	4.9	19.0	.54
6	Sept. 15	9.9	16.1	1.18	Sept. 26	10.0	17.8	1.03	5.4	20.1	.54
7	Sept. 18	9.5	18.0	1.14	Sept. 29	9.5	18.2	1.03	5.0	19.2	.59
8	Sept. 21	8.6	18.5	.94	Oct. 2	8.8	19.8	.88	4.9	19.4	.59
9	Sept. 24	8.6	21.5	.95	Oct. 5	8.1	22.0	.83	5.2	22.7	.51
10	Sept. 27.	8.7	19.8	.74	Oct. 8	7.9	20.8	.78	5.7	21.6	.56
11	Sept. 30	8.7	22.3	.80	Oct. 11	5.9	20.5	.63	4.9	20.8	.52
12	Oct. 3	6.8	20.7	.64	Oct. 14	5.6	21.5	.63	5.0	23.4	.48
13	Oct. 6	7.4	23.7	.60	Oct. 17	5.7	22.5	.58	3.8	24.0	.51
14	Oct. 9	6.4	23.5	.62	Oct. 20	5.7	24.3	.60	Insufficient Fruit		

The Pressure Test

In both 1927 and 1928 the pressure resistance of the fruit, as determined by the modified Murneek pressure tester (2) with a 5|16 inch plunger, proved the most dependable and the most convenient measure of the proper picking time and storage possibilities of the fruit. (See Tables I and II).

The pressure resistance was determined at 3-day intervals throughout the season. On each picking date readings were taken on two sides of each of twenty prunes selected as representative of the average run of fruit at that time. The pressures were taken without removing the skin.

FIG. I



Comparative amounts of shrivelling and decay in prunes after 11 days in 32° storage followed by 3 days at room temperature, 1928.

The condition of each picking at the end of 11 days in storage and 3 days at room temperature was taken as representative of the condition in which that fruit would have reached the consumer in the far eastern markets. The results of the two seasons work together indicate that for immediate shipment, fruit picked at pressures ranging from 11.5 lbs. to 8.5 lbs. will give the best results, this fruit reaching market in good physical condition and with good to prime quality. If necessary for a more favorable distribution of the crop the pressure range can be extended to 12.0 lbs. as a maximum and 8.0 lbs. as a safe minimum without serious loss in either quality or condition.

Figure I shows the storage behavior of fruit picked in the 1928 season, beginning at a pressure of 9.6 lbs. The results of the 1927 tests indicate that, at the stage of storage represented in Fig. I, there should be no deterioration in fruit picked at pressures up to 12.6 lbs.

Fruit picked at pressures above 12 lbs. will hold up well and may develop good color, but seldom attains the fine quality so essential to the continued well-being of the fresh prune industry. In fruit picked at pressures below 8.5 lbs. there is danger of excessive loss from deterioration, although the sound fruit in the pack usually retains a high quality.

For storage beyond the normal picking season fruit picked at pressures of 11.5 lbs. to 9.5 lbs. has given the best results. For shorter storage periods within the range of the picking season for the purpose of avoiding temporary over-supply of the markets, fruit picked at pressures as low as 8.5 lbs. has held up satisfactorily.

While it is apparent that the late pickings may hold up in storage to a later date than some of the early and mid-season lots (See Fig. IV), the length of the storage period for these late pickings is scarcely more than the time required to reach the eastern markets by immediate shipment. To withhold picking in order to store late in the season is undesirable on account of the heavy cullage necessary in fruit picked at that time.

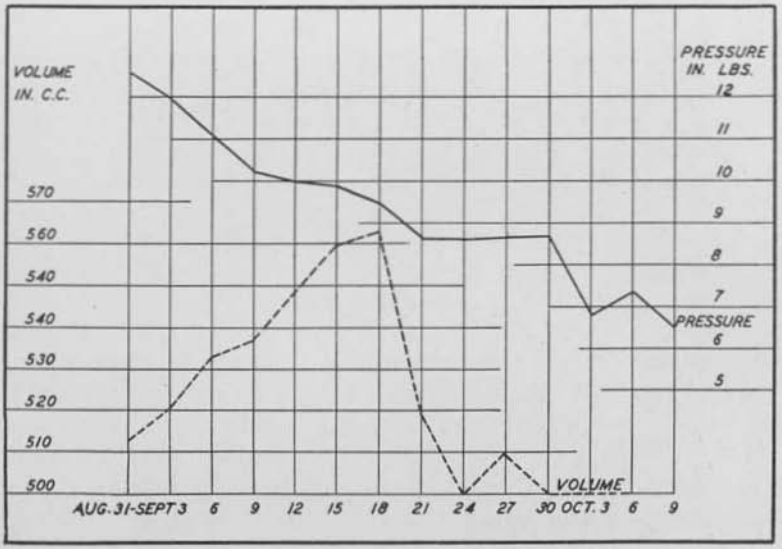
The first requisite of any maturity test that is likely to be adopted by the growers and shippers is that it be simple and readily adaptable to field and storage conditions. The pressure tester meets this requirement satisfactorily providing it is used with care and thought. The fruit to be tested must be selected as representative of the orchard run and should be taken from several trees. It is insufficient to use less than 20

prunes to determine the average maturity at any one time; 25 or 30 will give more dependable results.

The pressure should be applied with a steady, moderately rapid movement, as otherwise the flesh softens before the plunger has reached the point of contact at which the pressure is read. This softening due to a slow stroke results in a lowered reading. Pressure determinations should be made separately for each orchard except in cases of adjacent orchards under similar conditions of soil and culture.

Sugar and acid changes are not closely associated with maturity changes of prunes after they have been removed from the tree. Hence the pressure resistance, which alone indicates the ability of the fruit to continue holding up physically, is the only safe index of maturity of fruit already in storage. When the pressure resistance has dropped to 5 lbs. the fruit is at or very near the end of its storage life. For retail distribution before extensive deterioration has developed stored prunes should probably be in the hands of the retail trade before the pressure has dropped below 7 lbs., although definite data on this cannot yet be given.

Fig. II



Size increase in relation to maturity changes of prunes, 1927.

Size Increase and Maturity

Size increase of the fruit as the season advanced was measured in 1927 by the water displacement of 20 representative prunes at each picking date, taken always from the same tree; and by diameter measurements of 30 prunes selected and tagged early in the season. Both methods of measurement showed a steady increase in size of the fruit until maximum size was reached between September 18 and 21. Following that there was a rapid decrease in size apparently attributable to shriveling in the ripest specimens and dropping of the largest fruit. From August 31 until September 18 the average daily volume increase was .5 per cent (See Fig. II)

TABLE II

MATURITY READINGS ON PRUNES AT PICKING DATES, 1928

Lot No.	Date Picked	Pressures in Lbs.	Percent Sugar	Percent Acid	Flavor
1	Aug. 27	9.6	15.5	.58	Sour
2	Aug. 30	9.7	17.0	.60	Sour
3	Sept. 2	8.4	17.0	.41	Mildly Sour
4	Sept. 5	7.5	17.0	.71	Fair
5	Sept. 8	8.5	18.5	.59	Fair
6	Sept. 11	8.4	18.5	.68	Fair
7	Sept. 14	8.1	19.5	.62	Fair
8	Sept. 17	7.4	18.5	.62	Fair
9	Sept. 20	7.8	19.0	.60	Good
10	Sept. 23	7.6	20.5	.60	Very good
11	Sept. 26	7.6	21.5	.58	Very good
12	Sept. 29	7.1	23.0	.58	Prime
13	Oct. 2	7.1	23.5	.48	Prime
14	Oct. 5	6.4	22.0	.57	Prime
15	Oct. 8	5.8	23.5	.55	Prime
16	Oct. 11	5.3	25.0	.52	Prime
17	Oct. 14	5.7	26.0	.52	Flat-sweet

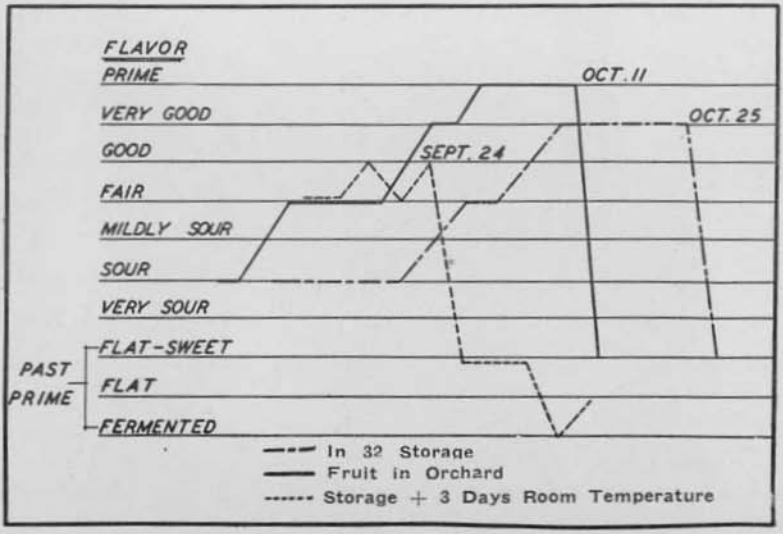
RESULTS OF STORAGE TESTS

Storage Temperatures

During the 1927 season prunes were stored at 32° F., at 45° to 55° F., and in common storage at higher temperatures. For short storage periods of from 7 to 11 days there was but little difference in the physical condition and edibility of the fruit held at 32° and that held at 45° to 55°, which was considered as comparable to the average temperatures of a refrigerator car. For longer storage periods the results at 32° were better than at the higher temperatures. All the fruit in the tests of 1928, therefore, was held at 32°.

In general, at the higher temperatures there was a more rapid ripening of the fruit, as indicated by the pressure resistance, sugar, acid, and flavor. Storage temperature retards the ripening processes, but a few days at room temperature following storage increases the rate of ripening and of deterioration over that of the orchard. Figure III shows the effect of cold storage, and of room temperature following cold storage,

FIG. III



Effect of storage and room temperatures on the rate of ripening of prunes picked on August 27, 1928.

on the rate of ripening of the fruit as indicated by changes in flavor.

Variability in Ripening

The irregularity of ripening of the fruit on individual trees constitutes by far the greatest obstacle to successful storage of prunes. At any time during the several weeks' picking season, except very early and very late, there can be found on any individual tree some prunes which are fully mature, some scarcely more than beginning to soften, and the remainder representing all stages in between. Under the present practice of picking all the fruit from an individual tree at one time there is placed into each pack, all through the season, a mixed lot of prunes representing all stages from the firmest to the ripest.

A test of fruit picked from one tree on September 30, 1927, showed differences in maturity ranging from 9.5 lbs. pressure in the least mature to 5.5 lbs. in the most mature fruit, with corresponding differences in flavor, color, flesh texture and quality. (See Table III). This is as great a difference as would be expected in the average of an entire orchard over a period of three weeks or more. The storage life of a pack made up of such a mixed lot of fruit will be limited practically to the storage life of the ripest fruit contained in it.

TABLE III

MATURITY DIFFERENCES OF PRUNES PICKED FROM ONE TREE SEPTEMBER 30, 1927

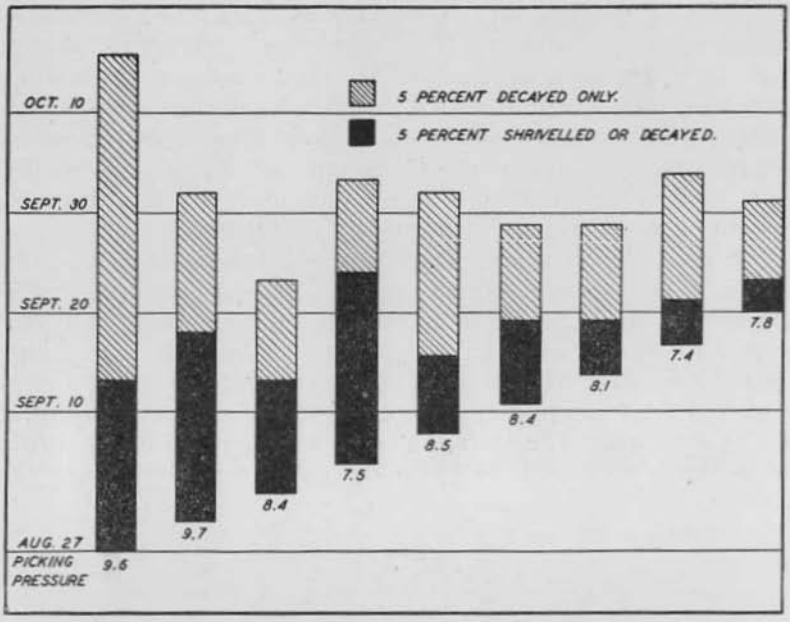
	Pressure	Skin Color	Flesh Color	Texture	Flavor
Least advanced fruit	9.5 lbs.	Dark Red	Dark Green	Crisp	Very sour
Farthest advanced fruit	5.5 lbs.	Purplish Black	Orange	Mealy	Sweet

Deterioration in Storage

Shriveling constitutes the most extensive form of deterioration of prunes in storage and is the first to take place. Although shriveling is not necessarily an indication of spoilage and may not greatly impair the quality, any considerable amount of it severely curtails the market value of the fruit. A shrivel-

ed prune is looked upon by the produce dealer as an aged prune and will be sold at once to a second-class trade at a low price. A sound lot of prunes showing no shriveling may be held several days for better prices and for a fancy trade.

FIG. IV

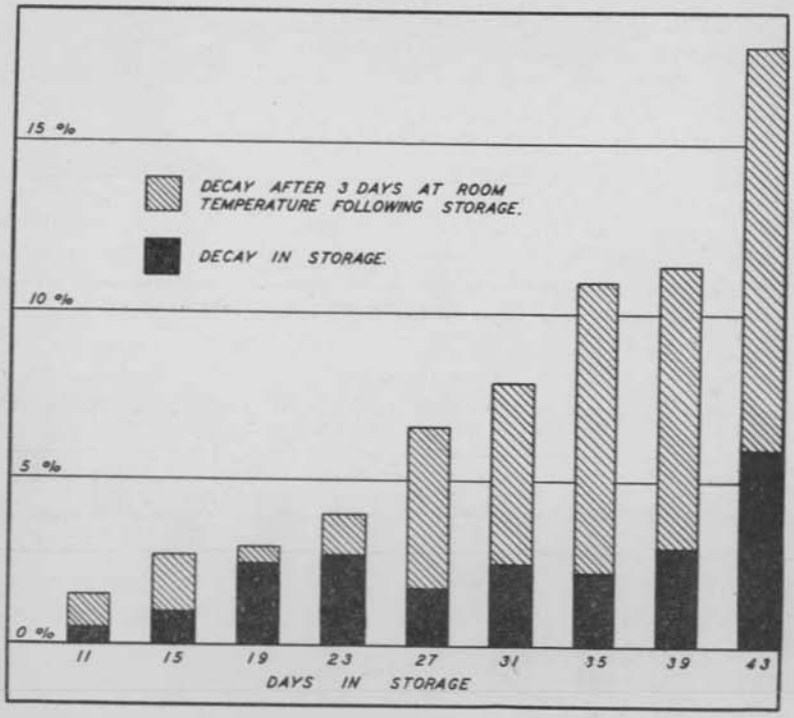


Relative effects of shrivelling and decay on length of storage period.

Shriveling constituted 73 per cent of all forms of deterioration in over 135 baskets of fruit examined immediately upon removal from storage in the 1928 tests. Early in the storage period the percentage of deterioration from shriveling is somewhat greater than the average, while later in the storage period decay and other types of breakdown are proportionately more prevalent. The latter is true as well of the fruit held at room temperature for a few days following removal from storage, the shriveling in these lots averaging only 56 per cent of all types of deterioration. (See Fig. IV.)

Preliminary tests during the past season indicated that shriveling can be reduced by storing under higher humidity than that ordinarily maintained in fruit storage rooms, but at the

FIG. V



Percentage of decay of prunes in 32° storage and 3 days after removal from storage to room temperature, 1928.

expense of increased spoilage from other causes. This phase of the problem requires further study.

All other types of deterioration noted in this work were arbitrarily classified as (1) soft rots, due principally to blue and gray molds; (2) internal breakdown, occurring as a browning and fermentation around the pit; and (3) cracking of the skin. These constituted respectively 24 per cent, 3 per cent, and less than 1 per cent of the total deterioration taking place during the cold storage period. At room temperatures following storage there was an increase in the percentage of deterioration due to sofe rots and internal browning. (See Table IV).

Deterioration Following Removal From Storage

One of the most difficult problems to be dealt with in the

storage of prunes arises from the extremely high rate of deterioration of the stored fruit upon removal to room temperatures. This rate increases with an increasing length of the storage period. In fruit held for 35 days at 32° F. the amount of deterioration taking place in three days after removal to room temperature was more than three times as great as that which had taken place during the entire storage period preceding. Since it is out of the question under present marketing practices for stored prunes to reach the consumer without at least three days, and often more, at room temperatures, the rapid breakdown under such circumstances is an all-important consideration in the storage of this fruit. (See Fig. V.)

TABLE IV

PERCENTAGES OF DIFFERENT TYPES OF DETERIORATION OF PRUNES IN 32° STORAGE, 1928

Time in Storage	Per cent of total deterioration due to shriveling	Per cent of total deterioration due to soft rots	Per cent of total deterioration due to cracked fruit	Per cent of total deterioration due to internal browning
7, 11 and 15 days	86	11	3-	1-
19, 23 and 27 days	71	25	4	0
31, 35, 39 and 43 days	65	33	2-	1-
Average, 7 to 43 days	73	24	3-	1-
Average after 7 to 43 days in 32° storage followed by 3 days at room temperature.	56	32	1	11

RECOMMENDATIONS

Since the results of the past two years' work on this problem are not considered conclusive the following notes are given as tentative recommendations to be followed until further study makes final recommendations possible.

1. On the basis of present information the storage of prunes should be looked upon principally as a measure for stabilizing the markets throughout the picking season by means of regulating shipments in accordance with supplies and demands.

2. If the price prevailing at the time of picking is sufficient to assure a reasonable margin of profit through immediate sale, it is doubtful if storage is to be recommended. The added cost

and the greater risk in speculation, in addition to the danger of placing an inferior product on the market, are scarcely warranted by the possibility of a somewhat greater profit. On the other hand, if the market price at picking time represents only a very narrow margin of profit, or perhaps a loss over the cost of production, storage seems advisable.

3. In cases when it is necessary to store for the purpose of extending the normal shipping season for the fruit, it is best to store the earliest pickings, ranging in pressure from 11.5 to 9.5 lbs.

4. All fruit to be stored, and especially that which is to be held beyond the normal picking season, should be rigidly culled, removing even soft fruit which may be perfectly sound.

5. Prunes for storage should be picked with stems attached; should be handled as little as possible; and should go into storage immediately after packing.

6. Too much confidence should not be placed in the appearance and condition of the fruit while it is still in storage, since more deterioration may take place in three days after removal from storage than during the whole storage period.

7. For immediate shipment to eastern markets fruit picked at pressures ranging from 11.5 to 8.5 lbs. should give the best results.

8. In view of the rapid breakdown of prunes upon removal from storage to higher temperatures it seems advisable under present practices that fruit to be held for any considerable length of time (two weeks or more), and fruit picked at pressures below 9.5 lbs., be stored in close proximity to the point of consumption.

SUMMARY

1. Prune storage studies in the Boise Valley have shown that, with proper care in picking and handling, storage of the Italian prune at 32° F. can be relied upon as a satisfactory means of holding the fruit for long enough periods to equalize shipments throughout the picking season and to relieve an occasional overproduction by slightly extending the normal shipping period.

2. Sugar and acid tests proved too susceptible to error to be suitable for maturity determinations under practical field and storage conditions.

3. The pressure resistance of the fruit as determined by the modified Murneek pressure tester served as the most convenient measure of proper picking time and storage possibilities of the fruit.

4. Skin color gave some promise as a means of determining picking maturity but will probably not prove as desirable as the pressure tester.

5. The irregularity of ripening of prunes on individual trees has constituted the greatest obstacle to successful storage. The mixed lot of fruit thus picked at any one time is limited in its storage life practically to that of its few ripest specimens.

6. Prunes picked very early (above 12 lbs. pressure), hold up well in storage but do not develop prime quality. Late picking shortens storage life.

7. There was an increase in size of prunes in the 1927 season amounting to .5 per cent per day from the time they first showed solid red color until they attained their maximum size about Sept. 18. Following this there was a decrease in size.

8. Storage at 32° retards the ripening process while 3 days at room temperature following a period in storage increases the rate of ripening over that of the orchard.

9. Shriveling proved to be the most extensive type of deterioration of prunes in storage and the first to take place. Early in the storage period shriveling is proportionately greater than late in the period, when there is a greater increase in other types of breakdown.

10. A rapid deterioration of the fruit takes place upon removal from cold storage to a display window at room temperature, emphasizing the importance of early disposal of such fruit after it reaches the retail trade. The rate of breakdown following removal from storage is roughly proportional to the length of the storage period.

11. Tenative recommendations are made for the handling of prunes for storage and for fresh fruit shipment.

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