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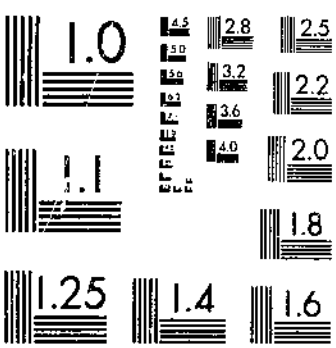
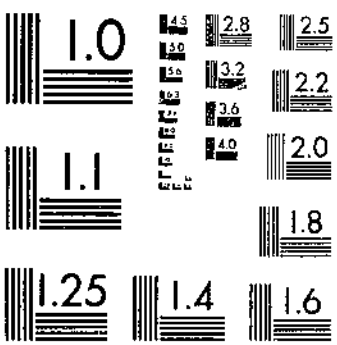


MICROCOPY RESOLUTION TEST CHART
NATIONAL BUREAU OF STANDARDS-1963-A



MICROCOPY RESOLUTION TEST CHART
NATIONAL BUREAU OF STANDARDS-1963-A

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WASHINGTON, D. C.

EFFECT OF STORAGE TEMPERATURES ON PEACHES [1]

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INTRODUCTION

Since peaches are harvested during the late summer, they may be exposed to relatively high temperatures of 80° to 90° F. or above after harvest. During transit they may be subjected to temperatures of 60° to 36°, depending on the method of refrigeration and their position in the load. Although peaches cannot be held in storage for long periods, it is often desirable that they be stored for a few weeks to extend the marketing period. It is important, therefore, to know the effect of different temperatures on the rate of ripening and on the dessert quality and composition of the fruit, and to determine the most desirable storage temperature and the maximum length of time that the fruit may be stored advantageously. The object of the investigations reported herein was to obtain information relative to these points.

MATERIAL AND METHODS

The peach-storage investigations extended over the four seasons of 1930 to 1933, inclusive, and were concerned principally with the four varieties Carman, Belle (Belle of Georgia), Elberta, and J. H. Hale. The fruit was obtained from a commercial orchard near Leesburg, Va., in 1930, 1931, and 1932, and from Arlington, Va., and College Park, Md., in 1933. The fruit was stored at the various temperatures the same day that it was picked or in some instances on the following morning.

The fruit was picked when it was considered to be shipping ripe. The date of picking and condition of the fruit when harvested are shown in table 1. The period during which pickings of a variety were

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made varied in different seasons from 6 days for Belle (August 15 to 21) to 15 days for Elberta (August 16 to 31). These variations may have been due to differences either in the time of ripening or in the maturity of the fruit at the time of picking. The data show that both factors were in part responsible, as the firmness of the varieties often varied considerably, indicating that the fruit was not of the same maturity when picked. On the other hand, the firmer lots were not always the earlier picked lots, indicating seasonal differences in the time of ripening. The dry weight, sugar, and acid content of the fruit of a variety also varied considerably between seasons, and this variation did not seem to be related to the maturity of the fruit as measured by its firmness (table 1).

TABLE 1.—*Condition of peaches at harvest*

Variety	Source	Date picked	Ground color No.	Firmness	Dry weight	Sugars		Acidity	
						Sucrose	Reducing	Total	pH
				Pounds	*Percent*	*Percent*	*Percent*	*Percent*	
Carman	Leesburg, Va	Aug. 5, 1930		9.5		6.2	4.4	0.61	
Do	do	Aug. 5, 1931		9.7		4.8	3.1	.68	3.63
Do	do	July 29, 1932		11.5	15.7	8.3	3.7	.96	3.43
Do	Arlington, Va	July 25, 1933	2.3	7.1	12.0			.80	3.48
Belle	Leesburg, Va	Aug. 19, 1930		8.4		7.3	4.3		
Do	do	Aug. 21, 1931		12.5	12.1	4.2	2.6	.55	3.69
Do	do	Aug. 15, 1932		8.4	15.9	6.6	3.5	.68	3.62
Do	College Park, Md.	Aug. 15, 1933		13.8	12.5			.66	3.73
Elberta	Leesburg, Va	Aug. 21, 1930		11.1		7.2	4.1		
Do	do	Aug. 31, 1931		5.5		4.8	3.1	.68	3.63
Do	do	Aug. 22, 1932		14.5	14.6	5.0	3.9	.77	3.51
Do	Arlington, Va	Aug. 16, 1933	3.0	12.3	11.9			.65	3.78
J. H. Hale	Leesburg, Va	Aug. 26, 1930		9.1		7.6	3.7	.78	
Do	do	Sept. 2, 1931		9.1	12.1	5.2	2.5	.59	3.58
Do	do	Aug. 26, 1932		14.3	15.9	5.1	4.4	.87	3.48
Do	College Park, Md.	Aug. 21, 1933	3.3	15.2	13.4			.83	3.56
N. J. 66–22	Arlington, Va	July 25, 1933	4.0+	9.4	12.2			.85	3.61
N. J. 127–22	do	do	4.0	10.8	12.2			.64	3.74
Hiley (shipping ripe)	do	Aug. 4, 1933	2.9	11.0	11.7			.82	3.55
Hiley (green)	do	do	2.1	11.4	11.2			.82	3.67
Slappy	do	July 28, 1933		11.4	11.0			.58	3.56
Champion (shipping ripe)	do	Aug. 7, 1933	2.4	11.6	12.4			.51	3.81
Champion (green)	do	do	1.7	13.3	11.3			.58	3.87
Early Crawford	do	Aug. 9, 1933		9.9	12.7			.92	3.62
Elberta	do	do	2.2	14.7	12.7			.67	3.78
Elberta (shipping ripe)	do	Aug. 16, 1933	3.0	12.3	11.9			.65	3.78
Elberta (green)	do	do	2.4	13.7					
Aughert (shipping ripe)	College Park, Md.	Sept. 11, 1933		12.1	12.5			.51	3.[illegible]
Aughert (firm ripe)	do	do		5.3	12.6				3.90
Late Crawford	do	Aug. 30, 1933		13.9	12.4			.70	3.57

[1] Variety may be Shippers' Late Red in 1930–32.

The ground color of the fruit at harvest was determined in 1933 by means of the apple and pear color chart (*17*).[2] Although the color shades on this chart did not correspond with those of some of the peach varieties, particularly the white-fleshed ones, it was possible to determine the approximate depth of color of most of them. Coe (*5*) has presented a color chart for peaches, but this was even less satisfactory than the apple chart.

[2] Italic numbers in parentheses refer to Literature Cited, p. 31.

In 1930 the studies were of a preliminary nature and the peaches were held at only 30° to 31° and 60° F. In 1931 and 1932 storage or ripening temperatures of 30°, 32°, 36°, 40°, 50°, 60°, 70°, and 80° were used and the rate of softening and the respiratory activity of the fruit were determined at these temperatures.

The firmness of the fruit was determined by means of the Magness and Taylor (*18*) pressure tester with a plunger five-sixteenths of an inch in diameter and with a penetration of five-sixteenths of an inch. Morris (*19*) and Coe (*5*) used similar plungers in their studies. Blake and Davidson (*2*), however, used a plunger three-sixteenths of an inch in diameter, which gave readings about 50 percent as high as with the $\frac{5}{16}$-inch plunger. Two tests were made on the pared flesh of each peach near the middle of each cheek, and 10 to 20 peaches were generally used each time.

Coe (*5*) reported pressure tests on the pared suture, at which point the fruit was generally considerably softer than on the cheeks. Blake and Davidson (*2*), on the other hand, found the suture to be only slightly softer than other parts of the fruit and recommended that 12 tests be made on each peach, at the suture, opposite the suture (dorsal side), on each cheek in the middle of the fruit, and also at the apex and bottom of the fruit. They also recommended that the tests be made on the unpared surface. Because of these differences in the methods of determining firmness, it is not generally possible to make direct comparisons between the firmness of the fruit as reported by the various investigators. The desirability of a uniform method of testing the firmness of peaches is obvious. Since a $\frac{5}{16}$-inch diameter plunger was the first to be used on peaches (*16*) and has been more commonly used and gives equally satisfactory results (*2*), its general adoption would seem desirable. It would also seem desirable to test the fruit at more than 1 point but hardly necessary to make as many as 12 tests on each fruit. The differences between the tests at the apex and at the bottom as reported by Blake and Davidson (*2*) were not consistent, and the tests around the middle were generally intermediate between those at the bottom and at the apex. The results of Blake and Davidson do not indicate that the average of the 2 cheeks at the middle varies significantly from the average of all 12 tests. Since this was the original method used (*16*), and as there does not appear to be any good reason for changing, its adoption as a standard method seems desirable.

The respiratory activity was determined on duplicate lots by means of the apparatus described by Haller and Rose (*12*).

For sugar determinations, longitudinal segments were cut from the sides of at least 20 peaches. These were ground in a food chopper and thoroughly mixed, and 50 gm. of the material was weighed out and extracted with approximately 80-percent alcohol by means of a Soxhlet extraction apparatus. The extract was made to volume and the sugars were determined in an aliquot of this by the Munson-Walker-Bertrand method.

Dry weights were obtained by drying the residue after extraction and by drying an aliquot of the extract to constant weight under vacuum at 70° F. Total dry weight was obtained by combining the dry weight of the residue with that of the extract.

The juice of the peach flesh was expressed through canvas by means of a hydraulic press, and the pH value determined with a saturated

calomel half-cell and a quinhydrone electrode. The total or titratable acidity was determined by titration of an aliquot of a water extract of the tissue to an end point corresponding to pH 7.0 as determined with the above apparatus. The percentage of acidity was calculated on the basis of the acid being 50 percent malic and 50 percent citric, as reported by Nelson (*20*).

At temperatures of 50°, 60°, 70°, and 80° F. the fruit was held continuously until ripe, and the composition was determined at this time. The fruit did not ripen at temperatures of 40°, 36°, 32°, and 30°, but lots were transferred to 70° at weekly intervals for ripening, and the composition was determined at the time of transfer and after the fruit had become ripe.

In 1933 additional varieties were used. Holding temperatures of 32°, 40°, and 70° F. only were used, except in a few instances where a temperature of 50° was used. The softening rates and respiratory activity at the different temperatures were not determined.

PRESENTATION OF RESULTS

Preliminary reports of certain phases of this work have been made (*10, 13, 14*).

RELATION OF FIRMNESS AT HARVEST TO PICKING MATURITY

The peaches varied considerably in firmness, and it was possible to obtain lots representing two or more stages of maturity at a single picking, as was done with certain varieties in 1933 (table 1). Fruit of different maturities was separated by color; the less mature lots generally were considerably firmer.

The average pressure test of the Elberta lots ranged from 11.1 to 14 pounds (table 1), except for the 1931 picking, which tested only 5.5 pounds. This lot had many ripe fruits and was too soft for desirable storage or shipping quality. The early picking in 1933, which was firmest, ripened with fair quality. These results indicate that Elberta peaches should be picked with an average pressure test between 11.0 and 14.5 pounds. Magness and Allen (*16*) recommended that Elbertas be picked at a pressure test between 12 and 16 pounds for shipment from California, and Coe (*5*) recommended 12 to 18 pounds for Utah conditions. On the other hand, Blake and Davidson (*2*) considered that firmer peaches were necessary under the more humid conditions of New Jersey and recommended 15 to 17 pounds for nearby shipment and 17 to 20 pounds for long-distance shipment. It seems likely that the fruit would tend to be softer at the same maturity under humid than under dry conditions and therefore should be picked somewhat softer in order to ripen with satisfactory dessert quality. The results reported herein for Virginia conditions indicate that the recommendations of Blake and Davidson were too high.

Although the J. H. Hale peaches were picked in 1930 and 1931 at average pressure tests of only 9.1 pounds (table 1), these lots had some peaches that were somewhat ripe and not firm enough for best shipping conditions. From these results it seems likely that satisfactory shipping and dessert quality would be obtained by picking this variety at pressure tests between 11 and 16 pounds. This agrees well with the recommendations of Coe (*5*) that they be picked at pressure tests between 12 and 17 pounds.

Belle peaches were picked with an average pressure test of 8.4 pounds in 1930 and 1932 (table 1). These lots, however, contained many soft fruits, and the pressure tests of 12.5 and 13.8 pounds in 1931 and 1933 represented more satisfactory shipping conditions.

Carman peaches were picked with an average pressure test of 7.1 pounds in 1933 (table 1), but this lot also contained many peaches that were too soft for satisfactory shipping. The results indicate that pressure tests of 9.0 to 12.0 pounds at harvest would give satisfactory shipping and dessert quality.

The pressure tests of certain other varieties are given in table 1 for the 1933 season. The results are fairly uniform for the different varieties and indicate that for many eastern-grown varieties a pressure test of 10 to 14 pounds at harvest represents a condition of the fruit at which it ripens with good dessert quality and would hold up well for shipping.

RELATION OF TEMPERATURE TO SOFTENING

The rate of softening at the different temperatures of the varieties used in 1931 and 1932 is presented in figures 1 and 2.

The peaches generally tested about 2 pounds or less when fully ripe and were in prime eating condition. The curves show that softening at 70° and 80° F. was very rapid and at about the same rate. At these temperatures the fruit became fully ripe and soft in 1 to 3 days, depending on the firmness at the time of picking. In 1932 Elberta required a longer time (about 5 days) to ripen. Even at 60° softening was very rapid, and in 3 to 6 days the fruit softened to a pressure test of 2 pounds or less. At 50° the softening was considerably slower and at least 6 to 10 days elapsed before the fruit reached good condition for eating. At 40° softening was greatly retarded and in only three lots did the fruit soften to 2 pounds or less after 3 weeks' storage. In 1931 Belle showed very little softening after storage for 24 days at 40°, and in 1931 and 1932 all varieties failed to ripen at this temperature before internal break-down became serious. At 36°, 32°, and 30° there was practically no softening, and frequently the fruit was significantly more firm at some of the inspections than at time of harvest. The daily rate of softening is shown in table 2.

TABLE 2. *Daily rate of softening of peaches at various temperatures*

Variety	Year	Daily rate of softening at—							
		80° F.	70° F.	60° F.	50° F.	40° F.	36° F.	32° F.	30° F.
		Pounds	*Pounds*	*Pounds*	*Pounds*	*Pound*	*Pound*	*Pounds*	*Pound*
Carman	1931	4.1	3.0	1.9	1.2	0.05	0.06	1.30	0.50
Do	1932	3.7	2.8	1.9	1.1	.40	.14	.07	.04
Belle	1931	5.3	5.3	2.0	1.2	.06	.10	.02	
Do	1932	6.2	4.1	1.9	1.7	.55	.10	.02	
Elberta	1931	2.5	2.0	1.1	.5	.20	.05	.01	.05
Do	1932	2.1	2.2	1.8	.9	.52	.17	−.05	−.02
J. H. Hale	1931	3.7	3.7	3.3	1.3	.38	.26	.11	.06
Do	1932	4.1	4.2	2.3	.9	.56	.20	.01	−.04
Average		4.0	3.4	2.0	1.1	.34	.14	.19	.20

Morris (*19*) determined the rate of softening of Elberta peaches at 60°, 50°, 40°, and 32° F. His results approximate those shown herein, except that he found somewhat more softening at 32°.

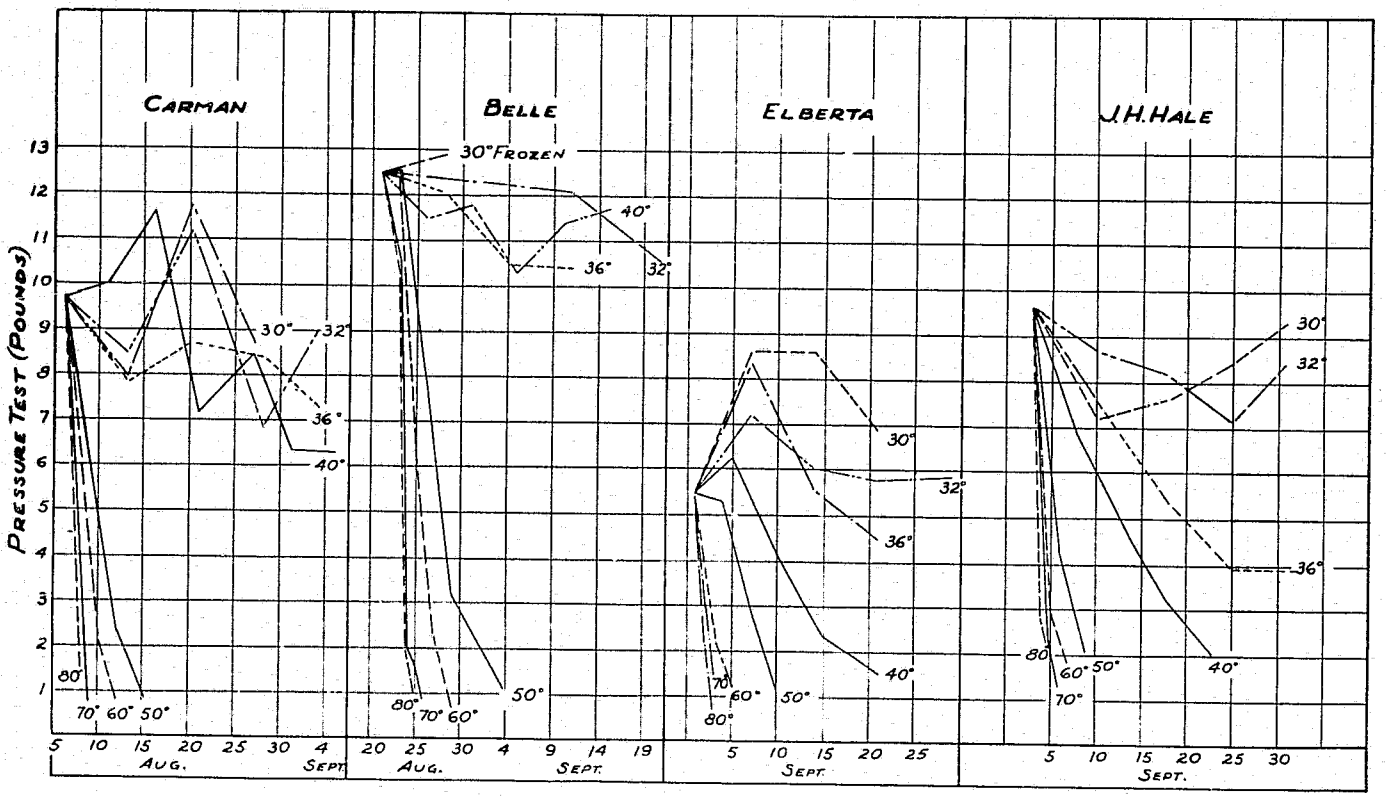

FIGURE 1.—Firmness of peaches in storage at various temperatures, 1931.

RELATION OF TEMPERATURE TO RESPIRATORY ACTIVITY

The respiratory rates, as shown by the carbon dioxide evolved, at the different temperatures, are shown in figure 3 for 1931 and in figure 4 for 1932. The rates were consistently higher in 1932 than in 1931. The average at all temperatures was 34 percent higher in 1932 than in 1931 for Carman, and 37, 14, and 23 percent higher for Belle, Elberta, and J. H. Hale, respectively. The higher respiratory rates in 1932 were associated with higher concentrations of sugars and acids (table 1) and with higher dry weights in Belle and J. H. Hale. Dry weights of Carman and Elberta at harvest were not determined in 1931, but the lower sugar and acid content would indicate a lower

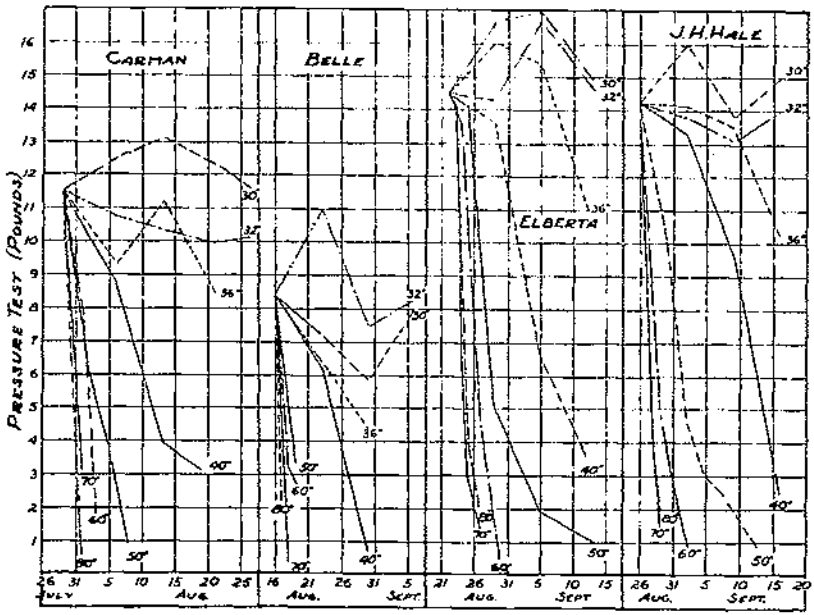

FIGURE 2. Firmness of peaches in storage at various temperatures, 1932.

dry weight for them also. Thus the lower respiratory activity in 1931 was apparently due to a dilution of the substrate, and probably no significant difference would be apparent on a dry-weight basis. A similar relation has been reported for strawberries (*11*).

In both years the Carman peaches respired considerably more rapidly than fruit of the other varieties, with no consistent or marked differences among the other varieties.

The rate of production of carbon dioxide per kilogram of fresh weight per hour varied from 3.8 to 6.2 mg. at 32° F. and from 81.5 to 141.2 mg. at 80°. In 1930 the respiratory rates were determined at 30° and 60° only. The rate at 30° in 1930 varied from 4.3 to 4.8 mg., which was somewhat lower than the rates at 32° in 1932 but generally higher than those in 1931. Although direct comparisons cannot be made, these results indicate somewhat lower respiratory rates at 30° than at 32°. The rates at 60° in 1930 were intermediate between those in 1931 and 1932.

The curves (figs. 3 and 4) show a rather rapid increase in respiratory activity with increased temperature. These results are in general agreement with those of Gore (*8*) but cover a wider range of temperatures. This change in rate may be expressed as Van't Hoff's temperature coefficient (Q_{10}) or the number of times the rate of activity is changed by each 10° C. (18° F.) increase in temperature. These temperature coefficients are given in table 3. A coefficient of 1.5 is considered typical of a physical reaction, whereas one of 2 to 3 or more at low temperatures is typical of a chemical reaction. The temperature coefficients of the respiratory rates of the peaches were

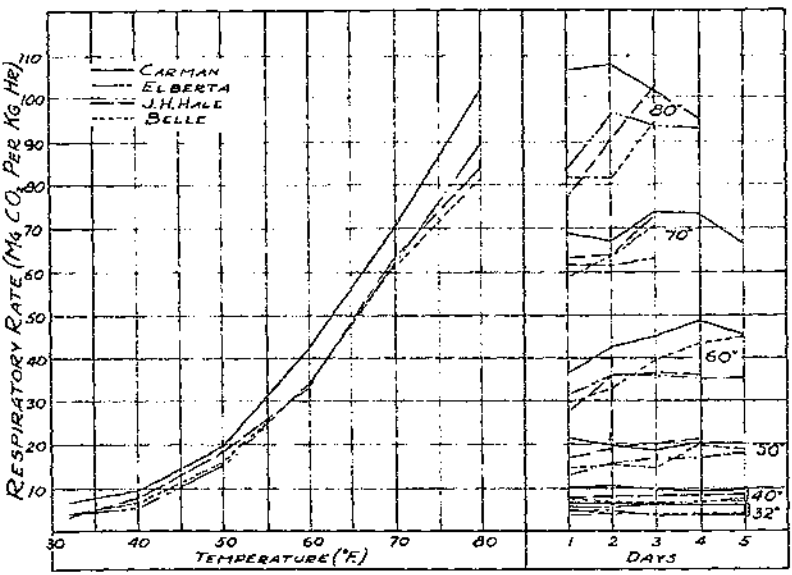

FIGURE 3.—Respiration of peaches in relation to temperature, 1931.

greater than 3 at the low temperatures and averaged slightly more than 4 between 32° and 50° F. but were only slightly greater than 2 at the higher temperatures, 62° to 80°.

TABLE 3. *Temperature coefficients (Q_{10}) of peach respiration*

Temperature range		Carman		Belle		Elberta		J. H. Hale		Average
°C.	°F.	1931	1932	1931	1932	1931	1932	19	1932	
0 to 10.0	32 to 50	3.05	5.00	3.85	4.05	4.10	3.92	4.80	4.30	4.13
5.6 to 15.6	42 to 60	3.80	3.25	4.00	3.48	4.05	3.20	3.20	3.48	3.56
11.1 to 21.1	52 to 70	2.95	3.01	3.05	3.20	3.15	3.05	3.00	3.38	3.11
16.7 to 26.7	62 to 80	2.10	2.37	2.05	2.23	2.25	1.96	2.15	2.37	2.18

As pointed out previously (*10*), the respiratory activity of peaches increased more rapidly with temperature increases than did the respiratory activity of some other fruits. Thus, with peaches, the respiratory rate at 70° F. ranged from 11.4 to 17.5 and averaged 15.4

times as great as at 32°, whereas with strawberries, oranges, lemons, and grapefruit the rate at 70° was only 7 to 8 times that at 32°. With apples (*17*) the rate at 70° was about 10 times that at 32°, and with Concord grapes (*15*) about 12 times.

Insofar as the rate of respiration indicates the rate at which the fruit deteriorates or ripens, these results emphasize the importance of prompt cooling after picking and indicate that cooling may be

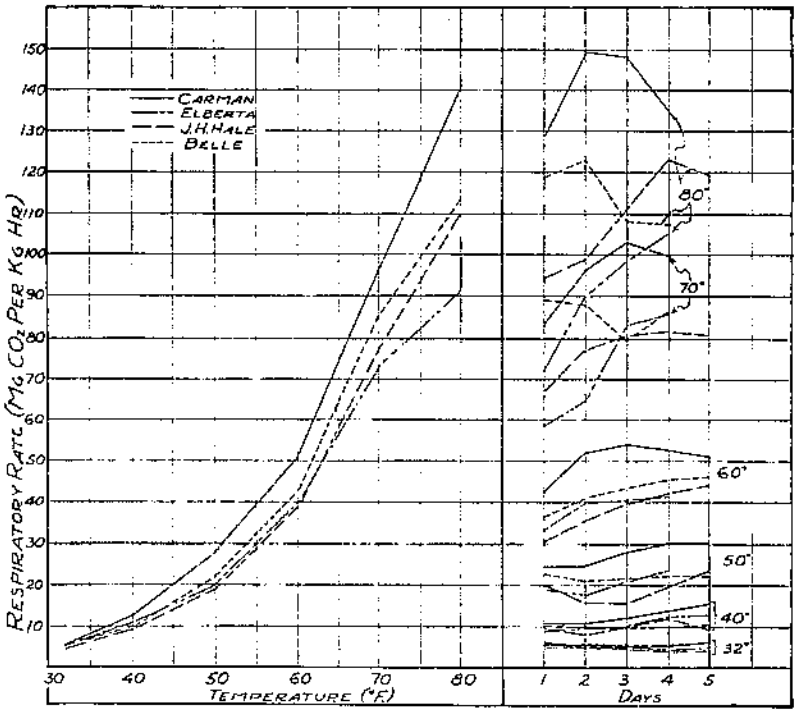

FIGURE 4.—Respiration of peaches in relation to temperature, 1932.

more important for peaches than for many other fruits. Thus, on the basis of respiratory activity, 1 day at 70° to 80° F. would be equivalent in the life of the fruit to about 2 days at 60°, 4 at 50°, 8 at 40°, or 16 days at 32° to 30°.

Theoretically the respiratory ratios (CO_2/O_2) may indicate the type of material respired, as the complete oxidation of a hexose sugar gives a ratio of 1.00 and the complete oxidation of malic or citric acid gives a ratio of 1.33. The ratios of the peaches at the different temperatures are given in table 4. There was no consistent difference in the ratio at the different temperatures or among the different varieties. The average ratio for all varieties and temperatures was 1.10, indicating that both sugars and acids were oxidized in the respiration, with somewhat more sugar than acid being respired. The analysis of the fruit, on the other hand, indicates a relatively greater loss of acid at 50°, 40°, and 36° F. than at the other temperatures.

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TABLE 4.—*Respiratory ratios (CO_2/O_2) of peaches at different temperatures*

Temperature (° F.)	Carman		Belle		Elberta		J. H. Hale		Average
	1931	1932	1931	1932	1931	1932	1931	1932	
32	0.87	1.10	0.96	1.10	1.20	1.17	1.08	------	1.05
40	1.00	[1] 1.10	1.06	[1] 1.12	1.23	[1] 1.10	1.11	------	1.10
50	1.03	1.11	[1] 1.16	[1] 1.08	1.18	[1] 1.14	1.31	1.15	1.13
60	.97	1.14	1.01	1.10	1.15	[1] 1.14	1.16	1.25	1.12
70	1.01	1.14	1.07	1.07	1.18	1.08	1.11	1.08	1.09
80	.94	1.12	1.14	1.09	[1] 1.31	1.07	1.16	1.13	1.12
Average									1.10

[1] Single determinations. All others average of duplicates. In some determinations an air leak in the respiratory apparatus resulted in excessively high ratios. Such results were discarded and only the single determinations used in these instances.

RELATION OF TEMPERATURE TO COMPOSITION

The dry weight, sugars, and total and active acidity of the peaches when stored and after ripening at temperatures of 50° to 80° F. are shown in figures 5 to 12. At 30° to 40° the peaches did not ripen, and the composition of this fruit was determined after 20 to 26 days at these temperatures and also after they were ripened at 70° after this length of time at the low temperatures. These results also are presented in figures 5 to 12.

PERCENTAGE OF DRY WEIGHT

The results do not indicate any consistent relation between the percentage of dry weight of the fruit and the temperature at which it was held or ripened. Belle had the highest dry weight at 50° F. in 1931, whereas in 1932 it was lowest at 50°. Elberta had a very high dry weight at 80° in 1932; the other varieties did not (figs. 9 to 12).

It will be noted that in some instances the percentage of dry weight increased during storage over that at harvest, whereas in other instances there was a decrease. Whether the percentage of dry weight increases or decreases during storage depends on the relative rate of moisture loss by transpiration and the rate of carbon loss by respiration.

SUGARS

In general the sugars follow the same trend as the percentage of dry weight. They tend to increase or decrease depending on the relative rate of transpiration and respiration.

ACIDITY

There was no consistent difference in the titratable acidity when the peaches were ripened at 80°, 70°, and 60° F. The acidity was generally considerably lower in peaches ripened at 50° than in those ripened at the higher temperatures; even lower acidity was obtained after 20 to 26 days at both 40° and 36°, although the fruit at these temperatures was not ripe. After 20 to 26 days at both 32° and 30° the acidity concentration was much greater than at 36° and 40° and averaged slightly higher than at 50°. When the peaches from the temperatures of 40° to 32° were ripened at 70° there was a further marked decrease in titratable acidity. The hydrogen-ion concentration showed a trend similar to that of the titratable acidity. These

acidity changes are of particular significance, since the peaches failed to ripen with good dessert quality at 50° and were generally mealy or developed internal break-down when ripened at 70° after 2 to 3 weeks' exposure to 40° and 36°. Although break-down occurred in

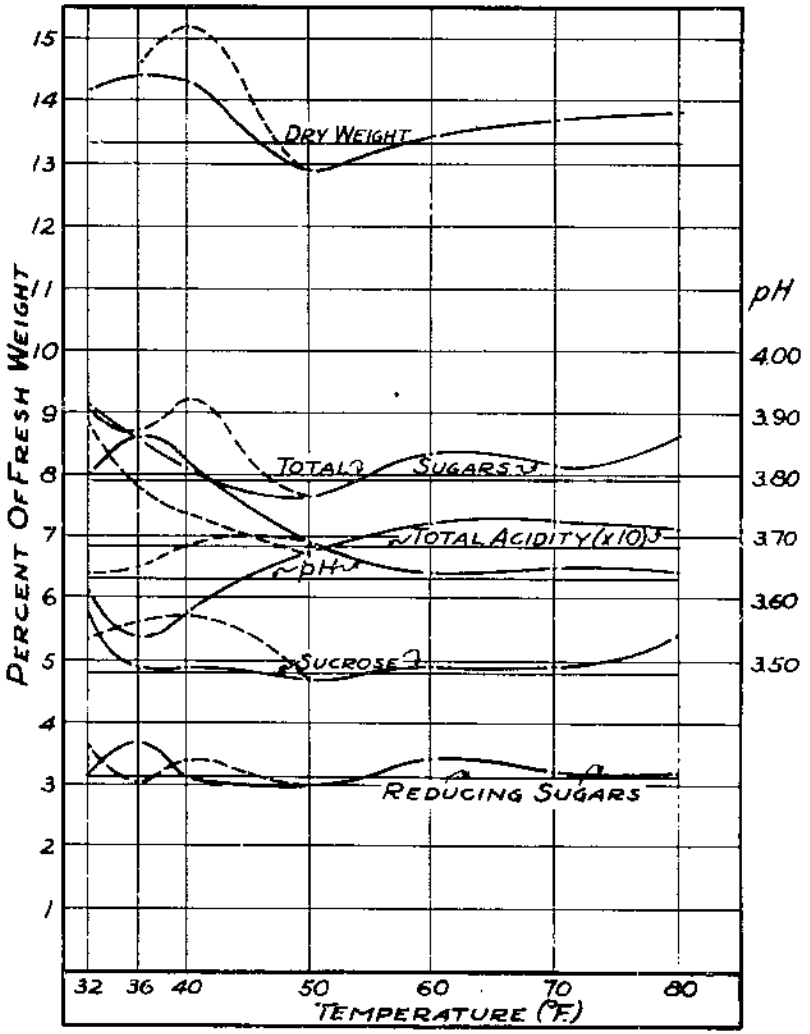

FIGURE 5.—Composition of Carman peaches when ripened at various temperatures, 1931. Straight lines represent composition when stored. Fruit held at various temperatures as follows: 80° F. for 3 days, 70° for 4 days, 60° for 8 days, 50° for 10 days, 40° for 21 days (broken lines) and 4 days at 70° (solid lines), 36° and 32° for 22 days (broken lines) and 3 days at 70° (solid lines).

peaches held at 32°, it was much less severe and developed later than at 36° and 40°. Thus, the relatively large loss of total and active acidity at 36° to 50° was associated with a greater susceptibility of the fruit to break-down at 36° and 40° and the development of poor

dessert quality at 50°. Apparently the metabolic balance was upset at the intermediate temperatures of 36° to 50° and resulted in abnormal ripening.

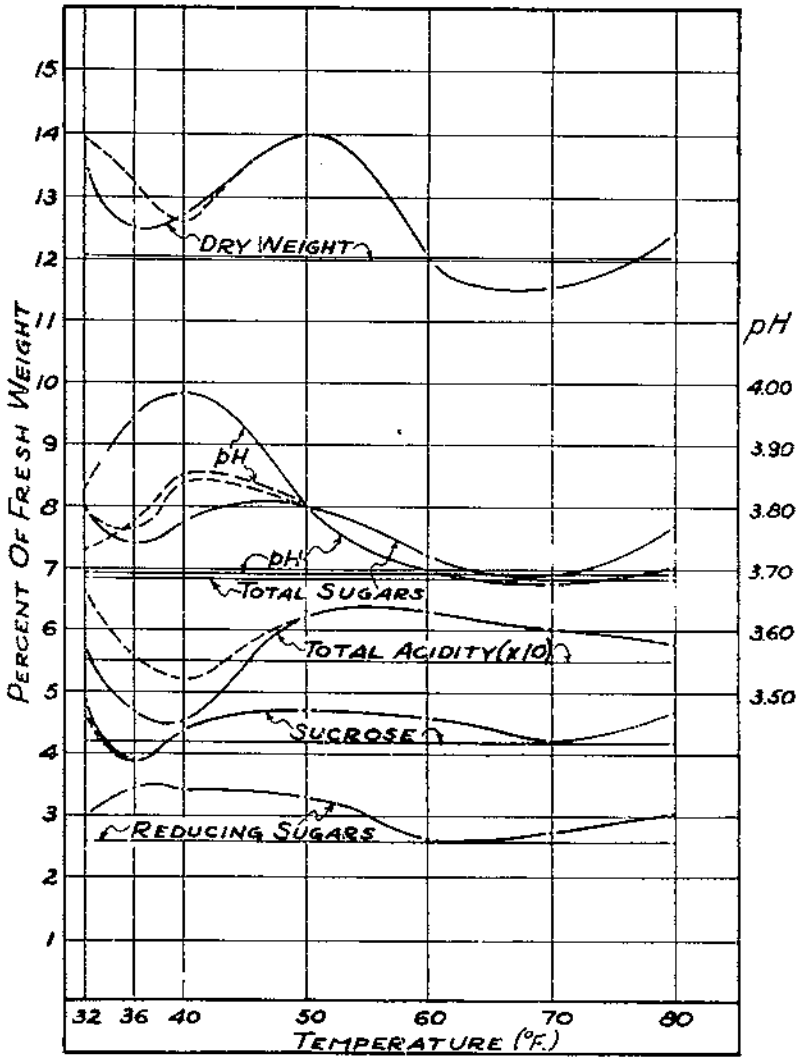

FIGURE 6.—Composition of Belle peaches when ripened at various temperatures, 1931. Straight lines represent composition at harvest. Fruit held at various temperatures as follows: 80° F. for 3 days, 70° for 4 days, 60° for 7 days, 50° for 17 days, 40°, 36°, and 32° for 25 days (broken lines) and 4 days at 70° (solid lines).

PECTIN CHANGES DURING RIPENING

In 1933 the soluble pectin in the expressed juice was determined when the peaches were harvested and after ripening at 70° F. and in some instances at 50°. The pectin was precipitated from 100 ml. of expressed juice by making up to 500-ml. volume with alcohol and filtering. The precipitate was dissolved with hot water and saponified

with sodium hydroxide. After standing, the solution was acidified with acetic acid and the pectin precipitated with a calcium chloride solution. The calcium pectate was filtered, washed, and weighed according to the method previously described (*9*). With apples, Haller (*9*) reported that the pectin in 100 ml. of expressed juice approximated

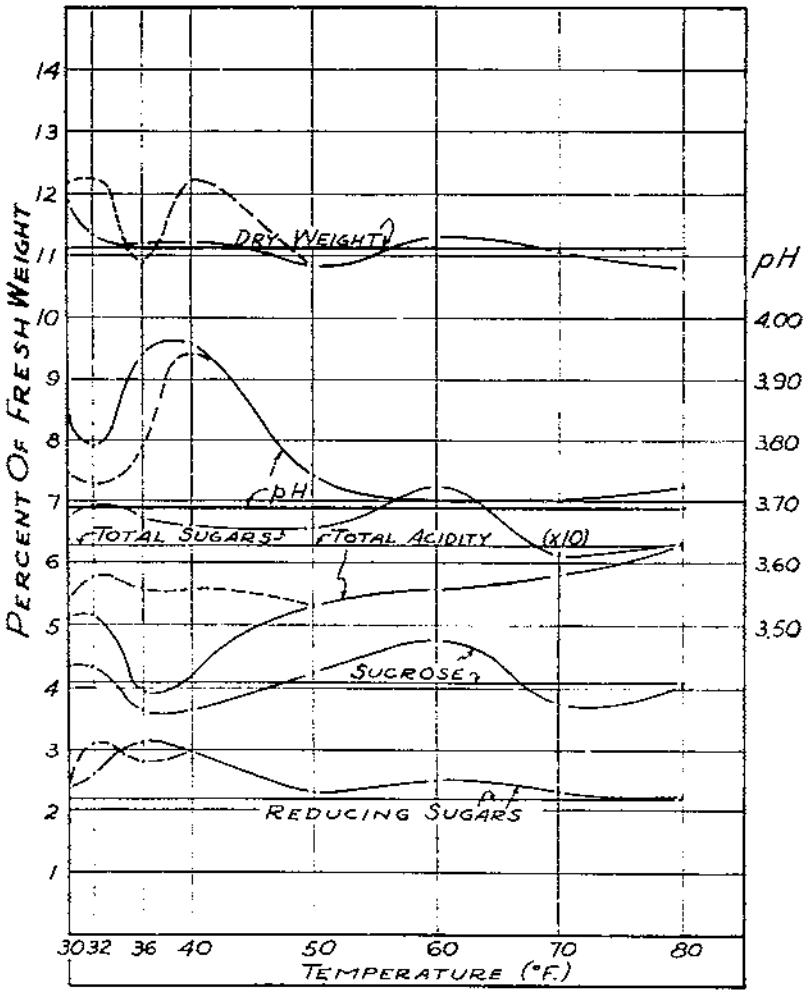

FIGURE 7.- Composition of Elberta peaches when ripened at various temperatures, 1931. Straight lines represent composition when stored. Fruit held at various temperatures as follows: 80° and 70° F. for 3 days, 60° for 4 days, 50° for 10 days, 40° and 36° for 22 days (broken lines) and 2 days at 70°, 32° for 23 days (broken lines) and 2 days at 70° (solid lines) and 30° for 23 days (broken lines) and 3 days at 70° (solid lines).

that extracted from 100 gm. of fresh tissue, and it seemed likely that this relation might also obtain with peaches. The amounts obtained (table 5), however, are of a considerably lower order of magnitude than those extracted from the tissue by Appleman and Conrad (*1*) and by Nightingale, Addoms, and Blake (*21*). The results indicate

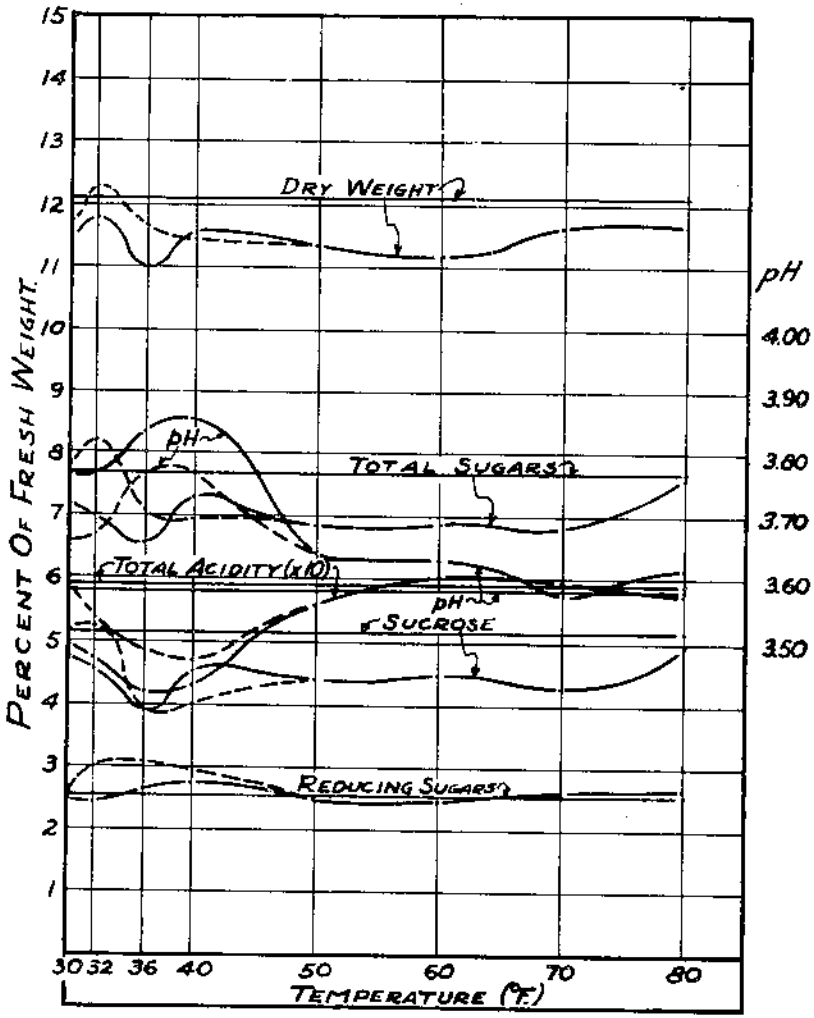

FIGURE 8.—Composition of J. H. Hale peaches when ripened at various temperatures, 1931. Straight lines represent composition when stored. Fruit held at various temperatures as follows: 80° F. for 2 days, 70° for 3 days, 60° for 5 days, 50° for 8 days, 40° for 26 days (broken lines) and 2 days at 76° (solid lines), 30° and 32° for 26 days (broken lines) and 3 days at 70° (solid lines) and 30° for 26 days (broken lines) and 3 days at 70° (solid lines).

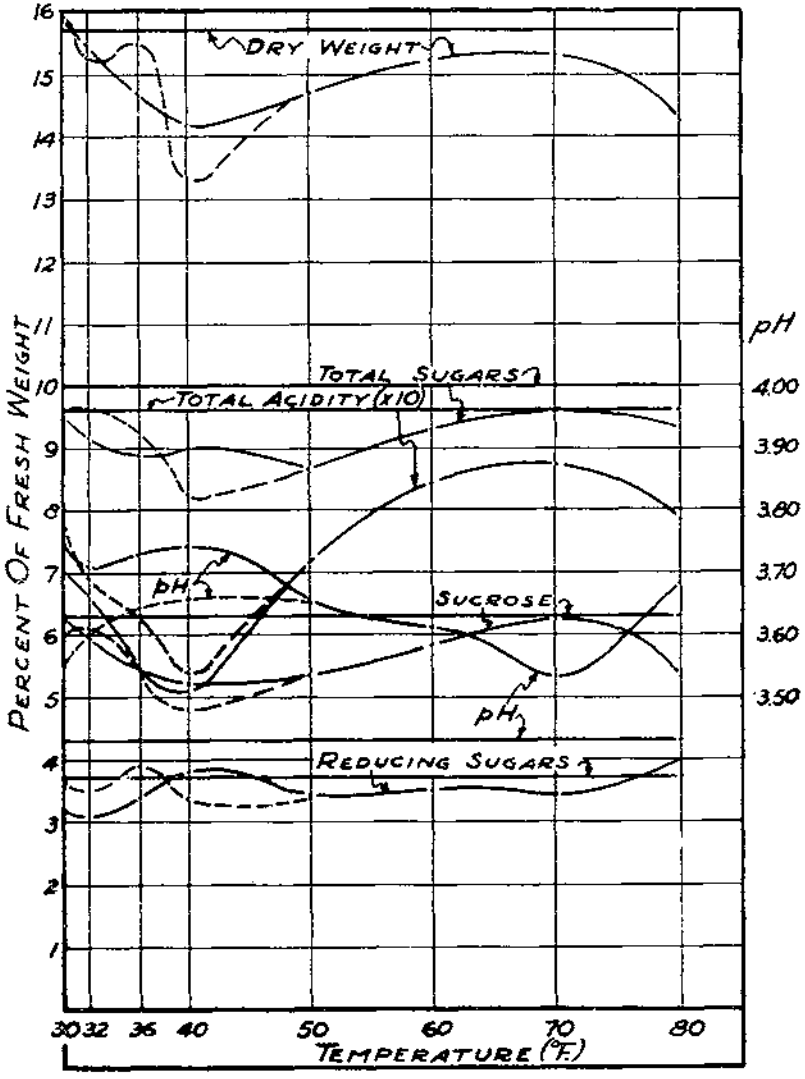

FIGURE 9.—Composition of Carman peaches when ripened at various temperatures, 1932. Straight lines represent composition when stored. Fruit held at various temperatures as follows: 80° and 70° F. for 4 days, 60° for 9 days, 50° for 17 days, and 40° for 20 days, 36°, 32°, and 30° for 22 days (broken lines) and 3 days at 70° (solid lines).

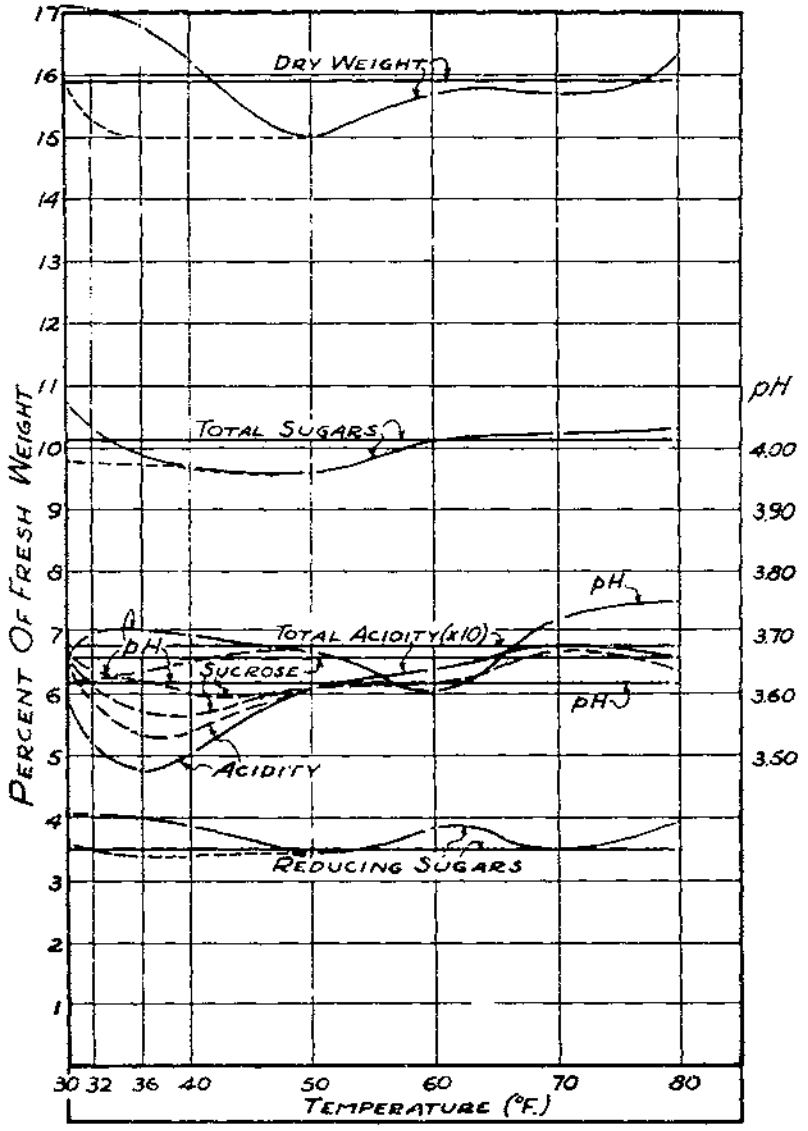

FIGURE 10.—Composition of Belle peaches when ripened at various temperatures, 1932. Straight lines represent composition when stored. Fruit held at various temperatures as follows: 80° F. for 3 days, 70° for 4 days, 60° for 7 days, 50° for 14 days, 32° and 30° for 2½ days (broken lines) and 2 days at 70° (solid lines).

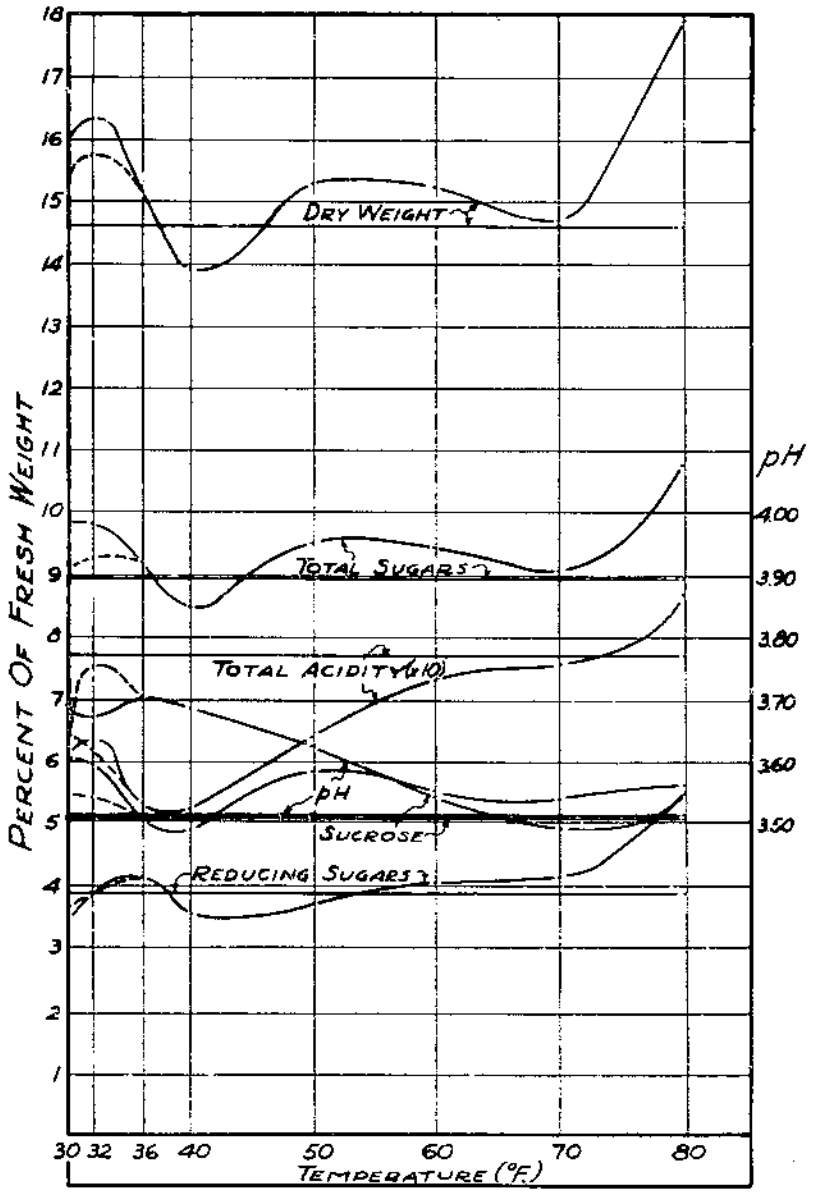

FIGURE 11.— Composition of Elberta peaches when ripened at various temperatures, 1932. Straight lines represent composition when stored. Fruit held at various temperatures as follows: 80° F. for 7 days, 70° for 8 days, 60° for 12 days, 50° for 22 days, 40° and 36° for 21 days, 32° and 30° for 22 days (broken lines) and 4 days at 70° (solid lines).

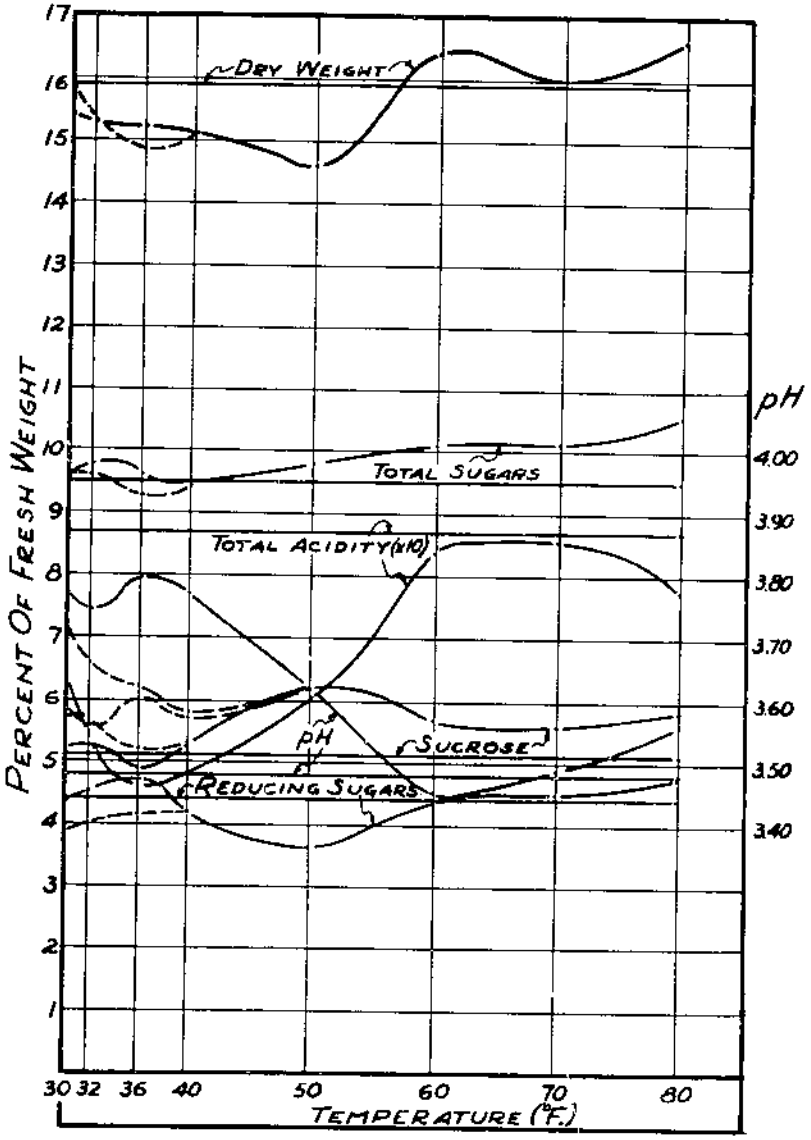

FIGURE 12.- Composition of J. H. Hale peaches when ripened at various temperatures, 1932. Straight lines represent composition when stored. Fruit held at various temperatures as follows: 80° and 70° for 5 days, 60° for 8 days, 50° for 18 days, 40° for 21 days, 36° for 21 days (broken lines) and 3 days at 70° (solid lines), 32° for 21 days (broken lines) and 6 days at 70° (solid lines) and 30° for 20 days (broken lines) and 7 days at 70° (solid lines).

relatively low concentrations of pectin in green or shipping-ripe peaches in which the average pressure test ranged from 7.1 to 15.2 pounds. When ripened at either 70° or 50° the soluble pectin had greatly increased and averaged over three times as much as at harvest. This relationship is in agreement with that found by Appleman and Conrad (*1*).

TABLE 5.—*Firmness and pectin content of peaches at harvest when ripened at 70° and 50° F., 1933*

[Pectin expressed as milligrams of calcium pectate per 100 ml. of juice]

Variety	Pressure test at harvest		Pectin at harvest		Pectin when ripened at temperature and for number of days shown in parentheses	
	Green	Shipping ripe	Green	Shipping ripe	70° F.	50° F.
	Pounds	*Pounds*	*Milligrams*	*Milligrams*	*Milligrams*	*Milligrams*
Carman		7.1		52.4	(5) 271.8	
New Jersey 66–22		9.4		42.0	(5) 166.3	(16) 189.2
New Jersey 127–22		10.8		26.5	(5) 232.2	
Hiley	11.4	11.0	43.8	54.3	(6) 297.8	
Slappey		11.4		52.0	(5) 179.2	
Champion	13.3	11.6	34.0	51.0	(3) 111.0	
Early Crawford		9.9		47.4		
Belle		13.8		102.5	(7) 272.9	(21) 303.0
Elberta	14.7			40.0		
Do		12.3		171.2	(12) 131.0	(19) 155.6
J. H. Hale		15.2		35.2	(4) 155.1	(15) 144.3
Augbert (Roberta)	[1] 5.3	12.1	[1] 219.6	108.9	(3) [1] 242.4	
Late Crawford		13.9		80.3	(6) 341.0	
Average				68.6	218.2	1,990

[1] Firm ripe fruit.

CATALASE ACTIVITY

The catalase activity of Elberta and J. H. Hale peaches was determined in 1933 during storage at 32° and 40° F. and when ripened at 70°. The results are shown in figure 13. The catalase activity is expressed as the total milliliters of oxygen evolved in 20 minutes. The curves for the two varieties are similar. The catalase activity at harvest was 7.1 and 5.8 ml. of oxygen for Elberta and J. H. Hale, respectively. It increased slightly with immediate ripening at 70°. At 32° and 40° there was little or no change during the first week, but there was a marked increase during the second week, particularly at 40°. After 2 to 5 weeks in storage the activity was considerably higher at 40° than at 32°. After the second week the activity at 32° gradually decreased, and by the fifth week it was as low as or slightly lower than at harvest, whereas at 40° it was still considerably above the activity at harvest. There was no apparent relation between catalase activity and development of internal break-down. Break-down was not associated with low catalase activity, as the activity was low at harvest, at which time the fruit ripened normally at 70°. Neither was it associated with high activity, as the maximum was attained generally after 2 weeks at 40° and 32°, yet the fruit ripened without break-down at this time.

RELATION OF TEMPERATURE TO STORAGE QUALITY

The condition of the fruit after storage is shown in tables 6 to 9. The amount of decay that develops on peaches after harvest may

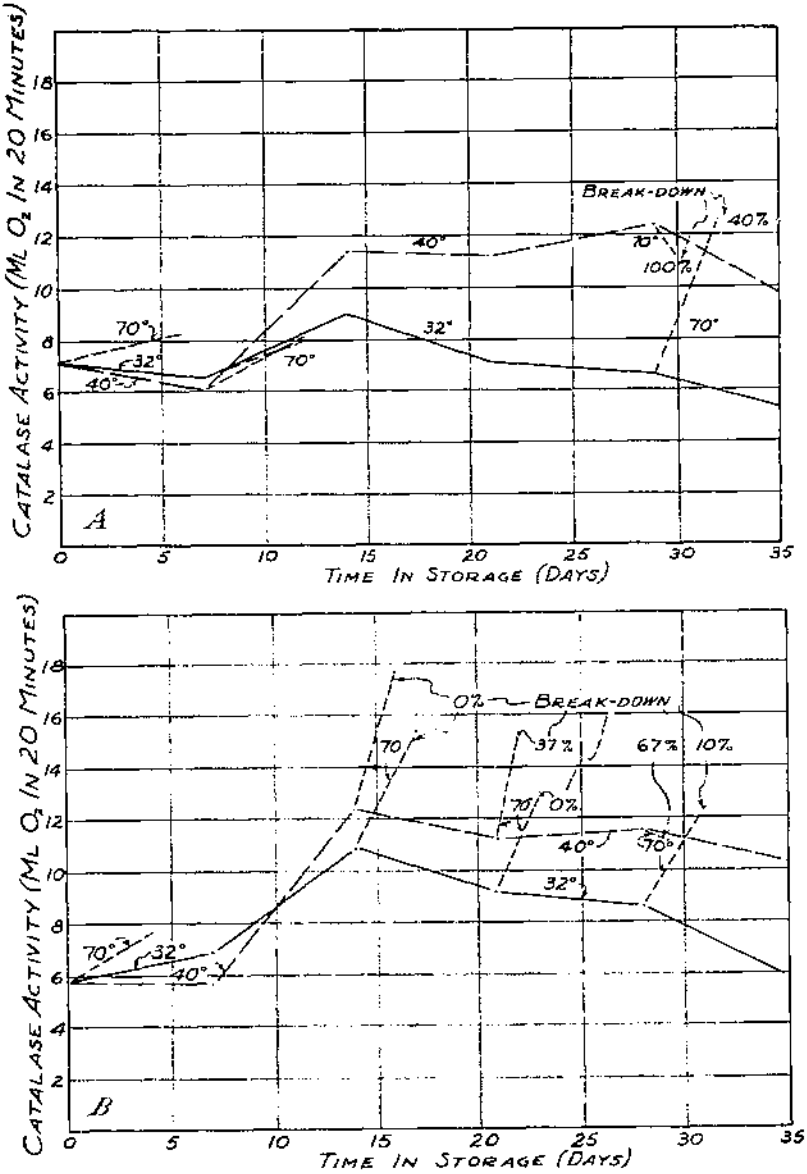

FIGURE 13.—Catalase activity of (*A*) Elberta and (*B*) J. H. Hale peaches in storage at 32° and 40° F. and ripened at 70°, 1933.

vary greatly, depending on weather conditions during the growing and harvest season. In 1931 and 1933 (tables 7 and 9) considerable decay (primarily brown rot) developed on the fruit, whereas in 1930 and 1932 (tables 6 and 8) relatively little decay was present. On the

other hand, the fruit was considerably more susceptible to internal break-down in 1932 than in 1931 (tables 7 and 8).

TABLE 6.— *Effect of storage time and temperature on ripening and quality of peaches, 1930*

Variety	Storage		Days at 70° F.	Sound	Decay	Soft or bruised	Shriveling	Condition and dessert quality [1]
	Temperature	Days						
	°F.			*Percent*	*Percent*	*Percent*		
Carman	70		4	84	8	8	None	Full ripe; very good.
	30 to 31	7	5	88	4	8	do	Full ripe; good to very good.
		14	5	88	0	12	do	Do.
		21	5	91	1	8	do	Full ripe; good.
Belle	70		6	66	28	6	do	Full ripe; good to very good.
	30 to 31	7	6	79	14	7	do	Full ripe; good to slightly sour.
		14	6	82	13	5	do	Do.
		21	6	79	18	3	Slight	Full ripe; fairly good to good.
Elberta	70		5	99	1	0	None	Ripe to slightly green; good to slightly bitter.
	30 to 31	7	4	97	0	3	do	Full ripe; good to slightly bitter.
		14	4	96	0	4	do	Full ripe, good.
		21	4	97	0	3	do	Do.
		28	4	98	1	1	Very slight	Good.
J. H. Hale	70		6	98	2	0	None	Full ripe; very good.
	30 to 31	7	6	94	6	0	do	Do.
		14	6	98	2	0	do	Do.
		21	5	93	7	0	Slight	Full ripe; good.
		28	5	96	4	0	do	Slightly overripe, good.

[1] No break-down was found in any lot.

TABLE 7. *Effect of storage time and temperature on ripening and quality of peaches, 1931*

Variety	Storage		Days at 70° F.	Sound	Decay	Break-down	Shriveling	Soft	Dessert quality
	Temperature	Days							
	°F.			*Percent*	*Percent*	*Percent*	*Percent*	*Percent*	
Carman	80	7		68	10	0	22	0	Fairly good; bitter.
	70	7		52	37	0	11	0	Very good.
	60	11		81	8	0	0	11	Do.
	50	14		76	14	0	0	10	Good; flat.
	40	14	4	76	14	0	0	10	Do.
	36	14	4	81	13	0	0	6	Good; slightly bitter.
	32	14	4	67	33	0	0	0	Very good.
	30	14	4	48	34	18	0	0	Good; slightly bitter.
	40	21	4	77	20	(2)	0	3	Fair to poor.
	36	21	3	59	10	(3)	(3)	1	Fair.
	32	21	3	87	9		(3)	4	Good to very good.
	80	5		33	67	0	0	0	Fair; slightly bitter.
	70	5		45	55	0	0	0	Good to very good.
	60	8		75	25	0	(2)	0	Good to very good; slightly bitter.
Belle	50	17		47	53	0	(4)	0	Very poor; sour, off flavor
	40	14	2	69	31	(4)			Poor; mealy; flat.
	36	14	3	42	57		(6)	1	Fair to poor; slightly mealy; flat.
	32	14	3	60	40	0	(6)	0	Fair to good; sour.
	30	14	3	0	100				
	32	21	3	46	54				Fair to poor.
Elberta	80	3		93	7	0	0	0	Good to fair; slightly sour and bitter.
	70	3		96	4	0	0	0	Do.
	60	4		100	0	0	0	0	Do.
	50	10		96	3	0	0	1	Good to fair; sour and bitter.
	50	17		89	10	0	0	1	Poor to fair; sour, off flavor.

See footnotes at end of table.

TABLE 7.—*Effect of storage time and temperature on ripening and quality of peaches, 1931*—Continued

Variety	Storage temperature	Storage days	Days at 70° F.	Sound	Decay	Breakdown	Shriveling	Soft	Dessert quality
	°F.			Percent	Percent	Percent	Percent	Percent	
Elberta	40	15	0	60	40	0	(5)	0	Poor; sour and bitter.
	36	15	5	70	30	0	(6)	0	Do.
	32	15	5	72	25	0	(6)	3	Fair; lacking flavor.
	30	15	5	53	41	(1) 6	(6)	0	Do.
	40	22	2	88	12	(7)	(6)	0	Poor; off flavor.
	36	22	2	98	4	(5)		0	Poor; lacking flavor.
	32	22	2	99	0	0	(3)	1	Fair to poor; lacking flavor.
	30	22	3	41	7	1 52		0	Poor; off flavor.
	80	2		87	13	0	0	0	Good to very good; sweet; juicy; mild.
	70	3		72	28	0	0	0	Do.
	60	5		73	27	0	0	0	Good to very good; juicy; sweet to slightly acid.
	50	8		87	13	0	0	0	Good; slightly sour and lacking flavor.
	50	15							Fair; sour; not overripe.
	40	14	4	18	82	(9)	0	0	Fair to poor; sour; bitter; off flavor.
J. H. Hale	36	14	4	29	71	0	0	0	Fair; slightly sour and slightly off flavor.
	32	14	4	53	47	0	0	0	Good; sweet to slightly sour; slightly lacking flavor.
	30	14	4	48	52	0	0	0	Do.
	40	21	2	44	56	(10)	0	0	Poor; sour to flat; off flavor.
	36	21	4	31	69	(11)	0	0	Poor; flat; mealy; off flavor.
	32	21	4	41	59	(12)	0	0	Fair to poor; slightly sour; lacking flavor.
	30	21	4	30	70	0	0	0	Fair to good; slightly lacking in flavor.

[1] Frozen.
[2] Incipient.
[3] Slight to bad.
[4] Very bad.
[5] Some at pit.
[6] Slight.
[7] Considerable.
[8] Mealy.
[9] Slight discoloration.
[10] Some appear dead at pit.
[11] Some.
[12] Few.

TABLE 8.—*Effect of storage time and temperature on ripening and quality of peaches, 1932*

Variety	Storage temperature	Storage days	Days at 70° F	Sound	Decay	Breakdown	Shriveling	Ripeness	Dessert quality
	°F.			Percent	Percent	Percent			
Carman	80	4	0	100	0	0	None	Ripe	Good; slightly sour.
	70	6	0	100	0	0	do	Ripe, tinge green.	Good; sour.
	60	9	0	100	0	0	do	do	Good; slightly sour.
	50	11	0	100	0	0	do	Firm ripe to slightly green.	Fair to poor; sour; off flavor.
	50	17	0	100	0	0	do	Ripe, yellow	Poor; off flavor.
	40	14	2	83	0	17	do	Ripe	Poor; dry and mealy.
	36	14	4	76	0	14	do	Soft ripe	Fair; bitter near pit.
	32	14	4	92	4	4	do	Ripe	Good to fair; slightly bitter near pit.
	30	14	4	100	0	0	do	Ripe, tinge green.	Good; very slightly bitter.
	40	21	0	63	0	37	do		Poor; mealy and dry.
	36	21	4	4	2	94	do		
	32	21	4	79	2	19	do	Ripe, tinge green.	Fair; rather sour.
	30	21	4	96	4	0	do	Firm ripe	Do.

TABLE 8.—*Effect of storage time and temperature on ripening and quality of peaches, 193[illegible]*—Continued

Variety	Storage		Days at 70° F.	Sound	Decay	Breakdown	Shriveling	Ripeness	Dessert quality
	Temperature	Days							
	°F.			Percent	Percent	Percent			
	80	2		98	2	0	None	Firm ripe	Good.
	70	4		93	7	0	do	Ripe	Good; sweet; juicy.
	60	6		97	3	0	do	Ripe, tinge green	Good.
	60	10		82	18	0	do	Ripe	Do.
	50	6		98	0	2	do	Firm ripe	Fair; slightly off flavor.
	50	20		33	64	3	do	Ripe	Poor; off flavor.
	40	7	3	29	24	47	do	do	Fair to poor.
Belle	36	7	3	74	26	0	do	do	Good.
	32	7	3	83	13	4	do	do	Very good.
	30	7	3	90	10	0	do	do	Good.
	40	14	2	37	5	58	do	Soft	Very poor; mealy, off flavor.
	36	14	2	10	12	78	do	do	Do.
	32	14	2	88	2	[1] 10	do	Firm ripe	Fair to poor; dry; lacking flavor.
	30	14	2	96	0	[1] 4	do	do	Fair; slightly juicy; lacking flavor.
	80	7		100	0	0	Bad	Firm ripe	Fair to good; slightly sour and bitter.
	70	7		100	0	0	None	do	Fair to good; slightly sour and astringent.
	60	10		86	14	0	do	do	Fair; rather sour.
	50	14		91	9	0	do	do	Poor; off flavor.
	40	7	5	80	15	5	do	do	Fair; slightly bitter.
	36	7	5	89	9	2	do	Firm	Fair; sour and slightly bitter.
	32	7	5	96	4	0	do	do	Fair; slightly sour.
	30	7	5	98	2	0	do	do	Do.
Elberta	40	14	4	87	2	11	do	Ripe	Fair to poor; slightly mealy, sour, and bitter.
	36	14	4	82	0	18	do	do	Fair; slightly mealy.
	32	14	4	100	0	0	do	do	Fair to good; slightly sour.
	30	14	4	98	0	[2] 2	do	Firm	Fair; sour.
	40	21	3	18	13	69	do	Ripe	Very poor; bitter, off flavor.
	36	21	3	10	0	90	do	Firm	Very poor.
	32	21	3	94	0	6	do	Firm ripe	Poor; sour and bitter.
	30	21	3	87	0	[2] 13	do	Firm	Do.
	80	5		100	0	0	Slight	Ripe, yellow	Good; sweet; juicy.
	70	5		98	2	0	None	do	Do.
	60	6		100	0	0	do	Firm ripe	Do.
	50	10		100	0	0	do	do	Poor to fair; off flavor; slightly sour.
	50	13		90	10	0	do	do	Poor; juicy but off flavor.
	40	14	3	73	4	23	do	Ripe	Fair; slightly mealy and sour.
	36	14	3	92	0	8	do	do	Fair to good; slightly mealy.
J. H. Hale	32	14	3	100	0	0	do	do	Good; juicy and fairly sweet.
	30	14	3	92	4	[1] 4	do	Firm ripe	Fairly good; rather sour.
	40	21	3	0	22	78	do		
	36	21	3	0	16	84	do	Firm	No external evidence of break-down.
	32	21	3	96	0	4	do	Firm ripe	Fair to good; slightly sour; lacking flavor.
	30	21	3	90	0	10	do	do	Fair; rather sour and lacking flavor

[1] Slight.

[2] Frozen.

TABLE 9.—*Effect of storage time and temperature on ripening and quality of peaches, 1938*

Variety	Storage		Days at 70° F.	Sound	Decay	Breakdown	Shriveling	Ripeness	Dessert quality [1]
	Temperature	Days							
	°F.			*Percent*	*Percent*	*Percent*			
Carman	70		6	85	15	0	None	Soft ripe	Good; slightly sour.
	40	14	3	91	9	[2] 50	do	do	Fair; mealy and lacking flavor.
	32	14	5	81	19	0	Slight	do	Fair to good; slightly sour.
	40	21	2	47	0	53	None	do	Very poor; mealy; off flavor.
	32	21	6	63	37	0	Slight	do	Fair.
Belle	70		8	67	33	0	None	Firm ripe	Good; juicy; slightly sour.
	50	21		98	2	0	None to slight	Soft ripe	Poor; off flavor.
	40	14	2	82	0	18	None	Firm ripe	Fair to poor; mealy; lacking flavor.
	32	14	3	100	0	0	None to slight.	Firm to full ripe.	Good to fair; juicy; slightly lacking flavor.
	40	21	1	63	0	37	None	Soft ripe	Poor; mealy; lacking flavor.
	32	21	3	100	0	0	do	Soft to firm ripe	Good; juicy; sweet.
	32	28	2	42	8	50	do	Firm ripe	Fair to poor; mealy; lacking flavor.
Elberta	70		5	19	81	0	do	Firm to ripe	Very good.
	50	13	6	74	26	0	None to slight.	Firm	Fair to poor; juicy; slightly off flavor.
	40	7	5	39	60	1	None	Firm ripe	Fair; sour; lacking flavor.
	32	7	5	38	62	0	None to slight	do	Good; slightly sour.
	40	14	2	68	16	[2] 16	None	Firm ripe to full ripe.	Fair to poor; mealy; off flavor.
	32	14	2	95	4	0	do	Firm to hard ripe.	Good; juicy; slightly sour.
	32	14	4	62	38	0	do	Firm ripe	Good; juicy; slightly bitter
	40	21	2	8	46	46	do	do	Poor; mealy; lacking flavor.
	32	21	4	29	67	[3] 4	None to slight.	Soft ripe	Fair; juicy; sour.
N. J. 127 22	70		6	99	1	0	None	do	Good; juicy; sweet (G).
	40	14	3	67	3	30	do	do	Fair to good; lacking flavor (F).
	32	14	5	99	1	0	do	Full ripe	Very good; juicy; sweet (G).
	32	21	6	94	6	0	do	do	Very good; juicy; sweet (F); slightly off flavor.
	32	28	6	52	48	0	do	Soft ripe	Good; juicy; sweet (F).
	32	35	4	84	16	0	do	Firm ripe	Good; juicy (F).
J. H. Hale	70		5	37	63	0	do	Firm ripe to full ripe.	Very good.
	50	15		43	57	0	do	Firm ripe	Poor; off flavor.
	40	7	3	56	44	0	do	do	Fair to good; juicy; fairly sweet.
	32	7	3	94	6	0	do	Firm ripe to hard ripe.	Fair; juicy; fairly sweet.
	40	14	2	54	46	0	do	Firm to hard ripe.	Fair; juicy; slightly acid.
	32	14	3	86	14	0	do	do	Good; very juicy.
	40	21	1	43	20	[3] 37	do	do	Fair to poor; slightly mealy; lacking flavor
	32	21	2	91	9	0	Slight	Firm ripe	Fair to good; slightly acid; lacking flavor

See footnotes at end of table.

TABLE 9.— *Effect of storage time and temperature on ripening and quality of peaches, 1933*— Continued

Variety	Storage		Days at 70° F.	Sound	Decay	Breakdown	Shriveling	Ripeness	Dessert quality
	Temperature	Days							
	°F.			*Percent*	*Percent*	*Percent*			
N. J. 66-22	70		6	98	2	0	None		(VG).
	50	14		99	1	0	do	Full ripe	Slightly off flavor; (F, off flavor).
	40	14	3	52	3	45	do	do	Fair to good; lacking flavor (F).
	52	14	5	100	0	0	do	do	Good; juicy; sour (G).
	40	21	2	52	0	48	do	do	Poor; mealy; lacking flavor (P).
	32	21	3	100	0	0	do	do	Good; juicy; slightly sour (G).
	32	35	4	100	0	0	do	do	Good; juicy to slightly mealy (F).
Hiley	70		6	80	20	0	do	Full ripe	Good to very good.
	50	12		89	11	0	Slight to medium.	Firm ripe	Poor.
	40	14	4	83	17	(0)	Slight	Full ripe	Fair to poor; slightly mealy; off flavor.
	32	14	5	55	45	0	None	Firm; to hard ripe.	Fair; juicy; sour.
	40	21	3	66	28	6	do	Firm to soft	Poor; mealy; lacking flavor.
	32	21	5	82	18	0	Slight to medium.	Full ripe	Fair.
	40	28	3	21	35	44	None	Firm ripe	Poor.
	32	28	4	73	19	8	None to slight.	Firm to hard ripe.	Fair to poor; dry; flavorless.
Slappey	70		5	94	6	0	None		Good; juicy; slightly sour
	40	21	4	78	16	6	do	Ripe	Fair; slightly mealy; slightly off flavor.
	32	21	4	91	9	0	Slight	Ripe to firm	Good; juicy; sweet.
	40	28	4	78	9	13	Medium	Full ripe	Poor; mealy; sour; off flavor.
	32	28	5	97	3	0	Medium to bad.	do	Fair to poor; slightly sour; slightly off flavor.
Champion	70		4	81	19	0	None	Full ripe to tinge green.	Good (G).
	50	16		67	33	0	None to slight.	Firm to full ripe.	Poor, dry; off flavor (P).
	40	14	3	63	30	7	None	Firm ripe	Fair to poor; slightly mealy; lacking flavor
	32	14	5	49	51	0	do	do	Fair to good; juicy (F); fairly sweet.
	40	23	2	58	42	(0)	None to slight.	Firm	Poor; mealy; lacking flavor (P-F).
	32	23	5	54	46	0	Slight to bad.	Ripe	Good; juicy; sweet (F).
Early Crawford	70		5	74	18	8	None	Soft ripe	Very good (VG).
	50	14		85	15	0	None to slight.	Firm to full ripe.	Fair; slightly off flavor
	40	7	3	92	8	0	None	Full ripe to firm ripe.	Good; juicy (G); sour.
	32	7	3	97	3	0	do	do	Very good; juicy (VG); slightly sour.
	40	14	4	72	28	0	do	Full ripe	Fair; slightly mealy; lacking flavor (F).
	32	14	4	88	12	0	do	Firm ripe to full ripe.	Fair to good (F-G); juicy; fairly sweet.
	40	21	2	49	19	32	do	do	Fair to poor; slightly mealy, lacking flavor (F-P).
	32	21	3	96	4	0	do	Firm	Fair to good; slightly bitter and sour (F-G)

See footnotes at end of table.

TABLE 9.—*Effect of storage time and temperature on ripening and quality of peaches, 1933*—Continued

Variety	Storage		Days at 70° F.	Sound	Decay	Breakdown	Shriveling	Ripeness	Dessert quality [1]
	Temperature	Days							
	°F			*Percent*	*Percent*	*Percent*			
Augbert (Roberta).	70		4	25	75		do	Firm ripe	Very good (G).
	40	7	4	32	68		do	Full ripe	Very good (G); juicy; sweet (F).
	32	7	3	72	28		do	do	Very good; juicy; sweet (G–F).
	40	14	1	69	22	9	do	do	Poor; dry (P–F).
	32	14	3	57	43	0	None to slight.	Firm ripe to soft ripe.	Very good; sweet; juicy (F).
	40	21	2	6	61	33	do	Soft ripe	Poor; mealy; lacking flavor (P).
	32	21	3	62	38	0	do	Firm ripe	Good; juicy; sweet (F).
	70		6	61	39	0	None	Hard ripe	Good to fair; slightly sour and astringent (G).
	40	7	4	78	22	0	do	Firm ripe	Good; juicy; sweet to slightly acid (F).
	32	7	4	76	24	0	do	Hard to firm ripe.	Very good; juicy; sweet (G–F).
	40	14	2	75	21	[3] 4	do	Firm ripe	Fair; slightly mealy; lacking flavor (F–P).
Late Crawford.	32	14	4	73	27	0	do	do	Very good; juicy; slightly astringent (G).
	40	23	2	53	47	0	do	do	Poor; slightly mealy; sour and off flavor (P).
	32	23	3	85	15	0	do	do	Very good; juicy; sweet (F).
	40	28	1	27	18	55	do	do	Poor, mealy; off flavor (P).
	32	28	2	91	9	0	do	do	Fair; fairly juicy; lacking flavor (F–P).

[1] Letters in parentheses refer to frozen-pack samples: G=good, F=fair, P=poor, V=very.
[2] Incipient. [3] Slight. [4] Trace in few. [5] Very slight. [6] Trace in some.

The growth rate of brown rot (*Sclerotinia fructicola* (Wint.) Rehm) at different temperatures has been studied by Brooks and Cooley (*3, 4*). They found that the growth rate increased greatly with increased temperatures, with the maximum rate on peaches at about 25° C. (77° F.). The rate dropped off rapidly up to 30° C. (86° F.), and growth of the fungus was practically inhibited at 35° C. (95° F.). The highest temperature (80° F.) used in the storage investigations reported herein should therefore be most favorable for the growth of brown rot.

At most temperatures the inspections were not made after a definite time interval but only after the fruit had ripened. At 70° and 80° F., however, the fruit ripened in about the same length of time, yet the percentage of the fruit showing decay averaged somewhat higher at 70° than at 80°. Although considerable difference between the two temperatures was found in some instances, the differences are not consistent, and it seems probable that they were due to sampling variability or other experimental error.

The percentage of the fruit showing decay in a given length of time was reduced, no doubt, by a further lowering of the temperature. The ripening of the fruit was also retarded, so that by the time the fruit was ripe at 60° and 50° F. there was generally as much decay as at the higher temperatures. Here again there was considerable variability

in the different lots with no consistent trend to indicate that the differences were significant. Some of the variability was probably due to differences in the maturity of the fruit at the different temperatures when the fruit was inspected.

At 40° to 30° F. the fruit did not ripen, and it was transferred to a higher temperature (70°) for ripening. Although little or no decay developed at the low temperatures, by the time the fruit had ripened at 70° there was generally as much decay as with immediate ripening at 70°. There was no consistent difference in the amount of decay that developed at 70° after storage at the different low temperatures.

Internal break-down of peaches has been described previously (*14*) and may consist of excessive mealiness without discoloration or of a water-soaked appearance near the pit followed by browning of the flesh and mealiness. At 80°, 70°, and 60° F. the peaches ripened normally, and although some became soft from overripeness, no typical break-down developed. At 50° the flesh was not discolored, but in some instances it became mealy and dry and did not ripen to a soft, juicy condition. This, together with the off-flavor that frequently developed at this temperature, indicated abnormal ripening.

At 40° and 36° F. the fruit generally softened slowly but did not become eating ripe before internal break-down developed. It was necessary, therefore, to ripen the fruit at higher temperatures, and 70° was used for this purpose. After 3 to 4 weeks at 36° and 40° internal break-down was generally apparent; after shorter intervals of 2 to 3 weeks at these temperatures the fruit was frequently sound when transferred to the higher temperature but developed internal break-down when exposed to the ripening temperature of 70°.

At 32° F. the fruit did not develop break-down until considerably later than at 36° and 40°, and it ripened to a soft, juicy condition at 70° for 1 to 3 weeks after it failed to ripen satisfactorily from 36° and 40°.

At 30° F. freezing injury occurred in some lots. When freezing injury did not occur, the results were similar to those on peaches stored at 32°.

These results agree with those reported by Davies et al. (*7*) for peaches under South African conditions. They found that Peregrine and Elberta and other varieties of peaches developed break-down earlier when stored at 37° and 34° F. than when stored at 31°, and that the dessert quality was maintained longer at the lower temperature. They observed that peaches held at 45° did not develop break-down, but that when they were ripened at this temperature the flavor was not so good as when ripened at 65°.

Davies et al. (*6*) and Van der Plank and Davies (*22*) found a similar relation between temperature and break-down of plums. They reported a maximum low temperature injury at intermediate temperatures of 37° and 40° F.

RELATION OF TEMPERATURE TO DESSERT QUALITY

The dessert quality of the peaches was judged by tasting the fruit when it became ripe under the various storage conditions. Direct comparisons of the relative quality of the fruit upon ripening could not be made in this way, as the fruit became ripe at different times under the various conditions. In order to be able to compare the flavor

directly, samples of the fruit were frozen in a 50-percent sugar sirup in 1933. After the storage season was over these samples were opened and direct comparisons were made of their dessert quality. In general the ratings given to the different lots by this method agreed very well with those given by tasting the fresh fruit.

At 80°, 70°, and 60° F. the peaches ripened with characteristic peach flavor and with good to very good dessert quality. When they were ripened at 50°, however, there was a marked decrease in dessert quality. Davies et al. (*6*) observed a similar loss of flavor in plums at 50° and in peaches (*7*) at 45°. At 50° the fruit either lacked characteristic peach flavor or had developed an off-flavor. Likewise at 40° and 36° there was a rapid loss in dessert quality. After only 1 week at these temperatures the quality was generally distinctly less desirable than upon immediate ripening, and after 2 weeks it was poor and either lacking in flavor or with an off-flavor. At these temperatures the dessert quality was usually undesirable, even before internal break-down was apparent, and though the fruit often appeared sound and normal, it was practically inedible.

At 32° and 30° F. the loss in dessert quality was less rapid than at 36° and 40°, so that the fruit could be held at the lower temperatures for 1 to 2 weeks longer and ripened at room temperatures with reasonably good quality.

These results are not in accord with those of Morris (*19*), who reported that under Washington State conditions storage temperatures of 40° and 50° F. retarded softening but permitted normal ripening of mature fruit, so that good-quality material was drawn from the storage rooms, whereas 32° storage seemed to prevent the normal ripening changes, so that fruit of all stages of maturity at harvest, which softened in such storage, was uniformly of very low quality. Morris apparently did not remove the peaches to room temperatures after storage, as would ordinarily occur in commercial practice, and this may account in part for the lack of accord between the results.

STORAGE LIFE OF PEACHES

These results indicate that for maximum storage life peaches should be held at 31° to 32° F. The length of storage life varied in different years. Since it is not possible to predict whether the season has been favorable for long storage, it is generally safe to store the fruit only for the shorter periods indicated.

Carman peaches were held for 3 weeks at 30° to 31° F. in 1930 and at 32° in 1931 and ripened at 70° with good quality and a high percentage of sound fruit. In 1932 the Carman peaches were satisfactory for only 2 weeks' storage at 32°; after 3 weeks there was considerable break-down and loss of dessert quality. In 1933 there was considerable loss in dessert quality after 3 weeks at 32° and much decay developed. Therefore Carman might be held for 2 weeks at 32° generally and for 3 weeks when growing conditions have been favorable to good keeping quality.

Belle kept satisfactorily in storage at 30° to 31° F. for 3 weeks in 1930. In 1931 it developed inferior dessert quality after 3 weeks at 32° but was satisfactory after 2 weeks. In 1932 the dessert quality deteriorated considerably after 2 weeks at 32° and slight break-down developed in some of the fruit, whereas in 1933 good dessert and storage quality were maintained for 3 weeks at this temperature.

These results indicate that Belle can be stored satisfactorily for 2 weeks, although under favorable growing conditions it might be held successfully for 3 weeks.

Elberta kept at 30° to 31° F. in 1930 for 4 weeks and ripened with good quality but was unsatisfactory after 5 weeks. In 1931, however, there was considerable deterioration in dessert quality even after 3 weeks at 32°, although there was practically no unsound fruit at this time. Similar results were obtained in 1932 and 1933. Although considerable decay developed in 1933, it was generally not so severe with ripening after storage as with immediate ripening. Although Elberta peaches may be held for 3 to 4 weeks with a high percentage of sound fruit, the flavor may deteriorate considerably in 3 weeks, and it is not recommended that the fruit generally be held more than 2 to 3 weeks.

With the J. H. Hale variety in 1930 the dessert quality was still good and the percentage of sound fruit high after 4 weeks at 30° to 31°. In 1931 considerable decay developed, being much higher after 2 and 3 weeks' storage than with immediate ripening, and there was also considerable depreciation in dessert quality after 3 weeks' storage at 32°. In 1932 and 1933 the fruit held up well at 32° for 3 weeks. The results indicate that the maximum storage life of this variety is generally 3 weeks, with 4 weeks possible under favorable conditions.

Results for 1933 (table 9) indicate the reasonable storage life of other varieties to be about 3 weeks for Hiley, Slappey, Champion, Early Crawford, and Augbert (Roberta), and 3 to 4 weeks for Late Crawford and two New Jersey crosses, N. J. 66–22 and N. J. 127–22.

DISCUSSION

These results indicate the importance of prompt cooling of peaches after harvest if any considerable time is to elapse before consumption of the fruit. If the respiratory rate is used as a measure of the rate of ripening, the results indicate that 1 day at 70° F. is about equivalent to 2 days at 60°, 4 at 50°, 8 at 40°, or 16 at 32°. The rate of softening was also much more rapid at 70° and 80° than at the lower temperatures. Most lots had softened to 2 pounds pressure or less in 2 to 4 days at 70° and 80°, in 4 to 7 at 60°, and in 8 to 11 at 50°. At 40° many of the lots did not soften to 2 pounds after 3 weeks, and at 32° practically no softening occurred and in some instances there was an increase in firmness.

Neither the respiratory activity nor the rate of softening, however, indicates the length of storage life under all temperature conditions. The storage life at the low temperatures was not so long as that indicated by either the respiratory rates or the firmness of the fruit, because of internal break-down and loss of flavor. At the higher temperatures the rate of softening probably indicates the rate of ripening more nearly than does the respiratory activity. At 70° and 80° the peaches softened at nearly the same rate and became fully ripe at about the same time, whereas the respiratory rate averaged about 40 percent greater at 80° than at 70°.

Although these results indicate the importance of prompt cooling of the fruit, they also indicate that the cooling should continue if possible to 32° F. and not stop between 50° and 36° for any extended holding, since abnormal ripening takes place at these latter temperatures. This abnormal ripening is shown by the development of unde-

sirable flavor at 50° and by the rapid loss of flavor, and the development of internal break-down and mealiness at 40° and 36°. These changes are associated with a rapid loss of total and active acidity.

These results indicate that it is possible to hold some varieties of peaches long enough for export shipment to overseas markets, provided the fruit is cooled promptly and held during transit at temperatures of 31° to 32° F. Such shipments are made from South Africa (7) with a period in transit of approximately 24 days.

The percentage of dry weight of the fruit was found to increase during storage in some instances and to decrease in others. With the high respiratory activity observed at the high temperatures there would result an appreciable loss of dry matter, which would tend to lower the percentage of dry weight. At 70° F. the average respiratory rate of the various lots in 1931 and 1932 was 73.5 mg. of carbon dioxide per kilogram-hour. Assuming that the carbon dioxide evolved came from the complete oxidation of a hexose sugar, there would be a loss of 0.12 gm. of sugar per 100 gm. of fresh weight per day. This would be equivalent to a loss of 0.88 percent of the total average dry weight per day, or about 4.4 percent loss in 5 days. In the oxidation of 0.6 gm. of sugar during a 5-day period at 70° there would be formed 0.24 gm. of carbon dioxide and 0.36 gm. of water This water would become part of the tissue water. If no water were lost by transpiration during this time the average dry matter per 100 gm. of fresh weight would be reduced from 13.7 to 13.1 gm., the average water content increased from 86.3 to 86.66 gm., and the percentage of dry weight reduced from 13.7 to 13.13. If the water were lost as fast as it was being formed by respiration, then the percentage of dry matter would be reduced to 13.18 percent. In order for the percentage of dry weight to remain constant during 5 days' ripening at 70° there would need to be a total loss in weight of 4.38 gm. per 100 gm. of original fresh weight. Of this, 0.24 gm. would represent the loss of carbon, 0.36 gm. the loss of water equivalent to that formed by respiration, and 3.78 gm. the loss of some of the original water present. The analyses show that the average percentage of dry weight decreased from 13.7 to 13.6 percent, which would represent a total loss in weight of about 3.7 percent in 5 days at 70°.

The heat of respiration may be an important factor in the refrigeration of the fruit. The peaches in a carload (approximately 390 bushels of 48 pounds each) weigh more than 9 tons. Assuming that the carbon dioxide evolved represents the complete oxidation of a hexose sugar, there would be enough heat of respiration produced by a carload of peaches to melt from 1,150 to 2,000 pounds of ice per day at 80° F., 870 to 1,370 pounds at 70°, 225 to 390 pounds at 50°, and only 55 to 90 pounds at 32°. Thus, if peaches were loaded into a car at 80° and no cooling occurred, they would evolve an average of 20,736 B. t. u. per day, which would be sufficient to increase the temperature of the load by slightly more than 1°, or would require the melting of 1,440 pounds of ice to maintain the temperature at 80°.

SUMMARY AND CONCLUSIONS

The firmness of a number of varieties when picked in a shipping-ripe condition generally averaged between 9.0 and 14.0 pounds, as determined by pressure tests on the pared cheeks. The dry weight of the fruit when picked ranged from 11.0 to 13.4 percent in 1933 but

was considerably higher in 1932. The range of total acidity was 0.51 to 0.96 percent, and the pH value ranged from 3.43 to 3.90.

There was practically no softening of the fruit at 32° F. The rate of softening increased with increased temperatures and was very rapid at 70° and 80°.

The respiratory rates at 32° F. ranged from 3.8 to 6.2 mg. of carbon dioxide per kilogram-hour and increased rapidly with temperature to 81 to 141 mg. of carbon dioxide at 80°. The influence of temperature on the rate of respiration of peaches was greater than with many other fruits.

Storage temperature did not affect the percentage of dry weight and of sugars except as it influenced the relative rates of water loss by transpiration and carbon loss by respiration.

The percentage of total and active acidity was not influenced by ripening at temperatures of 60° to 80° and 32° F. They were somewhat reduced at 50° and markedly reduced at intermediate temperatures of 36° and 40°.

The relatively rapid loss of acidity was associated with abnormal ripening at 50° F., as indicated by poor dessert quality and by the development of internal break-down or low-temperature injury at 40° and 36°.

The amount of soluble pectin in the juice increased greatly with the ripening and softening of the fruit.

There was no apparent relation between catalase activity and the development of internal break-down.

The results did not indicate any difference in the percentage of decay developing in the fruit from different temperatures after it was allowed to become ripe.

Internal break-down or low-temperature injury developed earlier at 36° and 40° F. than at lower or higher temperatures. There were some indications of break-down at 50° but none at 60° to 80°.

There was generally a marked loss in the flavor of peaches ripened at 50° F. as compared with those ripened at higher temperatures. There was a more rapid loss of flavor at 40° and 36° than at 32°.

The results indicate that peaches cannot be held in storage for more than 2 to 4 weeks, depending on the variety and growing conditions, without serious loss of dessert quality or the development of break-down.

On the basis of these results a temperature of 32° is recommended for the storage of peaches.

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