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CHANGES WROUGHT IN THE GRAPEFRUIT IN THE PROCESS OF MATURATION.

Part II.—Factors Affecting the Composition of the Fruit.

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CHANGES WROUGHT IN THE GRAPEFRUIT IN THE PROCESS OF MATURATION.

PART II.[1]—FACTORS AFFECTING THE COMPOSITION OF THE FRUIT.

INTRODUCTION.

In Part I of this work an account has been given of the natural changes occurring in the composition of the fruit as it hangs on the tree under natural conditions, with hardly any reference to the factors, natural or otherwise, that may affect this composition aside from the brief reference made to rainfall.

The factors affecting these natural changes as well as the changes undergone by the fruit after it has been separated from the tree and the conditions affecting these latter changes will now be taken in consideration.

They will be discussed under the same numbers and in the order in which they appeared in Vol. IV, No. 4 of this JOURNAL, p. 8; to wit,

5. Influence of rainfall on the ratio and rate of maturity of the fruit.
6. Influence of the type of soil on the composition of the fruit.
7. Relation of soil composition to quality of fruit.
8. Effect of storing and sweating the fruit on its composition and quality.

INFLUENCE OF RAINFALL.

Comparing the behavior of the Duncan fruit during successive seasons we find the following average composition:

TABLE No. 1.

Season.	Average weight.	Per cent skin.	Per cent juice.	Per cent solids in juice.	Per cent citric acid.	Ratio of solids to acid.	Invert sugar per cent.	Total sugar per cent.	Cane sugar per cent.
1916–17	602. 3	28. 25	43. 57	8. 7	1. 205	7. 23	3. 045	5. 258	1. 448
1917–18	573. 0	24. 39	38. 97	9. 24	1. 255	7. 63			
1918–19	486. 0	26. 47	42. 25	9. 38	1. 164	8. 06	3. 298	6. 078	2. 64

The averages for the seasons 1917–18 and 1918–19 show less weight per fruit, less juice, more solids in solution in the juice,

[1] Part I of this work appeared in THE JOURNAL OF THE DEPARTMENT OF AGRICULTURE OF PORTO RICO, Vol. IV, No. 4, October 1920.

and a higher ratio of solids to acids than the averages for the season 1916 to 1917. In previous paragraphs attention was called to the differences between the averages for Duncan and Marsh Seedless fruits for the seasons 1916–17 and 1917–18 and the fact was revealed that both these varieties showed differences in the items indicated above when the results for the two seasons were compared. It was then intimated that weather conditions might be responsible, at least in part, for these variations. Also the fact that the same trees were not used consecutively through succeeding seasons was brought out as another contributive cause to the variation. The averages of the trees that were used consecutively and the precipitation data for the period of time involved will now be presented.

The data concerning the trees which were used continuously from 1916 to 1918 were already given on page 64. So that only the additional data required, referring to trees used both during the season 1917–18 and 1918–19, will now be presented. The trees concerned were:

Owner or manager of plantation.	Number assigned to tree 1917–18.	Number assigned to tree 1918–19.
E. D. Stevens	4	12
M. L. David	6	14
W. K. Kaehrle	8	18

TABLE No. 2.

AVERAGES FOR EACH TREE PER SEASON.

	Tree No. 4 or 12.		Tree No. 6 or 14.		Tree No. 8 or 18.	
	1917–18	1918–19	1917–18	1918–19	1917–18	1918–19
Average weight in grams	574. 88	584. 77	449. 89	386. 86	632. 45	494. 43
Per cent skin	22. 10	24. 41	24. 12	27. 05	25. 07	27. 14
Per cent juice	41. 65	40. 97	38. 79	44. 23	37. 32	42. 64
Per cent solids in juice	8. 814	8. 80	9. 76	10. 26	9. 49	8. 41
Per cent acid	0. 9888	0. 9972	1. 356	1. 226	1. 416	1. 041
Ratio of solids to acid	8. 91	8. 82	7. 19	8. 36	6. 70	8. 07

AVERAGES FOR ALL TREES PER SEASON.

Season.	Average weight in grams.	Per cent skin.	Per cent juice.	Per cent solids in juice.	Per cent acid.	Ratio of solids to acid.
1917–18	552. 40	23. 75	39. 25	9. 354	1. 253	7. 46
1918–19	388. 68	26. 20	42. 62	9. 156	1. 088	8. 41

From the above tables it may be seen that the same trees had

a tendency to have more juice during the season 1918–19, but they had much less weight per fruit and a higher ratio and higher percentage of skin, while the percentage of solids and acids was a little lower.

The results for 1918 bear also the same relations to those of 1917 already pointed out. (See page 2.)

The precipitation data here presented have been taken from the reports of the Porto Rico Section, Weather Bureau of the United States Department of Agriculture. Only the data referring to the Northern division, where all of the groves sampled lie, have been taken in consideration.

The periods of time covered have been from March of one year to March of the succeeding year inclusive, as this was approximately the period covered by the development of the fruit from bloom until the last samples were picked. However, the precipitation for the period covered by the fruit from blooming time to complete development of the fruit, that is from March to October of the same year, has also been considered.

Northern Division. Period.	Precipitation in inches.	
	Total.	Mean per month.
March 1916 to March 1917, inclusive	84. 87	6. 53
March 1917 to March 1918, inclusive	76. 82	5. 91
March 1918 to March 1919, inclusive	59. 69	5. 59
March 1916 to October 1916, inclusive	66. 58	8. 32
March 1917 to October 1917, inclusive	47. 50	5. 93
March 1918 to October 1919, inclusive	41. 28	5. 16

The divergence prevailing between the amount of rainfall which obtained for the season 1916 to 1917 and for the two consecutive seasons 1917 to 1919 is evident. This is especially to be noted if the periods from March to October of each year are compared, and this was the time when the rainfall was bound to influence most the composition of the fruit, as it was really the formative period. From these figures we find that there was much more rainfall in 1916 than in 1917 or 1918 and that the precipitation for the period of observation for the last two years was very nearly the same. This explains, although, possibly, only partially, the difference noted in the composition of the fruit sampled during 1916–17 as compared with the fruit picked on the two succeeding seasons.

It is true that the rainfall data herein reported do not explain consistently the differences noticed among the fruit of the two latter

seasons, but the fact that the two sets of figures differ from the 1916–17 averages in the same order, although within different ranges, is rather significant.

The indication is, then, that the amount of rainfall has an influence on the composition of the fruit, in that there is more juice developed with a lower concentration of solids in solution and a lower ratio of solids to acids during rainy seasons. This does not seem to be a case of simple dilution of the fruit juice due to an excess of water absorption, for if it were so, the ratio would not be affected. The rate of formation of solids seems to be influenced by this disturbance. In connection with this, it is well to remark that the 1916–17 fruit, in general, reached maturity rather late in the season, the first average ratio of 7 not appearing in the Duncan fruit until November 3rd and in the Marsh's seedless until November 21st (excepting the sample picked on September 22nd for reasons already stated), while in the 1917–18 crops the Duncan fruit showed a ratio of 7 with the first sample picked on September 21st, and the Marsh's seedless in October 21st. The 1918–19 crop came to maturity promptly also, as the first sample picked on October 28th, had a ratio of 7.509. There was considerable fruit with a ratio of 7 which was picked and shipped during September, but no samples were collected during this month.

Influence of Soil.

This factor was studied regardless of the fertilizers applied; however, it should be borne in mind that the figures presented represent a liberal assortment of conditions through a number of years, and that in a general way, the fertilizers applied have not varied much due to the fact that standard formulas introduced by the Fruit Exchange have been widely used. Besides, any differences that might have occurred have been probably mostly offset by the number of plantations and the number of years through which these tests have been made. It should also be stated that so far it has not been definitely proven that fertilizers affect to a very large extent the composition of the fruit. In fact, C. F. Kinman, in his bulletin on "Citrus Fertilization Experiments in Porto Rico,"[1] maintains that fertilizers had no effect on the quality of the fruit in his experiments.

[1] "Citrus Fertilization Experiments in Porto Rico," by C. F. Kinman, Horticulturist—Bulletin No. 18 of the Porto Rico Agricultural Experiment Station, Mayagüez.

INFLUENCE OF TYPE OF SOIL ON THE QUALITY OF THE FRUIT.

Mr. Cady in his records, after stating that on September 20th and October 4th and 18th grapefruit was tested from forty-nine different groves, and giving the averages obtained in these tests expressed the following conclusion:

"These analyses also show that 'Duncan' fruit grown on sandy loam has a higher ratio than when grown on clay loam or sandy soil. The ratio for Duncan fruit grown on sandy, clay or clay loam, average about the same."

There were not sufficient samples of "Marsh Seedless" to form any definite conclusions as to the soil best suited for the production of the best fruit. The work that has been done seems to point to sandy loam, as with the "Duncan."

To test this conclusion further, as well as to gain an idea of the effect of soil type on other constituents of the fruit, the data obtained on the trees tested on the succeeding seasons were grouped separately according as the soil was predominately clay or sandy. No attempt was made to differentiate between clay and clay loam, or sandy and sandy loam, but it was thought preferable to simplify matters and group together the results obtained with trees on sandy soil and sandy loam on the one hand, and clay soil and clay laom on the other.

All the fruits used for these comparisons have been of the "Duncan" variety.

Below are given tables representing the composition of the fruit grown in the two types of soils, by months and by seasons.

In these two tables, as well as in succeeding ones, the percentages of the different contents in one table for each date specified have been compared with the corresponding percentages on the same date in the other table. For example, the percentage of skin found on fruit raised in clay soil for the period September 16–30, 30.2 per cent, was compared with the percentage of skin found on fruit grown in sandy soil during the same period, September 16–30. The greater of the two figures has always been marked with a plus (+) sign and the lesser with a minus (—) sign. Where the two figures have been regarded as equal an equality sign (=) has been used on both figures.

In this way the number of instances that a given ingredient has been higher or lower in fruit raised on a certain type of soil as compared with fruit raised on another, may be readily ascertained.

TABLE No. 3.

SHOWING INFLUENCE OF TYPE OF SOIL ON THE COMPOSITION OF THE JUICE DURING THE SEASON 1916–17.

Date of picking.	Per cent skin.	Per cent juice.	Per cent solids.	Per cent acid.	Ratio solids to acid.	Per cent invert sugar.	Per cent cane sugar.	Per cent total sugar.	Type of soil.	Remarks.
September 16–30	+30.20	+39.78	—8.20	—1.29	+6.39	—2.860	=2.29	—5.271	Clay	Averages of 8 samples.
October 9–24	+29.21	—40.13	—8.50	+1.311	—6.48	+3.120	—2.058	—5.287	Clay	Averages of 8 samples; in four other samples solids and acids were determined and results included in averages.
November 2–21	+27.52	+45.27	—8.34	—1.120	—7.45	+3.155	—1.810	—5.060	Clay	Averages of 12 samples.
December 19	—26.888	+50.07	—8.58	+1.150	—7.48	—2.852	—2.216	—5.185	Clay	Averages of 5 samples.
January 17	27.95	+46.25	—8.816	—1.185	—7.44	+3.721	—1.483	—5.282	Clay	Averages of 6 samples
Averages for the season	+28.35	+44.30	—8.39	—1.211	—6.93	+3.143	—1.971	—5.218	Clay	

TABLE No. 4.

SHOWING INFLUENCE OF TYPE OF SOIL ON THE COMPOSITION OF THE JUICE DURING THE SEASON 1916–17.

Date of picking.	Per cent skin.	Per cent juice.	Per cent solids.	Per cent acid.	Ratio solids to acid.	Per cent invert sugar.	Per cent cane sugar.	Per cent total sugar.	Type of soil.	Remarks.
September 16–30	—25.53	—38.73	+8 47	+1.395	—6.07	+3.080	=2.28	+5.480	Sandy	Averages of 6 samples.
October 5–23	—28.97	+41 56	+8.94	—1.273	+7.02	—3.056	+2.459	+5.645	Sandy	Averages of 6 samples.
November 3–21	—27.32	—41.29	+8.845	+1.163	+7.61	—2.930	+2.506	+5.568	Sandy	Averages of 7 samples.
December 8–29	+29.60	—42.69	+8.920	—1.135	+7.85	+3.080	+2.280	+5.480	Sandy	Averages of 7 samples.
January 17		—42.46	+9.330	+1.198	+7.78	—3.500	+2.206	+5.823	Sandy	Averages of 6 samples.
Averages for the season	—27.85	—41.06	+8.90	+1.232	+7.224	—3.129	+2.346	+5.590	Sandy	

The tables given for the season 1916–1917 point to the following conclusions:

1. The percentage of skin has been higher in the fruit from clay soil. In four instances in which comparisons have been possible, the fruit from the trees growing in clay soil have had a higher percentage of skin in three. The average content of skin for the season is higher in the fruit from clay soil. The percentage of this ingredient, however, showed a decrease toward the end of the season in the clay soil, and an increase in the sandy soil.

2. The percentage of juice was higher in the fruit raised in clay soil. It was higher in every instance except one, in October. Increased in both cases, but to a greater extent in the fruit from clay soil.

3. The percentage of solids has been slightly higher in the fruit from sandy soil, having shown up higher in every instance. In both cases there was an increase in this ingredient as the season advanced, but the rate of increase was slightly higher in the fruit from sandy soil.

4. No preponderance can be established in the acid content of one fruit upon the other. The difference in averages is only 0.021 per cent in favor of the sandy soil, and out of six comparisons possible, in three cases is this ingredient higher in clay soil and lower in three cases, than in sandy soil. The acid decreased in both cases; started with a higher percentage in sandy soil, but decreased at a faster rate in the latter type of soil.

5. The ratio of solids to acids was higher in fruit from sandy soil. It was higher in every case in which they were compared except one, in September. This ratio increased in both cases but at a faster rate in sandy soil.

6. The percentage of total sugars was a little higher in sandy soil, being higher in every case in which a comparison was made. It was practically constant throughout the season in the fruit from clay soil, and increased slightly toward the end of the season in sandy soil.

7. *Invert sugar.*—This ingredient was present in practically the same proportions in both kinds of fruits.

8. *Cane sugars.*—The percentage of cane sugar was higher in sandy soil. It was higher in every instance compared, except in September, when the two percentages may be regarded as equal. There was much fluctuation in the content of this ingredient in

the fruit from clay soil, while it was more uniform, with a slight tendency to increase in the fruit from sandy soil.

The results of this season give a decided advantage to the fruit raised in sandy soil on the one raised in clay soil except for the juice content. This is in accord with Mr. Cady's findings.

TABLE No. 5.

SHOWING INFLUENCE OF TYPE OF SOIL.

Constructed from averages of analyses of fruit from different groves picked and analyzed on the same date.

Fruit from trees growing in clay soil.

Season 1917–18.

Five samples of 12 fruits each were picked on each of the dates noted below.

Date picked.	Per cent skin.	Per cent juice.	Per cent solids.	Per cent acid.	Ratio.
September 21	—25.475	—38.120	— 9.055	—1.373	+6.59
October 4	+23.953	+47.830	+ 9.676	+1.339	—7.22
October 25	—22.256	—37.360	+ 9.690	+1.336	+7.25
November 12–17	+23.883	+33.330	+ 9.666	—1.202	+8.04
December 10	—24.966	—39.366	+ 9.616	+1.240	—7.75
January 17	+27.000	+41.000	+11.100	+1.550	—7.16
Averages for the season	—24.592	+39.503	+ 9.800	+1.340	+7.313

TABLE No. 6.

SHOWING INFLUENCE OF TYPE OF SOIL.

Constructed from averages of analyses of fruit from different groves picked and analyzed on the same date.

Fruit from trees growing in sandy soil.

Season 1917–18.

Five samples of 12 fruits each were picked on each of the dates noted below.

Date picked.	Per cent skin.	Per cent juice.	Per cent solids.	Per cent acid.	Ratio.
September 21	+26.510	+44.005	+9.290	+1.451	—6.40
October 4	—23.666	—38.540	—8.843	—1.217	+7.25
October 25	+23.333	+39.066	—8.890	—1.299	—6.84
November 12–17	—23.070	—31.380	—9.133	+1.282	—7.12
December 10	+25.233	+39.630	—9.216	—1.143	+8.06
January 17	—26.500	—36.350	—9.150	—1.220	+7.50
Averages for the season	+24.718	—38.161	—9.087	—1.268	—7.166

The tables above, giving averages for the season from September 1917 to January 1918 inclusive, show the following results:

1. The percentage of skin was nearly the same in the fruit from sandy soil as in the fruit from clay soil, being very slightly higher in the former. In half of the instances in which comparisons were

established, the skin was higher in the fruit from sandy soil, and in the other half higher in the fruit from clay soil. It increased toward the end of the season in clay soil, and was practically constant in sandy soil. This is not in accord with the observations made the previous year.

2. *Juice.*—Average content was a little higher in the fruit from clay soil, although only in half of the instances in which comparisons were established is this preponderance noticeable. The percentage of juice increased in clay soil and decreased in sandy soil. These observations agree partially with those made the previous season.

3. *Solids.*—Higher in clay soil, in every instance except in September, and also in the averages. Increased in both, but at a slightly greater rate in sandy soil. This last observation agrees with last season's but the first is contrary to last season's results.

4. *Acid.*—Higher in clay in four instances out of six and in the average. Decreased in both, but at a faster rate in sandy soil. This agrees partially with the results obtained the previous season.

5. *Ratio of solids to acids.*—The average ratio for the season was slightly higher in the fruit from clay soil. This gain, however, is evident in only half of the comparisons made. Increased at practically the same rate in both cases. This does not agree with last season's results.

This season's observations do not give any decided advantage to one fruit over the other.

TABLE No. 7.

SHOWING INFLUENCE OF TYPE OF SOIL.

Constructed from averages of analyses of fruit from different groves picked and analyzed on the same date.

Fruit from trees standing on sandy soil.

SEASON 1918–19.[1]

Date picked.	Per cent skin.	Per cent juice.	Per cent solids.	Per cent acid.	Ratio.	Per cent invert sugar.	Per cent cane sugar.	Per cent total sugar.
October 28	+25.500	—37.840	—8.796	—1.1550	+7.62	—3.338	-------	-------
November 12	+26.770	+41.750	—8.580	—1.0470	+8.20	—3.873	—4.119	—8.207
November 26	—24.813	+44.050	—8.570	—1.0430	+8.21	—1.819	—2.570	—4.525
December 12	—25.390	+45.060	—8.630	—1.0420	+8.28	+3.163	—2.592	+5.890
January 2	—23.706	—40.210	—8.600	—0.9619	+8.94	—2.886	+2.429	—5.443
January 20	—26.508	+41.640	—8.533	—0.9896	+8.62	—3.323	+2.291	—5.735
February 24	—25.810	—43.371	—8.733	—0.9213	—9.47	—3.733	—1.933	—5.768
Averages for the season	—25.642	—41.988	—8.635	—1.0228	+8.442	—3.236	—2.557	—5.928

[1] Three samples of 10 fruits each were picked on each one of the dates noted, except on October 28th, when only two samples were picked.

TABLE No. 8.

SHOWING INFLUENCE OF TYPE OF SOIL.

Constructed from averages of analyses of fruit from different groves picked and analyzed on the same date.

Fruit from trees standing on clay soil.

SEASON 1918–19.[2]

Date picked.	Per cent skin.	Per cent juice.	Per cent solids.	Per cent acid.	Ratio.	Per cent invert sugar.	Per cent cane sugar.	Per cent total sugar.
October 28	—25.320	+39.280	+10.950	+1.4810	— 7.39	+3.739	------	------
November 12	—26.600	—41.680	+10.300	+1.3570	— 7.59	+4.213	+4.337	+8.779
November 26	+24.996	—41.820	+ 9.390	+1.3380	— 7.42	+2.241	+2.747	+5.136
December 12	+32.400	—43.350	+10.400	+1.3940	— 7.46	—2.747	+2.688	—5.577
January 2	+25.940	+43.800	+ 9.716	+1.1580	— 8.28	+3.606	—2.400	+6.133
January 20	+30.230	—40.163	+ 9.250	+1.1510	— 8.03	+3.713	—2.237	+6.069
February 24	+27.247	+47.435	+10.300	+1.0007	+10.30	+4.210	+2.470	+6.810
Averages for the season	+27.533	+42.504	+10.200	+1.2685	— 8.041	+3.522	+2.754	+6.421

[2] Four samples of 10 fruits each were picked on each one of the dates noted, except on October 28th and December 12th when only three samples were obtained.

During this season from September 1918 to February 1919, the results of the analyses performed present the following comparison:

1. *Skin.*—Higher in clay soil in five instances out of seven and in the average. In this respect results agree with those for 1916–1917.

Increased in clay and was nearly constant in sandy soil. In this respect results agree with those of 1917–18.

2. *Juice.*—Higher in clay soil. This is in agreement with results obtained in the two previous seasons. Increased in both cases, but at a faster rate in sandy soil, the same as in 1916–1917. This gain is shown in four instances out of seven in which a comparison was possible.

3. *Solids.*—Higher in clay, the same as in 1917–18. This preponderance is evident in every comparison made, the same as in 1917 to 1918 except for September.

Decreased in both cases.

4. *Acid.*—Higher in clay, the same as in 1917–18. In every instance was the acid of fruit from clay soil higher during this season.

Decreased both in clay and sandy soil, the same as in previous seasons.

5. *Ratio of solids to acids.*—Higher in sandy soil in every instance

except one, the same as in 1916–17. Increased in both cases, but at a faster rate in sandy, coinciding again with results for 1916–17.

6. *Total sugars.*—Higher in clay, opposite to results obtained in 1916–17. In both cases decreased.

7. *Invert sugar.*—Slightly higher in clay soil. Higher in every instance except one, in December.

8. *Cane sugar.*—Higher in clay be approximately 0.2 per cent. Decreased in both kinds of fruit in about the same proportion.

Having compared the results obtained in each season separately it is well now to compare the total averages for the three seasons together.

Two tables are given below, summarizing each the results obtained with fruits from sandy and from clay soil. The average composition of the fruit for each month from September to January inclusive, and for all the months through the three seasons are given.

TABLE No. 9.

SHOWING INFLUENCE OF TYPE OF SOIL ON THE COMPOSITION OF THE JUICE.

Summary of Three Seasons, (1916–17, 1917–18, 1918–19) by Months.

COMPOSITION OF FRUIT GROWN IN CLAY SOIL.

Month fruit was picked and analyzed	Season	Per cent skin	Per cent juice	Per cent solids	Per cent acid	Ratio of solids to acids	Per cent invert sugar	Per cent cane sugar	Total sugar	Remarks
September	1916-17	30.20	39.780	8.200	1.290	6.356	2.860	2.290	5.08	Average of 8 groves
	1917-18	25.475	38.12	9.055	1.373	6.595	.....	.....	.....	
	1918-19	.....	.....	.....	.....	.....	.....	.....	.....	
Average for month for the 3 years.....	.....	27.837	38.950	8.627	1.3315	6.475	2.860	2.29	5.08	
October	1916-17	29.21	40.130	8.50	1.311	6.484	3.120	2.058	5.290	Average of 8 groves
	1917-18	23.104	42.596	9.683	1.337	7.242	.....	.....	.....	
	1918-19	25.32	39.280	10.95	1.481	7.393	3.769	.....	.....	
Average for month for the 3 years.....	.....	2 .878	40.668	9.711	1.376	7.039	3.4445	2.058	5.290	
November	1916-17	27.52	45.270	8.340	1.120	7.446	3.155	1.810	5.012	Average of 12 groves
	1917-18	23.883	33.33	9.666	1.202	8.041	.....	.....	.....	
	1918-19	25.798	41.75	10.347	1.347	7.509	3.228	3.542	.....	
Average for month for the 3 years.....	.....	25.733	40.1166	9.3736	1.223	7.665	3.1915	2.676	6.009 *	
December	1916-17	26.888	50.070	8.580	1.150	7.460	2.852	2.216	5.188	Average of 5 groves
	1917-18	24.966	39.366	9.616	1.240	7.754	.....	.....	.....	
	1918-19	32.400	43.350	10.400	1.394	7.460	2.747	2.688	.....	
Average for month for the 3 years.....	.....	28.084	44.262	9.532	1.2446	7.558	2.7995	2.452	5.3814*	
January	1916-17	27.95	46.25	8.816	1.185	7.439	3.721	1.483	5.340	Average of 6 groves
	1917-18	27.00	41.00	11.100	1.550	7.161	.....	.....	.....	
	1918-19	28.085	41.980	9.483	1.159	8.217	3.659	2.318	.....	
Average for month for the 3 years.....	.....	27.678	43.077	9.799	1.296	7.6056	3.490	1.9005	5.4912*	
Total average of monthly averages for the 3 seasons.	.....	27.042	41.4147	9.4085	1.2942	7.269	3.1571	2.2753	5.5730	

The average ratios of solids to acids were found, not by adding all ratios and dividing by their total number, but by dividing the average per cent solids by the average per cent acids. In the same way the average total sugars was found by converting the average cane sugar to invert sugar, and adding this to the average invert sugar. The averages for total sugars were calculated by reducing the averages for sucrose to their corresponding invert sugar equivalents and adding these to the invert sugar averages.

[1] The per cent solids and acids represent averages of 12 groves.

TABLE No. 10.

SHOWING INFLUENCE OF TYPE OF SOIL ON THE COMPOSITION OF THE JUICE.

Summary of Three Seasons, (1916–17, 1917–18, 1918–19) by Months.

COMPOSITION OF FRUIT GROWN IN SANDY SOIL.

Month fruit was picked and analized	Season	Per cent skin	Per cent juice	Per cent solids	Per cent acid	Ratio of solids to acids	Per cent invert sugar	Per cent cane sugar	Per cent total sugar	Remarks
September	1916-17	25.53	38.730	8.470	1.395	6.071	3.080	2.280	5.58	
	1917-18	26.51	44.005	9.290	1.451	6.402	.....	.....	.....	
	1918-19	.....	.....	.....	.....	.....	.....	.....	.....	
Average for month for the 3 years.....	.....	26.02	41.3675	8.880	1.423	6.240	3.080	2.280	5.48	
October	1916-17	28.97	41.560	8.940	1.273	7.022	3.056	2.506	5.655	Average of 6 groves Average of 10 groves
	1917-18	23.499	38.803	8.866	1.258	7.047	.....	.....	.....	
	1918-19	26.50	37.84	8.796	1.155	7.615	3.338	.....	.....	
Average for month for the 3 years.....	.....	26.323	39.401	8.8673	1.2286	7.217	3.197	2.506	5.655	
November	1916-17	27.32	41.290	8.845	1.163	7.605	2.930	2.280	5.628	Average of 6 groves
	1917-18	23.07	31.380	9.133	1.282	7.124	.....	.....	.....	
	1918-19	25.791	37.840	8.706	1.155	7.615	3.338	2.592	.....	
Average for month for the 3 years.....	.....	25.39	38.366	8.8673	1.2000	7.389	3.197	2.436	5.833	
December	1916-17	26.600	42.690	8.920	1.135	7.859	3.080	2.206	5.480	Average of 7 groves
	1917-18	25.233	39.630	9.216	1.143	8.063	.....	.....	.....	
	1918-19	25.390	45.060	8.630	1.042	8.282	3.163	2.350	.....	
Average for month for the 3 years.....	.....	26.741	42.460	8.9453	1.1066	8.083	3.1213	2.283	5.6864	
January	1916-17	.....	42.465	9.330	1.198	7.788	3.500	2.3762	5.828	Average of 6 groves
	1917 18	26.50	36.350	9.150	1.220	7.500	.....	2.459	.....	
	1918-19	25.107	40.925	8.566	0.9757	8.771	3.104	.....	.....	
Average for month for the 3 years.....	.....	25.8035	39.9133	9.0153	1.1312	7.9696	3.302	.....	5.706	
Total averages for all months for all 3 years		26.0562	40.526	8.912	1.2152	7.3377	3.1176	2.459	5.6173	

A study of the figures presented by these tables leads to the following conclusions:

1. *Skin.*—Higher in clay in the total average, and in every monthly average, except in October.

2. *Juice.*—Higher in clay in the total average, and in every monthly average, except September.

3. *Solids.*—Higher in clay in the total average, and in every monthly average, except September.

4. *Acid.*—Higher in clay in the total average, and in every monthly average, except September.

5. *Ratio.*—Slightly higher in sandy soil. Out of five monthly averages the ratio is higher in the fruit from the sandy soil in only three instances, and in no case does this difference reach 0.6.

6. *Total sugars.*—Slightly higher in sandy soils in every monthly average, except November. Differences small.

7. *Invert sugar.*—Very slightly higher in clay. Practically the same in both.

8. *Cane sugar.*—Higher in sandy soil, in the total average and in three monthly averages. Equal for both types of soils in the averages for the months of September and December.

Considering all the data given above in its entirety, we find a tendency on the part of the fruit raised in clay soil to contain more juice and more solids and acid in solution in the juice. This fruit has generally shown up to be more coarse and sour, as shown by the higher percentage of skin and acid.

The fruit from sandy soil, although containing less juice, appears to be of better quality, as shown by the smaller percentage of skin, the slightly higher ratio of solids to acids, and higher sucrose content. The higher percentage of sucrose in the fruit from sandy soil, coupled with the slightly higher content of invert sugar in the fruit raised in clay soil, seem to indicate a greater amount of inversion in the latter, due, probably, to the higher acid content of the fruit from clay soil.

In connection with these differences it is observed that the skin, juice, solids, and acid, do not appear to be higher in the fruit from clay soil until after September, or may be October. This indicates a lower rate in the formation of these products in trees grown in clay soil.

Again, notice that the total sugars are higher in the fruit from

sandy soil in every monthly average except November, which once more shows slowness on the part of fruit from trees growing in clay soil to attain their maximum content of the different ingredients.

The fact that cane sugar becomes equal for both kinds of fruit in December, and thereafter appears to be lower in the fruit from clay soil, points again to a more rapid inversion in the fruit from this type of soil.

These general deductions, however, should be taken only as indications rather than as definite conclusions, as only in the case of the juice content were the results uniform throughout the three seasons.

It should be remarked here that these results agree with those reported by H. D. Young of the California Agricultural Experiment Station, in Vol. VIII, No. 4, pages 135–136 of the *Journal of Agricultural Research,* in so far as total sugars and acid are concerned, but point to quite different conclusions in regard to juice content.

INFLUENCE OF CHEMICAL COMPOSITION OF SOIL ON NUTRITIVE INGREDIENTS CONTAINED BY THE FRUIT.

The following table is self-explanatory.

TABLE No. 11.

FERTILIZER ELEMENTS IN GRAPEFRUIT—INFLUENCE OF CHEMICAL COMPOSITION OF SOIL.

Table giving fertilizing constituents of soils, and the maximum, minimum, and average content of these constituents for the seasons for each corresponding tree.

The composition of the fruit from each tree tested is given opposite the analysis of the soil in which the tree stood.

Tree No.	Soil composition				Composition of the fruit										
	Nitrogen per cent	Phos. acid per cent	Potash per cent	Insol. matter per cent	Dry matter per cent	Nitrogen per cent			Phos. acid per cent			Potash per cent			Ratio of solids to acid
						Max.	Min.	Aver.	Max.	Min.	Aver.	Max.	Min.	Aver.	
12	0.42	0.102	Traces	88.68	14.10	0.108	0.100	0.088	0.063	0.037	0.0484	0.150	0.116	0.1368	9.459
	(0.14)	(traces)	.....	*(81.51)*											
13	Ditto	Ditto	Ditto	(Ditto)	13.20	0.111	0.077	0.0811	0.059	0.033	0.0440	0.119	0.090	0.113	8.53
	0.106	0.114	0.0014	83.48											
14	*(0.078)*	*(0.090)*	*(0.0030)*	*(81.79)*	13.31	0.098	0.075	0.0794	0.049	0.037	0.0433	0.203	0.115	0.150	8.822
	0.112	0.109	0.027	83.59											
15	*(0.089)*	*(0.106)*	*(0 005)*	*(78.59)*	13.81	0.0957	0.071	0.0781	0.048	0.032	0.0422	0.192	0.104	0.151	8.19
	0.189	0.180	0.043	66.09											
16	*(0.157)*	*(0.114)*	*(0.007)*	*(67.54)*	14.59	0.102	0.081	0.0863	0.050	0.028	0.0433	0.168	0.105	0.155	7.838
	0.195	0.160	0.026	72.92											
[1] 17	*(0.134)*	*(0.147)*	*(0.010)*	*(71.32)*	16.63	.....	.....	0.125	.....	.....	0.0512	.....	.....	0.198	6.575
	0.189	0.134	0.085	87.95											
18	*(0.134)*	*(0.150)*	*(0.053)*	*(84.56)*	13.43	0.088	0.072	0.080	0.053	0.031	0.0413	0.191	0.197	0.1455	8.32
Average	.....	.....	.....	.....	14.15	.....	.....	0.0868	.....	.....	0.0449	.....	.....	0.1553	8.247

[1] Not included in the averages.

In the part of the table showing the soil composition the figures in italics enclosed in parentheses represent composition of subsoil corresponding to the soil the composition of which is shown by figures directly over them. For full analysis of soils and subsoils see page 17, Part I.

A study of this table will not support any definite conclusions; however, it is suggestive of what the conclusions might be if more data were available on the subject. For one thing, it shows no connection whatever between the amounts of phosphoric acid and potash in the soil and the proportions of these ingredients in the fruit. To show this more forcibly we have arranged below the phosphoric acid and potash contents of the soils in the descending order of these ingredients and have placed opposite the corresponding percentages found in the fruits raised each, thus:

TABLE No. 12.

Tree number.	Percentage of phosphoric acid in soil.	Percentage of phosphoric acid in fruit.	Tree number.	Percentage of potash in soil.	Percentage of potash in fruit.
15	0.180 (0.114)	0.0433	18	0.085 (0.053)	0.1455
18	0.134 (0.150)	0.0413	16	0.043 (0.007)	0.155
14	0.144 (0.090)	0.0433	15	0.027 (0.065)	0.151
15	0.109 (0.106)	0.0422			
12	0.102 (Traces)	0.0480	14	0.0014 (0.003)	0.150
13	Ditto	0.044	13	Traces	0.113
			12	Traces	0.1368

As regards nitrogen, however, the fruit grown on the soils higher in nitrogen seem to contain more nitrogen than those grown on the soils poorer in this ingredient, but only when the differences are considerable among the soils, are these effects noticeable in the fruit. Averaging again the soils in the descending order of their nitrogen content and writing opposite each the nitrogen content of the corresponding fruit we have:

Tree number.	Nitrogen content of soil.	Nitrogen in fruit.
12	0.42 (0.13)	0.1036
13	Idem	0.096
16	0.189 (0.157)	0.095
18	0.189 (0.134)	0.080
15	0.112 (0.089)	0.0832
14	0.106 (0.078)	0.0839

Considering the nitrogen content of both soil and subsoil, the first three soils have a higher nitrogen content than the last three, and the average percentage of nitrogen found in the fruits picked from the trees in the first soils is higher than the average found in the fruit obtained from the trees in the last three soils.

Again it should be stated that no account has been taken of the fertilizers applied, and that consequently the effect of fertilizers may have obscured the effects of the composition of the soil. However, as six groves were used in the comparison, it would be very significant that precisely in the soils lower in nitrogen should the trees receive smaller amounts of nitrogenous fertilizers.

EFFECT OF CHEMICAL COMPOSITION OF THE SOIL ON THE QUALITY OF THE FRUIT.

No definite relation has been found to exist between the chemical composition of the soil and the quality of the fruit. To make this record complete, as well as to give support to our statement, a table is given below wherein the factors affecting the quality of the fruit are given opposite the chemical composition of the soils on which the trees stood. In giving the soil analyses only the chief ingredients are reported. For full analyses of the soils see page 17, Part I.

TABLE No. 13.

TABLE ILLUSTRATING THE LACK OF CONNECTION BETWEEN CHEMICAL COMPOSITION OF SOIL AND QUALITY OF FRUIT.

SEASON 1916–17.

Tree No.	Chemical composition of soil				Factors affecting quality of fruit					
	Nitrogen Per cent	Phosphoric acid Per cent	Potash Per cent	Lime Per cent	Juice Per cent	Skin Per cent	Acid Per cent	Solids Per cent	Ratio of solids to acid	Sugar
A	0.050	0.130	0.100	0.05	43.76	29.00	1.247	8.05	6.45	4.54
B	0.120	0.191	0.0097	0.35	45.74	27.00	1.250	6.75	6.75	5.21
D	0.112	0.191	0.039	0.20	42.79	29.40	1.240	8.55	6.89	5.32
E	0.168	0.606	0.097	0.40	38.88	25.67	1.270	9.12	7.18	5.87
G	0.168	0.331	0.174	0.15	42.26	27.27	1.237	9.37	7.58	5.95
I	0.121	0.350	0.019	0.10	42.51	27.59	1.124	8.64	7.68	5.32
J	0.214	0.191	none	0.15	43.33	28.66	1.310	8.91	6.77	5.47
N	0.089	0.1000	0.0097	0.30	42.77	27.99	1.160	8.62	7.39	5.43
SEASON 1918–19.										
12	0.42	0.102	Traces	none	40.97	24.40	0.997	8.80	8.82	5.85
13	0.42	0.102	Traces	none	42.25	25.33	1.031	8.61	8.35	5.92
14	0.106	0.114	0.0014	Traces	44.23	27.05	1.226	10.26	8.36	6.87
15	0.112	0.109	0.027	none	41.88	26.74	1.210	9.50	7.85	6.69
16	0.189	0.180	0.043	0.221	40.01	28.07	1.369	10.36	7.56	6.78
18	0.189	0.134	0.085	0.188	42.64	27.14	1.041	8.41	8.07	6.32

Effect of Storing the Fruit.

For the purpose of gaining knowledge as to the changes suffered by the fruit after separating it from the tree, and during the time that it may be held in storage, a number of fruits were picked from a few plantations, keeping the fruits from the different plantations in separate batches. Each batch was then divided into lots of an equal number of fruits each, one lot was analyzed immediately, while the others were stored, and one analyzed on each succeeding week. The idea was to compare the results of the analyses of the succeeding lots among each other and with that of the first.

Below, three tables are presented, showing the results obtained with fruits stored for a period of eight to nine weeks.

TABLE No. 14.

TABLE TO SHOW CHANGES UNDERGONE BY FRUIT AFTER PICKING, STORED WITHOUT SWEATING.

One hundred and fifty grapefruits were picked from the same tree in Mr. C. W. Dreier's grove, February 28, 1916, divided into lots of 15 each and analyzed every week, as follows:

Variety and No. of Fruits	Date picked	Date analyzed	Total No. of rots	Average size	Average weight	Per cent loss in weight	Thickness of skin	Per cent skin	Per cent juice	Per cent solids	Per cent acids	Ratio	Per cent Invert sugar	Per cent total sugar as invert	Per cent cane sugar	Ratio invert sugar to sucrose
15 Duncan....	February 28..	February 29..	No	56	540	No	1/4	26.90	46.00	8.30	1.230	6.70	3.91	6.11	2.08	1.87
15 Duncan....	February 28..	March 8.....	No	56	536	4.20	1/4	29.10	45.40	8.60	1.260	6.80	4.16	5.63	1.35	3.08
15 Duncan	February 28..	March 13.....	No	54	544	5.50	1/4	30.97	41.63	8.70	1.300	6.70	3.50	4.89	1.27	2.75
15 Duncan....	February 28..	March 20.....	No	54	528	10.50	3/16	23.94	49.30	8.70	1.310	6.60	3.50	4.89	1.27	2.75
15 Duncan....	February 28..	March 28.....	9	54	529	11.20	3/16	25.20	51.10	8.90	1.360	6.50	3.50	4.89	1.27	2.75
15 Duncan....	February 28..	April 3.....	7	54	544	19.80	3/16	20.30	44.00	8.70	1.290	6.70	2.69	5.14	2.33	1.15
15 Duncan....	February 28..	April 10.....	8	54	544	17.30	3/16	21.50	49.00	8.60	1.280	6.70	3.67	5.63	1.84	2.00
15 Duncan....	February 28 .	April 19.....	8	54	529	27.60	1/4	23.10	51.40	9.10	1.400	6.50	3.67	5.63	1.84	2.00
15 Duncan....	February 28..	April 25.....	9	54	537	22.30	1/4	21.20	47.20	9.50	1.400	6.80	2.44	4.40	1.84	1.22
15 Duncan....	February 28..	May 2.....	8	54	529	27.80	3/16	20.00	48.00	9.70	1.400	6.90	2.84	4.63	1.67	1.70
Averages of all samples, except the first.			49	54	535.5	16.30	7/32	23.92	47.45	8.944	1.333	6.70	3.33	5.08	1.631	2.06

Grapefruit picked on April 4, 1916, from same tree as were the 150 fruits reported above analyzed as follows: size, 54; per cent juice, 48; per cent solids in juice, 9.0; per cent citric acid, 1.35; per cent solids to acid, 6.6.

TABLE No. 15.

TABLE TO SHOW CHANGES UNDERGONE BY FRUIT AFTER PICKING, STORED WITHOUT SWEATING.

One hundred and fifty grapefruits were picked March 2, 1916, brought to the laboratory. divided into lots of 15 each and the lots analyzed successively at intervals of one week, as follows:

Variety and No of fruits	Date picked	Date analized	Total No. of rots	Average size	Average weight	Per cent loss in weight	Thickness of skin	Per cent skin	Per cent juice	Per cent solids	Per cent acid	Ratio	Per cent invert sugar	Per cent total sugar	Per cent cane sugar	Ratio invert sugar to sucrose
15 Duncan....	March 2.....	March 7.....	No	54	544	No	5/16	27.50	39.10	9.10	1.00	9.10	4.160	6.110	1.83	2.270
15 Duncan....	March 2.....	March 13.....	2	46	567	1.50	3/8	29.06	44.00	8.90	0.90	9.90	3.500	5.330	1.76	1.988
15 Duncan....	March 2.....	March 20.....	2	54	499	5.60	1/4	26.10	40.30	9.20	0.90	10.40	2.400	4.520	2.00	1.200
15 Duncan....	March 2.....	March 28.....	2	46	570	11.60	1/4	27.60	35.30	9.30	0.88	10.50	3.10	5.870	2.65	1.160
15 Duncan....	March 2.....	April 3.....	4	46	548	8.80	1/4	24.50	41.50	9.40	0.98	9.60	3.10	5.870	2.65	1.169
15 Duncan....	March 2.....	April 10.....	5	46	552	18.80	1/4	23.80	41.10	10.20	1.08	9.40	4.16	6.600	2.32	1.790
15 Duncan....	March 2.....	April 20	10	46	582	20.30	1/4	25.80	38.80	9.60	0.90	10.60	4.40	6.360	1.84	2.390
15 Duncan....	March 2.....	April 25	10	40	605	20.00	5/16	25.50	34.80	10.20	1.10	9.20	1.95	3.500	1.43	1.360
15 Duncan....	March 2.....	May 2.....	10	40	620	21.00	1/4	21.00	32.90	9.70	1.05	9.20	2.80	4.600	0.78	3.590
Averages of all samples.....			.....	46	563	11.95	9/32	25.65	38.63	9.51	0.976	9.766	3.285	5.812	1.917	1.878
Averages of all samples, except the first.			.....	46	567.8	11.95	9/32	25.42	38.57	9.56	0.966	9.85	3.177	5.212	1.926	1.827

TABLE No. 16.

TABLE TO SHOW CHANGES UNDERGONE BY FRUIT AFTER PICKING, STORED WITHOUT SWEATING.

Two hundred grapefruits from La Isabela Grove picked March 2, 1916, brought to laboratory March 7, divided into lots of 16 each and the lots analyzed successively at intervals of one week, as follows:

Variety and No. of fruits	Date picked	Date analyzed	Total No. of rots	Average size	Average weight	Per cent loss in weight	Thickness of skin	Per cent skin	Per cent juice	Per cent solids	Per cent acid	Ratio solids to acid	Per cent invert sugar	Per cent total sugar	Per cent cane sugar	Ratio invert sugar to sucrose
15 Duncan....	March 2.....	March 7.....	No	36	507	No.	7/16	29.80	35.20	8.80	0.84	10.40	3.00	4.12	1.00	3.000
15 Duncan....	March 2.....	March 14.....	No	36	672	3.70	7/16	29.80	35.20	9.00	0.85	10.20	2.69	5.38	2.59	1.038
15 Duncan....	March 2.....	March 21.....	3	36	779	10.20	7/16	30.10	28.80	9.30	0.83	11.20	2.69	5.87	3.18	0.045
15 Duncan....	March 2.....	March 28.....	1	36	748	9.10	7/16	31.80	30.20	9.60	1.10	8.70	2.93	4.89	1.84	1.592
15 Duncan....	March 2.....	April 3.....	4	36	710	12.90	7/16	31.70	26.00	9.00	1.10	11.20	2.44	5.38	2.62	0.931
15 Duncan....	March 2.....	April 10.....	2	36	711	16.20	7/16	28.80	27.90	10.00	1.00	10.00	3.10	5.87	2.65	1.170
15 Duncan....	March 2.....	April 20.....	5	36	665	21.50	7/16	27.50	26.90	9.10	0.75	12.10	2.93	4.10	1.05	2.930
15 Duncan....	March 2.....	April 25.....	5	36	726	18.60	1/2	30.30	27.40	9.50	1.00	9.50	2.93	3.67	0.62	4.720
15 Duncan....	March 2.....	May 2.....	4	36	710	24.50	7/16	30.00	18.90	9.80	1.10	9.90	2.93	3.67	0.63	4.720
Averages of all samples.....			.....	36	692	12.966	7/16	29.81	28.50	9.34	0.94	10.35	2.85	4.77	0.808	2.327
Averages of all samples, except the first..			3	36	715.2	14.587	7/16	30.00	27.66	9.41	0.966	10.35	2.83	4.85	1.896	2.58

From the above tables the following one, summarizing the results of the three experiments they represent, was constructed by averaging the results of the different analyses obtained for fruits which had been kept approximately the same number of days.

These averages, then, approximate the mean comparative composition of fruit stored for different periods of time from one to nine weeks.

With the data given by this table as a basis, the graph which accompanies it was drawn, so as to represent more objectively the results obtained.

In these graphs the number of days that the samples were kept in storage were taken for abscisæ, and the percentages found at the end of the number of days indicated by the points on the abscisæ, for ordinates. The curves for all of the sugars have been plotted together, and those for juice solids, and acid, in another group. In the plate for the sugar curves the ratios of invert sugar to sucrose have been shown by vertical lines erected at the points designating the number of days the fruit had been in store when the analysis was made. In a similar way are shown the ratios of solids to acids on the acid and solids plate. The scales used are indicated in the corresponding plates.

TABLE No. 17.

SHOWING SUMMARY OF CHANGES UNDERGONE BY GRAPEFRUIT DUE TO STORAGE.

Fruits picked February 28th and March 7th and stored for a period of 8 to 9 weeks. Four hundred and sixty fruits were used in all.

No of days in storage	Total No. of rots	Per cent loss in weight	Thickness of skin	Per cent skin	Per cent juice	Per cent solids	Per cent acids	Ratio of solids to acid	Per cent invert sugar	Per cent total sugar	Per cent sucrose	Ratio invert sugar to sucrose
2 to 5	No	No	5/16	28.06	40.10	8.73	1.023	8.53	3.690	5.411	1.636	2.25
9 to 12	2	3.13	6/16	29.32	41.53	8.87	1.003	8.80	3.450	5.448	1.90	1.81
14 to 19	5	7.43	5/16	29.05	36.91	9.06	1.01	8.97	2.863	5.124	2.15	1.33
21 to 26	3	10.40	6/16	27.78	38.26	9.20	1.096	8.39	3.176	5.195	1.92	1.65
29 to 32	17	10.96	6/16	27.18	39.53	9.10	1.146	7.94	3.013	5.306	2.18	1.38
35 to 39	15	18.26	6/16	24.30	37.66	9.63	1.123	8.57	3.316	5.875	2.433	1.36
49 to 50	23	19.70	6/16	21.93	38.23	9.10	0.976	9.32	3.660	5.317	1.576	2.32
54 to 57	24	22.06	6/16	26.30	37.86	9.60	1.166	8.23	2.850	4.213	1.296	1.18
61 to 63	22	23.90	5/16	23.06	36.76	9.67	1.273	8.61	2.752	4.045	1.23	2.23

These tables and the graphs if examined together with due regard for the factors of variation that are inseparable from an experiment of this nature, will reveal the following facts:

1. On storing fruit a certain number of fruits rot, and this

number increases as the period of storage prolongs. Taking the total number of fruits treated and the total number that went to rot, we find in these experiments an almost uninterrupted increase in the number of rots, varying (see table No. 17) from 4 per cent at the end of the twelfth day, to 4.8 per cent at the end of the sixty-third day. In other words, out of a total of (450) fruits stored, two rot during the first twelve days, 24 during the week comprised between the fiftieth and the fifty-seventh day, and 22 from the fifty-seventh to the sixty-third day.

However, the number of rot fruits that may occur varies much according to the condition and the handling of the fruit, as is evident from the fact that in two instances 49 and 45 fruit respectively rotted from two batches containing 150 fruits each, while only 24 fruits rotted out of a third batch containing 200 fruits.

2. The loss in weight of the fruit is another very noticeable change undergone by the fruit on being stored. In the table of averages this factor increases uninterruptedly from the fifth day on to the sixty-third, when a maximum loss of 23.9 per cent occurred. This successive loss of weight may be also noticed if the tables for the different experiments are examined, although with slight variations. Among the individual samples, as high a loss as 27.8 per cent at the end of the ninth week has been observed. The average loss for the whole period of storage, however, fluctuates between 11.95 per cent and 16.35 per cent.

3. The percentage of skin, as given by the table of averages, decreases somewhat during the period of storage, while the thickness of the rind remains practically constant within the limits of time of these experiments. This decrease in the percentage of the skin, is not, however, shown by the fruit in the batch of 200 fruits (see table 16), but is clearly shown by the other two batches of 150 fruits each. All we can say, then, is that there is a tendency on the part of the percentage of skin to diminish during the period of storage but that this must not necessarily be so.

4. The percentage of juice diminishes during the storage of the fruit. This change is very marked in the 200 fruits batch, is present with less force in the 150 fruits batch picked on March 2nd (see table 15) and is not noticed at all in the fruit from Mr. Dreier's grove (see table 14). It is, however, fairly well established by the table of averages, and clearly shown by the graph. In the graph, the straight line connecting the two extremes of the curve has a general slant downward; only two points in the curve

appear over this line, and no point in it comes up to the level of the first.

5. The percentages of solids and of acid both increase at about the same rate. Notice that the straight lines joining the extremes of these curves both slant upward and are practically parallel. However, fluctuations are present, especially in the acid curve, which reveal original differences among the samples, so that no definite conclusion can be made. Notice in the table of averages that except for two samples (the 5th and 7th from the top) all other ratios of solids to acid lie fairly close together, with no definite tendency to either increase or decrease. This again suggests that the changes in the solids and the acids, if there were any, took effect at approximately the same rate and in the same direction This is clearly shown by the diagram.

6. Now as to sugars: During the last two weeks all sugars dropped to their lowest levels. Notice the coincidence that precisely during these two weeks the acid content was higher than at any other time during the experiment (see table 17). It is significant that this drop in the sugar content and increase in acidity is manifest in a general way, in each separate batch tested. The curves show further that all sugars have a general tendency to decrease while the acidity increases, as evidenced by the downward slant of the straight lines joining the extremes of the curves. The curves themselves, however, show a number of irregularities some points falling above and some below the straight lines referred to. On examining these variations, notice that with very few exceptions the invert sugar and the sucrose curves vary in opposite directions, as shown by the approaches and divergences of the points along the lines, and the almost total absence of parallelism among the different segments of the curves. Attention should be paid to the fact that up to the thirty-ninth day of storage the curve for sucrose indicates rather an increase, but that after the thirty-ninth day the decline is very marked and evident. Up to the thirty-ninth day all points in the curve are higher than the first, while beyond this point the reverse is true. On the curves for total sugar there is only one point higher than the first, the one corresponding to the thirty-ninth day, after which there is an uninterrupted decline. The curve for invert sugar declines all along until the thirty-ninth day, after which it climbs up to its higest point, practically as high

as the first, which it attains on the fiftieth day, to decline again until the end. Again, notice that the highest point after the first on the invert sugar curve corresponds with the lowest on the acid curve, and that the decline in the invert sugar curve following the fiftieth day is accompanied by a corresponding climb in the acid curve.

From the above-established facts a number of possible conclusions can be reached, subject, of course, to further investigation, as the writer does not believe that the data at hand are enough to claim definite knowledge on the matter.

1. Care should be exercised in the handling and selection of fruit which is to be stored. The methods to be used are not the subject of this paper, but may be found distributed in the literature on citrus fruit, and are pretty well known now.

2. Stored grapefruit loses steadily in weight when kept in storage. This should not be a matter of any concern to the industry, as fruits are not sold on the basis of their weight, but rather of their quality.

3. The loss in weight of the fruit during the period of storage may be regarded as due to evaporation, which brings about a sort of natural drying process when no agents of putrefaction are present. To this loss of moisture should be attributed the loss in weight of the skin, and in the proportion of juice, as well as the increase in the substances in solution, acids included. That this is so, is evidenced by the fact that, in a general way, there are very little changes noticed in the ratio of solids non-acids to acids, which fact points to a simple process of concentration. The variations in ratio that occur are irregular, and not in any fixed direction. Most of the moisture lost, however, seems to come from the skin, as the loss in weight from this part of the fruit was nearly 20 per cent of the original, while the loss in weight of the juice was only over 8 per cent. The loss of water of the skin during the period of storage was not enough to cause any shrinkage in the skin, as shown by the fact that its thickness did not decrease.

4. The only chemical changes induced by storage that were noticeable at all were undergone by the sugars. Up to approximately the sixth week of storage, the sugars do not seem to be very much affected, but thereafter inversion and decomposition ensue. The sucrose inverts, and the invert sugars in turn, especially after the seventh week, decompose into non-sugars. There is a hint that at

least a part of the products of decomposition of the invert sugar may be acids. This is clearly shown by the curves. If we join by straight lines the points in the sugar curves corresponding to the thirty-ninth day of storage with the points at the extreme right of the corresponding curves, the straight lines for the sucrose and the invert sugar curves will be found to diverge, with the invert sugar lines slightly slanting downward. This shows both inversion of sucrose and loss of invert sugar. On the total sugar curve we get a line strongly slanting downward, an unmistakable sign of loss of sugar. The upward slant of a line similarly drawn on the acid curve supplies the hint of the formation of acids.

Effect of Sweating.

COMPARATIVE ANALYSES OF GRAPEFRUIT OF THE "DUNCAN" VARIETY, SWEAT AND UNSWEAT, HELD IN STORAGE FOR THE SAME LENGTH OF TIME.

By sweating grapefruit is meant the process of holding the fruit for a definite length of time in a closed compartment in a warm, moist atmosphere so as to bring out the color of the fruit. This process is illegal when used to conceal unripeness and inferiority of the fruit, as in that event the consumer would be led to believe that a fruit which is really unfit for human consumption was in perfect edible condition. Ripe, good fruit, which is wholesome and fit to eat, but which has retained a greenish tinge in spite of its ripeness, may be improved in appearance by this method. The following experiments were undertaken to determine what changes, if any, are wrought in the composition of the fruit by the process of sweating.

It is fitting to introduce the subject by quoting from Mr. Cady's records the notes that he left, which summarize his procedure and his observations and conclusions. They follows:

"CHANGES THAT TAKE PLACE IN HOLDING SWEATED AND UNSWEATED FRUIT.

"These tests were from five different groves. Eighty fruits were taken from each grove and divided into lots of forty each. Forty fruits were sweated forty-eight hours at a temperature of from 90 to 95 degrees Fahr. The other forty were held in the laboratory for analysis. Ten fruits were analyzed each week from the sweated and unsweated lots. Below are three sets of tables showing averages of the first and last analyses of the five groups.

FIRST LOT.

UNSWEAT FRUIT.

Analyzed.	Picked.	Skin per cent.	Juice per cent.	Solids per cent.	Acid per cent.	Ratio.	Total sugar per cent.	Invert sugar per cent.	Cane sugar per cent.
Sept. 22_	Sept. 28	29.35	39.67	8.8	1.42	6.2	5.65	3.03	2.51
Sept. 22_	Oct. 26_	25.18	41.23	9.7	1.43	6.8	5.28	3.63	1.71
		—4.17	1.56	.9	.01	.6	—.37	.60	—.80

FRUIT SWEAT 48 HOURS AT FROM 90 TO 95° FAHR.

Sept. 22_	Sept. 28	26.20	30.92	9.1	1.40	6.4	5.60	3.11	2.37
Sept. 22_	Oct. 26_	22.23	45.73	9.8	1.46	6.7	5.67	3.93	1.82
		—3.97	14.81	.7	.06	.3	.07	.82	—.55

SECOND LOT.

UNSWEAT FRUIT.

Picked.	Analyzed.	Skin per cent.	Juice per cent.	Solids per cent.	Acid per cent.	Ratio.	Total sugar per cent.	Invert sugar per cent.	Cane sugar per cent.
Oct. 20_	Oct. 26_	27.33	42.66	9.1	1.28	7.2	5.78	3.27	2.39
Oct. 20_	Nov. 24	24.33	46.06	10.1	1.38	7.3	6.19	4.16–	1.91
		—3.00	3.40	1.0	.10	.1	.41	.89	—.48

FRUIT SWEAT 48 HOURS AT FROM 90 TO 95° FAHR.

Oct. 20_	Oct. 26_	26.99	42.85	9.5	1.29	7.3	5.17	3.04	2.01
Oct. 20_	Nov. 24	24.28	45.63	10.3	1.37	7.5	6.15	4.19	1.84
		—2.71	2.78	.8	.08	.2	.98	1.15	—.17

THIRD LOT.

UNSWEAT FRUIT.

Picked.	Analyzed.	Skin per cent.	Juice per cent.	Solids per cent.	Acid per cent.	Ratio.	Total sugar per cent.	Invert sugar per cent.	Cane sugar per cent.
Dec. 2__	Dec. 8__	28.00	42.64	9.5	1.23	7.7	5.87	3.20	2.45
Dec. 2__	Jan. 5__	27.89	43.66	10.0	1.28	7.8	6.44	4.52	2.30
		—.11	1.02	.5	.05	.1	.57	1.32	—.15

FRUIT SWEAT 48 HOURS AT FROM 90 TO 95° FAHR.

Dec. 2__	Dec. 8__	28.15	42.33	9.8	1.27	7.7	5.93	3.40	2.41
Dec. 2__	Jan. 5__	20.47	41.41	10.0	1.33	7.5	6.19	3.74	2.38
		—7.68	.92	.2	.06	.2	.26	.34	—.03

"From these figures we find that the ratio in the first lot of fruits increased .6 in the unsweat fruit, and .3 in the sweat fruit. The ratio in the third lot increased .1 for unsweat fruit and decreased .2 for sweat fruit, and in the second

lot increased .1 for the unsweat fruit and .2 for sweat fruit. The conclusion drawn from the above is that grapefruit with a ratio from 6 to 6.5 will increase about one-half per cent on holding a month, but when the ratio increased to 7 or over there is very slight increase, if any.''

This is as far as Mr. Cady's notes and comments go according to the records found in the files.

In order to go still farther with this important topic, the writer gathered all the analytical data left by Mr. Cady on the subject, and sorted and arranged them in different ways, so as to bring forth whatever facts they might be made to reveal. From them the tables that follow were constructed.

It appears from the records that six groves were selected and marked B, D, E, F, G and H. From each grove eighty fruits were collected every month, and each batch of eighty fruits divided into two lots of forty fruits each. One of these lots was sweated and the other was not. Both lots were stored away in the laboratory, and samples of ten fruits each analyzed from each lot simultaneously at intervals of approximately one week. This was done from September 21st to December 8th, 1916.

The period of sweating varied from 48 to 72 hours.

A table summarizing the results of all the analyses performed is first given. It presents the comparative analyses of all samples of sweated and unsweated fruits that were kept for the same number of days in storage in the laboratory. In this table the progress of the changes taking place during the storage of the fruit are shown.

Again graphs have been plotted to show to better advantages the points that will shortly be made. In these graphs, as in the previous, the abscisæ stand for number of days in storage and the ordinates represent percentages of the item the curve represents. The scales used are given in the plots. The ratios of invert sugars to sucrose and of solids to acids are represented by vertical lines.

TABLE No. 18.

COMPARISON OF CHANGES UNDERGONE BY FRUIT STORED WITHOUT SWEATING AND FRUIT STORED AFTER SWEATING.

The average of all samples which had been kept the same number of days in storage before analyses were taken, and with these averages the following table was constructed:

Number of days after picking fruit was analyzed	7 to 8 days		12 to 18 days		19 to 23 days		24 to 32 days		34 to 40 days	
	Sweat	Not sweat	Sweat	Not sweat	Sweat	Not sweat	Sweat	Not sweat	Sweat	Not sweat
Thickness of skin.	9/32"	19/64"	17/64"	17/64"	17/64"	8/32"	15/64"	8/32"	8/32"	9/32
Per cent number of rot.	No	1	2	4	15	5	16	16	26	19
Percent loss in weight.	1.942	2.212	7.286	5.993	8.737	9.30	16.966	12.99	14.733	13.50
Per cent skin.....	29.00	28.22	25.04	27.46	25.79	25.28	24.58	24.94	22.87	24.09
Per cent juice.....	41.01	41.79	42.00	42.07	42.67	42.26	42.59	42.83	46.64	44.92
Per cent solids....	9.37	9.07	9.20	9.14	9.53	9.60	99.99	9.98	9.81	9.53
Per cent acid.....	1.312	1.267	1.373	1.355	1.400	1.352	1.406	1.390	1.363	1.40
Ratio of solids to acids.	7.14	7.16	6.70	5.71	6.88	7.10	7.10	7.18	7.19	6.80
Invert sugar.....	3.415	3.315	3.473	3.046	3.607	3.517	4.263	3.903	3.970	3.75
Total sugar as invert.	6.189	6.439	5.666	5.362	6.440	5.867	6.259	5.794	5.787	5.86
Cane sugar or saccharose.	2.625	3.015	1.988	2.200	2.691	2.232	1.896	1.796	1.726	2.00
Ratio of invert sugar to saccharose.	1.300	1.102	1.746	1.384	1.343	1.575	2.218	2.175	2.300	1.87

A study of these curves in connection with the table from which they were plotted again confirm the view that the only chemical change of importance that occurs in the composition of stored fruit, whether it be sweated or not, is the inversion of sucrose and the decomposition of invert sugar.

Looking at the curves representing the variations in juice content, it seems as if the percentage of juice had increased in these experiments. This is in opposition to results obtained in the previous experiments. However, if we examine the table, we will find a marked, almost uninterrupted decrease in the percentage of skin of all the stored fruit. In the sweated fruit the range has been much wider than in the unsweated fruit, the difference between the percentages of skin at the end of the first week and at the end of forty days being 7.13 per cent in the former case and only 4.13 per cent in the latter. Notice that the thickness of skin has diminished, showing a shrinkage, which together with the diminution in percentage point very clearly to a heavy loss of moisture on the part of skin. On the other hand, the percentages of solids and of acids, have remained practically constant, the curves indicating only a

very slight increase, due again to a small amount of evaporation from the juice, as evidenced by the fact that the ratio of solids to acids has hardly suffered any change. This makes it all clear that the apparent increase in the percentage of juice has been due to a disproportional loss of moisture by evaporation from the rind. This view is further confirmed by the fact that the increase in the juice content appears to be greater in the sweated fruit, just where the loss in percentage of the rind is higher. Notice again that the highest percentages of juice, which occurred during the last week of storage, coincide with the lowest percentages of skin, and the highest juice content registered belongs to the fruit with the lowest percentage of rind of all.

The figures for the sugar contents and the curves plotted from them explicitly confirm the results obtained in the previous experiments on storing. Again the invert sugar increases and the sucrose decreases simultaneously during the period of storage, while the total sugars have a slight tendency to decrease. This is better shown by the straight lines joining the extremes of the curves. The decrease in total sugars is not quite so marked as in the previous experiments, but this only confirms our previous statement that it was after the fifth or sixth week that the decomposition of sugar was very marked. In these instances, however, the decrease started after the third week and proceeded at a slow rate. At this same time the inversion of sucrose became more pronounced.

As seen, these changes take place to practically the same extent in both the sweated and the unsweated fruit and at practically the same rate as shown by the fact that the straight lines joining the ends of the curves for a given component are practically parallel, or slant but very little. Whatever small difference there is, is in the direction of a faster rate of change for sweated fruit. In general the ratios of invert sugar to sucrose is higher in the sweated fruit.

In conclusion, then, we find that the only change in the chemical composition of the fruit induced by storage is in connection with the sugars, manifested as an inversion of the sucrose, and a decomposition of invert sugar; that this change is affected by sweating only to a small extent, making it proceed a little faster in sweated fruit.

As regards ratio of solids to acids, it is hardly affected at all by storage, whether the fruit be stored after sweating or without sweating.

The per cent loss in weight was practically the same in both cases, and although the number of rots was larger in sweated fruit, the conclusion is by no means justified that it was the sweating that caused this difference, as large differences in the number of rots have been observed among lots of fruits stored without sweating.

Sweating, then, may be said not to affect to any material extent the composition of the fruit aside from the yellowing of the rind.

These conclusions are further supported by a table left by Mr. Cady, which represents the mean composition of sweated and unsweated fruit during the whole season, irrespective of the length of time the fruit was stored. As for each sweated sample stored for a given time there was always a corresponding unsweated sample stored for an equal period of time, the results are, of course, comparable. The table follows:

TABLE No. 19.

TABLE TO SHOW IF THERE IS ANY CHANGE BROUGHT ABOUT BY SWEATING.

Table constructed with the averages of all analyses of sweated and unsweated fruit from six trees, for the period from September 1916 to the middle of January 1917. Eighty fruits were picked each month from each of 6 trees set aside for the purpose. Forty fruits were sweat and the other forty were not. Ten fruits of each lot were separately analyzed each succeeding week. Duncan grapefruit from B, D, C, F, G, H plantations.

	Sweat.	Not sweat.
Average weight	520	534
Per cent loss in weight	10.3%	9.0%
Per cent skin	23.45%	24.18%
Per cent juice	43.33%	43.11%
Per cent solid in juice	9.6%	9.5%
Per cent citric acid	1.35%	1.35%
Ratio of solid to acid	7.1	7
Invert sugar	3.64%	3.55%
Total sugar as invert	5.49%	5.74%
Cane Sugar	1.91%	2.01%

In this table please notice again the smaller percentage of skin with a corresponding larger juice content in the sweated fruit, the identity in the percentages of solids, acid, and ratio of solids to

acid in both cases, and the differences in the sugars. The invert sugar is higher and the cane sugar lower in the sweated fruit, while the proportion of total sugars is slightly higher in the unsweated fruit.

To see whether the time of the year when the fruit was picked had any effect on these results, a series of tables, five in number designated as 20–A, 20–B, 20–C, 20–D and 20–E, were constructed. Each table presents the results obtained with fruit picked from the six trees within a given month, and establishes comparisons between samples of sweated and unsweated fruit analyzed the same number of days after picking. This gives, then, one table for each month on which fruit was picked. The averages of each one of these five tables for the whole period of storage, as given in the last two columns to the right of each, are then grouped together in one table for convenience in reference.

To show comparison between sweated fruit and fruit which has not been sweated, six trees were set aside in six different plantations and eighty to one hundred fruits picked every month from each of the trees. These fruits were divided into two equal lots, one lot was sweated and the other was not. Both lots were stored away in the laboratory and samples of ten fruits each were periodically analyzed at intervals of one week, more or less. The averages of the results obtained for samples picked on the same third of the month and analyzed the same number of days after picking, were tabulated, and are presented in these following tables, 20–A, 20–B, 20–C, 20–D and 20–E.

TABLE No. 20–A.

FRUIT PICKED SEPTEMBER 21st TO 30th, 1916.

Number of days after picking fruit was analyzed.	7 to 8 days Average of 2 samples		12 to 13 days Average of 3 samples		20 to 21 days Average of 2 samples		32 days Average of 4 samples		40 to 41 days Average of 6 samples		Average of all analyses for the whole period of storage	
	Sweat	Not sweat	Sweat	Not sweat	Sweat	Not sweat	Sweat	Not sweat	Sweat	Not sweat	Sweat	Not sweat
Average size	60	50	56	56	55	60	54	54	56	54	56	54
Average weight	536.6	575	553.6	529.3	510	507.5	536	555	567	570	542	547
Thickness of skin	1/4"	9/32"	5/16"	5/16"	5/16"	1/4"	7/32"	9/32"	1/4"	11/32"	17/64"	19/64"
Total number of rot	No	No	1	2	No	2	5	11	14	8	20	23
Per cent juice	39.94	40.93	38.45	37.94	39.67	41.09	42.06	41.09	45.39	41.80	41.10	40.46
Per cent skin	30.57	28.32	28.54	27.35	27.71	26.75	26.07	27.98	25.15	23.89	27.61	26.85
Per cent solids	8.96	8.25	9.20	9.26	9.55	9.80	9.77	9.82	10.16	9.37	9.53	9.30
Per cent loss in weight	0.566	0.85	5.46	5.03	8.05	11.75	12.55	14.42	11.19	13.75	7.56	9.16
Per cent acid	1.44	1.34	1.42	1.42	1.45	1.44	1.47	1.47	1.43	1.41	1.44	1.42
Ratio of solids to acids	6.23	6.15	6.45	6.50	6.60	6.85	6.62	6.67	7.12	7.01	6.606	6.55
Invert sugar per cent	3.05	2.70	3.26	3.23	3.91	3.70	4.68	3.79	4.21	3.99	3.82	3.482
Total sugar as invert per cent	5.66	5.55	5.54	5.87	6.60	6.47	5.68	5.56	5.87	5.73	6.04	5.849
Cane sugar or saccharose per cent	2.44	2.67	2.125	2.51	2.57	2.65	1.88	1.65	1.54	1.75	2.11	2.246
Ratio invert sugar to saccharose	1.25	1.01	1.534	1.286	1.521	1.396	2.489	2.297	2.733	2.28	1.81	1.550

TABLE No. 20–B.

FRUIT PICKED OCTOBER 6, 1919.

Number of days after picking fruit was analyzed	12 days		23 to 24 days		36 days		Average of all analyses for the whole period of storage	
	Sweat	Not sweat	Sweat	Not sweat	Sweat	Not sweat	Sweat	Not sweat
Average size	64	62	64	64	57	64	62	63
Average weight	497.5	482.5	475	484	499	485	490.6	483
Tickness of skin	1/4"	1/4"	7/32"	7/32"	1/4"	1/4"	15/64"	15/64"
Total number of rot	No	No	No	1	5	1	5	2
Per cent skin	21.94	28.70	25.44	23.86	21.59	23.78	23	25.44
Per cent juice	46.83	46.00	44.78	46.18	49.72	47.52	47.11	46.56
Per cent solids	9.00	8.50	9.20	9.06	9.30	9.33	9.16	8.96
Per cent loss in weight	6.45	8.25	9.06	6.90	16.86	11.10	10.79	8.75
Per cent acid	1.43	1.425	1.49	1.40	1.48	1.496	1.47	1.44
Ratio of solids to acid	6.30	5.90	6.16	6.46	6.26	6.36	6.23	6.22
Invert sugar per cent	3.21	3.21	3.36	3.03	3.85	3.37	3.47	3.20
Total sugas as invert per cent	5.50	5.14	5.30	5.05	5.46	5.54	5.42	5.24
Cane sugar, or saccharose per cent	2.17	1.80	1.81	1.87	1.48	1.82	1.82	1.91
Ratio invert sugar to saccharose	1.479	1.783	1.855	1.620	2.608	1.643	1.904	1.675

TABLE No. 20–C.

FRUIT PICKED OCTOBER 20th TO 27th.

Number of days after picking fruit was analyzed	8 days		21 to 22 days		33 days		Average of all analyses for the whole period of storage	
	Sweat	Not sweat	Sweat	Not sweat	Sweat	Not sweat	Sweat	Not sweat
Average size	54	59	59	59	55	59	56	59
Average weight	550	527.5	501	542.5	541.5	525	530.8	531.6
Tickness of skin	5/16"	11/32"	9/32"	9/32"	1/4"	7/32"	9/32"	9/32"
Total number of rot	No	No	10	1	5	3	15	4
Per cent skin	30.71	30.42	25.59	27.90	25.31	24.01	27.20	27.44
Per cent juice	40.42	40.00	42.43	39.91	44.02	43.74	42.29	41.22
Per cent solids	9.50	9.30	9.90	9.45	10.20	10.10	9.87	9.78
Per cent loss in weight	3.00	1.85	8.87	7.17	22.65	9.55	11.51	6.19
Per cent acid	1.33	1.26	1.37	1.27	1.42	1.42	1.34	1.32
Ratio of solids to acids	7.10	7.35	7.17	7.37	7.15	7.07	7.36	7.41
Invert sugar per cent	3.58	3.58	3.56	3.63	4.28	4.03	3.81	3.74
Total sugar as invert per cent	5.75	5.87	5.99	5.98	6.11	5.99	5.95	5.91
Cane sugar, or saccharose per cent	2.04	2.16	....	2.19	1.71	1.88	1.875	2.08
Ratio invert sugar to saccharose	1.754	1.657	.....	1.665	2.50	2.14	3.082	1.798

TABLE No. 20–D.

FRUIT PICKED NOVEMBER 3rd TO 6th.

Number of days after picking fruit was analyzed	8 days		18 to 19 days		35 days		Average of all analyses for the whole period of storage	
	Sweat	Not sweat	Sweat	Not sweat	Sweat	Not sweat	Sweat	Not sweat
Average size	52	55	54	54	54	54	53	54
Average weight	540	570	570	615	547.5	463.4	552.5	549.5
Tickness of skin	1/4"	9/32"	1/4"	1/4"	1/4"	1/4"	1/4"	1/4"
Total number of rot	No.	No.	1	2	7	10	8	12
Per cent skin	26.58	26.00	24.66	26.34	21.88	24.60	24.34	26.65
Per cent juice	41.23	41.38	40.72	42.27	44.31	45.44	42.25	43.03
Per cent solids	9.25	9.15	9.40	9.65	9.97	9.90	9.54	9.57
Per cent loss in weight	1.95	2.45	9.95	4.70	16.15	15.65	9.35	7.60
Per cent acid	1.21	1.21	1.27	1.22	1.18	1.30	1.22	1.24
Ratio of solids to acids	7.60	7.55	7.35	7.95	8.42	7.65	7.82	7.72
Invert sugar per cent	3.63	3.58	3.95	2.70	3.85	3.91	4.81	3.40
Total sugar as invert per cent	5.99	6.11	5.75	6.11	6.23	6.24	5.99	6.15
Cane sugar, or saccharose per cent	1.24	2.41	1.67	2.29	2.16	2.20	1.67	2.30
Ratio invert sugar to saccharose	2.927	1.485	2.365	1.179	1.782	1.777	2.281	1.478

TABLE No. 20–E.

FRUIT PICKED DECEMBER 2nd TO 8th.

Number of days after picking fruit was analyzed	8 days		23 days		32 to 33 days		Average of all analyses for the whole period of storage	
	Sweat	Not sweat	Sweat	Not sweat	Sweat	Not sweat	Sweat	Not sweat
Average size	44	56	54	54	54	54	51	55
Average weight	515.7	533.2	541.7	565.2	514	530	523.8	543.8
Average tickness of skin	5/16"	5/16"	1/4"	1/4"	1/4"	1/4"	7/32"	7/32"
Total number of rot	No	1	4	1	6	2	10	4
Per cent skin	28.14	28.15	24.45	22.64	22.38	22.84	25	24.54
Per cent juice	42.44	44.88	43.83	42.41	41.69	43.66	42.66	43.65
Per cent solids	9.77	9.60	9.90	10.10	10.02	10.00	9.90	9.90
Per cent loss in weight	2.26	3.72	8.97	11.38	15.70	15.00	8.97	10.03
Per cent acid	1.27	1.26	1.29	1.30	1.33	1.28	1.30	1.28
Ratio of solids to acids	7.67	7.55	7.65	7.72	7.47	7.75	7.60	7.67
Invert sugar per cent	3.40	3.40	3.60	3.71	3.83	3.89	3.61	3.67
Total sugar as invert per cent	5.93	5.93	5.80	6.06	6.05	5.87	5.93	5.95
Cane sugar, or saccharose per cent	4.82	4.82	2.08	2.23	2.10	1.86	3.00	2.97
Ratio invert sugar to saccharose	0.705	0.705	1.730	1.663	1.823	2.091	1.203	1.235

TABLE No. 21.

CONSTRUCTED WITH THE AVERAGES OF TABLES No. 20–A, No. 20–B, No. 20–C, No. 20–D, No. 20–E.

Showing comparison between fruit that has been sweated and fruit that has not been sweated.

Date of picking	September 21 to 30		October 6		October 20 to 27		November 3 to 6		December 2 to 8		Averages of the averages of all analyses for the whole period of storage	
	Sweat	Not sweat	Sweat	Not sweat	Sweat	Not sweat	Sweat	Not sweat	Sweat	Not sweat	Sweat	Not sweat
Average size	56	54	62	63	56	59	53	54	51	55	55.6	57
Average weight in grams	542	547	490.6	483.8	530.8	531.6	552.5	549.5	523.8	543.8	527.9	531.1
Tickness of skin	17/64"	19/64"	15/64"	15/64"	9/32"	9/32"	1/4"	1/4"	7/32"	7/32"	1/4"	1/4"
Total number of rot	20	23	5	2	15	4	8	12	10	4	58	45
Per cent skin	27.61	26.85	23.00	25.44	27.20	27.44	24.34	25.65	25	24.54	25.43	25.98
Per cent juice	41.10	40.46	47.11	46.56	42.29	41.22	42.25	43.03	42.65	43.65	43.08	42.98
Per cent solids	9.528	9.30	9.16	8.96	9.87	9.78	9.54	9.57	9.90	9.90	9.599	9 50
Per cent loss in weight	7.56	9.16	10.79	8.75	11.51	6.19	9.35	7.60	8.97	10.03	9.636	8.342
Per cent acid	1.44	1.42	1.47	1.44	1.34	1.32	1.22	1.24	1.30	1.28	1.354	1.340
Ratio of solids to acids	6.606	6.55	6.23	6.22	7.36	7.41	7.82	7.72	7.60	7.67	7.08	7.08
Invert sugar per cent	3.822	3.482	3.81	3.20	3.81	3.74	3.74	3.81	3.40	3.61	3.772	3.498
Total sugar as invert per cent	6.04	5.849	5.42	5.24	5.95	6.91	5.99	6.15	5.93	5.95	5.978	5.920
Cane sugar, or saccharose per cent	2.111	2.246	1.82	1.91	1.875	2.18	1.67	2.30	3.00	2.97	2.095	2.301
Ratio invert sugar to saccharose	2.810	1.550	1.904	1.675	2.032	1.798	2.281	1.478	1.203	1.235	1.80	1.520

An inspection of the foregiong tables, especially the last, which summarizes the previous five, will again show that the data at hand does not show sweating to have any marked effect on the behavior of stored fruit. In the same manner, the time of picking of the fruit, within the limits of time herein included, may not be said to affect either the nature, extent, or the rate of the changes noted. With occasional exceptions, the storing of the fruit has had the effect of increasing the juice, decreasing the skin, increasing the solids and acids, giving a very slight increase to the ratio of solids to acids, increasing invert sugar, and decreasing sucrose, to about the same extent, and at approximately the same rate, and this irrespective of whether the fruit was sweated or not, or whether the fruit was picked in September or in December.

This may be seen to much better advantage from the following table and graph.

The table was constructed from tables 20–A, 20–B, 20–C, 20–D, and 20–E, as follows: The average of the first analyses performed after storage on the samples of fruit picked on the same date were compared with those of the last analyses, performed at the expiration of the period of storage, and with the average of all analyses performed during the storing of the fruit. This was done for both sweated and unsweated fruit. The differences whether positive (marked in table with a *plus* sign) or negative (marked in the table with a *minus* sign) were duly tabulated for each month and each component. The differences between the first analyses and the last, that is, between the first and the last columns (just before the columns of averages), in each of the tables A, B, C, D, E, were headed "Gain or loss of last week as compared with first week" in the table of reference. The differences between the first analyses and the averages, that is, between the first column and the very last (designated as "average of all analyses for the whole period of storage") in each table, A, B, C, D, E, appear under the heading "Gain or loss of average as compared with first week." From this column of the table the graph was drawn:

PLATE 1

Curves traced from Table No. 17 - Sugar Curves

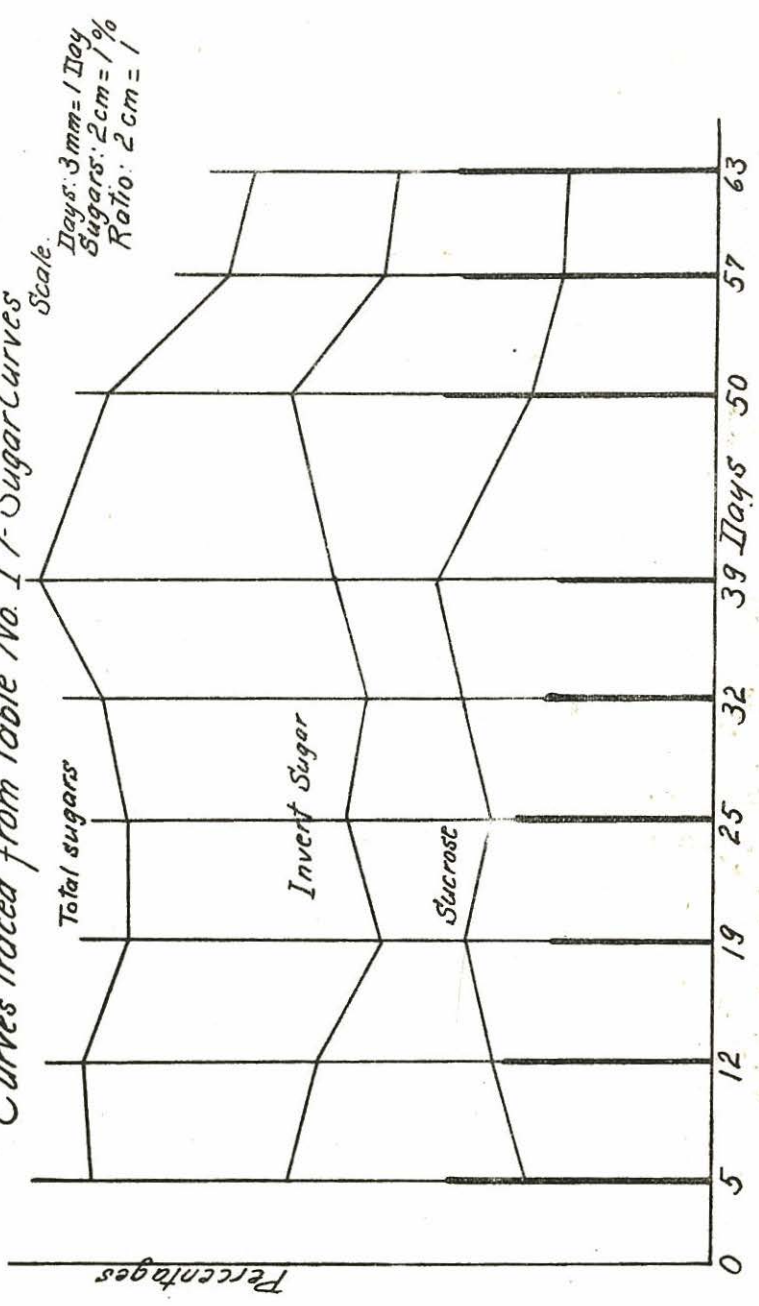
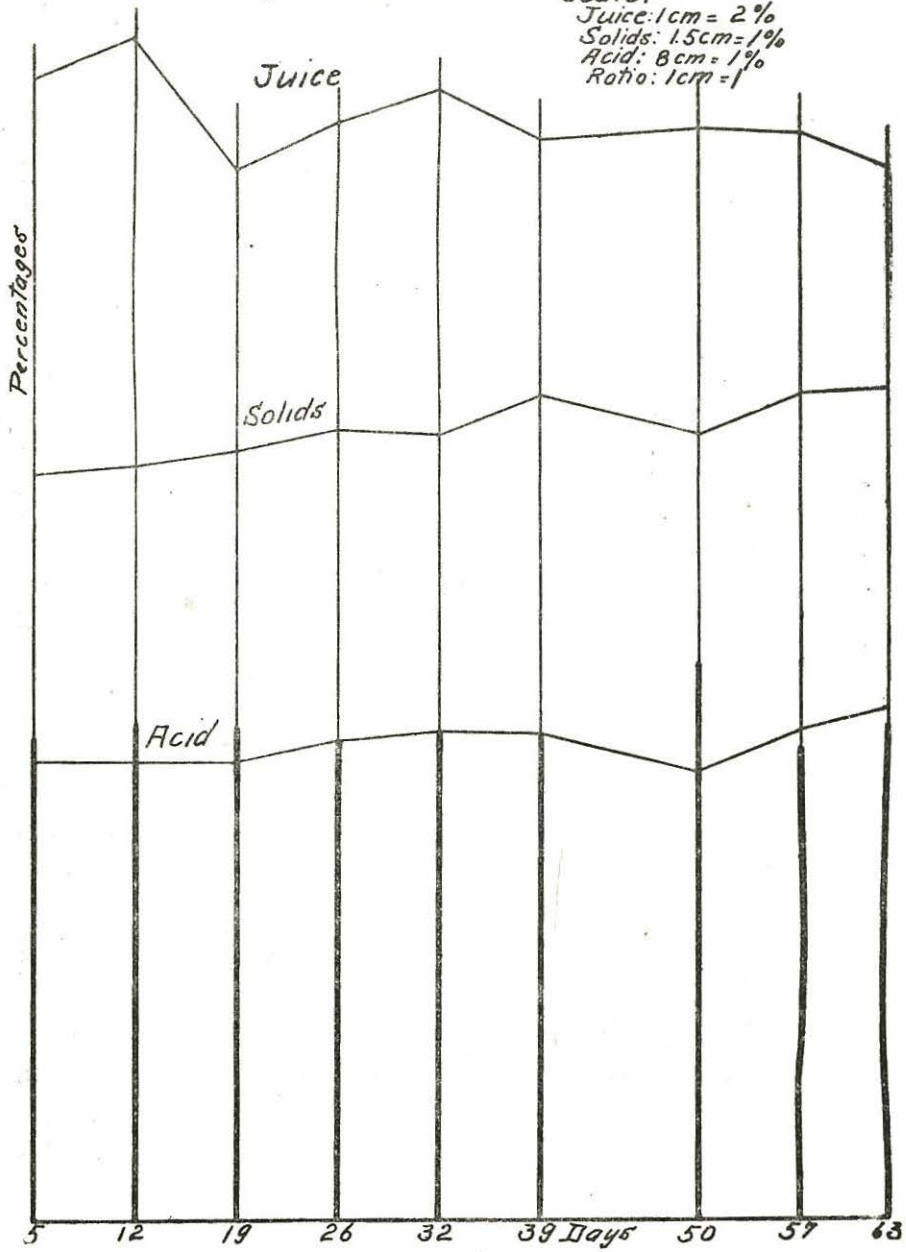


PLATE-1a

Curves traced from Table 17-Juice-acid-solids curves



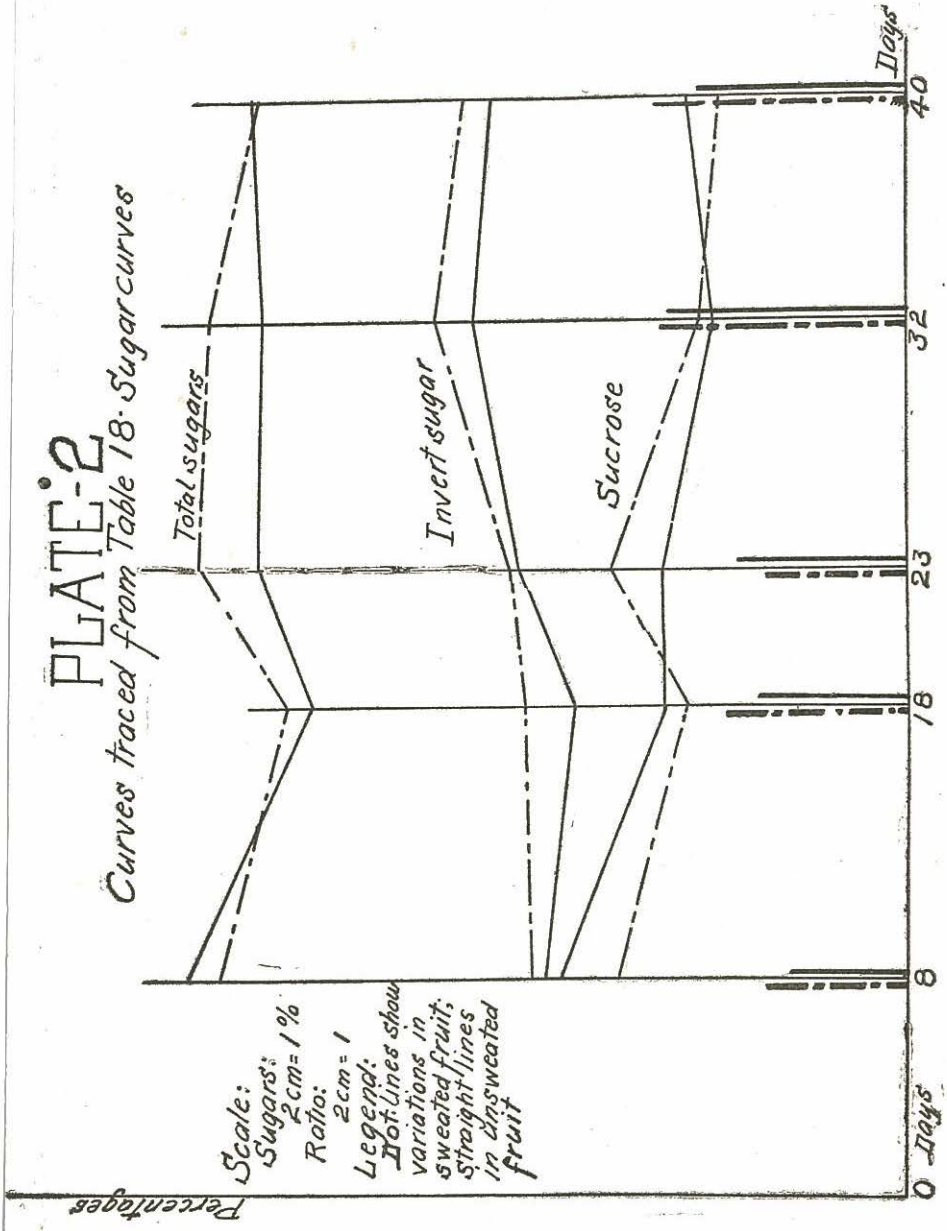


PLATE 2
Curves traced from Table 18. Sugar curves
Total sugars
Invert sugar
Sucrose
Scale:
Sugars: 2 cm = 1 %
Ratio: 2 cm = 1
Legend:
Dot lines show variations in sweated fruit; straight lines in unsweated fruit
Percentages
0 Days
8
18
23
32
40
Days

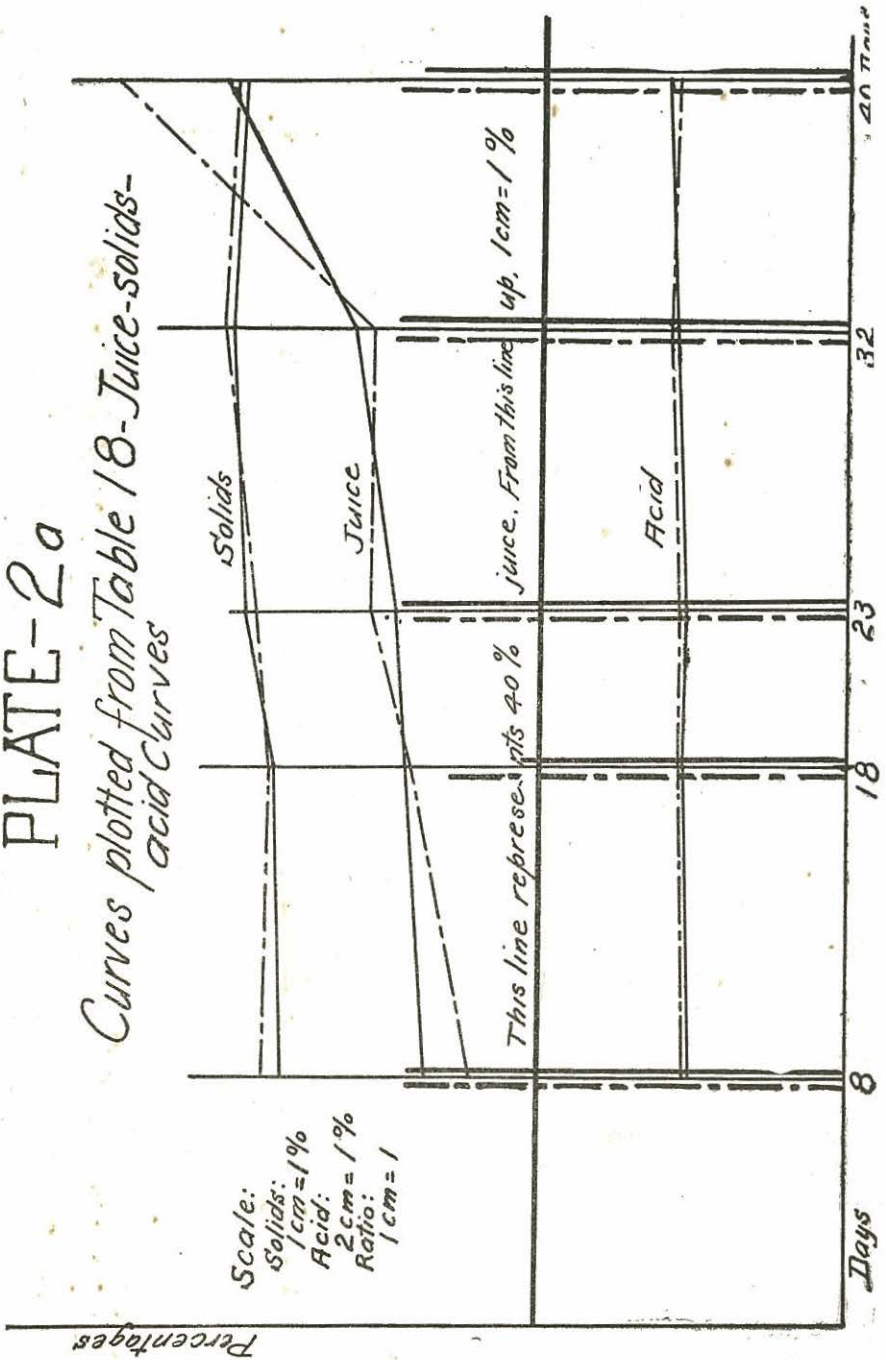
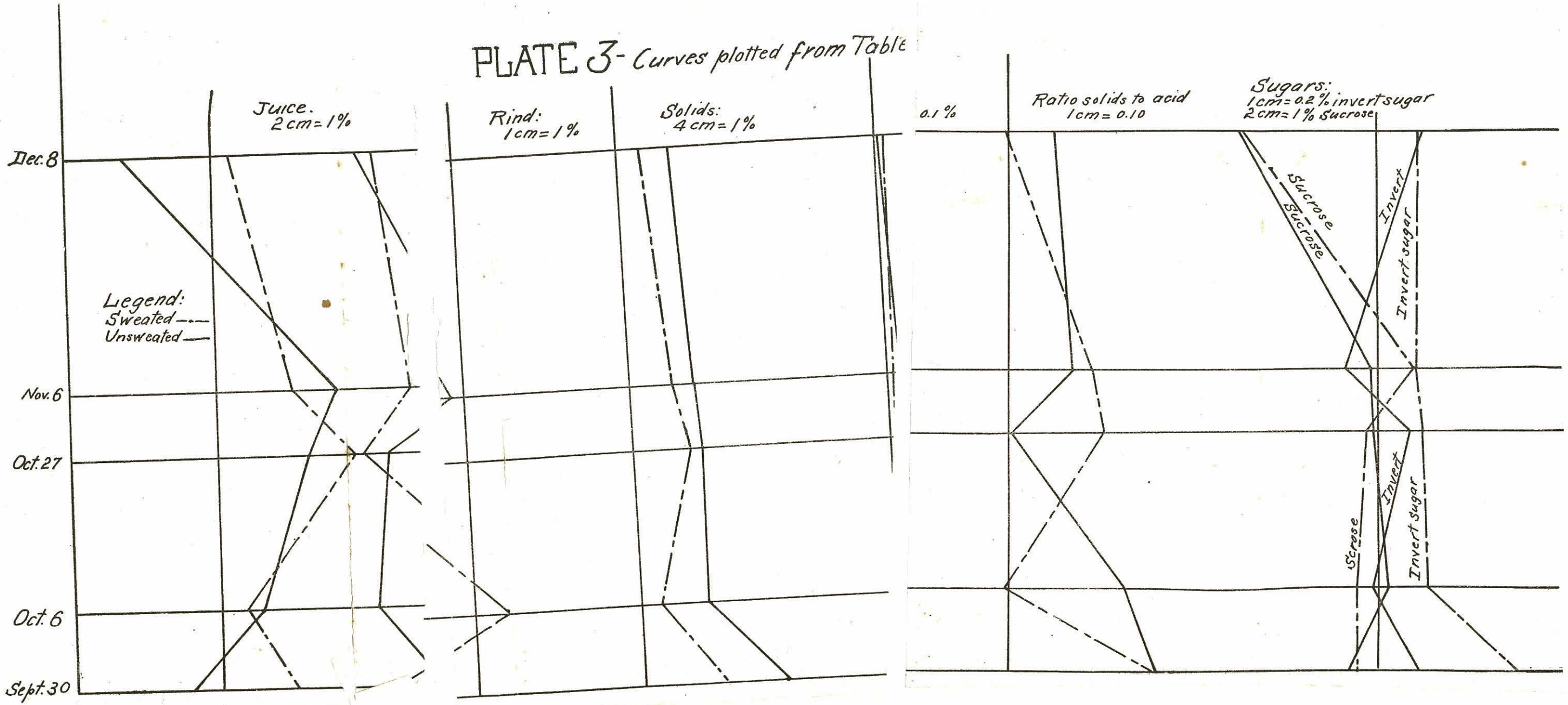


PLATE-2a
Curves plotted from Table 18-Juice-solids-acid curves
Solids
Juice
Acid
This line represents 40 % juice. From this line up, 1cm=1%
Scale:
Solids:
1cm=1%
Acid:
2cm=1%
Ratio:
1cm=1
Percentages
Days
8
18
23
32

PLATE 3- Curves plotted from Table



In the graph the vertical lines stand for the composition of the fruit at the end of the first week (in the case of fruit picked on October 6th the first analyses were performed after 12 days of storage), and the deviations are then marked with points, to the right of this line when positive, and to the left when negative; that is, all increases of the averages over the analyses at the end of the first week are represented by points to the right of the vertical line, and all decreases by points to the left of the same line. The horizontal lines crossing the vertical are spaced to represent the time of picking of the fruit.

Referring now to the curves. The curves for juice content cross each other frequently, thus showing that no one of the two sets of fruits predominates on the other as to their increase in the juice content. Two points of the curve for the unsweated fruit stand on the left of the vertical, but the fact that one corresponds to the fruit picked on September 30th and the other to fruit picked on December 4th, proves that this may not be attributed to any effect of the time of picking. All other points are on the right, thus showing an increase. This is also shown by the table, in which the average increase for the unsweated fruit appears slightly lower, due to the two irregularities mentioned.

All points of the curves representing differences in the percentage of skin, except one, stand on the left of the vertical. This shows a marked decrease, as evidenced by the table. Notice in the table that the average decreases are very near each other, being slightly higher for the unsweated fruit. The corresponding points for the sweated and the unsweated fruit do not lie very far apart from each other except for the fruit picked on October 6th.

The curves for solids follow practically the same course, both on the right of the vertical, their corresponding points lying pretty close together. The average increases shown by the table for both the sweated and the unsweated fruits differ only by 0.16 in favor of the unsweated fruit. After October 6th most points on both curves lie in a line differing but little from a straight line. Again is the influence of time of picking absent.

The acid curve for sweated fruit runs very close to the vertical, but this curve as well as that for unsweated fruit begin and end (if the points for September 30th are disregarded)[1] at about the

[1] Remember that for the fruit picked September 30th the time elapsed from the first to the last analyses was of 33 days, while for he other samples this time fluctuated between 24 and 27 days.

same distance from the vertical. The differences between the average increases for the sweated and the unsweated fruit was of only .02 in favor of the unsweated fruit must seem natural when the fact is taken in consideration that the increase in juice was less and the decrease in skin more, for this fruit. However, the differences are so small, that no great importance must be attached to them.

The "ratio of solids to acid" curves show fluctuations in their courses. The fact that the differences represented by the points for the samples gathered October 6th and for those gathered December 8th are very much the same precludes the possibility of the time of picking having any effect on the changes in ratio. According to the table, in both cases there has been a slight increase, .14 on the average for sweated fruit, and of .21 for unsweated fruit.

The curves for invert sugar and sucrose are interesting. The corresponding curves for both sweated and unsweated fruit begin and end in almost coinciding points. Both sucrose curves denote a decrease, and the two curves for invert sugar show an increase. Disregarding fluctuations, they indicate the same total amount of inversion at about the same rate. This is evidenced by the table, where the average increases in invert sugar and the average decreases in sucrose are almost equal for both sweated and unsweated fruit. Mark the fact that there was a slight gain in total sugars in both cases, and that this gain was identical for both kinds of fruit. The rapid turn to the left that the sucrose curves take after November 6th would seem to indicate a higher rate of inversion of sucrose in the fruits picked December 8th, but please notice that there has not been a corresponding sudden increase in invert sugar as was to be expected, if inversion to such a great extent had occurred. In regard to this, we may notice, by turning to table 20–E, that the percentage of sucrose given there for the fruit analyzed after the first week of storage is abnormally high. This may be due to differences in the sample.

The conclusion should be reached, then, that within the limits of time covered by the experiment and within the ratios of solids to acids represented by the samples tested, the time of picking of the fruit has hardly any effect on the behavior of the fruit when stored, whether this fruit be sweated or not.

Summary to Part II.

1. Excessive rainfall causes delay in the process of maturation

of grapefruit, and makes the fruit contain more juice, but less solids and acids. The ratio of solids to acids is lower in rainy seasons than when the rainfall is moderate.

2. The influence of the type soil on the composition and quality of the fruit is not very pronounced. Sandy soils seem to produce a better quality of fruit than clay soils, but more work along this line is necessary before a definite conclusion can be reached.

3. The chemical composition of the fruit does not seem to affect the quality of the fruit. Probably the use of fertilizers would mark any difference that might be introduced by the chemical composition of the soil.

4. As regards the influence of the chemical composition of the soil on the content of nutritive ingredients of the fruit, both the content of phosphoric acid and of potash of the fruit appear to be independent of percentage of these ingredients found in the soil. Nitrogen is the only element of nutrition the amount of which in the fruit may depend on the amount present in the soil. Again, the fertilizers used must be taken in consideration.

5. Sweating the fruit has very little effect on the composition of the fruit. The most noticeable change brought about by sweating is on the color of the fruit. Fruit that has been stored undergoes practically the same changes, whether it has been sweated or not, although it may be that the changes undergone by the sweated fruit are a little more pronounced than by the unsweated fruit.

6. The most important changes undergone by grapefruit on storing are:

(*a*) Loss in weight.

(*b*) Inversion of sucrose.

PREVIOUS PUBLICATIONS OF THE YEAR.

The Journal of the Department of Agriculture of Porto Rico—"Sugar Cane Varieties of Porto Rico—Part II," by F. S. Earle.

Circular No. 44.—"Los Comejenes de Puerto Rico," by George N. Wolcott.

Annual Report of the Insular Experiment Station of the Department of Agriculture and Labor of Porto Rico.

Circular No. 45.—"La Piroplasmosis" o "Fiebre de Tejas," por Jaime Bagué, V. M. D.

Circular No. 46.—"La Diarrea Blanca," por Jaime Bagué.

Circular No. 47.—"El Mejoramiento Sistemático de Nuestras Razas de Animales," por Jaime Bagué.

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