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THE RIPENING OF PEACHES.[1]

BY W. D. BIGELOW AND H. C. GORE.

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AT THE meeting of the Association for the Advancement of Science in December, 1903, the writers contributed an article on "The Ripening of the Apple." The present work is a continuation of a series of studies begun at that time. The methods employed in the study of the apple have been also applied to the study of the peach. The literature relating to the composition of the peach is very limited. The majority of the analyses that have been reported were made by old methods and are not to be credited for that reason at the present time. Of the analyses made according to modern methods but two are at all complete.[2]

For this work the writers had exceptional opportunities to secure a wide range of varieties of peaches grown under similar and well-known cultural conditions. The varieties were selected and secured by Mr. William A. Taylor, Pomologist in Charge of the Field Investigations of the Department of Agriculture. The work was so planned that the fruit of each tree of the varieties selected

[1] Read before the Association for the Advancement of Science, December 27, 1904.

[2] Kulisch: *Z. angew. Chem.*, 1894, p. 148, and Girard Bull. [Min. Agr. France], 1898, **17**, No. 7, p. 1523.

was sampled as carefully as possible at each picking. The examinations were made at three—and when possible, at four intervals of the life history of the peach. The times selected for the sampling were definite stages in the development of the fruit. They were as follows:

(1) *After the June drop.*—This period of the life history of the peach was selected as the first time of sampling because of the fact that it is the earliest point at which a sample can be secured of the fruit that will probably mature normally. The fruits which are not going to mature on account of imperfect fertilization or other cause, "shatter" or drop off at this time. Before securing the first sample, the trees were shaken and a portion of the fruit, which appeared to be firmly attached, selected from different sections of the tree was picked.

(2) *When the stone hardens.*—The peaches were carefully watched until the time when the stone could only be cut through with difficulty with a knife. The second sample of peaches was then secured.

(3) *When market ripe.*—Here the fruit is fully developed and almost the full degree of color has been attained. The flesh, however, is firm and the fruit will stand shipping. This is the commercial picking time.

(4) *When fully ripe.*—Here the peach is fully colored and somewhat larger than at the time of market ripeness. The flesh is soft and the fruit so easily bruised by handling that it will not stand shipment.

As stated before, in selecting all the samples the fruits were gathered from all sides of the tree and from the inner as well as the outer portions. In all cases the samples taken for analysis were of such size as to preclude, as far as possible, individual irregularities of composition. An attempt was made to secure a sample of such size that its composition would represent the composition of the average peach upon the tree at that time. Of the first samples picked about a hundred peaches were employed. Of the last samples, when the peach was fully ripe, about twenty peaches of each variety were secured for each sample. The fruit was gathered by one of us on the morning of the same day on which the analysis was begun. The varieties of peaches employed were Triumph, Rivers (or Early Rivers), Early Crawford, Stump (or Stump the World), Elberta, Orange Smock and Heath Cling (or

White Heath). The following characteristics of the varieties are taken from the description furnished by Mr. W. A. Taylor, through whom the peaches were secured. The complete description will be published in the bulletin from the Bureau of Chemistry in which the final full report of the work will be given. The Triumph is a soft-fleshed, semi-cling peach, little esteemed except for its extreme earliness. Its flesh is yellow, stained with red, firm, somewhat fibrous, juicy and mildly sub-acid. It is chiefly used for eating out of hand or for slicing.

The Rivers is a delicate fleshed, soft, easily bruised, semi-cling peach, chiefly prized for its earliness and productiveness. Its size is small to medium. Its flesh is greenish white, tender, melting, juicy and sub-acid.

The Early Crawford is a large freestone with yellow flesh stained red at stone. It is tender, melting, juicy, rich and sub-acid. It is highly esteemed for use in the fresh state and for canning.

The Stump is a medium sized freestone with white or greenish white flesh stained red at the stone. The flesh is tender, melting, moderately juicy, sub-acid. It is highly esteemed for canning.

The Elberta is a large freestone with yellow flesh stained red at stone. It is meaty, tender, moderately juicy and sub-acid. It is chiefly esteemed for its uniform large size, bright color and good shipping quality. It is a fairly good canner, but not highly esteemed as a dessert peach. As a commercial variety it is the most popular at the present time in the middle states and in southern peach districts.

The Orange Smock is a medium-sized freestone with light yellow flesh red at stone. The flesh is melting, moderately juicy and tart. Its season is late. It is used for canning and drying rather than in the fresh state.

The Heath Cling is of moderate size. Its flesh is creamy white and firm, melting, juicy, sweet and rich. Its season is very late. On account of its firm flesh and fine flavor it is popular for canning and preserving.

The fruit was grown on the farm of Mr. M. B. Waite, at Woodwardville, Md., in the summer of 1904. The season was abnormal. For six weeks prior to August 10th the atmosphere was very humid, resulting in the ruin of all peaches ripening up to that date. The rainfall then ceased and by August 20th the season became abnormally dry. No rain fell after that date until the latest of the

peaches were gathered. In comparing the ripening of the early and late peaches with each other, therefore, the varying climatic conditions to which the two classes were subjected must be taken into consideration. The fruits of the first two pickings were examined microscopically for starch. No starch was found in the embryo or in the stone, and none in the flesh with the exception of a thin layer of granules just under the epidermis of the fruit. The specimens which apparently had the largest amount of starch were examined quantitatively and 0.1 per cent. found to be present. This amount is, of course, negligible and no further determinations of starch were made.

The changes in composition of growing substances may be considered from two standpoints: First, the percentage composition of the substance at various stages of growth, showing the change in composition of the substance and hence the change in nature as it progresses. Second, from the standpoint of the actual weight of solids, water, starch, sugar, proteids, etc., in an individual of the species under examination. Obviously, the actual weights of each ingredient present in each peach at various stages of the life history of the fruit are of much greater interest and throw much more light on the changes in chemical composition than does the analysis of the peach itself without reference to its weight at different periods in its life history. Unfortunately, this matter has not always been given sufficient consideration in studying the ripening of fruits. In only two cases (Elberta and Orange Smock) were the peaches examined fully ripe. This is because it was impossible to preserve samples on the tree until they became fully ripe. In addition to the dropping of the peaches which would normally take place, the orchards were somewhat afflicted with *scab*, which increased the tendency of the peaches to drop.

The change in composition between the time of the hardening of the stone and the time of market ripeness is very great. During this period the weight of the peach is increased more than fourfold. The proportion of flesh to stone increases about seven times and the composition of the flesh itself goes through much greater changes than earlier in the life history of the fruit. The examination of samples at more frequent intervals would shed greater light on the life of the peach at the times when these changes begin and when they are greatest and for that reason would be valuable. The results here given are believed to be of value in that they mark

out the boundaries within which certain changes occur and limit the field in which further investigations of this nature can be carried on with profit. Taken in connection with the results given, a smaller amount of work will be necessary to accumulate details to make our knowledge of the life history of the peach much more complete than it is at present. We give here only the summaries of the various tables of analyses, showing the average change in composition of the six varieties of peaches studied.

Between the time of the June drop and the period of market ripeness the peaches increased in weight on an average of from 9.51 to 73.59 grams per peach. The percentage of flesh in the peach increased from 64.55 to 92.49, that is, the weight of the fleshy portion of the peach increased more rapidly than the weight of the stone. At the time of the June drop the stone constituted 32.5 per cent. of the weight of the entire peach, whereas, at the time of the market ripeness it constituted but 6.86 per cent. of the weight. The percentage of solids in the flesh of the peach remained fairly constant during its life history; that is, the increase in solids is fairly proportionate to the increase in water. On the other hand, the stone changes gradually in its nature. As it becomes harder and more mature the percentage of water decreases. The same is true of the embyro; that is, the solid content gradually increases with the maturity of the peach.

As has been stated before, absolute changes, as distinguished from relative changes in the composition of the growing fruit, can only be determined from the expression of the results in terms of grams per individual. In Table II is given the average composition of the six varieties of peaches examined in terms of grams per peach. It is apparent that the flesh of the peach increases rapidly, amounting to eleven times from the date of the June drop to the period of market ripeness. On the other hand, the increase in the weight of the stone is apparently small. The embryo almost doubles its weight between the time of the June drop and the hardening of the stone and after that its weight does not appreciably change. Since, as we noted in Table I, the amount of solids and water in the flesh of the peach (as percentage) remained practically constant the increase in the weight of the solids must be proportionate to the increase in weight of the flesh of the peach. This we find to be true in Table II. The solids increase from the 0.903 gram per peach at the time of the June drop to 9.719 grams at

the time of market ripeness. This is in keeping with the observation previously made that the percentage of solids in the stone increases while the weight of the stone remains practically constant throughout the life history of the peach. The weight of the solids in the embryo increases in somewhat the same proportion as the weight of the solids in the stone. It is also apparent that the decrease in marc (apparent in Table I) between the second and third periods at which the fruits were examined is relative and not absolute, since the weight of the marc in grams per peach is almost doubled between the time of the hardening of the stone and the period of market ripeness. The weight of the reducing sugar increases almost eight times between the time of the June drop and the time of market ripeness, and the increase in sucrose and acids is far greater than that of reducing sugar. The various forms of nitrogenous substances all increase in weight from the beginning to the end of the period of observation. There is no apparent tendency for proteids to be decomposed into simpler nitrogenous bodies or to be built up from the simpler forms in the growth of the peach. On the other hand, the relation between the amount of amido bodies and proteids is fairly constant throughout.

As was stated before, in some of the varieties under examination the peaches dropped from the trees before any of them became fully ripe. Samples of three varieties in the fully ripe state were, however, secured. In Table III the average composition of the three varieties is given in terms of grams per peach, both in the market ripe state and at the period of full ripeness. From an examination of this table it is apparent that a peach has not nearly reached its full weight at the time of market ripeness and that its increase in weight is due, not to increase in water content alone, but also to increase in solids. Both reducing sugar and sucrose increase during this period. On the other hand, the absolute increase in marc is considerably decreased and also that of acids.

An attempt was also made to determine the change of composition in peaches picked at the time of market ripeness and preserved in cold storage. Owing to the rapid deterioration of the peaches in storage, however, the results of the study of the influence of storage on their composition were not nearly as satisfactory as were obtained in the study of the influence of storage on the composition of apples. Unfortunately, the fact that we cannot store peaches for any great length of time after ripeness prevents us

from ascertaining whether, after full maturity and especially after picking, sucrose ceases to form and whether when formed it is converted into reducing sugar as is the case in the apple. The sucrose content of the apple increases after picking, owing to the hydrolysis of starch, and after the starch has entirely disappeared the sucrose content of the apple decreases owing to inversion. The peach has practically no starch at any period of its growth and after picking, the sucrose content does not increase. There appears to be a tendency toward the inversion of sucrose, but this is not nearly so marked as in the apple.

TABLE I.—PERCENTAGE COMPOSITION OF PEACHES.

(Average of six varieties.)

Time.	After June drop.	Hardening of stone.	Market ripe.
Average weight, grams....	9.51	16.75	73.59
Per cent. flesh.....	64.55	71.54	92.49
Per cent. stone.....	32.50	25.82	6.86
Per cent. embryo.....	2.94	2.89	0.65
Per cent. solids in stone...	9.37	27.35	66.94
Per cent. solids in embryo.	6.89	7.54	44.78
Analysis of flesh.			
Per cent. solids.....	14.77	16.97	14.04
Per cent. marc.....	7.37	7.71	2.51
Per cent. reducing sugar ..	2.71	2.26	1.98
Per cent. sucrose.....	0.18	1.57	5.70
Per cent. acid as H_2SO_4....	0.28	0.34	0.56
Per cent. nitrogenous bodies	0.98	0.81	0.35
Per cent. albuminoids[1]....	0.77	0.63	0.27
Per cent. amido bodies[2]...	0.21	0.18	0.08
Per cent. ash.....	0.75	0.68	0.40

TABLE II.—COMPOSITION OF PEACHES IN TERMS OF GRAMS PER PEACH.

(Average of six varieties.)

Time.	After June drop.	Hardening of stone.	Market ripe.
Average weight, grams....	9.51	16.75	73.59
Flesh, grams.....	6.12	11.89	68.11
Stone, grams.....	3.12	4.37	5.01
Embryo, grams.....	0.28	0.48	0.47
Solids in stone, grams.....	0.29	1.17	3.18
Solids in embryo, grams...	0.02	0.04	0.21
Composition of flesh.			
Solids, grams.....	0.90	2.01	9.72
Marc, grams.....	0.45	0.90	1.74
Reducing sugar, grams....	0.17	0.27	1.37

[1] By Stutzer method—albuminoid nitrogen, times 6.25.

[2] Amido nitrogen, times 4.25.

Time.	After June drop.	Hardening of stone.	Market ripe.
Sucrose, grams	0.01	0.16	3.94
Acid as H_2SO_4, grams	0.018	0.044	0.379
Nitrogenous bodies, grams.	0.060	0.099	0.181
Albuminoids,[1] grams	0.047	0.075	0.140
Amido bodies,[2] grams	0.013	0.023	0.041
Ash, grams	0.046	0.083	0.227

TABLE III.—COMPOSITION OF THE FLESH OF PEACHES AT MARKET RIPENESS AND AT FULL RIPENESS.
(Percentage of Total Solids.)

Serial No.	Variety.	Date. 1904.	Marc.	Reducing sugar.	Sucrose.	Acid as sulphuric.	Albuminoids.	Amido bodies.	Total nitrogenous bodies.	Ash.
				Market ripe.						
11248	Elberta	Aug. 25	18.71	14.42	41.85	3.34	.....	.....	.....	3.56
11295	Orange smock	Sept. 21	18.65	14.10	35.02	3.95	1.86	0.54	2.40	.....
11249	Stump	Aug. 25	17.70	13.04	40.77	3.24	.....	.....	.....	3.54
				Full ripe.						
11258	Elberta	Aug. 30	12.80	12.15	47.81	2.89	.....	.....	.....	3.28
11298	Orange smock	Sept. 26	17.05	17.49	46.07	3.37	1.82	0.374	2.19	.....
11250	Stump	Aug. 25	12.96	12.50	43.04	2.60	.....	.....	.....	3.43
Average, market ripe			18.35	13.85	39.21	3.51	.....	.....	.....	.....
Average, full ripe			14.28	14.05	45.64	2.95	.....	.....	.....	.....

A STUDY OF DURUM WHEAT.

BY F. A. NORTON.

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THE Departments of Agronomy and Chemistry of this station have been carrying on an extensive investigation of the so-called macaroni wheats during the past four years.

This variety of wheat, *Triticum durum*, is largely grown in the Mediterranean regions and on the plains of Southern Russia and Siberia, also to some extent in Argentine and India. It was recently imported for trial, especially in the semi-arid parts of the middle West, by the agricultural explorers of the Department of Agriculture. In the past France and Italy have consumed the greater part of the macaroni wheat produced, the wheat being used largely in the manufacture of macaroni, but to some extent as a

[1] By Stutzer method—albuminoid nitrogen, times 6.25.
[2] Amido nitrogen, times 4.25.