SOME CHEMICAL CONSTITUENTS OF PAPAYAS AND THEIR RELATION TO FLAVOR

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Flavor in any fruit is dependent upon so many factors that a complete treatise on the tastiness of even one kind of fruit like the papaya would occupy volumes of literature and would delve necessarily into quantities of technical data. For years scientific investigators have recognized the desirability of having some convenient quantitative measure for flavor, in order that their results might be expressed in terms such as would eliminare the variations always encountered when personal preferences in taste are used as criteria. With apples, for instance, some people prefer varieties with considerable tartness, and others would rather have those with a sweet flavor. With mangos, some prefer a rather pronounced turpentine taste, and others are emphatic in demanding a rather complete absence of this character.

The papaya seems to be an exception to the general rule in this regard. The writers, during the course of their efforts to develop more desirable varieties of this promising fruit, have noted a fairly definite agreement among papaya eaters that certain types or varieties are better flavored and more desirable than others. With these observations in mind, and recognizing the value in breeding and inheritance studies of having a quantitative measure suitable for expressing this flavor or taste factor, simple analyses were made of a group of papaya fruits generally agreed to have a desirable, sweet flavor and also of another group definitely of a flat, poor flavor. Following up this first phase of the work, analyses were obtained from representative fruits of a single, well-defiined variety, the Betty, to determine how consistently these particular constituents occurred within the fruits of that variety.

All of the analytical procedures followed in this work were based upon the Official Methods of Analysis as prepared by the Association of Official Agricultural Chemists (1). The constituents for which the fruits were analyzed were as follows:

(1) **Moisture or water content.** This was determined as loss in weight of the fresh pulp from drying to constant weight at 50 degrees C., in a blower oven. The residue remaining was the total solids.

(2) **Ash.** This was the residue remaining from burning the total solids until free from carbon. This burning was accomplished in a muffle at temperatures of from 500 to 700 degrees C., which was low enough to prevent the ash from fusing.

(3) **Acid.** This was determined from the juice as total free acid by titration with tenth normal sodium hydroxide, and is expressed as anhydrous citric acid. The juice was extracted from the pulp through cheesecloth in a hand press and then clarified by centrifugal force for 15 minutes at 2300 r. p. m.

(4) **Sugars.** These were determined from the pulp as free-reducing, hydrolyzable and total sugars. The Shaffer-Hartman method, using the cuprous titration, was employed. The inversion of the sugars was accomplished with hydrochloric acid under "Hertzfield conditions." The free-reducing and hydrolyzable sugars were calculated as dextrose from the Munson and Walker table.

The percentages expressed throughout the

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data are all based on the fresh pulp, except the acid, which was based upon the percentage of juice. All analyses were performed in duplicate so that the figures presented are the averages of two samples.

Section 1. **Differences in analyses between sweet-tasting and flat-tasting fruits.**

A large number of papaya fruits produced in the Station's 1939-40 varietal planting were brought into the laboratory and, among other measures of quality, were tasted. From time to time during the months of November, December, and January, fruits which possessed a decidedly "sweet" or "full" flavor were designated for analyses. Likewise fruits which exhibited a definite "flat" or "insipid" taste were also analyzed. The fruits were picked when definite yellow streaks appeared indicating proper maturity, and were allowed to ripen at room temperatures until they reached an edible condition. Several varieties or types are represented, and each fruit was from a different tree. Seven flat-tasting and nine sweet-tasting fruits were analyzed. The data are given in Table 1.

These data show that the differences in acid, moisture and ash contents were almost negligible. The sugar differences, however, were quite significant. There was a definitely higher percentage of total sugars in the sweet-tasting fruits, and this difference was largely due to the appreciably higher percentage of hydrolyzable sugars. In the sweet-tasting group, the fresh fruits analyzed 8.09 percent total, 5.38 percent free-reducing and 2.77 percent hydrolyzable sugars, as compared with flat-tasting fruits containing 5.41 percent total, 4.49 percent free-reducing and only 0.92 percent hydrolyzable sugars. The ratio of free-reducing to hydrolyzable sugars also seems indicative of sweetness. This ratio was 66.5 to 33.5 for the sweet-tasting

Table 1. Analyses of sweet-tasting and flat-tasting papaya fruits.

Fruit No.	% acid (as citric)	% moisture	% ash	% sugars			% of total sugar	
				Free-reducing	Hydrolyzable	Total	Free-reducing	Hydrolyzable
				Sweet-tasting				
1	0.062	89.2	0.322	4.48	2.85	7.33	61.9	38.1
2	0.038	88.3	0.439	4.65	3.40	8.05	57.8	42.2
3	0.035	88.7	0.486	4.35	3.93	8.28	52.5	47.5
4	0.028	90.4	0.491	6.05	1.70	7.75	77.1	22.9
5	0.036	88.1	0.336	7.75	3.15	10.90	71.1	28.9
6	0.035	89.6	0.389	5.27	2.42	7.69	68.5	31.5
7	0.022	90.7	0.436	5.08	1.54	6.62	81.6	18.4
Average	0.04	89.3	0.42	5.38	2.77	8.09	66.5	33.5
				Flat-tasting				
1	0.032	93.0	0.399	4.18	0.53	4.71	88.7	11.3
2	0.035	90.4	0.477	4.73	0.46	5.19	91.5	8.5
3	0.043	91.1	0.504	3.75	1.76	5.51	68.1	31.9
4	0.027	90.5	0.379	4.09	1.11	5.20	78.7	21.3
5	0.030	91.0	0.354	4.49	1.08	5.57	80.6	19.4
6	0.036	91.3	0.454	4.28	1.28	5.56	76.9	23.1
7	0.027	90.5	0.379	4.09	1.11	5.20	78.7	21.3
8	0.052	90.8	0.382	5.51	0.69	6.20	88.9	11.1
9	0.018	91.0	0.448	5.31	0.23	5.54	95.8	4.2
Average	0.03	91.1	0.42	4.49	0.92	5.41	83.1	16.9

group and 83.1 to 16.9 for the flat-tasting group.

A number of investigators, including Stahl (2) and Thompson (3) have reported on the chemical analysis of papaya, but, in the literature available to the writers, there is no reference to work in which analyses are correlated with taste of the fruit. The data reported in this paper are believed significant enough, however, to warrant the conclusion that taste or flavor in a papaya fruit is correlated definitely with the percentage of total and hydrolyzable sugars present. Undoubtedly other constituents such as organic acids and esters play a role in determining flavor also, but the data of this test indicate that the better flavored fruits certainly have a higher sugar content than the poor flavored fruits.

Section 2. Analysis of the Betty Variety

For the sugar content to be used even as a partial criterion of good flavor, it should be as constant for a single variety as is actual taste itself. In order to secure data on this point, analyses were made of fruits of the Betty variety. The Betty was arbitrarily selected for the purpose because it is a true breeding variety generally considered to have a good flavor.

Ten representative female Betty trees were selected for the test. From six of these trees, three fruits each were picked, one each in November, December and January. From the other four, only two each were picked, one each in December and January. The number of fruits analyzed from each tree was probably insufficient to yield data of absolute value, but so far as they were significant, it was found that about as much variation occurred between fruits on a single tree as between fruits from different trees. This would seem to indicate that the Betty has become fairly well "fixed" so far as the inheritance of these particular chemical constituents are concerned.

The average data for the twenty-six fruits analyzed in this test are given in Table 1. In order to show the extremes of variation the data for the individual fruits lowest and highest in each constituent are also given.

It must be remembered that the maximum and minimum data given in Table 2 are not for any one particular fruit all the way through, but simply show the extremes of variation in each constituent found in the variety as a whole. Although these extremes in variation are considerable, the standard deviations given in the table indicate that for at least 60 percent of the fruits the variations are not very great from the average. The extremes could easily be accounted for by errors in judging the maturity at picking time and the stage of edible softness. It is more difficult to judge these stages in the Betty than in most other varities, because instead of showing yellow streaks, the Betty turns a sort of bronze color on the tree when it is ready to pick. The fruits for this test were picked when this bronze color had developed over about 50 percent of the sur-

Table 2. Range of variation in analyses of the Betty Papaya.

				% sugars			% of total sugars	
	% acid	% moisture	% ash	Free-reducing	Hydro-lyzable	Total	Free-reducing	Hydro-lyzable
Minimum	.027	88.8	0.30	3.66	0.35	4.46	51.9	8.0
Maximum	.053	92.1	0.63	6.08	2.60	7.60	92.0	48.1
Average of 26 fruits	.039	90.6	0.46	4.71	1.32	6.03	77.3	22.7
Standard deviation	±.007	±0.9	±0.08	±0.53	±0.57	±0.87	±8.58	±8.58

face. The Betty is also noted for its lack of uniformity in ripening. Therefore, a certain amount of variation in flavor is normally expected. This probably will also hold true more or less for any other variety. The data are significant enough, however, to further bear out the contention reached in Section 1 of this paper that the percent total sugars, and to a lesser extent the percent of hydrolyzable sugars, might be used as a relative measure of sweet taste among papaya varieties. The percentage of total sugars is more easily obtained and, therefore, would be the more practical measure to employ..

It has been demonstrated that among the fruits analyzed in these experiments, definitely flat-tasting fruits contained about 5.41 percent total sugars and definitely sweet-tasting fruits contained about 8.09 percent total sugars. Analyses of fruits of the Betty variety, which averaged about 6.03 percent total sugars, indicated that the sugar content was consistent enough to be used as a measure of sweetness for selection and comparative purposes.

References

(1) Assoc. of Off. Agr. Chemists. Official and tentative methods of analysis. Assoc. of Off. Agr. Chemists, Wash., D. C. 4th ed 1935.

(2) Stahl, A. L. Composition of miscellaneous tropical and sub-tropical Florida fruits. Fla. Agr. Exp. Sta. Bul. 283. 1935.

(3) Thompson, Alice R. Composition of Hawaiian fruits and nuts. Hawaii Agr. Exp. Sta. Rept. 1914. pp 62-73.

EFFECT OF RECENT FREEZE ON LYCHEE, JABOTICABA AND MIMOSA BRACAATINGA

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The freeze in late January of this year has again afforded an opportunity for observations on the resistance to low temperature of subtropical fruit types, and windbreak plants under trial, including among others, the lychee, jaboticaba and **Mimosa bracaatinga.** There were lesser low temperature periods in December and January preceding the most severe period of January 20 to 29, with minimum temperatures on the last two days, January 27-28, and January 28-29. Under such conditions the plants were apparently thoroughly hardened off, and this should be kept in mind in evaluating the observations.

The Lychee

In estimating the cold resistance of the lychee, (Litchi sinensis) inspections have been made of several of the best known trees, and inquiries have been made in regard to others not visited. Where no temperature records were kept by the grower, the nearest Weather Bureau records are referred to in the discussion. The trees observed were mainly of the Brewster variety (6).

Mrs. Eva E. Collins of Homestead reports that her lychee tree was starting to bloom when the freeze occurred but suffered no injury to leaf or bloom. Trapp avocado and Haden mango trees nearby were badly frozen. A minimum of 27° F. was reported by Mrs. Collins. At Estero the two large trees belonging to Mrs. E. C. Trebell were visited shortly after the freeze and were found to be practically uninjured. Some leaves were