CARBOHYDRATE CONTENT OF TOMATO FRUIT

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The carbohydrate content of mature tomato fruit has received considerable attention since ATWATER and BRYANT (**1**) indicated the total sugar content to be about 3.39 per cent. and the starch less than 0.1 per cent. on the fresh basis. In a later publication of the same series containing revised data, CHATFIELD and ADAMS (**6**) gave the average reducing sugar content as 3.37 per cent. MYERS and CROLL (**11**) reported the reducing sugar content of two samples of tomatoes to be 3.39 and 2.91 per cent. and the total sugar content 3.47 and 3.25 per cent. BELL, LONG, and HILL (**2**) determined the available carbohydrate content of two samples to be 2.6 and 3.0 per cent., respectively. LAWRENCE and MCCANCE (**9**) have placed it at 2.4 per cent. ROSA (**13, 14**) has presented a study of the composition of tomatoes at different stages of maturity. For the mature fruit, the reducing sugar content of five samples varied from 2.63 to 3.80 per cent. For two of these the sucrose content, by invertase inversion, was 0.04 and 0.11 per cent. The starch content, by diastase inversion, varied from 0.012 to 0.52 per cent. for the five samples. For the same two samples upon which sucrose determinations were made the values for acid-hydrolyzable material, by hydrolysis with 5 per cent. hydrochloric acid, were 0.180 and 0.212 per cent. respectively. BENOY and WEBSTER (**3**) have reported that the total and reducing sugar concentrations were equal. They reported values of 2.43 per cent. for each, and 0.069 per cent. of starch on the fresh basis. BIGELOW and STEVENSON (**5**) and BIGELOW and FITZGERALD (**4**) have studied the chemical composition of commercial tomato products prepared in the eastern tomato-growing sections of the United States. Their values for reducing sugar content of filtrates from pulps averaged about 4.20 per cent. CRUESS, SAYWELL, and HARK (**8**) have given preliminary data on the composition of California tomatoes.

The present investigation was undertaken in order to secure a more complete knowledge of the carbohydrate composition of California tomatoes. The plan has been to study the composition of composite samples of both the entire fruit and the several more or less distinct botanical regions of the fruit. Determinations have been made of the reducing sugars, sucrose, starch, and acid-hydrolyzable material and the dextrose-levulose ratios.

Materials and methods

Large samples of from 15 to 20 previously frozen fruits were taken to reduce sampling error. Each fruit was quartered through the polar diameter and two alternate quarters were used for a composite sample. When it was desired to have samples of the core, locule, interlocular septa and outer walls,

the remaining quarters were cut through the equatorial diameter and the required portions then carefully secured. The samples were then ground in a food chopper and analyzed at once or were placed in cold storage (0° C.) if the analysis could not be completed immediately.

Reducing sugars were determined by the SHAFFER-HARTMAN method (**15**) after clarifying with saturated neutral lead acetate and deleading with sodium oxalate. Dextrose was determined by the method of LOTHROP and HOLMES (**10**). Sucrose was inverted with invertase for one hour at 55° C. The total reducing sugars present then were determined and the sucrose content calculated by difference. Starch was determined by the following modification of OLMSTED'S method (**12**). To a 25-cc. aliquot of the sample 0.1 gram of Taka-diastase was added. After careful mixing, the solution was brought to 55° C. and held at this temperature for one hour. After cooling and clarifying, the reducing sugars were determined as previously described. The acid-hydrolyzable carbohydrate material was determined by direct acid hydrolysis (**16**). This fraction includes the starch. Proper blanks were made for all determinations.

Total solids were calculated from the refractive index-total solids ratio determined by CRUESS and SAYWELL (**7**) for California tomatoes.

Results and discussion

For five samples analyzed, the sucrose content was 0.03, 0.05, 0.04, 0.02, and 0.07 per cent. respectively. Since these values were fairly uniform and all less than 0.10 per cent. it appeared that the sucrose content of mature fruit was relatively small and frequently less than 0.05 per cent. Consequently further determinations were not made. However, it is not intended to preclude the possibility of important physiological functions of sucrose.

Starch determinations were made on the above five samples. Values of 0.045, 0.038, 0.040, 0.031, and 0.037 per cent. starch were obtained. The first two samples were from vines of the San Jose Canner variety, the third and fourth from Santa Clara Canner vines, and the fifth from Stone. ROSA (**13, 14**) has reported values of 0.044, 0.052, 0.022, 0.034, and 0.012 per cent. on samples of ripe fruit of Earliana, Globe, and Stone varieties. Since the two series of results agreed quite closely, it appeared that the usual range of starch content of mature fruit was from 0.02 to 0.05 per cent., expressed on the fresh basis.

In order to secure data on reducing sugars representative of the state, samples from the more important tomato producing districts were analyzed with the results given in table I.

It would appear from table I that the average reducing sugar content of California tomatoes is somewhat higher than that generally recorded in the literature for other localities. Considerable variation was found in the

TABLE I

REDUCING SUGAR CONTENT OF MATURE TOMATO FRUIT GROWN IN CALIFORNIA
(EXPRESSED AS THE PRECENTAGE OF THE FRESH WEIGHT)

LOCALITY	REDUCING SUGARS	TOTAL SOLIDS	LOCALITY	REDUCING SUGARS	TOTAL SOLIDS
Arlington	3.28	6.57	Locke	3.96	7.22
Buena Park	3.62	8.13	Riverside	2.95	6.05
Burbank	3.45	7.30	Sacramento	4.01	6.82
Centerville	4.00	8.05	Salinas	3.94	6.82
Chino	3.04	6.88	San Fernando	3.33	6.43
Davis	3.54	6.93	San Jose	3.66	6.92
El Monte	3.38	6.42	Santa Clara	3.38	6.30
Fullerton	3.57	7.41	Sunnyvale	3.80	7.03
Hayward	3.81	7.22	Average	3.57	6.97

total solids and reducing sugars of samples from different districts within the state.

The results of the analyses of the cores, the locules, the interlocular walls and outer wall portions of alternate quarters of the fruit and a corresponding composite of these regions prepared from the remaining quarters are given in table II. Samples were taken October 2, 1931.

From these data it is apparent that the tissue of the core region is relatively high in reducing sugars, total solids, and acid-hydrolyzable contents. The locular material is considerably lower in total solids, reducing sugars, and acid-hydrolyzable material than any other portion of the fruit. The acid-hydrolyzable content is very much lower in the locular material. The walls approach the core and composite in composition except that they are somewhat lower in reducing sugars.

The results of the dextrose-levulose and total solids determinations on representative samples from several of the important tomato producing regions of the state are given in table III. It is interesting to note that the dextrose-levulose ratios generally are quite uniform and that the average levulose content is about 46 per cent. of the average total reducing sugar content.

Summary

The sucrose content of California tomatoes varied from very small quantities up to 0.05 per cent. and the reducing sugar content, from 3.30 to 3.70 per cent.; the dextrose content was about 1.2 times the levulose content. The starch content varied from 0.01 to 0.06 per cent., while the acid-hydrolyzable material varied from 0.10 to 0.30 per cent. The total solids content ranged from 6.5 to 7.0 per cent. on the average. All results are expressed on the basis of the fresh weight of the fruit.

TABLE II

COMPOSITION OF DIFFERENT REGIONS OF TOMATO FRUIT (EXPRESSED AS PERCENTAGE OF THE FRESH WEIGHT)

SAMPLE NUMBER	REGION	REDUCING SUGARS	TOTAL SOLIDS	SAMPLE NUMBER	REGION	REDUCING SUGARS	TOTAL SOLIDS	ACID-HYDROLYZABLE
		per cent.	*per cent.*			*per cent.*	*per cent.*	*per cent.*
1–1	Core	2.90	7.1	2–4	Core	2.61	5.2	——
	Locule	2.69	6.6		Locule	2.13	5.0	——
	Walls	2.32	6.6		Walls	2.38	5.0	——
	Composite	2.70	6.6		Composite	2.48	5.0	——
1–2	Core	3.30	6.3	3–2	Core	3.47	5.2	——
	Locule	2.90	6.0		Locule	3.15	5.1	——
	Walls	2.96	6.2		Walls	3.76	5.1	——
	Composite	3.08	6.2		Composite	3.67	5.2	——
2–1	Core	3.18	6.2	1–1–2	Core	3.61	6.3	0.245
	Locule	2.72	5.9		Locule	3.26	6.2	0.055
	Walls	3.04	6.2		Walls	3.30	6.2	0.265
	Composite	3.10	6.2		Composite	3.49	6.2	0.210
2–2	Core	2.60	5.8	1–2–2	Core	2.77	6.3	0.320
	Locule	2.13	5.1		Locule	2.30	5.8	0.060
	Walls	2.37	5.5		Walls	2.85	6.2	0.240
	Composite	2.49	5.6		Composite	2.96	6.2	0.235
1–3	Core	2.94	6.2	Marglobe (1)				
	Locule	2.52	5.8		Core	3.05	7.1	0.260
	Walls	2.79	5.8		Locule	2.53	7.2	0.065
	Composite	2.87	5.9		Walls	2.73	7.2	0.282
					Composite	2.92	7.2	0.275
1–4	Core	2.66	6.0	Santa Clara (3)				
	Locule	2.07	6.0		Core	3.30	5.1	0.210
	Walls	2.53	5.8		Locule	2.98	5.0	0.050
	Composite	2.62	5.9		Walls	3.07	5.0	0.370
					Composite	3.23	5.1	0.320
1–5	Core	3.36	6.3	Santa Clara (2)				
	Locule	2.86	6.2		Composite	2.67	5.1	0.295
	Walls	2.84	6.0	Marglobe (2)	Composite	3.92	7.2	0.260
	Composite	3.13	6.2	Marglobe (3)	Composite	3.93	7.2	0.295
				Bonnie Best	Composite	3.76	7.8	0.265
2–2	Core	2.86	5.0	Average	Core	3.06	6.1	0.259
	Locule	2.34	4.9	"	Locule	2.63	5.8	0.057
	Walls	2.39	5.0	"	Walls	2.84	5.9	0.289
	Composite	2.58	5.0	"	Composite	3.12	6.1	0.269

TABLE III

DEXTROSE AND LEVULOSE CONTENT OF MATURE TOMATO FRUITS
(EXPRESSED AS PERCENTAGE OF THE FRESH WEIGHT)

LOCALITY	DEXTROSE	LEVULOSE	RATIO D/L	TOTAL SOLIDS
	per cent.	*per cent.*	*per cent.*	*per cent.*
Burbank	2.06	1.85	1.11	6.9
Chino	2.06	1.71	1.20	7.1
San Fernando	1.93	1.73	1.11	6.6
San Fernando	2.11	1.68	1.25	6.9
San Fernando	2.04	1.81	1.13	6.4
Burbank	2.15	1.84	1.17	6.5
Burbank	2.06	1.92	1.07	6.3
Arlington	1.99	1.91	1.04	6.3
Arlington	1.98	1.92	1.03	6.4
El Monte	2.09	1.97	1.06	6.4
El Monte	1.89	1.59	1.19	6.2
Fruitvale	2.50	2.04	1.22	8.8
Fruitvale	2.37	1.97	1.20	8.4
San Jose	2.35	1.81	1.30	8.1
San Jose	2.24	1.73	1.29	7.9
Isleton	2.39	1.96	1.22	8.5
Palo Alto	2.12	1.78	1.19	8.1
Average	2.14	1.83	1.18	7.2

The average sugar content of tomatoes grown in this state appears to be somewhat higher than that previously reported in the literature.

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