A STUDY OF THE DEGREES BRIX AND BRIX-ACID RATIOS OF GRAPEFRUIT UTILIZED BY FLORIDA CITRUS PROCESSORS FOR THE SEASONS 1952-53 THROUGH 1955-56

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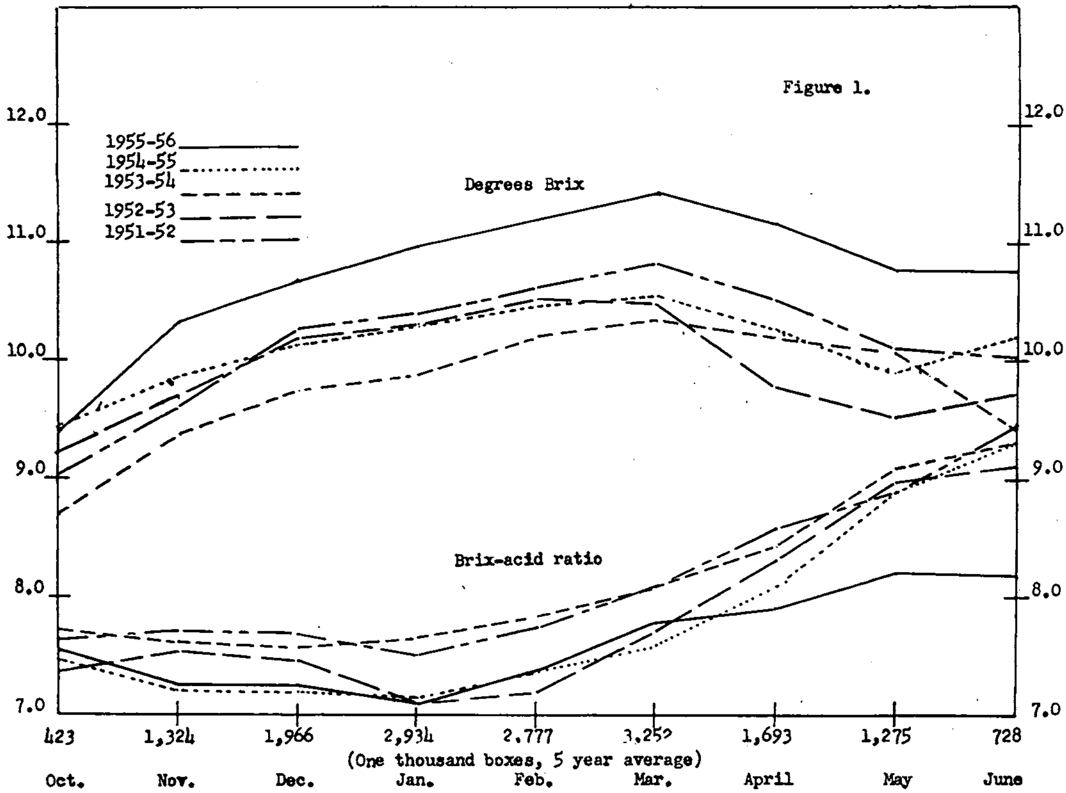
In February of 1956, our Division was asked by the citrus industry, through the Quality Advisory Committee of the Florida Canners' Association, to supply such tabulated data as we had available on the percentages of grapefruit utilized by citrus processors which would meet various Brix and ratio levels. The purpose of these data was to furnish additional information to the Advisory Committee on the availability of grapefruit for processing into a frozen concentrate which would be of a superior quality as compared to that previously produced from fruit meeting only basic maturity levels. At the time of the request, we were able to tabulate only a limited amount of data, taken entirely from the months of February and March for the past several seasons. This information was made available to the industry without delay, and was considered during the drafting of a Florida Citrus Commission regulation last March, setting up minimum requirements for grapefruit to be used in the production of frozen concentrated grapefruit juice, which were optional until September 1, 1956 (1).

During the summer of 1956, we tabulated this same type information for each month of the past four seasons. All information was obtained from our inspectors' work-sheets, which are standard forms used for recording analyses of loads of fruit received at processing plants. For reasons of simplicity, loads rather than boxes were used as the basic unit in this tabulation. The analyses of the individual loads were extracted and grouped in respective Brix and ratio brackets as follows: Degrees Brix—less than 9.0, 9.0 to 9.49, 9.5 to 9.99, 10.0 to 10.49, 10.5 to 10.99, and 11.0 degrees and higher; and ratios—6.0 to 6.49 to 1, 6.5 to 6.99 to 1, 7.0 to 7.49 to 1, 7.5 to 7.99 to 1, 8.0 to 8.49 to 1, 8.5 to 8.99 to 1, and 9.0 to 1 and higher. Each month was tabulated individually, and the percentages of loads falling into each of the categories for that period were calculated. The tabulations were drawn up so as to represent fruit received by all major processors, with each day's receipts for the months of October, November and June being completely covered, and with each alternate day's receipts being tabulated for the heavy six months of the processing season. In all, more than 137,000 individual loads were tabulated. Since this constitutes more than half of all grapefruit received by all processing plants during these seasons, statistical sample variation is not a complicating factor.

The results of the tabulation of the 1952-53 through 1955-56 seasons are shown in Tables 1 through 4. The tabulation was to have included the previous five seasons, but records for 1951-52 had been partially destroyed, and data were available for only the months of February and March. Table 5 is a partial summary of Tables 1 through 4, showing the percentages of loads received at processing plants which met certain selected minimums.

In addition to these especially compiled data which indicate the percentages meeting various Brix and ratio levels, our Division routinely tabulates and distributes seasonal summaries of percent citric acid and degrees Brix by week-endings, including volume of movement, for all fruit received at processing plants (2). This information is available to all segments of the citrus industry, and the tabulated data will not be repeated here. However, these data have been averaged monthly for the past five seasons and are graphically illustrated in Fig. 1. This information is hence a part of the present study, and it is from these



data that we can determine what time of the season the grapefruit utilized reaches its highest Brix level, together with appropriate ratios.

A further bit of information is included here, also. As a result of the optional compliance provision of the regulation previously mentioned, close records were maintained on the fruit received for concentrating during the period March 18 to July 1, 1956. Some 3700 loads were processed under this plan, and only a negligible portion failed to meet the minimum Brix of 9.5 degrees. However, some 20% were below the specified 7.5 to 1 ratio level, principally because of inadequate screening by fruit procurement departments. Nevertheless, the average ratio of the unsweetened grapefruit concentrate packed during this period was more than 9.0 to 1, as evidenced by our inspection records (3).

In attempting to evaluate the factual information we have presented here, it is necessary to make several assumptions: (1) That weather conditions will be no more unusual than those of the past five years. Hurricanes, freezes, and droughts may seriously affect the quality and movement of the grapefruit crop. (2) That cultural practices will remain essentially the same. Certain spray and other cultural practices may cause additional variables. (3) That fruit will be harvested at about the same periods as in the past. Changes in fruit utilization intervals would be most significant.

As can be seen from the tables, there is an ample supply of fruit meeting 9.5 degrees Brix with a minimum of 7.5 to 1 ratio any month from February through June. Since evaporation facilities are relatively idle during February and March, it is convenient for processors to concentrate grapefruit juice during these two months. However, those desiring to pack unsweetened juice will find it much less difficult if they can delay their operations until April or May, for the percentage of 9.0 to 1 ratio fruit has risen sharply by that time,

TABLE 1: Percent of Loads Meeting Various Degrees Brix-Ratio Combinations, Season 1952-53

OCTOBER 1952 — DEGREES BRIX

RATIO	-9.0	9.0	9.5	10.0	10.5	11.0&Up	TOTAL
6.0-1				0.3	0.4		0.7%
6.5		5.5	6.4	1.6			13.5%
7.0	17.9	18.2	8.6	2.9	1.0	0.2	48.8%
7.5	10.1	10.6	3.7	2.0	0.8		27.2%
8.0	2.5	2.3	1.5	0.4	0.1		6.8%
8.5	1.6	0.5	0.5				2.6%
9.0&Up	0.1	0.2	0.1				0.4%
TOTAL	32.2%	37.3%	20.8%	7.2%	2.3%	0.2%	100.0

NOVEMBER 1952 — DEGREES BRIX

RATIO	-9.0	9.0	9.5	10.0	10.5	11.0&Up	TOTAL
6.0-1				0.4	1.0	0.5	1.9%
6.5		2.8	5.2	3.9	2.1	2.2	16.2%
7.0	7.1	10.4	8.3	5.0	2.6	2.3	35.7%
7.5	4.8	7.3	5.6	3.4	2.4	2.7	26.2%
8.0	2.0	2.5	2.5	1.2	1.3	2.0	11.5%
8.5	1.1	1.1	1.5	0.6	0.6	0.6	5.5%
9.0&Up	0.3	0.6	0.6	0.7	0.6	0.2	3.0%
TOTAL	15.3%	24.7%	23.7%	15.2%	10.6%	10.5%	100.0

DECEMBER 1952 — DEGREES BRIX

RATIO	-9.0	9.0	9.5	10.0	10.5	11.0&Up	TOTAL
6.0-1				0.7	1.5	2.8	5.0%
6.5		2.3	7.5	6.8	4.3	4.4	25.3%
7.0	2.4	5.3	7.0	6.2	4.3	3.3	28.5%
7.5	1.8	3.4	5.6	4.1	3.1	2.3	20.3%
8.0	0.9	1.7	2.5	2.1	2.6	2.0	11.8%
8.5	0.4	0.6	0.9	1.1	1.2	1.1	5.3%
9.0&Up	0.2	0.5	0.6	0.7	1.0	0.8	3.8%
TOTAL	5.7%	13.8%	24.1%	21.7%	18.0%	16.7%	100.0

JANUARY — DEGREES BRIX

RATIO	-9.0	9.0	9.5	10.0	10.5	11.0&Up	TOTAL
6.0-1	0.7	1.3	1.7	3.6	4.9	5.0	17.2%
6.5	0.9	2.3	4.3	7.0	5.7	7.5	27.7%
7.0	1.5	2.8	4.7	6.2	4.6	4.1	23.9%
7.5	1.2	1.6	3.9	4.5	2.4	2.8	16.4%
8.0	0.8	1.0	1.3	1.2	1.2	1.6	7.1%
8.5	0.5	0.3	0.6	0.6	0.7	1.0	3.7%
9.0&Up	0.4	0.4	0.8	0.6	0.8	1.0	4.0%
TOTAL	6.0%	9.7%	17.3%	23.7%	20.3%	23.0%	100.0

FEBRUARY — DEGREES BRIX

RATIO	-9.0	9.0	9.5	10.0	10.5	11.0&Up	TOTAL
6.0-1	0.9	0.8	1.3	2.1	2.2	6.8	14.1%
6.5	1.3	1.7	3.3	4.3	4.2	9.0	23.8%
7.0	1.7	2.4	3.2	4.7	4.1	7.1	23.2%
7.5	1.0	1.3	2.2	3.9	4.4	4.9	17.7%
8.0	0.4	0.8	1.1	2.0	2.3	3.1	9.7%
8.5	0.5	0.3	0.7	1.1	1.0	2.1	5.7%
9.0&Up	0.8	0.9	0.6	1.0	0.7	1.8	5.8%
TOTAL	6.6%	8.2%	12.4%	19.1%	18.9%	34.8%	100.0

MARCH — DEGREES BRIX

RATIO	-9.0	9.0	9.5	10.0	10.5	11.0&Up	TOTAL
6.0-1	0.6	0.5	0.5	1.3	0.8	2.3	6.0%
6.5	1.4	1.4	1.5	2.6	1.8	6.4	15.1%
7.0	3.0	1.9	2.8	3.6	3.7	9.4	24.4%
7.5	2.4	2.2	3.0	3.3	3.1	6.9	20.9%
8.0	1.6	1.9	2.6	2.3	1.5	5.0	14.9%
8.5	1.6	1.6	1.1	1.4	1.1	2.1	8.9%
9.0&Up	1.5	1.4	1.8	1.8	1.4	1.9	9.8%
TOTAL	12.1%	10.9%	13.3%	16.3%	13.4%	34.0%	100.0

APRIL — DEGREES BRIX

RATIO	-9.0	9.0	9.5	10.0	10.5	11.0&Up	TOTAL
6.0-1	0.2	0.6	0.8	0.8	0.6	1.6	4.6%
6.5	1.1	0.7	1.1	1.4	0.8	1.5	6.6%
7.0	2.4	1.9	2.1	2.4	1.6	2.5	13.2%
7.5	4.0	2.2	2.9	1.6	1.9	2.6	15.2%
8.0	3.3	2.6	2.2	2.2	2.1	3.0	15.4%
8.5	3.8	2.0	3.3	2.2	1.3	1.7	14.3%
9.0&Up	8.3	5.1	5.3	4.2	3.8	4.0	30.7%
TOTAL	23.1%	15.1%	18.0%	14.8%	12.1%	16.9%	100.0

MAY — DEGREES BRIX

RATIO	-9.0	9.0	9.5	10.0	10.5	11.0&Up	TOTAL
6.0-1	0.9	0.7	0.6	0.6	0.4	0.2	3.4%
6.5	0.3	0.2	0.8	0.7	0.4	0.2	2.6%
7.0	1.6	1.0	0.8	0.9	0.3	0.8	5.4%
7.5	2.4	1.5	1.3	1.2	0.7	1.5	8.6%
8.0	3.9	1.9	2.3	1.9	0.9	1.3	12.2%
8.5	6.4	2.9	2.6	2.0	1.1	1.1	16.1%
9.0&Up	16.0	9.6	7.9	6.5	5.0	6.7	51.7%
TOTAL	31.5%	17.8%	16.3%	13.8%	8.8%	11.8%	100.0

JUNE — DEGREES BRIX

RATIO	-9.0	9.0	9.5	10.0	10.5	11.0&Up	TOTAL
6.0-1	1.0	3.1	2.5	1.9	0.5	0.4	9.4%
6.5	1.2	2.9	2.5	2.2	0.8	1.3	10.9%
7.0	1.3	2.9	3.3	2.5	1.2	1.1	12.3%
7.5	1.6	2.3	2.6	1.4	0.9	1.4	10.2%
8.0	2.4	2.1	1.7	2.2	1.5	1.6	11.5%
8.5	2.0	.9	1.6	1.8	1.6	1.6	9.5%
9.0&Up	9.7	6.1	8.8	3.7	4.0	3.9	36.2%
TOTAL	19.2%	20.3%	23.0%	15.7%	10.5%	11.3%	100.0

TABLE 2: Percent of Loads Meeting Various Degrees Brix-Ratio Combinations, Season 1953-54

	OCTOBER							NOVEMBER							DECEMBER						
	DEGREES BRIX							DEGREES BRIX							DEGREES BRIX						
RATIO	-9.0	9.0	9.5	10.0	10.5	11.0&Up	TOTAL	- 9.0	9.0	9.5	10.0	10.5	11.0 & Up	TOTAL	-9.0	9.0	9.5	10.0	10.5	11.0 & Up	TOTAL
6.0-1				0.2	0.3	0.3	0.8%				0.4	0.4	0.4	1.2%				0.5	0.9	1.5	2.9%
6.5		1.1	1.8	0.8	0.4	0.2	4.3%		2.0	4.9	4.3	1.9	1.7	14.8%		1.4	4.9	5.3	4.0	2.8	18.4%
7.0	17.8	8.1	5.3	1.7	0.3	0.4	33.6%	7.6	7.6	8.1	5.4	2.1	1.3	32.1%	4.1	4.3	6.7	7.6	4.0	2.1	28.8%
7.5	27.0	6.5	2.7	1.4	0.3	0.2	38.1%	7.9	6.6	5.6	3.6	1.5	0.8	26.0%	3.8	3.9	6.1	4.5	2.1	1.2	21.6%
8.0	10.5	3.0	1.0	0.2			14.7%	5.8	3.5	2.5	1.6	1.0	0.7	15.1%	3.5	3.5	3.6	2.4	1.4	0.8	15.2%
8.5	4.0	1.3	0.3	0.1			5.7%	2.6	2.0	1.1	0.5	0.4	0.2	6.8%	2.3	1.4	1.3	1.0	0.3	0.6	6.9%
9.0&Up	1.8	0.7	0.2	0.1			2.8%	1.5	1.1	0.6	0.5	0.2	0.1	4.0%	2.5	1.4	0.7	0.7	0.3	0.6	6.2%
TOTAL	61.1%	20.7%	11.3%	4.5%	1.3%	1.1%	100.0	25.4%	22.8%	22.8%	16.3%	7.5%	5.2%	100.0	16.2%	15.9%	23.3%	22.0%	13.0%	9.6%	100.0

	JANUARY							FEBRUARY							MARCH						
	DEGREES BRIX							DEGREES BRIX							DEGREES BRIX						
RATIO	-9.0	9.0	9.5	10.0	10.5	11.0 &Up	TOTAL	-9.0	9.0	9.5	10.0	10.5	11.0 & Up	TOTAL	-9.0	9.0	9.5	10.0	10.5	11.0 &Up	TOTAL
6.0 -1	0.5	1.0	1.1	2.0	1.9	2.0	8.5%	0.2	0.7	1.0	1.4	1.3	1.9	6.5%	0.2	0.5	1.1	1.7	1.0	1.9	6.4%
6.5	1.2	2.2	4.2	4.0	3.2	3.9	18.7%	1.0	1.6	2.6	3.1	2.6	3.9	14.8%	0.8	0.9	2.1	2.4	1.9	4.4	12.5%
7.0	2.5	3.3	5.3	4.7	3.0	4.0	22.8%	2.0	2.1	3.2	4.1	2.6	4.6	18.6%	1.4	1.5	2.7	3.2	2.6	5.1	16.5%
7.5	3.1	3.1	3.9	3.3	2.0	2.5	17.9%	1.5	2.2	4.2	4.9	2.6	3.5	18.9%	1.5	1.5	2.8	3.3	2.5	4.7	16.3%
8.0	2.4	2.1	2.4	2.3	1.6	1.5	12.3%	1.7	1.6	2.8	3.5	2.2	2.8	14.6%	1.4	1.7	2.3	2.5	2.3	4.0	14.2%
8.5	2.4	1.7	1.7	1.3	1.1	1.0	9.2%	1.2	1.1	1.8	2.7	1.7	2.0	10.5%	1.5	1.6	1.6	2.1	1.6	2.7	11.1%
9.0&Up	4.0	1.8	1.3	1.1	0.9	1.5	10.6%	2.6	2.5	2.5	2.4	2.0	4.1	16.1%	3.1	3.0	3.8	4.1	3.7	5.3	23.0%
TOTAL	16.1%	15.2%	19.9%	18.7%	13.7%	16.4%	100.0	10.2%	11.8%	18.1%	22.1%	15.0%	22.8%	100.0	9.9%	10.7%	16.4%	19.3%	15.6%	28.1%	100.0

	APRIL							MAY							JUNE						
	DEGREES BRIX							DEGREES BRIX							DEGREES BRIX						
RATIO	-9.0	9.0	9.5	10.0	10.5	11.0 &Up	TOTAL	-9.0	9.0	9.5	10.0	10.5	11.0 & Up	TOTAL	-9.0	9.0	9.5	10.0	10.5	11.0 & Up	TOTAL
6.0-1	0.4	0.2	0.3	0.2	0.4	0.8	2.3%	0.4	0.1	0.2	0.2	0.2	0.2	1.3%	0.9	0.2	0.1	0.2		0.1	1.5%
6.5	0.4	0.7	0.9	1.4	1.3	2.7	7.4%	0.7	0.5	0.5	0.4	0.3	0.7	3.1%	1.6	0.8	0.5	0.2	0.1	0.1	3.3%
7.0	1.0	1.1	2.2	2.2	2.2	4.3	13.0%	1.3	0.6	1.0	1.2	0.7	2.3	7.1%	2.4	0.9	0.9	0.5	0.7	0.9	6.3%
7.5	1.7	1.8	2.8	2.6	2.6	6.0	17.5%	2.2	1.4	1.5	1.7	1.8	4.2	12.8%	2.9	1.3	0.9	1.2	1.0	1.8	9.1%
8.0	1.6	1.9	2.4	2.4	2.5	4.1	15.1%	2.5	1.4	1.9	1.9	1.7	4.1	13.5%	3.6	1.7	1.2	1.1	1.5	2.5	11.6%
8.5	1.5	1.6	1.7	2.1	1.6	3.4	11.9%	2.7	1.8	1.8	1.6	1.6	3.1	12.6%	4.6	1.9	1.7	1.2	1.0	2.3	12.7%
9.0&Up	5.3	3.8	5.6	6.5	4.5	7.1	32.8%	10.8	6.7	9.3	8.1	6.1	8.6	49.6%	19.4	8.4	8.5	6.7	4.1	8.4	55.5%
TOTAL	12.1%	11.1%	15.9%	17.4%	15.1%	28.4%	100.0	20.6%	12.5%	16.2%	15.1%	12.4%	23.2%	100.0	35.4%	15.2%	13.8%	11.1%	8.4%	16.1%	100.0

TABLE 3: Percent of Loads Meeting Various Degrees Brix-Ratio Combinations, Season 1954-55

	OCTOBER							NOVEMBER							DECEMBER						
	DEGREES BRIX							DEGREES BRIX							DEGREES BRIX						
RATIO	-9.0	9.0	9.5	10.0	10.5	11.0 &Up	TOTAL	-9.0	9.0	9.5	10.0	10.5	11.0 & Up	TOTAL	-9.0	9.0	9.5	10.0	10.5	11.0 & Up	TOTAL
6.0 -1				0.6	0.2	0.2	1.0%				0.5	1.5	2.4	4.4%				1.1	2.0	4.6	7.7%
6.5		3.5	5.6	3.4	1.1	0.8	14.4%		2.5	7.9	7.4	4.5	4.5	26.8%	0.2	2.1	7.0	9.4	5.7	5.0	29.4%
7.0	13.0	15.0	9.4	3.6	1.2	0.4	42.6%	6.6	8.8	9.5	8.0	5.1	2.5	40.5%	3.1	5.0	8.0	6.6	5.2	3.2	31.1%
7.5	9.3	11.2	6.4	1.9	0.8	0.3	29.9%	3.3	4.2	4.8	3.4	2.1	1.0	18.8%	1.7	3.7	4.4	4.4	3.0	1.6	18.8%
8.0	2.3	4.0	2.1	0.8	0.1		9.3%	1.2	1.3	1.8	1.5	0.5	0.3	6.6%	0.6	1.3	1.7	1.7	1.1	0.7	7.1%
8.5	0.5	0.5	0.8	0.1			1.9%	0.4	0.3	0.5	0.3	0.2		1.7%	0.6	0.5	0.6	0.7	0.5	0.4	3.3%
9.0&Up	0.3	0.2	0.3	0.1			0.9%	0.3	0.4	0.4	0.1			1.2%	0.3	0.4	0.3	0.5	0.6	0.5	2.6%
TOTAL	25.4%	34.4%	24.6%	10.5%	3.4%	1.7%	100.0	11.8%	17.5%	24.9%	21.2%	13.9%	10.7%	100.0	6.5%	13.0%	22.0%	24.4%	18.1%	16.0%	100.0

	JANUARY							FEBRUARY							MARCH						
	DEGREES BRIX							DEGREES BRIX							DEGREES BRIX						
RATIO	-9.0	9.0	9.5	10.0	10.5	11.0 &Up	TOTAL	-9.0	9.0	9.5	10.0	10.5	11.0 & Up	TOTAL	-9.0	9.0	9.5	10.0	10.5	11.0 & Up	TOTAL
6.0 -1	0.9	1.5	2.2	3.8	3.7	6.2	18.3%	0.6	1.0	1.5	1.6	1.3	4.8	10.8%	0.5	0.5	0.8	0.8	1.2	3.1	6.[illegible]
6.5	1.7	2.6	4.1	5.0	5.9	7.5	26.6%	1.1	1.5	2.7	3.4	3.3	9.4	21.4%	0.9	0.8	1.2	2.5	2.3	5.7	14.4[illegible]
7.0	1.2	2.4	3.9	5.1	4.9	6.1	23.6%	1.2	1.5	2.5	4.1	3.9	7.6	20.8%	1.1	1.4	2.2	3.2	3.0	8.7	19.6%
7.5	1.2	1.6	3.0	3.0	3.0	2.9	14.7%	1.6	1.7	2.9	4.2	3.2	5.4	19.0%	1.7	1.6	2.3	3.1	2.8	6.1	17.6%
8.0	0.8	0.9	1.7	1.9	1.4	1.3	8.0%	1.2	1.5	2.5	3.2	2.3	3.6	14.3%	1.8	1.8	2.2	2.5	1.9	4.7	14.9%
8.5	0.5	0.6	0.7	0.8	0.8	0.6	4.0%	1.1	0.8	1.4	1.2	.0.7	1.7	6.9%	1.2	1.0	2.1	1.4	1.6	2.8	10.1%
9.0&Up	0.6	0.7	0.8	0.9	1.0	0.8	4.8%	0.9	1.0	1.1	1.1	0.6	2.1	6.8%	2.4	2.5	2.8	3.0	2.4	3.4	16.5%
TOTAL	6.9%	10.3%	16.4%	20.5%	20.5%	25.4%	100.0	7.7%	9.0%	14.6%	18.8%	15.3%	34.6%	100.0	9.6%	9.6%	13.6%	16.5%	15.2%	35.5%	100.0

	APRIL							MAY							JUNE						
	DEGREES BRIX							DEGREES BRIX							DEGREES BRIX						
RATIO	-9.0	9.0	9.5	10.0	10.5	11.0 &Up	TOTAL	-9.0	9.0	9.5	10.0	10.5	11.0 & Up	TOTAL	-9.0	9.0	9.5	10.0	10.5	11.0 & Up	TOTAL
6.0 -1	0.5	0.3	0.5	0.8	0.3	1.9	4.3%	0.1	0.3	0.2	0.3	0.3	0.3	1.5%				0.4	0.4	0.6	1.4%
6.5	1.1	1.1	1.5	1.5	1.4	3.3	9.9%	0.2	0.3	0.3	0.4	0.5	0.9	2.6%			0.3	0.4	0.3	0.8	1.8%
7.0	1.9	1.5	1.9	2.2	3.1	6.5	17.1%	1.3	0.6	0.6	1.3	1.4	2.1	7.3%	0.5	0.4	0.2	0.8	0.5	1.2	3.6%
7.5	3.3	1.6	2.9	2.3	2.0	5.7	17.8%	2.1	0.9	1.4	2.0	1.4	4.4	12.2%	0.9	0.6	0.8	1.3	2.0	2.0	7.6%
8.0	2.4	2.1	2.6	2.7	1.9	4.1	15.8%	2.9	2.0	2.3	2.3	1.9	3.6	15.0%	1.6	1.2	1.3	1.9	2.0	2.6	10.6%
8.5	1.9	2.0	1.7	2.2	1.3	3.5	12.6%	2.9	1.6	2.6	2.1	1.3	3.2	13.7%	1.4	1.6	1.9	1.8	2.4	3.2	12.3%
9.0&Up	5.4	3.8	3.6	3.8	2.4	3.5	22.5%	10.1	8.2	8.5	8.3	5.6	7.0	47.7%	15.0	6.6	9.1	9.5	7.9	14.6	62.7
TOTAL	16.5%	12.4%	14.7%	15.5%	12.4%	28.5%	100.0	19.6%	13.9%	15.9%	16.7%	12.4%	21.5%	100.0	19.4%	10.4%	13.6%	16.1%	15.5%	25.0%	100.0

TABLE 4: Percent of Loads Meeting Various Degrees Brix-Ratio Combinations, Season 1955-56

	OCTOBER							NOVEMBER							DECEMBER						
	Degrees Brix							Degrees Brix							Degrees Brix						
RATIO	-9.0	9.0	9.5	10.0	10.5	11.0 & Up	Total	-9.0	9.0	9.5	10.0	10.5	11.0 & Up	Total	-9.0	9.0	9.5	10.0	10.5	11.0 & Up	Total
6.0-1				0.4	0.2	0.3	0.9%				0.5	1.4	3.6	5.5%				0.8	2.0	7.2	10.0%
6.5		1.9	4.8	2.2	1.9	0.1	10.9%		0.9	3.6	6.9	5.7	10.7	27.8%		0.7	3.3	5.6	5.5	11.9	27.0%
7.0	11.1	9.6	9.7	5.0	2.7	0.5	38.6%	2.5	3.6	5.9	6.9	6.9	10.0	35.8%	1.8	2.1	3.1	4.6	5.9	12.2	29.7%
7.5	8.3	8.2	7.3	3.5	1.4	0.2	28.9%	2.3	2.3	3.6	4.0	3.3	4.0	19.5%	1.1	1.4	2.7	3.0	4.1	6.5	18.8%
8.0	5.4	3.6	2.5	1.2	0.5		13.2%	1.6	1.2	1.5	1.4	0.9	1.0	7.6%	0.7	0.7	1.3	1.4	1.8	2.2	8.1%
8.5	2.4	0.9	1.1			0.2	4.6%	0.4	0.3	0.5	0.6	0.2	0.3	2.3%	0.4	0.4	0.5	0.5	0.6	0.9	3.3%
9.0 & Up	1.0	0.6	0.7	0.5	0.1		2.9%	0.6	0.3	0.2	0.2	0.1	0.1	1.5%	0.4	0.3	0.1	0.7	0.5	1.1	3.1%
TOTAL	28.2%	24.8%	26.1%	12.8%	6.8%	1.3%	100.0	7.4%	8.6%	15.3%	20.5%	18.5%	29.7%	100.0	4.4%	5.6%	11.0%	16.6%	20.4%	42.0%	100.0

	JANUARY							FEBRUARY							MARCH						
	Degrees Brix							Degrees Brix							Degrees Brix						
RATIO	-9.0	9.0	9.5	10.0	10.5	11.0 & Up	Total	-9.0	9.0	9.5	10.0	10.5	11.0 & Up	Total	-9.0	9.0	9.5	10.0	10.5	11.0 & Up	Total
6.0-1	0.8	1.0	1.5	2.7	3.2	11.6	20.8%	0.2	0.4	0.6	0.8	1.6	8.1	11.7%	0.3	0.2	0.3	0.6	0.9	5.0	7.3%
6.5	1.0	1.4	2.1	3.9	3.9	14.1	26.4%	0.7	0.6	1.2	2.1	2.9	14.7	22.2%	0.6	0.5	1.0	1.8	2.1	9.9	15.9%
7.0	1.1	1.5	1.8	3.5	3.4	11.3	22.4%	0.6	0.8	1.6	2.1	2.6	13.7	21.4%	0.6	0.8	1.0	2.3	2.4	11.6	18.7%
7.5	1.0	1.2	1.7	2.0	2.5	7.3	15.7%	0.3	0.9	0.8	1.9	2.0	12.2	18.1%	0.5	0.7	0.8	2.0	2.8	13.1	19.9%
8.0	0.6	0.8	1.0	1.2	1.3	3.3	8.2%	0.4	0.4	1.0	1.2	1.6	8.8	13.4%	0.4	0.6	1.2	1.0	1.6	9.4	14.2%
8.5	0.5	0.2	0.5	0.5	0.5	1.5	3.7%	0.5	0.3	0.6	0.7	0.8	4.6	7.5%	0.6	0.3	0.4	1.0	1.6	7.2	11.1%
9.0 & Up	0.5	0.3	0.2	0.4	0.5	0.9	2.8%	0.7	0.5	0.6	0.7	0.8	2.4	5.7%	1.3	0.6	0.9	1.3	1.4	7.4	12.9%
TOTAL	5.5%	6.4%	8.8%	14.0%	15.3%	50.0%	100.0	3.4%	3.9%	6.4%	9.5%	12.3%	64.5%	100.0	4.3%	3.7%	5.6%	10.0%	12.8%	63.6%	100.0

	APRIL							MAY							JUNE						
	Degrees Brix							Degrees Brix							Degrees Brix						
RATIO	-9.0	9.0	9.5	10.0	10.5	11.0 & Up	Total	-9.0	9.0	9.5	10.0	10.5	11.0 & Up	Total	-9.0	9.0	9.5	10.0	10.5	11.0 & Up	Total
6.0-1	0.3	0.3	0.5	0.6	0.7	3.7	6.1%	0.1	0.2	0.5	0.7	1.0	2.8	5.3%	0.3	0.4	0.4	0.5	1.0	1.9	4.5%
6.5	0.6	0.5	0.7	1.3	1.3	8.1	12.5%	0.4	0.4	0.6	0.9	1.4	4.7	8.4%	0.4	0.3	0.8	1.5	1.3	4.1	8.4%
7.0	0.8	0.7	1.3	1.5	1.9	10.5	16.7%	0.7	0.7	1.3	1.7	1.7	6.2	12.3%	1.0	0.7	1.7	2.7	2.3	5.9	14.3%
7.5	0.7	1.0	1.3	2.1	2.3	10.2	17.6%	1.7	1.0	1.9	1.8	2.2	8.2	16.8%	1.2	0.9	1.3	2.4	3.0	7.0	15.8%
8.0	0.7	1.0	1.7	2.1	1.7	7.8	15.0%	1.2	1.0	2.4	2.2	2.5	6.9	16.2%	1.0	1.0	1.5	2.1	2.6	7.4	15.6%
8.5	0.6	0.6	1.0	1.5	1.5	6.2	11.4%	0.7	0.9	1.6	1.8	2.1	6.0	13.1%	0.7	0.8	1.5	2.0	2.2	5.9	13.1%
9.0 & Up	2.2	1.8	2.0	2.4	2.9	9.4	20.7%	2.2	2.4	3.5	4.5	4.8	10.5	27.9%	2.9	2.2	3.0	4.4	4.3	11.5	28.3%
TOTAL	5.9%	5.9%	8.5%	11.5%	12.3%	55.9%	100.0	7.0%	6.6%	11.8%	13.6%	15.7%	45.3%	100.0	7.5%	6.3%	10.2%	15.6%	16.7%	43.7%	100.0

and percentage-wise is more than four times as great in May as in February. Now, it is true that the bulk of the crop has normally been harvested earlier (4), so fruit procurement departments would have to arrange for suitable supplies in advance with appropriate picking dates.

In the interest of efficiency, if for no other reason, it behooves concentrators to use fruit with the highest Brix obtainable. From the Brix-ratio graphs (Fig. 1) we can see that this point has generally been reached in March of each of the years studied. However, if selected high Brix crops were held for an additional two months, sugar content would remain rather constant while ratio would continue to increase (5). In practice, the economics of such a policy might be variable, of course, and will not be considered here.

The real problem then, seems to be in obtaining fruit of suitable ratios, but this should not be an insurmountable one. Those operators who control a major portion of their supply should keep a regular check on the development of their blocks. Enough data should be available to enable field production men to project the probable ratio curve after the first few months. Operators depending

Table 5: Partial summary of tabulated data showing percentages meeting certain minimum ratios at 9.5 degrees Brix level.

Percent of loads with 7.5 to 1 ratio

	October	November	December	January	February	March	April	May	June
1955-56	19.2	21.9	27.9	25.3	40.7	53.1	56.1	62.9	62.1
1954-55	13.7	16.9	22.7	24.6	37.2	45.1	46.2	57.9	64.3
1953-54	6.5	20.9	27.6	29.4	45.7	49.3	57.9	59.0	45.1
1952-53	9.1	26.5	31.7	25.0	32.9	40.3	44.3	44.0	40.3
Averages	12.1	21.6	27.5	26.1	39.1	47.0	51.1	56.0	53.0

Percent of loads with 8.0 to 1 ratio

	October	November	December	January	February	March	April	May	June
1955-56	6.8	7.0	11.6	11.8	23.8	34.4	40.2	48.8	48.4
1954-55	4.3	5.6	9.3	12.7	21.5	30.8	33.3	48.7	58.2
1953-54	1.9	9.4	13.7	17.7	30.5	36.0	43.9	49.8	40.2
1952-53	2.6	12.4	16.6	11.4	17.5	24.0	35.3	39.3	34.0
Averages	3.9	8.6	12.8	13.4	23.3	31.3	38.2	46.7	45.2

Percent of loads with 8.5 to 1 ratio

	October	November	December	January	February	March	April	May	June
1955-56	2.6	2.2	4.9	5.0	11.2	21.2	26.9	34.8	34.8
1954-55	1.3	1.5	4.1	6.4	9.9	19.5	22.0	38.6	50.4
1953-54	0.7	3.6	5.5	9.9	19.2	24.9	32.5	40.2	33.9
1952-53	0.6	5.4	7.4	6.1	9.0	12.6	25.8	32.9	27.0
Averages	1.3	3.2	5.5	6.9	12.3	19.6	26.8	36.6	36.5

Percent of loads with 9.0 to 1 ratio

	October	November	December	January	February	March	April	May	June
1955-56	1.3	0.6	2.4	2.0	4.5	11.0	16.7	23.3	23.2
1954-55	0.4	0.5	1.9	3.5	4.9	11.6	13.3	29.4	41.1
1953-54	0.3	1.4	2.3	4.8	11.0	16.9	23.7	32.1	27.7
1952-53	0.1	2.1	3.1	3.2	4.1	6.9	17.3	26.1	20.4
Averages	0.5	1.2	2.4	3.4	6.1	11.6	17.8	27.7	28.1

largely on purchased fruit will have to insist on very rigid requirements as to acceptable lots. In either case, field men will have to know within very close limits the actual Brix and ratio that may be expected before picking crews move into a block for harvesting.

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DIACETYL PRODUCTION IN ORANGE JUICE BY ORGANISMS GROWN IN A CONTINUOUS CULTURE SYSTEM

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INTRODUCTION

The development of an off-flavor and odor during the manufacture of frozen orange juice concentrate has resulted in severe economic losses to a number of citrus concentrate packers. This off-flavor is reminiscent of "buttermilk" and is a result of the accumulation of diacetyl, a metabolic product of certain bacteria. Other than the work by Kilburn and Tuthill (11), former studies on the growth characteristics of these organisms and their production of diacetyl in orange juice has been limited to static batchwise cultures. Kilburn and Tuthill (11) used the continuous culture method to show the relationship between data obtained by plate count, microsopic count, and diacetyl analysis, and thereby validated the use of the latter analysis as a quality control tool in the citrus industry.

It was considered appropriate to supplement this applied investigation with a more basic approach to the characteristics involved in the formation of diacetyl in orange juice in a continuous culture system. This technique manages a unique separation of the rate of diacetyl production by a given organism from that organism's rate of growth. Batchwise investigations are necessarily a summation of growth and metabolic product formation and the latter cannot be studied separately.

In the continuous culture system the vessel or fermentor in which the test organisms are growing and forming metabolic products is supplied with fresh sterile medium at a constant rate. A constant volume is maintained in the fermentor by having an overflow rate that is constant as well as equal to the input rate of the fresh medium. By appropriate adjustment of the flow rate through the fermentor, a constant microbial population density of actively growing organisms can be maintained. At this constant population the rate of product formation can be studied without being affected by variations in the number of organisms.

THEORY OF PRODUCT FORMATION IN A CONTINUOUS CULTURE SYSTEM

To assist the reader, the following nomenclature will be used in the development of equations:

a = diacetyl concentration at time t (in p.p.m.)

a_0 = diacetyl concentration at zero time (in p.p.m.)

k = growth rate constant (in reciprocal hours)

k' = reaction rate constant for diacetyl formation (in p.p.m. formed per hour by one million organisms per ml or a population density of one.)

R = medium flow rate (in ml per hour)

t = time (in hours)

V = capacity of the fermentor (in ml)

x = bacterial population density at time t (in million organisms per ml)