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The Dextrose, Levulose, Sucrose, and Acid Content of the Juice from 39 Grape Clones

by

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One of the primary objectives of grape-breeding research at the University of Illinois is the development of high-quality table varieties. The concentrations of sugars and acid and their relationships are major factors in determining the degree of quality possessed by a variety. Because of the facts that levulose is sweeter than either sucrose or dextrose and that sucrose is sweeter than dextrose these 3 sugars should be determined separately. The differences in sweetness among them have been reported by Gortner (1949), Moncrieff (1946), and, in reference to grape quality, by Amerine and Thoukis (1958), and Winkler (1962). The ratio of sweetness to acid is the most important taste factor in quality ratings.

Varieties having high levulose and sucrose contents would provide maximum sweetness. This must be balanced with the proper amount of acid to provide a pleasing taste. Because of the above facts the work reported here was done to provide information concerning potentially desirable parents for breeding. Fruit was used from 39 clones, including native American species, American-type, French hybrid, and *vinifera* varieties. This seems to be the first report on the composition of native American species other than *V. rotundifolia*, Gore (1916) and Savage *et al.* (1941).

Terminology. The terminology relating to maturation and ripening is that recommended by Lott (1945 a), which refers to the pre-harvest life processes of the fruit as maturation, and to the post-harvest processes as ripening. Quality and related terms, composition, and color in general are used in accordance with the definitions of Lott and Rice (1955 b), by which the meaning of quality refers only to the combination of flavor, which is made up of taste and aroma, with texture. The descriptive color terms conform to the ISCC-NBS system as described by Kelly and Judd (1955).

Material and Methods

The grapes were taken from four-year-old vines trained to the Munson system and bearing full crops, in an experimental vineyard of the Department of Horticulture at Urbana, Illinois, U. S. A.[1]) They were harvested as near to maturity as could be determined. Each collection consisted of approximately 10 pounds of clusters. They were stored at 32° F and 90 to 95% relative humidity until the next morning when duplicate berry samples of 2 pounds each were selected from each clone. Only the mature berries were used from each cluster, discarding all that were damaged in any way and also those which were immature or abnormally small.

The samples were put through a Seprosieve[2]), which is constructed to collect the juice and pomace separately, and leaves the pomace with no free moisture. The juice was centrifuged in 250 ml. tubes for 10 minutes, at 500 times gravity in the middle

[1]) The varieties Ribier (Alphonse Lavallee), Thompson Seedless (Sultanina), and Tokay were selected in Urbana, Ill. retail markets; they were grown in California.

[2]) From Enterprise Manufacturing Co., Philadelphia, Pa., U. S. A.

of the length of the tube; this left it free of visible suspended particles. Duplicate samples of the centrifuged juice were used for each determination.

A Zeiss hand sugar refractometer, by which the percentage is read directly, was used to determine soluble solids. The pH was read with a Beckman glass-electrode meter on 75 ml. of juice in a 100 ml. beaker. Titratable acidity was determined on 10 ml. of juice diluted to 200 ml. with distilled deionized water in a 600 ml. beaker and kept agitated with a motor-driven stirrer, using 0.1 N sodium hydroxide for titration and the pH meter to obtain the results shown in the tables and figures; acid percentages were calculated as tartaric.

Sugar concentrations were determined on 10.0 gram samples of juice, which were clarified by adding and stirring in 1 ml. of saturated neutral lead acetate. The mixture was allowed to stand for 5 minutes and then transferred onto 9 cm. Whatman No. 4 filter paper in a 106 mm. porcelain Büchner funnel in a 500 ml. filter flask and the filtrate carried through with slight suction. The sample was washed 10 times, using only enough water each time to cover it completely.

The extract was transferred from the filter flask to a 250 ml. beaker and enough saturated potassium oxalate solution added to precipitate the excess lead. It was then filtered on Munktell's No. 2 filter paper in an 80 mm. glass funnel, catching the filtrate in a 250 ml. volumetric flask. After washing the percipitate thoroughly, the filtrate was made to volume and aliquots were taken for the determination of dextrose, levulose, and sucrose by the methods previously described by LOTT and RICE (1955 a).

Results

The sugar concentrations in the 30 clones having less than 2% sucrose are shown in table 1. Some sucrose was present in 21 of these, but generally less than 0.50%. In all clones, including the 9 varieties that had more than 2% sucrose (table 2), dextrose varied from 3.56% in Champagne to 9.48% in Tokay, or 2.66 times as much; levulose ranged from 4.56% in *V. champini*-Barnes to 12.41% in *V. cordifolia* #15, or 2.72 times as much; the sucrose percentage was 0 in some and highest at 5.59% in Kendaia; total sugars varied from 10.68% in *V. champini*-Barnes to 21.83% in *V. cordifolia* #15, or 2.04 times as much. These data are presented graphically in Fig. 1.

The dextrose content, Tables 1 and 2, was less than that of levulose in all but one of the 39 clones, the exception being *V. champini*-Barnes, Table 1. This is shown clearly by the levulose-dextrose ratios, which varied from 0.81 in *V. champini*-Barnes, Table 1, to 1.73 in Sweet Blue, Table 2.

The percentage of the total sugars that occurred as dextrose ranged from 24.7% in Sweet Blue, Table 2, to 53.0% in *V. champini*-Barnes, Table 1. Levulose made up from 38.4% of the total sugars Erie, Table 2, to 58.7% in Ontario, Table 1.

The concentrations of dextrose, levulose, and sucrose in the 9 varieties having more than 2% sucrose are recorded in Table 2. The percentage of the total sugars made up by each of the 3 sugars in each of these 9 varieties is shown in Fig. 2. Sucrose consisted of only 13.8% of the total sugars in Concord Seedless but nearly one-third in Kendaia and Sweet Blue. Levulose and sucrose combined constituted from 64.2% of the total sugars in Buffalo to 75.3% in Sweet Blue.

The per cent of soluble solids, Table 3, varied from the low 13.6 in *V. champini*-Barnes to 24.5 in *V. cordifolia* #15, or 80.1% more.

The per cent of acid, as tartaric, was determined at pH 7.0 and at pH 8.2 because both have been variously used as endpoints by investigators, AMERINE (1965). The

Table 1

Sugar concentrations in the juice of grape clones having less than 2 per cent sucrose 1965

Clone	Per cent of:				Ratio Lev./Dex.	% of total sugars as	
	Dextrose	Levulose	Sucrose	Total sugars		Dextrose	Levulose
Species							
V. berlandieri # 2	8.00	9.65	0	17.65	1.21	45.33	54.67
V. champini-Vermorel	5.63	5.88	0	11.51	1.04	48.91	51.09
V. champini-Barnes	5.66	4.56	.46	10.68	.81	53.00	42.70
V. cinerea # 27	7.39	8.80	0	16.19	1.19	45.65	54.35
V. cordifolia # 15	9.25	12.41	.17	21.83	1.34	42.37	56.85
Jaeger 52[1])	7.19	9.17	0	16.36	1.28	43.95	56.05
Jaeger 70[2])	5.23	5.82	.55	11.60	1.11	45.09	50.17
V. riparia # 50	7.89	8.30	0	16.19	1.05	48.73	51.27
V. rupestris 43—46	6.19	7.38	0	13.57	1.19	54.62	54.38
American							
Catawba	7.08	8.83	.41	16.32	1.25	43.38	54.11
Concord	6.85	9.31	.12	16.28	1.36	42.08	57.19
Tetraploid Concord	6.20	7.47	0	13.67	1.20	45.35	54.65
Delaware	9.03	12.27	.17	21.47	1.36	42.06	57.15
N. Y. 33873	8.78	10.95	.62	20.35	1.25	43.14	53.81
N. Y. 15305	8.66	10.26	.88	19.80	1.18	43.74	51.82
N. Y. Muscat	8.52	10.90	.36	19.78	1.28	43.07	55.11
Ontario	7.80	11.59	.36	19.75	1.49	39.49	58.68
Seneca	9.16	11.33	.61	21.10	1.24	43.41	53.70
French Hybrid							
Ill. 182—1	9.05	10.10	.25	19.40	1.12	46.65	52.06
J. S. 23—416	8.99	10.39	.71	20.09	1.16	44.75	51.72
Seibel 11342	8.29	9.97	0	18.26	1.20	45.40	54.60
S. V. 5—276	8.68	11.13	.17	19.98	1.28	43.44	55.71
S. V. 12—375	7.56	9.58	0	17.14	1.27	44.11	55.89
S. 8357	6.49	7.99	.45	14.93	1.23	43.47	53.52
V. vinifera							
Black Monukka	8.63	9.92	.60	19.15	1.15	45.07	51.80
Geant de Palestine	7.44	7.92	.18	15.54	1.06	47.88	50.97
Ribier[3])	7.98	9.43	.67	18.08	1.18	44.13	52.15
Thompson Seedless[4])	8.63	12.09	.18	20.90	1.40	41.29	57.85
Tokay	9.48	11.27	.17	20.92	1.19	45.32	53.87
Trieste	6.16	7.99	.31	14.46	1.30	42.60	55.26

[1]) This is a selection of *V. lincecumii*.
[2]) This is a species hybrid of *V. lincecumii* × *V. rupestris*
[3]) Alphonse Lavallee.
[4]) Sultanina.
Note: [1]), [2]), [3]), and [4]) apply also to table 3.

actual difference in percentage points at the two pH levels ranged from .03 in Erie to .09 in S. 8357 in all clones but the species, in which it varied from .06 in Jaeger 52 to .22 in *V. rupestris* 43—46, Table 3.

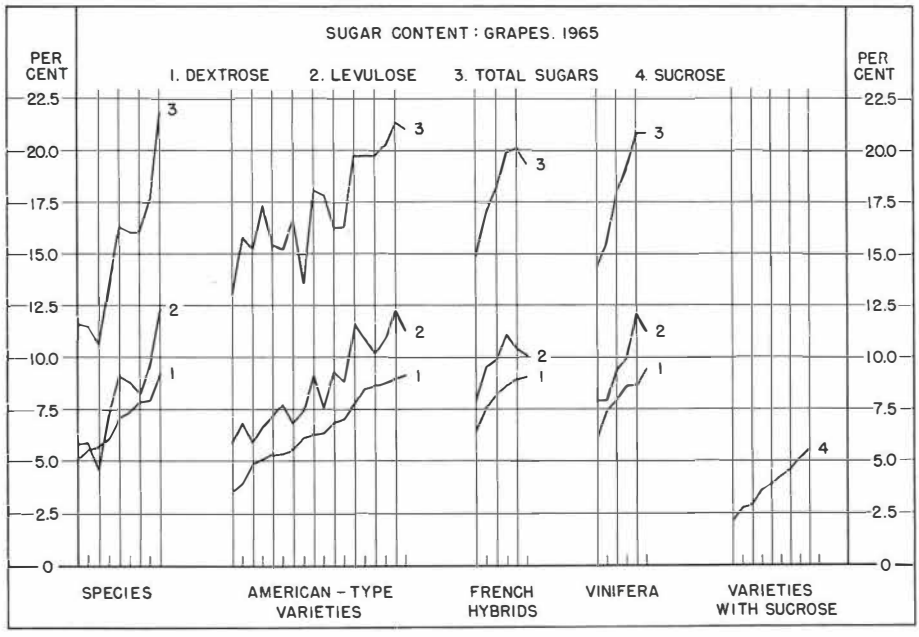

Fig. 1: Sugar content of the 39 grape clones.
Per cent of total sugars = sum of the percentages of dextrose, levulose, and sucrose. Clones in each of the 4 groups to the left are arranged in ascending order of dextrose percentage. At the extreme right are shown the 9 varieties having more than 2% sucrose, arranged in ascending order of sucrose content.

The increase in concentration from titrating to pH 8.2 in comparison with pH 7.0 varied in the species from 3.26% (*V. cordifolia* #15) to 16.18% (*V. rupestris* 43–46), in the American-type varieties from 4.11% (Erie) to 11.11% (N. Y. Musact), in the French Hybrids from 5.11% (S.8357) to 12.28% (Ill. 182-1), and in *vinifera* from 8.45% (Geant de Palestine) to 16.28% (Thompson Seedless). These differences can be at-

Table 2

Sugar concentrations in the juice of grape varieties having more than 2.0 per cent sucrose. 1965.

Variety	Per cent of:				Per cent of total sugars as:			Levulose / Dextrose	(Levulose & Sucrose) / Dextrose
	Dextrose	Levulose	Sucrose	Total sugars	Dextrose	Levulose	Sucrose		
Bath	6.29	9.09	2.76	18.14	34.67	50.11	15.22	1.45	1.88
Buffalo	6.41	7.57	3.90	17.88	35.85	42.34	21.81	1.18	1.79
Captivator	5.54	6.84	4.29	16.67	33.23	41.03	25.74	1.23	2.01
Champagne	3.56	5.95	3.68	13.19	26.99	45.11	27.90	1.67	2.71
Concord Seedless	5.46	7.76	2.12	15.34	35.59	50.59	13.82	1.42	1.81
Erie	4.86	5.88	4.59	15.33	31.70	38.36	29.94	1.21	2.15
Fredonia	5.39	7.22	2.91	15.52	34.73	46.52	18.75	1.34	1.88
Kendaia	5.08	6.70	5.59	17.37	29.25	38.57	32.18	1.32	2.42
Sweet Blue	3.93	6.80	5.18	15.91	24.70	42.74	32.56	1.73	3.05

Table 3
Acidity and soluble solids in the juice of grape clones. 1965.

Clone	Per cent of acid: at pH 7.0	at pH 8.2	Ave.	pH	% Soluble solids	% of Soluble solids as acid*	Soluble solids / Acid*	Total sugars / Acid*
			Species					
V. berlandieri # 2	2.16	2.25	2.20	3.18	20.2	10.90	9.18	8.02
V. champini-Vermorel	2.30	2.43	2.36	3.10	14.6	16.18	6.19	4.88
V. champini-Barnes	2.08	2.17	2.12	3.16	13.6	15.62	6.42	5.04
V. cinerea # 27	4.66	4.82	4.74	2.73	20.4	23.22	4.30	3.42
V. cordifolia # 15	3.68	3.80	3.74	2.82	24.5	15.25	6.55	5.84
Jaeger 52	.96	1.02	.99	3.39	17.7	5.58	17.88	16.53
Jaeger 70	1.22	1.32	1.27	3.37	13.8	9.19	10.87	9.13
V. riparia # 50	4.19	4.34	4.27	2.69	20.4	20.92	4.78	3.79
V. rupestris 43—46	1.36	1.58	1.47	3.64	18.2	8.07	12.38	9.23
			American					
Bath	.68	.72	.70	3.18	18.8	3.71	26.86	25.91
Buffalo	1.01	1.05	1.03	3.21	19.1	5.39	18.54	17.36
Captivator	.74	.81	.77	3.32	17.8	4.34	23.12	21.65
Catawba	1.17	1.26	1.21	3.27	17.3	7.01	14.30	13.49
Champagne	.88	.92	.89	3.31	15.0	5.93	16.85	14.82
Concord	.86	.91	.89	3.25	17.1	5.18	19.21	18.29
Concord Seedless	.82	.89	.86	3.37	16.6	5.16	19.30	17.84
Tetraploid Concord	.86	.91	.88	3.52	15.6	5.67	17.73	15.53
Delaware	.82	.87	.84	3.32	22.2	3.80	26.43	25.56
Erie	.73	.76	.74	3.28	16.5	4.51	22.30	20.72
Fredonia	1.02	1.08	1.05	3.17	17.0	6.16	16.19	14.78
Kendaia	.81	.86	.84	3.26	18.5	4.53	22.02	20.68
N. Y. 33873	.52	.57	.55	3.61	21.0	2.61	38.18	37.00
N. Y. 15305	.53	.59	.56	3.64	20.0	2.79	35.71	35.36
N. Y. Muscat	.45	.50	.47	3.70	20.6	2.30	43.83	42.09
Ontario	.33	.37	.35	4.05	20.0	1.75	57.14	56.43
Seneca	.61	.67	.64	3.48	21.2	3.03	33.13	32.97
Sweet Blue	.73	.79	.76	3.64	17.8	4.26	23.42	20.93
			French Hybrid					
Ill. 182—1	.57	.64	.60	3.60	20.0	3.02	33.33	32.33
J. S. 23—416	.73	.77	.75	3.35	20.6	3.65	27.47	26.79
Seibel 11342	.79	.85	.82	3.42	18.7	4.40	22.80	22.27
S. V. 5—276	.75	.80	.77	3.44	20.6	3.75	26.75	25.95
S. V. 12—375	.79	.84	.81	3.34	18.3	4.44	22.59	21.16
S. 8357	1.76	1.85	1.80	3.18	17.1	10.54	9.50	8.29
			V. vinifera					
Black Monukka	.65	.73	.69	3.59	19.6	3.52	28.41	27.75
Geant de Palestine	.71	.77	.74	3.68	16.4	4.51	22.16	21.00
Ribier	.38	.44	.41	3.97	18.6	2.20	45.37	44.10
Thompson Seedless	.43	.50	.47	3.90	21.6	2.15	45.96	44.47
Tokay	.36	.40	.38	3.62	21.6	1.77	56.84	55.05
Trieste	.45	.51	.48	3.93	15.4	3.12	32.08	30.13

* In these calculations the acid percentages used were the averages of the percentages at pH 7.0 and pH 8.2.

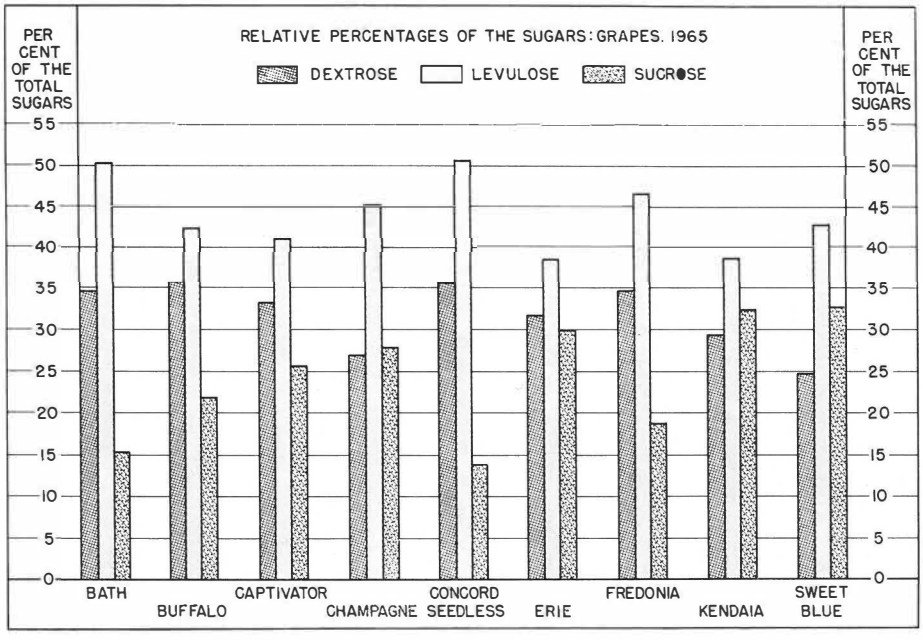

Fig. 2: The percentage of the total sugars made up by dextrose, levulose, and sucrose in each of the 9 varieties having more than 2% sucrose.

tributed to variations in buffer effect in this zone, as illustrated by *V. rupestris* 43-46 and Concord in Fig. 4.

In the subsequent consideration of the acid concentrations the average of the percentages obtained at pH 7.0 and pH 8.2 will be used for each clone. These averages were used also in calculating the values in the last 3 columns to the right in table 3.

The average titratable acidity varied from 0.35% in Ontario to 4.74% in *V. cinerea* #27, or 13.6 times as much. The pH ranged from 2.69 in *V. riparia* #50 to 4.05 in Ontario, table 3.

The relation of pH to titratable acidity is illustrated by Fig. 3. The 3 highest acid percentages were omitted in order to maintain an effective scale. In spite of a highly significant correlation coefficient of −.7793 between per cent of acid and pH, table 4, there were wide variations in the per cent of acid at certain pH values, table 3 and Fig. 3. This resulted from differences between clones in their buffer systems, as shown by the fact that at pH 3.18 the acid percentages were 0.70 in Bath, 1.80 in S. 8357, and 2.20 in *V. berlandieri* #2, or more than three times as much as in Bath. A similar situation existed at pH 3.64 where the percentages were 0.56 in N. Y. 15305, 0.76 in Sweet Blue, and 1.47 in *V. rupestris* 43-46.

The wide differences in buffer action between clones is shown in Fig. 4. The much more effective buffer systems in *V. rupestris* 43-46 are obvious, especially that between pH 6.0 and pH 9.0.

The titration curves in Fig. 4 show that in *V. rupestris* 43-46 the equivalence point was much nearer to pH 7.0 than pH 8.2, which is the end point most frequently used by U. S. A. investigators, and that it was near pH 7.5 in the mature Concord sample.

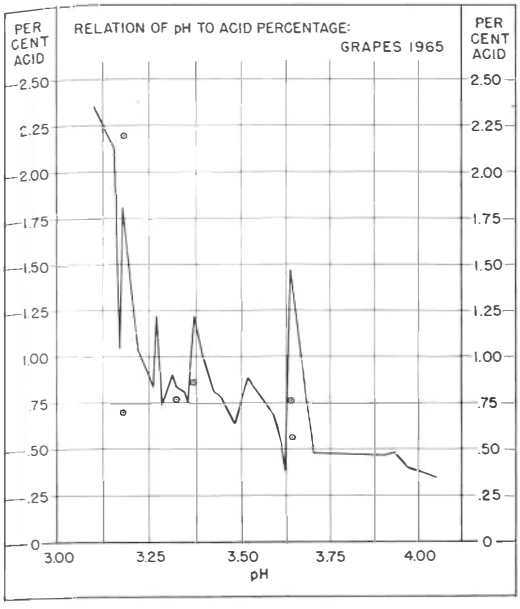

Fig. 3

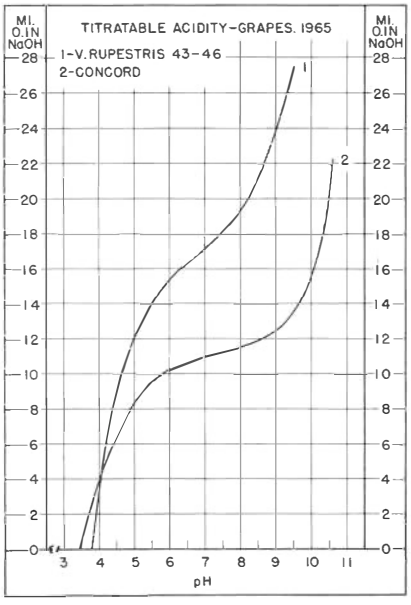

Fig. 4

Fig. 3: Comparison of pH with per cent of titratable acid.
To show differences in buffer effects. The 3 highest percentages (4.74, 4.27, and 3.47) not shown. to maintain an effective scale.

Fig. 4: Illustrating wide differences in buffer effects.

The relationships between certain determinations are shown by the correlation coefficients in table 4. Their contribution toward an understanding of the composition of the juice has been mentioned above, and will be given further consideration in the Discussion.

Discussion

In discussing the results obtained in this and other investigations concerning the composition of the fruit of grape clones two major groups of factors merit consideration, namely, the methods used and the concentrations of the constituents determined.

Sampling. Amerine and Roessler (1958) have reviewed recent literature on this subject. They reported that the results of their comparison of individual berry, cluster, and whole vine field sampling for estimating degree of maturation were similar. They suggested berry sampling as the most practical because it is the simplest and most rapid of the three methods. They took 3 berries each from low, middle, and high on each cluster, from 3 clusters on the left, middle and right of the vine and from opposite sides of the row, from enough vines to provide 100- or 200-berry samples.

Such sampling may not be feasible in experimental plantings because of a lack of enough vines to provide a sufficient number of berries for a sample. In such cases whole clusters can be used, discarding all abnormal or damaged berries; replicate samples can be obtained by the method described by Lott (1967) with Concord. In any case, only berries at the same apparent stage of maturation should be used be-

Table 4

Correlation coefficients in grapes. 1965.[1])

Variables compared	Species	American types	French hybrid	*V. vinifera*	All
Soluble solids and specific gravity	.9964	.9758	.9154	.9317	.9972
Soluble solids and total sugars	.9559	.9382	.9814	.9984	.9213
Soluble solids less acid and total sugars	.9493	.9885	.9932	.9963	.9777
Titratible acidity and total sugars	.4651[3])	—.5732	—.8600	—.3871[2])	—.2304[3])
Titratible acidity and pH	—.9353	—.7606	—.8290[2])	—.5162[3])	—.7793
Soluble solids : acid ratio and total sugars : acid ratio	.9880	.9938	.9992	.9995	.9991

[1]) All coefficients shown are significant at the 1% level unless otherwise indicated.
[2]) Significant at the 5% level.
[3]) Not significant.
Note: In all acid calculations the figures used were the averages of the percentages at pH 7.0 and pH 8.2.

cause of the fact that the composition changes markedly during maturation. Abnormally small berries should be discarded because their composition differs significantly from that of normal berries.

Juice extraction. Most investigators have used juice, rather than extracts from whole berries, in the study of grape composition. The discussion of LOTT (1967) on this point is equally applicable here. CALDWELL (1925) and CLORE *et al.* (1965) have reported that there are differences in composition in the various tissues of the grape berry and the consequent necessity of pressure extraction if juice samples representative of the whole berry are to be obtained.

The Seprosieve used here is well-suited to juice extraction because it can be adjusted to provide a drip-free or so-called dry pomace. Centrifuging is necessary to remove suspended solids so that pipetting can be done accurately; this did not affect the composition of the juice. Also, duplicate samples did not vary more than 0.02 percentage points in soluble solids or titratable acid content, and not more than 0.02 in pH; frequently, identical results were obtained from duplicate samples.

CALDWELL (1925) has pointed out that low percentages of sucrose may be obtained in pasteurized juice samples because of the possibility of its inversion during pasteurization. Some investigators have used pasteurized samples, following either hot or cold pressing. It would seem that the extraction method and subsequent handling of the juice should be based upon the objective of the investigation.

If the objective is to determine the effect of variety, stage of maturation, or production practices upon the characteristics of a commercial juice, then commercial methods should be used or simulated. However, if the objective is to determine the composition of the mature fruit of a number of clones, as in the investigation reported here, the berries should be cold-pressed to give drip-free pomace, and the resulting juice analyzed as soon as possible.

AMERINE and ROESSLER (1958) state that the screw-type press and the Waring blendor extracted more highly-buffered material from the seeds. The Seprosieve is a screw-type extractor and does crush the seeds. This may account partly for the difference in buffer effect shown in Fig. 4, because the seed in *V. rupestris* 43-46 made up a greater portion of the berry than in Concord, which may have resulted in greater seed crushing. However, it does not seem probable that this could account for a difference as great as that shown in Fig. 4.

Analyses. It is highly desirable that dextrose and levulose percentages be determined separately because of the difference in sweetness between them, rather than collectively as reducing sugars as usually has been done by American investigators. If the convenient method of LOTHROP and HOLMES (1931) is used for these determinations it is necessary to decolorize the sample with decolorizing carbon to avoid erroneously high dextrose percentages. The necessity for this step in the analyses of plant tissues has been shown by MORRIS and WESP (1932) in corn plant tissues and by LOTT (1945 b) for fruit tissues. The LOTHROP and HOLMES method was used by WEBSTER *et al.* (1934) and WEBSTER and CROSS (1942) for Concord grape juice, and by AMERINE and THOUKIS (1958) for 19 grape varieties; in none of these investigations was decolorizing mentioned. In the determination of dextrose and levulose in 8 *vinifera* varieties KLIEWER (1965) decolorized the solution but used a different method for determining dextrose and levulose.

The variable methods which have been used to determine titratable acidity make comparison of results difficult. CALDWELL (1925) and WEBSTER and CROSS (1942) titrated to a visual endpoint, using phenolphthalein as the indicator, REYNOLDS and VAILE (1942) titrated to pH 8.0, and SHOEMAKER (1935) was unspecific. AMERINE (1965) recommends titrating to pH 8.2 for *vinifera* grapes and states that the O. I. V. (1962) defines the endpoint as pH 7.0, with which he does not agree.

It is doubtful that any visual estimation of the titration endpoint should be considered as anything more than an approximation when phenolphthalein is used as the indicator. The endpoint of phenolphthalein is at pH 8.2 which was beyond the equivalence point in both clones shown in Fig. 4. This was also found by LOTT (1967) with Concord during maturation and ripening. In the samples of both these investigations it was impossible to obtain reproducible endpoints at the 1 + 19 dilution used because the concentration of pigments obscured them. Greater dilutions were cumbersome and the endpoints were still questionable.

Consequently, in fruit juices the endpoint should be determined with a pH meter. To be correct, the equivalence point should be determined for each sample. Since this is time-consuming it is usually more desirable to determine an approximate equivalence point by preliminary tests and use it throughout a series of samples. ROBERTS (1935) has reported pH 7.5 to 7.9 as the equivalence point for some fruit extracts. SINCLAIR *et al.* (1945) reported it to fluctuate narrowly about pH 7.8 in Valencia orange juice.

Sucrose. The occurrence of sucrose in grapes was reported early in this century by ALWOOD (1910), and GORE (1916), followed by CALDWELL (1925) whose extensive literature review and discussion on the subject should be studied by all who are interested in grape composition.

ALWOOD and EOFF (1916) reported an unusually sweet seedling grape to have as much as 10.36% sucrose, with a maximum total sugar content of 20.29%. They show an acid content of 0.25% to 0.30% at maturity. Unfortunately, this clone seems to have been lost, since no later mention of it was found in the literature. They state that "It appears to belong to the *labrusca* group".

Sucrose was not present in significant concentrations in *vinifera*, French hybrid or representative clones of the native American species examined. Only in certain clones of American-type grapes which are derived in large part from the native species, *V. labrusca*, did sucrose constitute an important part of the total sugars. Whether *V. labrusca* is a specific carrier of sucrose remains unanswered since no representative samples of wild *V. labrusca* clones were available for analysis when this work was done.

The data for the three clones, Concord, Concord Seedless, and tetraploid Concord show that Concord Seedless differed markedly in per cent of sucrose from Concord and tetraploid Concord. It does not appear that there is a clear association between stenospermocarpy and higher sucrose levels since N. Y. 15305 and N. Y. 33873 in the American-type groups as well as Black Monukka and Thompson Seedless in the *vinifera* group are all stenospermacarpic but had relatively low sucrose levels. The origin of Concord Seedless is clouded in uncertainty though it has generally been assumed that this clone is a seedless mutant of Concord. However, as SLATE *et al.* (1962) have pointed out "This is the only seedless Concord type ever brought to the attention of this Station. Concord is widely grown and this seedless variant is very conspicuous; hence it must be an extremely rare mutant, if it is indeed a mutant of Concord."

It seems to the writers that if the seedless variant of Concord is an extremely rare mutant then a double mutant of the same clone for seedlessness and relatively high sucrose level must be an even rarer mutant in a variety so widely grown as the Concord. It is tentatively suggested that the presence of the higher sucrose level in Concord Seedless may be interpreted as corroborative evidence that Concord Seedless is not a seedless mutant of Concord but a distinct though perhaps genetically related clone.

Soluble solids. The soluble solids content is frequently referred to as an index of the sugar content. In table 4 it is shown that there was a high significant correlation between soluble solids and total sugars in each of the 4 clonal groups, and in all of them collectively.

That the soluble solids percentage cannot always be relied upon as an index of sugar content is shown by the data in table 3 on the percentage of the soluble solids that occurred as acid. *V. cinerea* #27 had 20.40% soluble solids, which was moderately high. But when its 4.74% of acid was substracted from 20.40% soluble solids the remainder was only 15.66%, which is low for grapes. At the other extreme, Ontario had essentially the same soluble solids content, 20.00%, but only 0.35% acid which, subtracted from 20.00% leaves 19.65%, or 25.5% more than the 15.66% remainder in *V. cinerea* #27. This means that high acid clones must have a correspondingly higher soluble solids content if the sugar content is to be adequate. This situation was present in *V. cordifolia* #15, which had the high acid content of 3.74%, but also the highest soluble solids content, 24.5%, and the highest total sugar content, 21.83%, in all 39 clones.

Soluble solids-acid ratio. The data on the soluble solids-acid ratio, table 3, show that its use as an index of the degree of quality, even though commonly used, is not necessarily directly correlated with degree of quality. Considering the American-type varieties which were rated very good, Concord, Delaware, Kendaia, and Sweet Blue, the ratio ranged approximately between 20 and 25. Yet there were others in this range or higher that had lower quality. The ratio of 57 in Ontario resulted largely from the low acid content. So, the ratio must be interpreted in terms of the content of sugars and acid separately, as well as together. A further complicating taste factor is the wide range in the relative concentrations of the different sugars, which affects the degree of sweetness, as was previously discussed.

The total sugar-acid ratio, table 3, gives a more nearly accurate index of degree of quality than does the soluble solids-acid ratio because the acid is not included as it is in soluble solids. For example, in *V. cinerea* #27 the soluble solids-acid ratio was 25.73% greater than the total sugars-acid ratio, whereas in Ontario the soluble solids-acid ratio was only 1.26% greater than the total sugars-acid ratio. Much of

this difference resulted from the fact that the acid content of *V. cinerea* #27 was 13.54 times as great as that of Ontario.

Buffer effect. Even though *V. rupestris* 43-46 ranked eighth highest in per cent of acid there were 30 clones with lower pH values, and 23 of these had lower acid percentages than *V. rupestris* 43-46 rather than the higher percentages indicated by their pH values.

The review of MONCRIEFF (1946) shows fairly general agreement that sour taste is not the result of any definite pH but of the titration capacity of the solution. This is borne out by the present data. The pH of the juice of *V. rupestris* 43-46 was 3.64, which would indicate low to moderate acidity. Actually it was much more sour than the Concord juice which had a pH of 3.25, and the per cent of acid was 1.47% in comparison with 0.89% in Concord.

Composition in relation to varietal development. The wide variation in the sugar and acid content of these 39 clones points to a considerable potential for breeding programs where selection for such characteristics may be desirable. For example, in developing table varieties for cool growing season areas where a sufficiently high soluble solids content is difficult to obtain, the use of parental types with high levulose-dextrose ratios or high levulose + sucrose-dextrose ratios and low acidity would offer the most efficent way of obtaining high palatibility in a given degree-day heat summation since maximum sweetness per soluble solids content would be realized. Significant gains in developing extra early varieties might well be realized also by utilizing this same approach in conjunction with conventional selection methods for early maturity. As a similar example, if the objective was the development of wine varieties for hot growing season areas the difficulty experienced with many standard wine varieties in obtaining sufficiently high tritatable acidity and lower pH values would indicate the use of high acid selections from the species *V. cinerea* and *V. cordifolia* as possible sources for this character. These same high acid sources may well be tested in combination with teinturier *vinifera* types or the moderately high acid teinturier French hybrid types such as Seibel 8357 to produce red wine types with superior color stability and brilliance.

Summary

1. The dextrose, levulose, sucrose and acid contents of the juice from 39 grape clones were determined to obtain information for use in breeding improved varieties. The 39 clones represented a survey of *Vitis* comprising native American species, American-type, French hybrid, and *vinifera* varieties.
2. Wide variation existed in the percentages of each sugar, in pH, titratable acidity, and buffer systems.
3. Sucrose was present in significant amounts only in clones which were derivatives of *V. labrusa*.
4. The levulose-dextrose ratio varied from 0.81 to 1.49; in only one clone was it less than 1.00.
5. The per cent of acid ranged from 0.35 to 4.74; the pH from 2.69 to 4.05.
6. The desirability of the standardization of sampling, extraction, and analytical methods in order that valid comparisons may be made between the results of various investigations is pointed out.
7. Certain aspects of the potential use of the information from these data in the development of improved grape varieties is presented.

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