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Fermentability of Corn Syrups with Different Dextrose Equivalents Added to Various Grape Juices[1]

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It was found that neither the enzymes of the grapes nor those of wine yeast *Saccharomyces ellipsoideus* strain 223 attacked the higher polysaccharides present in corn syrups. The alcohol yield of the corn syrups approached but did not quite reach theoretical assuming that all of the dextrose equivalent (DE) solids were fermented. Glucose, sucrose, and 95 DE corn syrup fermented at about the same rate and yielded comparable alcohol contents. At equal solids content, the 42 DE syrup fermented slower in most cases and yielded lower alcohol content than higher DE syrups.

The addition of sugar as a yeast food for the production of alcohol is practiced in wine-producing regions when the natural sugar content of the grape is insufficient for adequate alcohol production. The process is called "chaptalization" after its French originator, M. Chaptal.

When the grapes are high in acid, or have a pronounced flavor, the juice may be extended ("ameliorated") by addition of a sugar-water syrup. Sucrose and dextrose are the sugars permitted by U.S. Federal regulation for use in wine manufacture. No data have been found in the scientific literature referring to the use of corn syrups for ameliorating grape juice musts, or to the fermentability of corn syrups for use in wine manufacture. Such data are desirable if a scientific basis is to be laid for advocating the use of corn syrup for amelioration.

Corn syrups are sold commercially in different grades based upon their dextrose equivalent (DE). This is a measure of the reducing-sugar content calculated as anhydrous dextrose and expressed as a percentage of the total dry substance (2). Corn syrups contain dextrose, maltose, and varying percentages of higher sugars as shown in Table 1. The dextrose and maltose are fermentable by yeasts. Generally speaking, the higher the dextrose equivalent, the higher the percentage of fermentability of the corn syrup. However, when corn syrup is added to fresh, unheated grape juice in the manufacture of wine, there is the possibility that enzymes present in the juice might hydrolyze some of the higher sugars, making them available for fermentation. This study was designed to determine whether fermentability of corn syrups of several dextrose equivalents added to grape juices was higher than would be expected on the basis of their dextrose equivalents.

MATERIALS AND METHODS

Wines were prepared from nine grape varieties by use of sucrose, glucose, or corn syrups to standardize solids contents before fermentation. Solids were adjusted to 22% in all wines, except the New York State Muscat which was raised to 26%. Since it would be used as a sweet wine, the residual sugar after fermentation would not be objectionable. Amelioration (reducing acidity by extending the volume with syrup) was practiced to the extent of 30% in Delaware, Elvira, New York Muscat, New York 22994 (a Seibel 4643 × Ontario cross), and Seibel 10878 wines. Bright's Hybrid 159, Dutchess, and Foch were ameliorated 15%, and Seibel 5279 was not ameliorated.

The wines were inoculated with a standard wine yeast, *Saccharomyces ellipsoideus* strain 223. Sulfur dioxide was added in the form of potassium metabisulfite at a level of 100 ppm of SO_2. Frequent samplings were made during the first 3 weeks of fermentation to follow the fermentation by means of alcohol determinations. The wines were racked from their lees at 3 and 6 months and bottled at 9 months.

The percentage of alcohol was determined by use of a Dujardin-Salleron ebulliometer.

Calculation of theoretical yield of ethyl alcohol. Calculation of theoretical yield was based upon the

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TABLE 1. *Representative analyses[a] of corn syrups with different dextrose equivalent ratings*

Analysis[b]	Dextrose equivalent		
	42	63	71
	%	%	%
Total solids	80.2	81.8	82.0
Moisture	19.8	18.2	18.0
Ash	0.25	0.25	0.25
Fermentable extract	39.0	70	82
Monosaccharides	19.0	37.4	41
Disaccharides	14.6	34.1	40
Higher sugars	66.4	28.5	18

[a] As specified by Anheuser-Busch Laboratories (1).

[b] The *p*H used for all dextrose equivalent ratings was 5.0.

equation: 180 g of glucose ($C_6H_{12}O_6$) $\rightarrow$ 92 g of ethyl alcohol (CH_3CH_2OH) + 88 g of CO_2.

The ethyl alcohol by volume was determined directly from the amount of ethyl alcohol (in grams) produced per 100 ml of fermenting must (3).

For example, in a must containing a total solids volume of 22%, approximately 2% of the solids is nonfermentable grape solids. The remaining solids are generally fermentable sugars or 20% of the total volume. In 100 ml of 22%-solids grape must, there are, therefore, about 20 g of fermentable sugars which could theoretically yield, according to the above equation, 10.2 g of ethyl alcohol. The 10.2 g of ethyl alcohol per 100 ml of wine represents an alcohol content of 12.9% by volume. Actual yields of ethyl alcohol as determined with the ebulliometer were compared with theoretical yield to determine the efficiency of conversion of the various carbohydrate sources.

RESULTS AND DISCUSSION

Grape varieties fermented, with percentage of solids contributed by added sugars or corn syrups, are shown in Table 2 along with theoretical (calculated) and measured yields of ethyl alcohol.

Yields of ethyl alcohol on the basis of sucrose added ranged from 90.8 to 100% of theoretical, whereas glucose was fermented to yield from 89.4 to 97% of theoretical in various grape musts. Corn syrup with a dextrose equivalent of 42 yielded ethyl alcohol ranging from 81.3 to 97.4% of theoretical. The fact that ethyl alcohol yield did not exceed theoretical yield, based upon reducing sugars present, indicates that neither the enzymes of the grape nor those of the wine yeast attacked the higher polysaccharides present in the corn syrups. Corn syrup with a dextrose equivalent of 63 was fermented to an extent of 72.6 to 95.9% and was, therefore, somewhat less effectively fermented than would have been expected, based upon its content of reducing sugars. Corn syrup with a dextrose equivalent of 71 was fermented to the extent of 74.1 to 98.4% of theoretical. The corn syrup with highest dextrose equivalent (95 DE) was fermented to the extent of 80.5 to 98.5% of theoretical in various juices. Corn syrups were fermented most poorly in Elvira must and best in Delaware must.

Corn syrup (42 DE) has a content of only 33.6% dextrose plus maltose, whereas 63 and 71 DE corn syrups have combined dextrose plus maltose contents of 71.5 and 81%, respectively. If theoretical yields had been calculated on the basis of dextrose plus maltose contents in the corn syrups, 42 DE syrup would have shown a better fermentability than when calculated on the basis of reducing-sugar content, whereas 63 and 71 DE syrups would have shown up poorer.

Residual solids in the wines after fermentation were inversely proportional to the degree of fermentability of the carbohydrate source used (Table 2). Thus, 42 DE corn syrup, followed by 63 and 71 DE corn syrups, left the largest residues in the wines. If it is desirable to increase the body

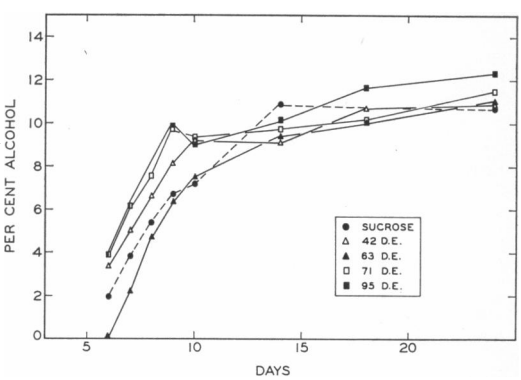

FIG. 1. *Fermentability of sucrose and 42 to 95 DE corn syrups in Delaware must.*

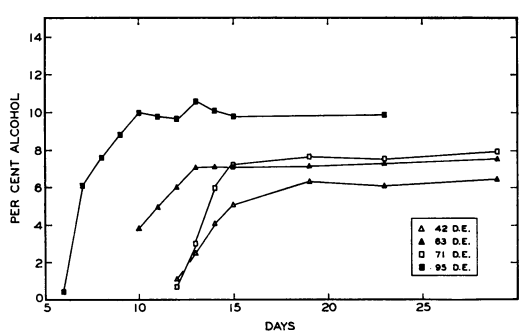

FIG. 2. *Fermentability of 42 to 95 DE corn syrups in Elvira must.*

TABLE 2. *Comparison of theoretical and measured yields of ethyl alcohol in grape musts containing added sucrose, glucose, or corn syrups with different dextrose equivalents*

Grape variety	Sugar added	Solids added (g/100 ml)	DE[a]	Fermentable sugar added (g/100 ml)	Grape sugar (g/100 ml)	Total fermentable sugar (g/100 ml)	Ethyl alcohol yield (%/volume)		Ethyl alcohol yield per cent of theoretical	Residual solids after fermentation (dry wt. g/100 ml)
							Theoretical	Measured		
Seibel 5279	Sucrose	4.8	100	4.8	15.2	20.0	12.9	11.9	92.3	1.87
	Glucose	4.8	100	4.8	15.2	20.0	12.9	12.1	93.7	1.84
Bright's Hybrid	Sucrose	4.0	100	4.0	16.3	20.3	13.1	12.0	91.6	3.05
	Glucose	4.0	100	4.0	16.3	20.3	13.1	11.8	90.2	3.12
Foch	Sucrose	3.7	100	3.7	16.5	20.2	13.0	11.8	90.8	2.81
	Glucose	3.7	100	3.7	16.5	20.2	13.0	12.2	93.8	2.79
	CS[b]	3.7	42	1.6	16.5	18.1	11.7	11.4	97.4	5.24
New York Muscat	CS	10.3	95	9.8	14.2	24.0	15.5	14.5	93.7	2.72
	CS	10.3	71	7.3	14.2	21.5	13.9	12.2	87.8	8.74
	CS	10.3	63	6.5	14.2	20.7	13.4	11.7	87.4	10.05
	CS	10.3	42	4.3	14.2	18.5	11.9	10.4	87.4	11.64
Elvira	CS	10.9	95	10.4	9.5	19.9	12.8	10.3	80.5	2.92
	CS	10.9	71	7.7	9.5	17.2	11.2	8.3	74.1	8.98
	CS	10.9	63	6.9	9.5	16.4	10.6	7.7	72.6	9.24
	CS	10.9	42	4.6	9.5	14.1	9.1	7.4	81.3	9.91
New York 22994	Sucrose	5.2	100	5.2	15.2	20.4	13.2	13.0	98.5	2.30
	Glucose	5.2	100	5.2	15.2	20.4	13.2	11.8	89.4	2.30
	CS	5.2	42	2.2	15.2	17.4	11.2	9.9	88.3	6.76
Seibel 10878	Sucrose	7.7	100	7.7	12.8	20.5	13.2	12.7	96.2	2.32
	Glucose	7.7	100	7.7	12.8	20.5	13.2	12.8	97.0	2.46
	CS	7.7	71	5.4	12.8	18.2	11.7	10.6	90.6	7.29
	CS	7.7	63	4.8	12.8	17.6	11.3	10.4	92.1	8.55
Dutchess	Sucrose	4.4	100	4.4	15.8	20.2	13.0	12.7	97.8	1.95
	CS	4.4	71	3.2	15.8	19.0	12.2	10.3	84.4	4.30
	CS	4.4	63	2.8	15.8	18.6	12.0	10.8	90.0	5.12
Delaware	Sucrose	4.3	100	4.3	16.1	20.4	13.2	13.2	100	1.96
	CS	4.3	95	4.1	16.1	20.2	13.0	12.8	98.5	1.98
	CS	4.3	71	3.1	16.1	19.2	12.4	12.2	98.4	4.28
	CS	4.3	63	2.7	16.1	18.8	12.1	11.6	95.9	5.00
	CS	4.3	42	1.8	16.1	17.9	11.5	11.2	97.4	5.62

[a] Per cent fermentable.
[b] Corn syrup.

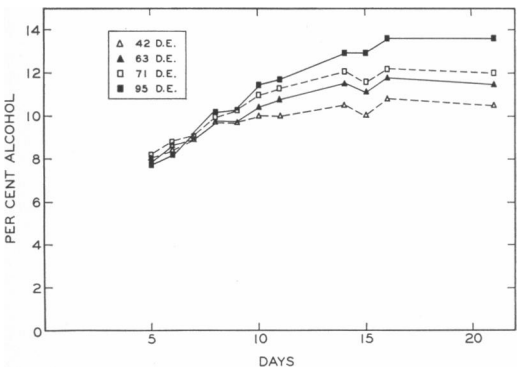

FIG. 3. *Fermentability of 42 to 95 DE corn syrups in New York Muscat must.*

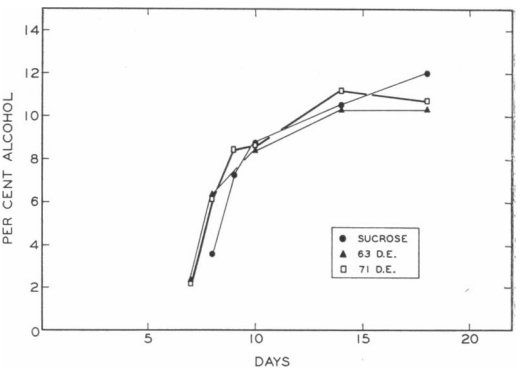

FIG. 4. *Fermentability of sucrose and 63 and 71 DE corn syrups in Dutchess must.*

of a wine, it would be possible to do this by selection of the proper corn syrup for amelioration of the starting juice.

Rates of fermentation. Glucose, sucrose, and 95 DE syrups fermented at about the same rate and yielded a comparable alcohol content. In general, at a given solids concentration in the must, the 42 DE syrup fermented slower and yielded a lower final alcohol content than the other corn syrups. However, with Delaware must, the 42 DE syrup fermented faster than either the 63 DE syrup or sucrose (Fig. 1). The 63 DE syrup fermented faster than 71 DE syrup in Elvira must but yielded a final alcohol concentration which was lower than that produced by the higher DE syrup, as would be expected (Fig. 2). In New York State Muscat must, all the corn syrups fermented at about the same rate (Fig. 3), but the final alcohol concentration reflected the relative contents of fermentable carbohydrate. Sucrose, 63 DE, and 71 DE corn syrups fermented at about the same rate in Dutchess must (Fig. 4).

ACKNOWLEDGMENT

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LITERATURE CITED

1. ANHEUSER-BUSCH LABORATORIES. HI-FIR corn syrup—sweet music for sweets. Anheuser-Busch Laboratories, St. Louis, Mo.
2. CORN INDUSTRIES RESEARCH FOUNDATION. 1958. Corn syrups and sugars. Technical Service Committee, Corn Industries Research Foundation, Inc., Washington, D.C.
3. LANGE, N. A. 1946. Handbook of chemistry, 6th ed., p. 1343. Handbook Publishers, Inc., Sandusky, Ohio.