In addition to the marked stimulation which magnesium sulphate causes when it is used in dilutions from *m*/16384 to *m*/524288, it increases the vitality of the seedlings. The seedlings grown in the magnesium sulphate outlived those in the control by two or three weeks, and in some cases by a greater period.

From the foregoing results and conclusions, it is then evident that magnesium sulphate, in the absence of other salts, is not necessarily injurious in its effects, but on the other hand may be highly beneficial; while any *inhibitory* action is due to the presence of a relatively *large proportion* of magnesium in the solution.

Lastly the writer wishes to acknowledge the assistance of Dr. William J. Gies under whose direction these experiments have been carried on in the laboratories of the New York Botanical Garden.

[Contribution from the Division of Foods, Bureau of Chemistry, U. S. Department of Agriculture].

STUDIES ON APPLE JUICE.

By H. C. Gore

Received May 17, 1907.

Experimental work on the preparation of unfermented apple juice was carried out during the past season at the large fruit farm of Mr. Isaac Pollard at Nehawka, Nebraska. The results of this work are given in the Year-Book of the Department of Agriculture for 1906. Very briefly the method which was developed for the preparation of the juice consisted first in removing the sediment from the juice of the fresh fruit by passing it twice through a milk separator. The juice was then carbonated if desired, canned, or bottled, and finally sterilized by heating for short periods of time at temperatures not exceeding 70°.

Other lines of work relating to apples were carried on at the same time and as the literature on the chemistry of this important fruit in America is rather meagre, it is believed that the data here presented will be of interest.

Analyses of the following juices were made:

(a) Juices of the cull apples employed for cider making.

(b) Juices from the cider-mill at various times during the season.

(c) Juices of standard varieties of apples grown at Nehawka.

(d) Juices of summer apples in regard to their value for vinegar stock.

(e) Juices of decaying apples.

The methods employed were briefly as follows: Solids were determined by the Brix spindle. This method has been shown by Browne[1] to be quite accurate for fruit juices. Determination of acid: ten gram samples of juice were diluted with distilled water, heated to boiling, and titrated with tenth normal alkali, using phenol phthalein as indicator. Sugars were

[1] This Journal, 23, 875.

TABLE I

ANALYSES OF JUICES OF CULL APPLES

Variety and condition of sample	Date of Picking 1906	Date of Analysis 1906	Weight per apple grams	Solids per cent	Acid as Malic per cent	Reducing Sugar as invert percent	Total Sugar as invert percent	Sucrose per cent	Undetermined solids
Maidens' Blush, over-ripe	......	Aug. 22	135.9	11.77	.14	5.74	9.62	3.69	2.20
Porter "	......	" "	113.3	13.30	.25	7.06	10.15	2.93	3.06
Wealthy, over-ripe and undersized	......	" "	95.2	11.75	.27	6.50	9.02	2.39	2.59
Florence crab, over-ripe, very mealy	Aug 21	" "	30.6	16.97	.87	11.40	11.66	.25	4.45
Dyer, over-ripe	......	" "	145.0	14.17	.43	7.50	10.63	2.97	3.27
Porter, unripe and undersized	......	" "	45.0	9.52	.28	6.04	6.94	.85	2.35
Autumn Strawberry	......	" 24	105.5	11.64	.22	6.91	9.45	2.41	2.10
Haas	......	" "	102.0	12.79	.59	6.36	9.70	3.17	2.67
Fall Winesap, undersized	Aug 27	Sept. 2	77.2	13.18	.64	6.81	10.21	3.23	2.50
Wolf River, wormy	" 24	" "	275.0	12.93	.69	6.74	9.59	2.71	2.79
Pound Sweet, wormy or damaged by hail	" 28	" "	220.0	12.63	.04	7.84	10.25	2.29	2.46
Seek-no-further, undersized	" 28	" "	76.0	12.64	.52	7.27	9.43	2.05	2.80
Yellow Bellflower, undersized or wormy	" 29	" "	146.2	14.09	.60	7.84	10.66	2.68	2.97
Northern Spy, wormy	......	" "	213.7	13.24	.69	7.07	10.10	2.88	2.60
Fameuse, undersized	......	" 10	....	13.67	.59	8.33	10.32	1.89	2.86
Shackleford, undersized	......	" "	....	11.87	.42	6.31	8.53	2.01	3.13
White Bellflower, wormy or damaged by hail	......	" "	....	12.42	.54	5.90	9.25	3.18	2.80
" " undersized	Sept. 11	" 17	121.2	13.06	.46	7.97	10.51	2.41	2.22
Tolman, undersized	" "	" "	58.5	13.07	.12	7.92	10.40	2.36	2.67
Grimes, undersized	" 12	" "	60.6	13.76	.47	7.04	10.49	3.28	2.97
Northwestern Greening, wormy or damaged by hail	" 22	" 28	184.5	12.68	.44	7.45	9.99	2.41	2.38
Rhode Island Greening, wormy	" 25	" "	211.3	12.03	.50	6.30	10.54	4.03	1.20
Scott Winter, wormy or damaged by hail	" "	" "	114.3	12.68	1.32	6.26	9.38	2.96	2.14
York Imperial, wormy or undersized	Oct. 2	Oct. 13	79.0	13.15	.55	7.18	9.85	2.54	2.88
Jonathan, undersized	" "	" "	63.6	14.32	.55	8.50	13.72	4.96	.31[1]
Missouri, undersized	" "	" "	48.8	16.17	.74	8.36	12.43	3.87	3.20
Ben Davis, Wormy	" 5	" "	101.9	12.45	.63	6.50	9.50	2.85	2.47
Roman Stem, Wormy	" 6	" "	99.7	14.17	.57	6.46	11.35	4.65	2.49
Winesap, Wormy	" 13	" "	97.9	12.85	.62	7.29	10.09	2.66	2.28
Maximum				16.97	1.32	11.40	13.72	4.96	4.45
Minimum				9.52	.04	5.74	6.94	.25	.31[1]
Average				13.07	.50	7.20	10.13	2.78	2.58

[1] See P 1114.

determined by the gravimetric method, using the tables of Munson and Walker[1], and alcohol by the official method of the Association of Official Agricultural Chemists[2]. The value called undetermined solids is the difference between the solids, and the sum of the acid, reducing sugar, and sucrose.

(a) Culls are apples which cannot be marketed, and are, therefore, used by the cider mills. At the packing house, apples were rejected for market purposes for a variety of reasons. They were either over-ripe for packing, wormy, or otherwise injured, or under-sized—less than two inches in diameter. Samples of these apples were taken from the packing house as often as new varieties were received. Care was taken in all cases to secure representative samples consisting of about a peck of apples. For analysis the samples were ground in a meat chopper and received in a cloth bag, from which the juice was expressed by pressure. The analyses of the juices are given in Table 1. Generally speaking, the juices of these apples became richer in sugar and acid as the season progressed. The undetermined solids, consisting of nitrogeneous matter, tannin, ether extract, pectin, and ash, remained practically constant during the season. The low value shown for the Jonathan variety is probably due to an error in determining the solids. Attention is called to the high acid content of the variety Scott's Winter. The variety is unique in this respect. The flavor of the fruit was remarkably sharp, and very agreeable.

(b) The juices from the mill were analyzed at intervals during the season. Like the juices of the cull apples, the mill juices increased gradually in sugar content and acid. The analyses are given in Table 2. Ow-

TABLE 2

COMPOSITION OF MILL JUICES

Description	Date 1906	Solids per ct.	Acid as Malic per ct.	Reducing Sugars as Invert per ct.	Total Sugars as Invert per ct.	Sucrose per ct.	Undetermined Solids per ct.
Early Fall Apples	Aug. 13	....	.24	7.02	8.45	1.34	....
	" 27	11.85	.36	7.67	9.46	1.70	2.12
	Sept. 5	11.14	.30	6.38	8.36	1.88	2.58
	" 12	11.33	.38	7.50	9.25	1.66	1.79
Largely Grimes Golden	" 13	12.30	.24	7.62	10.15	2.40	2.04
	" 27	12.88	.39	7.72	10.45	2.59	2.18
Largely Ben Davis	Oct. 2	13.00	.50	7.82	10.28	2.34	2.34
	" 6	12.45	.57	7.01	9.92	2.76	2.11
	" 8	13.40	.54	7.36	10.74	3.21	2.29
	" 11	13.09	.52	6.24	10.10	3.67	2.66
Maximum		13.40	.57	7.82	10.74	3.67	2.66
Minimum		11.14	.24	6.24	8.36	1.34	1.79
Average		12.38[1]	.40	7.23	9.72	2.35	2.23[1]

[1] Average of 9 determinations.

[1] This Journal, 28, 663.

[2] U. S. Dept. of Agr., Bur. of Chem. Bull., 46, p. 57.

ing to the fact that the mill ran irregularly and that wind-falls and custom apples were constantly being mixed in the bins with the culls from the packing house, no comparison between the composition of the mill juice and that of the juice from cull apples is possible.

(c) Samples of eleven standard varieties grown at Nehawka were secured when the main crop was picked and the juice of the fruit was analyzed when the apples became ripe, that is, when the starch of the apples had practically disappeared. Some samples, indeed, were quite over-ripe at the time of analysis, showing mealiness or withering, and probably some loss of acidity. The results of these analyses are given in Table 3.

TABLE 3.

ANALYSES OF JUICES OF RIPE FALL AND WINTER APPLES GROWN AT NEHAWKA, NEB.

	Wt. per Apple Grams.	Solids per cent.	Acid as Malic per cent.	Reducing Sugar as Invert per cent.	Total Sugar as Invert per cent.	Sucrose per cent.	Undetermined Solids per cent.
Gano[1]	169.8	....	.38	6.79	10.27	3.31	...
York Imperial	153.6	12.57	.43	7.82	10.84	2.87	1.45
Arkansas	162.7	13.44	.45	8.89	11.82	2.78	1.32
Roman Stem[1]	127.5	14.79	.36	7.64	12.97	5.06	1.73
Wine Sap	112.9	14.14	.43	8.95	11.49	2.41	2.35
Rhode Island Greening[2]	156.0	11.99	.57	7.45	10.26	2.67	1.30
White Winter Pearmain	209.2	12.59	.46	5.55	10.95	5.13	1.45
Grimes Golden[3]	101.3	13.19	.28	7.42	12.08	4.43	1.06
Fameuse[2]	92.2	13.89	.34	8.87	11.50	2.50	2.18
Jonathan[2]	99.8	13.74	.40	9.65	11.93	2.17	1.52
Ben Davis[1]	157.8	12.02	.48	7.50	11.25	3.56	.48
Average		13.24[1]	.42	7.87	11.40	3.35	1.48

The average of the analyses in Table 3 is compared in Table 4 with the averages of analyses of juices of Eastern grown apples, compiled by Van Slyke[5]. From the table it will be noted that the solids and sugar content of Nebraska apples are practically the same as the solids and sugar content of apples grown in Eastern states. An exception is to be noted, however, in the case of the New York apple juices, since these seem to be considerably richer than other apple juices in solids and sugar. The Nebraska apple juices were slightly poorer in acid than juices from the Eastern apples, but this is probably accounted for by the fact that the

[1] Mealy.

[2] Slightly mealy and slightly withered.

[3] Slightly withered.

[4] Average of 10 determinations.

[5] N. Y. Exp. Sta. Bull., 258, p. 449.

samples analyzed were somewhat over-ripe, since loss in acidity is known to occur under these conditions.

TABLE 4

AVERAGE ANALYSES OF APPLE JUICES FROM DIFFERENT LOCALITIES

Locality	Specific Gravity	Solids	Acid as Malic	Reducing Sugars	Total Sugar as Invert	Sucrose	Ash	Number of Analyses
Nebraska	....	13.24	.42	7.87	11.40	3.35	..	11
New York[1]	1.064	15.11	.53	9.28	13.33	3.85	.23	13
Pennsylvania[1]	1.056	13.31	.58	7.67	11.47	3.61	.28	11
Virginia[1]	1.053	13.31	.52	7.00	10.41	3.35	..	77
Washington, D.C.[1]	1.054	13.39	.51	6.84	10.00	3.48	.33	21

(d) Summer apple juices are not considered by growers to be of value for vinegar stock, owing to the difficulty of preparing a vinegar of standard strength. The juices are rather low in sugar and the alcoholic fermentation usually takes place at summer temperatures. If the surface of the juice is freely exposed to the air acetic fermentation is almost sure to develop, since, as is well known, summer temperatures favor the growth of acetic acid bacteria. Acetic acid, so formed will retard the alcoholic fermentation, or even stop it entirely. This is well known from the work of La Far.[2] The resultant product will contain unfermented sugar, and as the juice originally contained only barely enough sugar for standard vinegar, the vinegar produced will be low in acetic acid.

At Nehawka, an opportunity was offered to study two varieties of summer apples with regard to their value as vinegar stock. Two lots of juice from culls consisting of over-ripe Early Harvest and Duchess apples were prepared at the mill, and at once poured into clean 50 gallon barrels. Four barrels of Duchess and two barrels of Early Harvest apple juice were obtained. The barrels were closed with cotton plugs, and the fermentation was carried on in a room at a temperature of about 70° F., with and without the addition of pressed yeast in the different experiments. Space was left in each barrel for the formation of a head. In all cases fermentation set in rapidly. Heads formed which foamed over, resulting in some loss of liquid. As soon as the heads subsided fresh cotton plugs were inserted so as to retain the protective layers of carbon dioxide gas on the surfaces of the ciders. At the end of twenty days[3], alcohol, acid, and solids were determined. The analyses of the original juices and those made on the cider are given in Table 5. The results show that nearly the theoretical yield of alcohol can be readily obtained from these juices by fermentation. The usual loss of acid incident to fermentation of fruit juices by yeast is shown. The addition of pressed yeast increased the

[1] Taken from the summary of analyses compiled by Van Slyke. loc. cit.

[2] Landw. Jb. 1895, 24, 445.

[3] The fermentation was doubtless completed before this time, but owing to other work the juices were not analysed as soon as dry.

yield of alcohol only slightly. The dry cider obtained could probably have been handled successfully in a quick process generator to produce vinegar of 4 per cent. strength. The vinegar so produced, however, would have been quite low in solids.

TABLE 5.

ANALYSES OF FRESH AND FERMENTED JUICE OF SUMMER APPLES.

Description of Sample.	Date of Analysis, 1906.	Solids, per cent	Acid as malic per cent.	Reducing Sugar as Invert per cent.	Sucrose per cent.	Alcohol gr. 100 lbs.	Pressed Yeast added per bbl.
Duchess Apple Juice, pressed July 31	Aug. 23[1]	10.54	.75	7.56	.35	––	—
Early Harvest apple juice, pressed July 31	"	10.84	.42	8.06	.57	—	—
Duchess apple cider, fermented by wild yeast	" 20	1.99	.28	.11	—	3.82	—
Duchess apple cider, fermented by brewers' yeast.	"	1.61	.27	.09	—	4.05	⅛
Duchess apple cider, fermented by brewers' yeast.	"	1.77	.38	.06	—	4.21	¼
Duchess apple cider, fermented by brewers' yeast.	"	1.87	.44	.04	—	3.81	⅜
E. Harvest apple cider, fermented by wild yeast	"	1.85	.31	.11	—	4.09	—
E. Harvest apple cider, fermented by brewers' yeast.	"	1.55	.34	.12	—	4.34	¼

(e) This work has its practical significance in that at times when running a cider mill decayed apples are encountered and it is a question of some importance as to their value as vinegar stock and as to the influences of decayed apple juice on the juice of sound apples in regard to proper fermentation into vinegar. The question of the wholesomeness of vinegar made from decayed apple juices is not considered here.

Sample No. 25 was the juice of thoroughly decayed summer apples which were taken from bins at the cider mill. The juice obtained had an odor of acetic acid, but possessed no disagreeable, musty odor or taste. Its analysis is given in Table 6. This sample served to indicate the general character of the changes which ensue on decay. The sucrose originally present was practically all inverted. The total sugar, of which about 8 per cent. was probably present before decay set in, was considerably lessened in amount and 0.75 per cent. alcohol and 0.67 per cent. of acetic acid were found. The character of the changes, therefore, would seem to be similar to those which go on when a fruit juice is fer-

[1] These juices were not analyzed at once, owing to lack of laboratory facilities. Samples were therefore preserved by addition of sodium benzoate, and analyzed later. On this account the values for sucrose are probably a little lower, and those for reducing sugars a little higher than the true values, due to inversion of sucrose on standing.

mented into vinegar except that the inversion of the sucrose, the formation of alcohol, and its oxidation into acetic acid go on more or less simultaneously.

TABLE 6

CHEMICAL CHANGES IN JUICE OF DECAYING APPLES

Serial No.	Description of Sample	Date of Analyses 1906	Acid as Acetic per ct.	Reducing Sugar as Invert per ct.	Total Sugar as Invert per ct.	Sucrose per ct.	Alcohol gr. per 100 cc.
25	Juice from decayed apples.......	Aug. 28	.67	5.67	5.76	.09	.75
43	" " sound portions of apples	Sept. 8	..	7.52	10.13	2.67	none
44	" " decayed " " "	" 8	..	7.45	8.26	.77	none
67	" " sound apples	" 18	.22	7.00	8.79	1.70	none
68	" " decayed apples	" 18	.12	7.56	7.83	.26	.28
96	" " " "	Oct. 9	2.18	2.80	2.86	.06	.47

Samples 43 and 44 were juices from sound and decayed portions respectively of ripe Autumn Strawberry apples. Partly decayed fruit was used and sound and decayed sections from opposite sides of each apple were used for the two samples.

These contrasting analyses served to show the character of the first changes which go on in decaying apples. The conspicuous changes were the inversion of sucrose and considerable loss of sugar. No alcohol had as yet been formed. Unfortunately acid was not determined.

Samples Nos. 67 and 68 were juices from sound and decayed apples, respectively, selected from a lot of over-ripe Autumn Strawberry Apples. The analyses show inversion of sucrose in the juice of the decaying apples, loss in sugar, and in addition, some formation of alcohol. They also show a notable lessening of acid. No acidification had as yet set in.

Sample 96 was a sub-sample from No. 68 which was allowed to decay further. It showed again, as did sample No. 25, the composition of decayed apples but in a more advanced stage. The sucrose was nearly all gone; there was present slightly less than 3 per cent. of reducing sugar, about ½ per cent. of alcohol, and over 2 per cent. of acetic acid. The presence of acetic acid is known to hinder alcoholic fermentation, and this accounts for the presence of unfermented sugar, La Far having shown that as little as ½ per cent. acetic acid may considerably retard fermentation by yeasts, while 1 per cent. entirely stopped alcoholic fermentation in case of 12 out of 15 races of yeasts which he studied.

The above analyses indicate the general course of the chemical changes which go on in decaying apples. Similar analyses, carried on with mycological control would probably give results of much interest. The tendency of decaying apples to yield juices rich in acetic acid is clearly shown. This fact must be considered as affecting unfavorably the value of the juice for vinegar stocks in view of the tendency of acetic acid to interfere with alcoholic fermentation. In other words the manufacture of a vinegar of standard strength may be seriously affected by an admixture of acetified apple juice with juice of sound apples.

THE ESTIMATION OF CELLULOSE IN WOOD BY THE CHLORINATION METHOD.

BY A. L. DEAN AND G. E. TOWER.

The chemical constitution of woody tissues presents a problem of great complexity. Any single sample of wood contains a number of complex compounds whose nature is but little understood. If all kinds of wood were chemically alike, or even if the wood from all parts of the same tree was identical, the study of woody tissue would be simplified. The older idea, especially the idea prevalent amongst botanists, was that the cell walls of woody tissues were composed of "cellulose" which became impregnated with "lignin." Later and more careful studies appear to have established the fact that the foundation of woody cell walls is not a simple cellulose, but a compound cellulose, to which the name lignocellulose, has been given. This lignocellulose may be split up into cellulose on the one hand, and the lignone group on the other. The cellulose which results from the cleavage differs to a marked extent from the normal type cellulose of the cotton fiber. The lignone complex appears to contain cyclical groups and to be related to the carbohydrates in no very definite fashion.

Besides the lignocellulose which makes up the major portion of wood, there are always present a number of different bodies which are apparently not chemically united to the lignocellulose. Amongst these substances two are prominent; the so-called wood gum, which may be extracted with cold dilute alkaline solutions, and the group of the ether soluble resins.

It was stated above that the lignocellulose might be split into the two constituent radicals, cellulose and lignone. This cleavage is not easily carried out quantitatively, inasmuch as the treatments which remove the lignone tend to attack the cellulose. The isolation of cellulose from wood is carried out on an enormous scale in the manufacture of paper pulp by the sulphite and soda processes. These methods are said to always involve some loss of cellulose, and unless carefully regulated the loss is likely to be great.

A number of methods have been elaborated for the estimation of the quantities of cellulose in vegetable cell walls. They are all tedious, and the cellulose obtained by several of them is apparently a variable and ill defined product. Cross and Bevan[1] have elaborated a method for the estimation of cellulose in the lignocellulose of jute fiber, a method which

[1] Cellulose: an Outline of the Chemistry of the Structural Elements of Plants, Cross and Bevan, London, 1895.