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Apple Cider and Cider Products

By J. A. Clague and C. R. Fellers

Greater care in the application of approved known methods in the production and preservation of apple cider and cider products should make for an enlarged demand for these popular by-products of the fruit industry. This bulletin gives the results of investigations in this field.

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APPLE CIDER AND CIDER PRODUCTS

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Production of year-round marketable cider from apples which are below market grade has long been the hope of the apple growers of this country. However, as yet no preserved sweet cider beverage has attained the popularity prophesied for it at the time of its innovation. Some of the reasons for such a condition are: (1) Insufficient care in selection and blending of varieties. (2) Use of immature and unripe fruit; that is, apples picked at the same time as those intended for market and then culled out, rather than tree-ripened fruit. (3) Faulty manufacturing practices due to lack of technical knowledge about the processing and preservation of apple cider.

To present information gathered from experiments on several varieties of Massachusetts apples as well as work done by investigators in other states and countries is the object of this bulletin. It is hoped that the information presented will answer many of the questions confronting fruit growers and others when they consider the manufacture of cider.

COMPOSITION OF THE MORE IMPORTANT MASSACHUSETTS APPLE VARIETIES[1]

In this country cider-making quality is not ordinarily considered in the selection of apple varieties for the orchard. In many of the European countries the growing of apples especially for manufacture into cider has been practiced for hundreds of years. This is one reason why in England, for example, the annual consumption of cider is two gallons per capita, while in this country it is not much over one quart per capita.

However, it should be noted that in England the term cider denotes a fermented, usually carbonated or sparkling, apple juice, while in this country cider refers to the unfermented juice unless preceded by the term "hard." An apple variety which might make a good sweet cider would not necessarily be satisfactory for manufacture into sparkling cider, although Davis (12) found that the Baldwin made a good sparkling cider, and here it has proved to be one of the best for sweet cider.

It is generally conceded that the Russet apple is the best single variety for manufacture into cider. However, by judicious blending of cider from two or more varieties, a product can often be made which is better than the juice from any one variety.

This laboratory has rated cider made from some of the more important Massachusetts apples as follows: 1. Roxbury Russet. 2. Baldwin. 3. Northern Spy. 4. Rhode Island Greening. 5. McIntosh. 6. Ben Davis. 7. King. 8. Wealthy.

The more important physical and chemical characteristics of the ciders listed above were determined during the seasons of 1933 and 1934. Crab-apple cider was also analyzed in 1933. The results obtained, which are shown in Table 1, should be an important aid in the blending of ciders as well as giving a comparison of the composition of a good cider apple such as Russet with that of a poor one such as Wealthy.

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[1]Many of the analytical results presented in this section are taken from the master's thesis of Eunice M. Doerpholz, Mass. State College, 1935.

Specific Gravity

The determination of specific gravity was made using a hydrometer at a temperature of 21° C. (70° F.). The figure given in the table represents the number of times heavier the cider is than an equal volume of water when both are measured at a standard temperature. Specific gravity may be used as an approximate method of determining the amount of alcohol formed during the fermentation of cider. A nine-point drop on the hydrometer scale is equal to approximately 1 percent of alcohol by volume, so that a sweet cider with a specfic gravity of 1.050 at the start of the fermentation would have to be fermented to 1.041 to get a 1 percent alcoholic content by volume.

As will be seen from Table 1, the highest specific gravity was found in the Russet and crab-apple ciders, the lowest in the McIntosh and Wealthy ciders.

Degrees Brix

The Balling or Brix test indicates roughly the percentage of sugar in the juice, or, more exactly, the concentration of a sucrose solution of the same density as the juice being tested.

The determination was made with a hydrometer of the same type as that used for the specific gravity determination, the difference being that the Brix hydrometer has a scale calibrated in degrees from 0° to 30° or 30° to 60°, depending on the sugar concentration of the liquid to be measured. The actual sugar content is usually 1.5 to 2 percent less than the degrees Brix as this reading is influenced by other soluble solid material in the juice such as minerals, acids, pectin, proteins, etc. However, the determination is very simple and rapid and is one that any cider manufacturer will find helpful. The Russet and crab-apple ciders had the highest Brix reading of all the varieties tested.

The Brix reading may also be used to estimate the percentage of alcohol formed during fermentation. A decrease of one degree on the Brix scale indicates that approximately one half of one percent by weight (0.5%) of alcohol has been formed. For example, if the Brix reading was 12° at the start of the fermentation and if at the end of a week the reading had dropped to 6°, the alcohol content of the cider would be roughly 3 percent.

pH Determination

Measurement of pH was made with a quinhydrone electrode during the 1934 season and by the colorimetric method during the 1933 season. This determination is not one that the average cider maker will use, but the pH value is an important factor to be considered in blending ciders. The reason for this is that two ciders might have the same total acid content but because of other constituents in the juice, the "active" acidity or pH might be different. It is the "active" acidity which determines the relative sourness or acid taste of a product. A low pH value indicates a high degree of "active" acidity and vice versa

The results in Table 1 indicate that the pH varies somewhat from season to season and that there is also considerable difference between varieties. Of the ciders made during the 1933 season McIntosh had the lowest pH and Ben Davis and King the highest. Cider from the two latter varieties also had the highest pH in 1934, while Russet and Wealthy had the lowest.

TABLE 1. COMPOSITION OF CIDERS MADE FROM SEVERAL VARIETIES OF MASSACHUSETTS APPLES

VARIETY	Specific Gravity		Degrees Brix		pH		Viscosity		Pectin Percent		Tannin Percent		Total Acid Percent		Ash Percent	
	1933	1934	1933	1934	1933	1934	1933	1934	1933	1934	1933	1934	1933	1934	1933	1934
Baldwin	1.055	1.041	14.1	11.8	3.2	3.5	3.8	3.2	.10	.10	.08	.06	.56	.48	.16	.19
Ben Davis	1.045	1.045	10.9	11.5	4.0	3.7	4.2	3.8	.08	.31	.05	.06	.33	.43	.20	.16
King	1.055	1.050	12.5	12.9	4.0	3.6	5.1	7.3	.18	.26	.04	.07	.40	.53	.16	.17
McIntosh	1.045	1.040	12.2	11.5	3.1	3.5	4.3	4.6	.18	.11	—	.08	.41	.48	.24	.15
Northern Spy	1.045	1.045	11.8	12.0	3.2	3.4	4.0	2.2	.08	.09	.08	.08	.48	.49	.18	.13
Rhode Island Greening	1.045	1.045	11.2	12.0	3.2	3.5	4.7	5.6	.16	.30	.04	.07	.44	.47	.14	.12
Roxbury Russet	1.065	1.065	15.5	16.0	3.9	3.3	5.1	4.7	.18	.32	.07	.06	.61	.67	.15	.15
Wealthy	1.040	1.045	9.8	11.5	3.6	3.3	4.7	4.2	.15	.28	.05	.05	.57	.61	.23	.19
Crab	1.065	—	16.0	—	—	—	—	—	.09	—	.25	—	.75	—	.38	—
Average	1.051	1.047	12.7	12.4	3.5	3.5	4.5	4.5	.13	.22	.08	.07	.51	.52	.20	.16

Viscosity

The ratio of the rate of flow of cider to the rate of flow of water is a measure of viscosity. The determination must be made at a given temperature in order to have the results comparative. In this study, the time required for cider to pass between two marks on a pipette, divided by the time for the same volume of water to pass between the marks—is the value given as the viscosity. The higher the viscosity, the more "body" the juice will have. The body can be determined approximately by the "feel" of the cider in the mouth, but the method described above gives a more definite basis of comparison.

Viscosity will vary with the quality of the fruit. A hard, ripe fruit usually yields a cider with a low viscosity, while cider made from fruit of the same picking after storage of several months will have a very high viscosity. As the cells break down during storage, the pectin, one of the constituents causing a high viscosity, is more readily extracted with the fruit juice and results in a cider of high viscosity. Because freezing also tends to break the cell walls, cider made from apples which were frozen and subsequently thawed is very oily in consistency and has a high viscosity.

Pectin

The alcohol precipitate method as recommended by the A.O.A.C. (1) was used to determine the pectin content of the ciders. As has been mentioned in the previous section, it is the pectin which is the factor responsible for the "body" of a cider and the pectin content of the apple juice depends to a large extent upon the condition of the fruit at the time of pressing. Although apples are rich in pectin, the amount found in cider is low because the juice is cold pressed and pectin is only sparingly soluble in cold fruit juices. The lowest pectin content in the ciders examined was 0.08 percent in the Northern Spy and Ben Davis ciders made in 1933; the highest was in the Russet cider made in 1934.

Tannin and Coloring Matter

To determine the exact amount of tannin in a fruit juice would require a very involved procedure. Hence, the method commonly used for the determination of tannin is by titration with a standard potassium permanganate solution using indigo carmine solution as an indicator. Because the potassium permanganate reacts with the coloring matter in the ciders as well as with the tannin, the value obtained is designated as "tannin and coloring matter". The method is given in detail by the A.O.A.C. (1).

Tannin is an important constituent of apple cider in that it contributes the astringent taste which gives so much character to a good cider. Crab-apple cider had the highest tannin content, 0.25 percent, of any of the varieties tested, as might be expected from the astringent taste of the crab-apple. The other ciders had less than one-third the tannin content of the crab-apple, the maximum being 0.08 percent in the Northern Spy, McIntosh and Baldwin.

Total Acid

This determination was made by diluting 10 cc. of the cider with 100 c.c of distilled water, bringing the solution to a boil, cooling and titrating with 0.1 normal sodium hydroxide solution, using phenolphthalein as an indicator.

Crab-apple cider was found to have the highest total acid content, 0.75 percent. Russet was next with a content of 0.61 percent in 1933 and 0.67 percent in 1934. Acidity was calculated as malic acid.

Ash

From the standpoint of taste and flavor, the ash content of a cider is of little significance. The chief value of an ash analysis is as an indication of the mineral content of the product analyzed.

The determination was made by evaporating 25 grams of cider down to dryness in an electric oven and then burning it to an ash in a muffle furnace at a temperature of 700°–800° C. (1292°—1472° F.). By weighing the empty container before the cider is put into it and the same container with the ash in it, the percentage of ash can be calculated.

The ash content of the ciders compared favorably with that found in the whole apple. Sherman (23) gives 0.176 as the ash content of apples and in this investigation the ash content varied from 0.12 to 0.38 percent, crab-apple cider having the highest value.

Discussion

Most of the ciders varied in composition from one season to the next. There are so many factors which might be the cause of this variation that it is not feasible to discuss all of them here. Shaw (22) and Caldwell (3, 4, 5, 6,) have shown the effect of climatic and other conditions on the composition of apples and apple juices.

It is interesting to note the composition of the Russet cider, as it was found to be the best for drinking purposes. This cider was higher in sugar content than any of the other ciders tested, with the exception of the crab-apple cider, during both the 1933 and 1934 seasons, and also had the highest total acid content and a fairly high tannin content to give the right "tang" to the juice. The Wealthy cider, on the other hand, had a fairly high acid content, but was low in sugar and tannin. From the standpoint of palatability, this cider was the least desirable of any made in this study.

BLENDING

It is not possible to give any rule for blending ciders that will prove infallible. The most important factors to be considered are the degrees Brix, the tannin content, the pH, and the total acidity.

According to Charley (9), English cider apples are put into three classifications as follows:

1. **Sharp juices** with a malic acid content greater than 0.45 percent.
2. **Sweet juices** with a malic acid content less than 0.45 percent, and with a tannin content less than 0.2 percent.
3. **Bittersweet juices** with a malic acid content less than 0.45 percent, and with a tannin content greater than 0.2 percent.

This classification does not take into account the sugar content of the apples since English cider apples are used chiefly for making a fermented beverage. However, the sugar content of the cider apples is given as 12.5 percent, so on the basis of the grouping shown above, most of the ciders studied in this investigation would be classed as sweet juices.

Since none of the common dessert apples have a high tannin content, and since the so-called bittersweet cider apple is not grown to any extent in this country, the crab-apple would probably have to be used in blending to supply astringency as it has a tannin content of 0.25 percent. Caldwell (5) has shown that French cider varieties are adaptable to conditions in this country and are desirable for blending with American dessert varieties.

For the benefit of those who might wish to blend ciders with more accuracy than is possible by taste or flavor, the method of Pearson's Square is given.

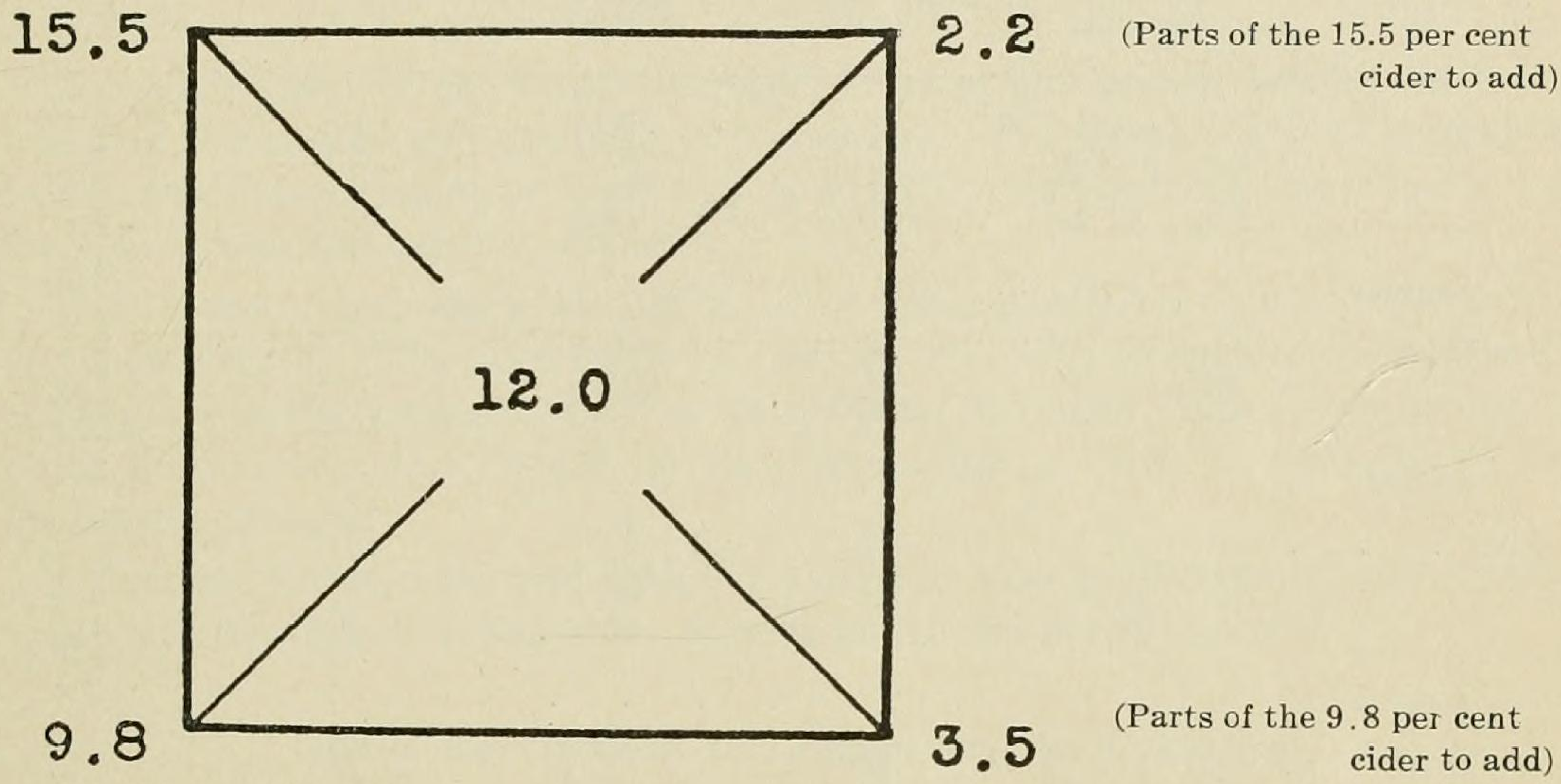

Figure 1. Pearson's Square

The procedure in using the square is best illustrated with an example If a cider containing 12 percent sugar is desired as the finished product, the figure 12 is put in the center of the square, as illustrated in Figure 1. The two ciders available are, say, a 15.5 percent cider and a 9.8 percent cider. Then the figure 15.5 is put in the upper left-hand corner and the figure 9.8 in the lower left-hand corner. The results obtained by substracting the figures in the corners from the center figure (always subtracting the less from the greater) are placed diagonally opposite from the original figure on the right-hand side. In the example given, 12 would be subtracted from 15.5 giving 3.5 as the result, and 9.8 would be subtracted from 12 giving a result of 2.2. So, to get a cider with a sugar content of 12.0 percent, 2.2 parts of the 15.5 percent cider should be mixed with 3.5 parts of the 9.8 percent cider. "Parts" may refer to quarts, gallons, or barrels of cider depending on the quantity at hand, or the method of measuring available. It would not be possible to use the method for calculating the amount of dry sugar to add without making other allowances. Pearson's Square may also be used in the manner given above for adjusting the acid or tannin content of ciders by blending. It is also a convenient tool for adjusting the acid content of vinegar.

PRESSING

According to Chenoweth (11) the yield of cider depends principally upon four factors:

1. The variety of apple.
2. The condition of the fruit.
3. The type of equipment.
4. The method of manipulation.

Yields of cider obtained from several varieties of apples pressed at different seasons of the year are shown in Table 2. Pressings were all made on a power press so that variations in the yield of cider caused by the type of equipment and method of manipulation were reduced to a minimum

The highest yield of cider, 4.4 gallons per bushel, was obtained from Baldwin apples pressed in October. The lowest yield, 2.4 gallons per bushel, was obtained from Russet apples pressed in April.

Table 2. Effect of Variety and Date of Pressing on the Yield of Cider

Variety	Date of Pressing	Weight of Apples Pounds	Weight of Cider Pounds	Gallons of Cider	Yield per 50 lb. bushel Gallons
Baldwin	Oct. 11, '34	85.5	66.5	7.6	4.4
	Jan. 15, '35	88	60.5	7.0	4.0
	Apr. 3, '35	126.5	79	9.1	3.6
	Mar. 2, '36	155.5	88.5	10.2	3.3
Average					3.8
Ben Davis	Jan. 15, '35	84	43.3	4.9	2.9
	Mar. 11, '35	84	38.5	4.4	2.6
	Mar. 2, '36	186.5	95.7	11.0	2.9
Average					2.8
King	Nov. 3, '34	86	48.5	5.6	3.3
	Jan. 15, '35	90	50	5.7	3.2
	Nov. 25, '35	93	61.8	7.1	3.8
	Jan. 23, '36	79	40.5	4.7	3.0
Average					3.3
McIntosh	Oct. 11, '34	82.5	58.5	6.7	4.0
	Oct. 25, '34	83.0	52.0	6.0	3.9
	Nov. 6, '34	42.0	25.	2.9	3.5
	Mar. 11, '35	91.5	50	5.7	3.1
	Nov. 25, '35	93	61.8	7.1	3.8
	Jan. 23, '36	81	45	5.1	3.1
Average					3.6
Northern Spy	Nov. 27, '34	91	57	6.6	3.6
	Apr. 3, '35	127.5	67.5	7.8	3.1
	Jan. 23, '36	126	87.5	10.1	4.0
	Mar. 2, '36	78.5	44.5	5.1	3.2
Average					3.5
R. I. G.	Oct. 11, '34	40	26	3	3.8
	Nov. 27, '34	94	58	6.7	3.6
	Apr. 3, '35	138.5	76	8.7	3.1
	Jan. 23, '36	100	66.5	7.6	3.8
Average					3.6
Russet	Nov. 27, '34	88	52.5	6.0	3.4
	Apr. 3, '35	120	50	5.7	2.4
	Jan. 23, '36	112	68.5	7.9	3.5
	Mar. 2, '36	68.5	46.5	5.3	3.9
Average					3.3
Crabapple	Nov. 25, '35	88	50.5	5.8	3.3

It should be noted, however, that the next year Russet apples gave a yield of 3.9 gallons to the bushel when pressed in March, the highest yield of any variety pressed at that time of year. Ben Davis apples gave the lowest average yield, but the pressings were all made late in the season so that the figures do not give a true indication of the yield which might be obtained in the fall of the year.

Baldwin, Russet, Northern Spy, Rhode Island Greening, and McIntosh all retained their cider-making qualities well into the February following the autumn they were picked, when they were held under good storage conditions. Aside from the increased yield obtained when sound, ripe fruit is used, the aroma and quality of the cider is also a factor to be considered.

Type of Equipment

Manufacturers of cider-making equipment have various types of mills from small hand mills with a capacity of 60 to 90 gallons a day to large power mills capable of producing more than 6,000 gallons of cider in a 10-hour day.

Although formerly the less efficient hoop or barrel type of press was used in the hand mills, now the rack and cloth press is standard equipment for practically all the mills.

Method of Manipulation

Increased yields of cider may be obtained by proper care in grating the fruit, building the cheese and applying the pressure. The grater type of pulper is better than the crusher for grinding the fruit. Grinders as supplied by the manufacturers are usually efficient.

The layers of the cheese should be of uniform thickness equal to the depth of cheese frame. The pulp must be packed into all corners and should be of the same density throughout to insure uniform pressure. The pressure should be applied slowly and should be maintained for at least 10 minutes at the maximum pressure.

A deeper-colored cider and a higher yield can also be obtained if the ground apple pulp is allowed to stand for several hours before it is pressed.

Other Factors to be Considered in Pressing

1. Washing. It is recommended that the apples be dipped for 5 minutes in a diluted acid wash followed by thorough rinsing in running water to remove the bulk of any spray residue and to decrease the amount of dirt and number of spoilage organisms on the fruit. Even washing the apples in water, while not as good as the acid wash, greatly improves the keeping qualities of the cider.

2. Iron is dissolved by prolonged contact with either the ground pulp or the cider, and under certain conditions is apt to cause blackening of the cider. Hence, all contact with iron should be reduced to a minimum.

3. Care of the cloths. Satisfactory press cloths may be obtained from a cider mill supply house. They should be thoroughly washed, boiled, and rinsed before using and, if possible, after each day's pressing. When used dry the cloths are apt to impart an undesirable flavor to the cider, so that it is advisable to soak the cloths overnight in clean cold water before a pressing is to be made with them.

4. Containers for the cider should be absolutely clean and free from any odors.

5. Unless cider is to be clarified with Pectinol (discussed later), it should be chilled as soon after pressing as possible. A temperature of 32° F. or below is the best storage temperature, but cider has been held for as long as a month at 40° F. without appreciable fermentation.

Action of Apple Juice and Cider on Metals

The acids in cider have a corrosive action on certain metals. The extent of this action on some of the more common metals, is given in the following list prepared by Charley (9):

Iron — Strong action with formation of green and brown tannates.
Tin — Slight action.
Copper — Badly attacked.
Aluminium — Slight action.
Zinc — Badly attacked.
Lead — Badly attacked.
Stainless steels — No action.

Proper selection of the metal equipment to be used in cider manufacture would not only be more economical over a period of years, but would also eliminate any danger of health hazards such as might occur if lead were exposed to the cider for any length of time. Off flavors and colors would also be developed if an excess of metals such as zinc, copper, and iron were dissolved in the cider.

A Small-Scale Apple-Juice Extractor

A machine for extracting apple juice on a small scale has been developed by Dr. Jenkins of Keene, New Hampshire. The purpose of the extractor is to enable soda-fountain operators and soft-drink dispensers to extract juice from fresh apples directly into a glass. The machine consists essentially of (1) a motor-driven disk covered with teeth which grinds the apple to a pulp, (2) a filter chamber containing a permanent non-clogging, metallic filter screen. The finely pulped apple is thrown by centrifugal force into the filter chamber and the juice is filtered through the metallic screen and led through a small pipe into the container. The solids automatically discharge through a separate pomace spout. (See Fig. 3.)

The juice extracted by this machine should not be classed as cider but rather as apple juice since it does not have the flavor or color of cider However, it is very palatable and should prove popular as a soda-fountain drink. Apple juice made by this extractor and sold in the same way as fresh orange juice should lead to an increased consumption of apples. Moreover, the fresh apple juice made by this machine was found to be as rich in vitamin C as the apple from which it was made, if consumed immediately, whereas pasteurized cider or cider held for a few days in storage was deficient in vitamin C.

Treatment of Containers

Cider can be spoiled very easily by storage for a few hours in a foul barrel. Several methods are available for the cleaning and sweetening of barrels.

Where live steam is available, thorough washing with hot water followed by treatment with live steam and a cold-water rinse is good procedure. Of course, use of hot water and steam removes paraffin from paraffin-lined barrels, and after such treatment it would be necessary to reline the container.

A moldy barrel should have the head removed and all the mold scraped off as well as the layer of wood underneath. Hot 5 percent soda ash (sodium carbonate) solution should then be scrubbed around the inside of the barrel after which it should be steamed or rinsed with several changes of hot water. Used barrels that appear to be sound should also be given the treatment with the hot soda ash solution.

Another method of sterilizing and deodorizing moldy or sour containers is to fill them with a solution of sodium hypochlorite (available at any drug store), or chloride of lime containing 500 parts per million of available chlorine, repeating the treatment until the container smells sweet. Thorough and repeated rinsing is necessary after this treatment.

Burning of sulphur in empty barrels before they are stored helps to keep them in good condition from one season to the next. Sulphur strips can be obtained from a cider makers' supply house.

Emphasis has been placed on the cleaning of barrels because they are so difficult to clean. Whenever possible it is better to keep cider in glass containers which can be kept clean and sterile with little trouble.

CLARIFICATION

The object of clarification of cider is to make the juice more easily filterable. Substances in the cider tend to form a slimy film on the filtering surface and slow down the speed of filtration. Hence, the clarification methods have as their object the breaking up of the viscous suspension so that the filter-clogging material is precipitated to the bottom of the container. The three best methods are given below.

Flash Heating Method

Carpenter and Walsh (8) suggest coagulating the suspended colloidal material by heating the cider to 180° F. for 20 seconds and cooling immediately. This method is satisfactory but requires flash pasteurization equipment.

Gelatin-Tannin Method

Numerous precipitating agents such as tannin and gelatin, white of egg, isinglass and blood, have been suggested as a means of clarifying cider. Of these the tannin-and-gelatin treatment is the most satisfactory for cider.

Addition of gelatin and tannin to the cider causes a fluffy precipitate to form which gradually settles to the bottom leaving the upper part of the liquid clear. Apparently the precipitate is caused by a combination of the pectin, gelatin and tannin. Apple cider ordinarily contains enough tannin to react with the gelatin, but to take care of the loss by precipitation additional tannin is added so that the taste will not be changed.

Since ciders differ in composition, it is necessary to test any given lot of cider to determine the amount of gelatin and tannin to add. For this purpose the following test solutions are made up. The description of the process is taken from Walsh (26). (See Figs. 4. and 5.)

Solution 1. Dissolve ⅓ ounce of tannin in 5.95 fluid ounces of 95 per cent alcohol. Then add 23.8 fluid ounces of water and mix thoroughly.

Solution 2. Dissolve ¾ ounce of gelatin in 23.8 fluid ounces of water and add 5.95 fluid ounces of 95 per cent alcohol. Heat a portion of the water and add the powdered gelatin slowly, stirring continuously. Then add the rest of the water and dissolve the gelatin by heating in a pan of hot water or double boiler and stirring. Add the alcohol and mix well.

These solutions should be kept in separate stoppered glass containers and may be used as needed, the alcohol acting as a preservative in both cases. In some cases the gelatin solution will jell when cold, but it can be liquefied when needed by putting the container in hot water.

Four white glass quart bottles should then be filled up to the neck with cider and numbered 1, 2, 3, and 4. Then add to each bottle the following amounts of solution 1 (tannin) and solution 2 (gelatin):

	Bottle No. 1	Bottle No. 2	Bottle No. 3	Bottle No. 4
Sol. 1 cubic centimeters....	10	10	10	10
Sol. 2 cubic centimeters....	5	10	15	20

(**Note:** A measuring cylinder or pipette, graduated in cubic centimeters may be purchased from a drug store or from a chemical supply or cider supply house. The test solutions could also be made up at a drug store.)

Measure and add the amounts of solution shown to each bottle, adding the tannin solution first in all cases and shaking well after the addition of each solution. Let the bottles stand 10 minutes and the bottle which shows the most clear juice is the one to which the proper proportions of tannin and gelatin were added.

The quantity of gelatin and tannin to use for 100-gallon batches of cider is then found by referring to Table **. For smaller amounts of cider, proportionate amounts of tannin and gelatin are used. For example, if bottle No. 3 showed the greatest amount of clear juice at the end of the 10 minute period, 1.25 ounces of tannin and 4.2 ounces of gelatin should be added to 100 gallons of cider; for 50 gallons, one-half these amounts, or 0.63 ounce of tannin and 2.1 ounces of gelatin should be added to the cider.

Table ** Amounts of Gelatin and Tannin to be Used for 100 Gallons of Cider Based on Different Tests

	Bottle No. 1	Bottle No. 2	Bottle No. 3	Bottle No. 4
Tannin, ounces	1.25	1.25	1.25	1.25
Gelatin, ounces	1.50	3.00	4.20	6.00

When the correct amounts of gelatin and tannin have been determined, the proper amount of tannin is dissolved in about 2 quarts of hot water (for a 100-gallon batch) and is then poured into the container of juice in a thin stream, stirring constantly. Ten minutes after the tannin has been put in the juice, the gelatin solution prepared by dissolving powdered gelatin in hot water as described for the test solution is added in like manner, with constant stirring. If the correct amounts of gelatin and tannin have been used, the juice starts to clear at once, and if left undisturbed, will be ready for filtration after standing 16 to 24 hours.

Disadvantages of the gelatin and tannin method are: (1) the cider is bleached by the treatment; (2) the precipitate is not as compact as with the Pectinol treatment; (3) the procedure is more complicated than the Pectinol method.

Advantages of the gelatin and tannin treatment are: (1) no heating is required during the treatment; (2) there is not as much loss of viscosity, unless the cider is subsequently filtered through a very fine filter. (3) The precipitation can be accomplished at a lower temperature than is possible with the Pectinol treatment.

Pectinol Method

The simplest method of clarifying cider is with Pectinol, an enzyme preparation made from certain molds with sugar as the vehicle. Pectinol breaks the soluble pectin in the cider down into simpler substances some of which are insoluble and settle out. As the insoluble material precipitates out it carries down other turbid colloidal matter which has lost the protective influence of the pectin.

The length of time required for the enzyme to clarify the cider depends on the temperature of the cider and the concentration of the enzyme. The following table taken from Hickok and Marshall (17), shows the quantities of Pectinol which are required to clarify cider under varying conditions of time and temperature. These figures are approximate since ciders vary in their composition.

Ounces of Pectinol Required to Clarify 100 Gallons of Cider under Certain Specified Conditions of time and Temperature

Temperature (Fahr.)	Time allowed for action of Pectinol: 5 hours	15 hours	30 hours	48 hours
40°	....	30	15	10
60°	54	18	9	6
100°	14	5	....	....

The manufacturers recommend adding the Pectinol as soon after pressing as possible, using one pound for every 100 gallons of juice. The Pectinol should be sifted directly into the juice with gentle stirring and the juice permitted to stand overnight at room temperature (70° F.). There is no appreciable fermentation when the cider is held at room temperature for the time recommended, provided the juice is filtered and processed immediately after the clarification treatment.

Pectinol-treated cider must be heated at 140° F. for 10 minutes after clarification is complete to stop the enzyme action, as otherwise the pectin remaining in the juice is gradually broken down during storage and forms a deposit in the container. Pasteurization of the cider at any temperature above 140° F. will, of course, also stop the enzyme action.

Centrifuge Method

High speed centrifuges which are now on the market have been used to clarify cider, but we have never seen cider treated by this method and cannot say how satisfactory it is. Tests conducted on a small scale with cream separator and basket type centrifuges were unsatisfactory.

However, according to Marston (19) the supercentrifuge is used extensively in the manufacture of sparkling fermented cider in England. Charley (9, 10) reports that such ciders are more fruity and mellow than filtered ciders. Fermentation can be practically stopped by centrifuging. In the early stages, this treatment caused a small reduction in the fermentation rate, but when fermentation had gone far enough for the specific gravity to be down to about 1.025 it was stopped almost completely. The drawback to the use of this method is the slight haze permeating the cider. To get a brilliantly clear cider it is usually necessary to filter after centrifuging.

Effect of Clarification by Gelatin-Tannin and Pectinol on the Composition of Ciders

Samples of cider made from eight varieties of apples were clarified by the Pectinol and the gelatin-tannin methods and filtered. The filtered ciders as well as an untreated portion from each lot were then tested for ash, pectin, total acid, tannin and coloring matter, viscosity, pH, specific gravity, and degrees Brix. Results of this test are shown in Table 3.

The viscosity was much lower in the Pectinol-treated cider than in the gelatin-tannin and the untreated ciders. This is in agreement with the organoleptic test, since the gelatin-tannin treated cider has much more "body" than the Pectinol-clarified product.

While the pectin content is apparently decreased to the same extent by both methods of clarification, it must be remembered that the alcohol precipitate method was used in the determination. The alcohol would precipitate some of the decomposition products of the pectin which would show in the table as pectin. However, the decomposition products would be of such a nature that they would not affect viscosity as much as the pectin found in the untreated juice or in the gelatin-tannin treated product.

The pH of the various juices was affected but slightly by the clarification treatment.

The average of the total acidity values would indicate that the Pectinol treatment slightly increases and the gelatin-tannin treatment decreases the total acid content of cider. The increase in acidity in the Pectinol-treated

TABLE 3. — COMPOSITION OF CIDERS CLARIFIED BY THE GELATIN-TANNIN AND THE PECTINOL METHODS

Variety	Un-treated	Pectinol Treated	Gelatin-Tannin Treated	Un-treated	Pectinol Treated	Gelatin-Tannin Treated	Un-treated	Pectinol Treated	Gelatin-Tannin Treated	Un-treated	Pectinol Treated	Gelatin-Tannin Treated
	Specific Gravity			**Degrees Brix**			**Tannin**, percent			**Ash**, percent		
Baldwin	1.0409	1.0360	1.0470	11.8	11.0	11.5	.06	.04	.02	—	.21	.19
Ben Davis	1.0450	1.0450	1.0450	11.5	11.0	11.0	.06	.04	.02	—	.22	.16
King	1.0500	1.0500	1.0500	12.9	12.4	12.0	.07	.05	.03	—	.25	.17
McIntosh	1.0400	1.0397	1.0383	11.5	9.7	9.7	.08	.04	.03	—	.16	.14
Northern Spy	1.0452	1.0450	1.0450	12.0	11.0	11.9	.08	.05	.04	—	.18	.13
Rhode Island Greening	1.0450	1.0450	1.0450	12.0	12.0	11.9	.07	.07	.02	—	.15	.12
Roxbury Russet	1.0652	1.0600	1.0600	16.0	14.8	15.9	.06	.05	.04	—	.37	.15
Wealthy	1.0450	1.0409	1.0404	11.5	10.4	9.9	.05	.04	.05	—	.20	.18
Average	1.0470	1.0452	1.0463	12.4	11.5	11.7	.07	.05	.03	—	.22	.16

	Viscosity			Pectin, percent			pH			Total Acidity, percent		
Baldwin	3.2	1.3	3.3	.10	.04	.05	3.5	3.5	3.6	.48	.44	.38
Ben Davis	3.8	1.4	3.4	.31	.19	.21	3.7	3.6	3.9	.43	.47	.33
King	7.3	1.7	3.1	.26	.19	.17	3.6	3 5	3.5	.53	.55	.44
McIntosh	4.6	1.3	1.5	.11	.03	.07	3.5	3.5	3.5	.48	.42	.38
Northern Spy	2.2	1.3	2.1	.09	.07	.06	3.4	3.4	3.4	.49	.58	.45
Rhode Island Greening	5.6	1.8	5.0	.30	.16	.15	3.5	3.4	3.4	.47	.58	.47
Roxbury Russet	4.7	1.5	4.5	.32	.17	.11	3.3	3.4	3.4	.67	.78	.57
Wealthy	4.2	1.4	2.9	.28	.12	.12	3.3	3.3	3.3	.61	.60	.57
Average	4.5	1.5	3.2	.22	.12	.12	3.5	3.5	3.5	52	.55	.45

juice is probably due to some of the decomposition products of pectin, such as pectic acid, which are formed by the action of Pectinol, but is so slight as to be of doubtful significance. Some of the slight decrease in the gelatin-tannin treated juice might be ascribed to the loss of tannin or tannic acid.

The clarified ciders had a lower specific gravity and Brix value than the untreated ciders, Pectinol causing more of a decrease in both instances than gelatin-tannin. Loss of pectin would be one factor responsible for the decrease in specific gravity and Brix value, but more important would be the small loss in sugar content through fermentation during the required settling period.

The average content of tannin and coloring matter was lowered more than a half by treatment with gelatin-tannin, but only a little less than a third by the Pectinol treatment. Since the gelatin-tannin treated cider is much lighter in color than the Pectinol treated, it is not surprising to find such a variation in the amount of tannin and coloring matter as determined chemically.

Ciders clarified with Pectinol had a higher ash content than did the gelatin-tannin treated juices.

FILTRATION

Much of the cider produced is not filtered, but experience shows that a clear cider is much preferred by the consumer. Small cider manufacturers often press the cider and store it in tanks overnight to settle. By siphoning the cider from the upper levels of the tanks, a fairly clear product can be obtained. Too long storage must be avoided or fermentation will occur and defeat the purpose of the tank clarification. In this state the semi-clarified juice may be filtered through a cloth filter or even through a filter press though a filter-aid is necessary if the latter is used. This process is best carried on in cool weather.

The muddy residue can be used for vinegar stock.

Muslin Tube Filter

A simple homemade filter has been developed at Michigan State College by Hickok and Marshall (17.) (See Fig. 6.) Their description of the muslin tube fruit juice filter and its operation follows:

> The set-up for performing the filtering operation consists of three principal parts:
>
> 1. A mixing and supply tank.
> 2. Elevation of the supply tank to provide a pressure head on filter unit.
> 3. The collecting or filtering unit.
>
> The collecting unit is the novel and most essential part of the outfit. It is a long, slender, cloth tube, closed at one end, with the other end connected to a rubber hose extending from the supply tank. This tube is laid in a horizontal position in a trough. When the mixture of cider and filter aid is fed into the closed tube, the pressure swells the tube to its full dimensions. The cider is forced out rather uniformly over the entire surface of the tube and the filter aid forms a cake of uniform thickness on the inside. The trough is given a slight slope so that the clear juice runs out of one end into a receptacle.
>
> The cloth tube is made of unbleached muslin, sewed to give a diameter of approximately three inches. A tube of a larger diameter will not support the filter cake satisfactorily and subsequent cracking and breaking of the cake may cause cloudiness in the filtered cider. A tube one yard long is most convenient. It cleans easily, coats evenly in a short time, and is the usual cloth width sold. It is recommended that both ends of the tube be left open to facilitate cleaning. In use, the dead end should be folded back, carefully gathered and tied, preferably with a single miller's knot.

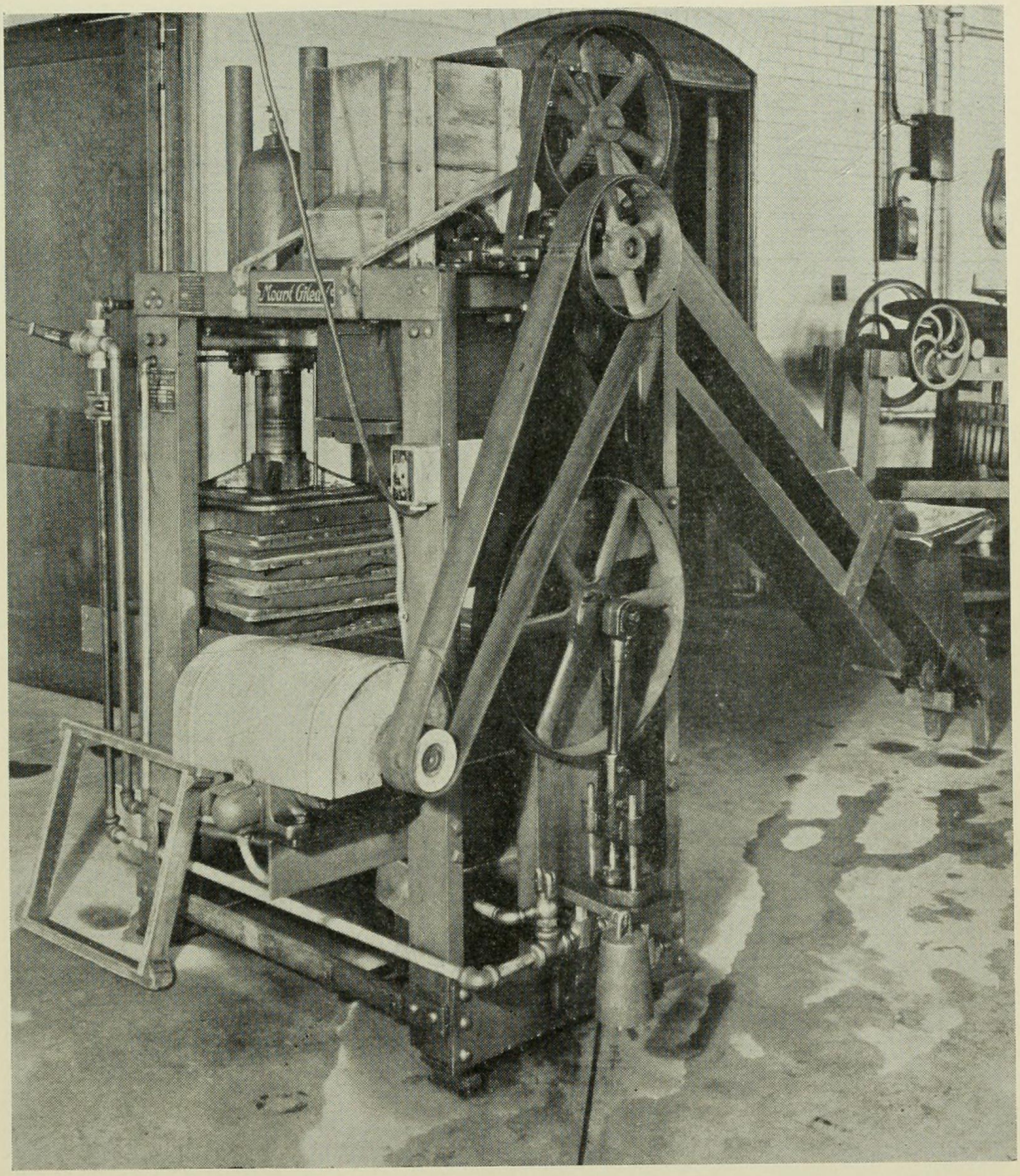

Figure 2. Hydraulic Press in the Food Manufacturing Laboratory
Small size with a capacity of 2½ bushels to a pressing.

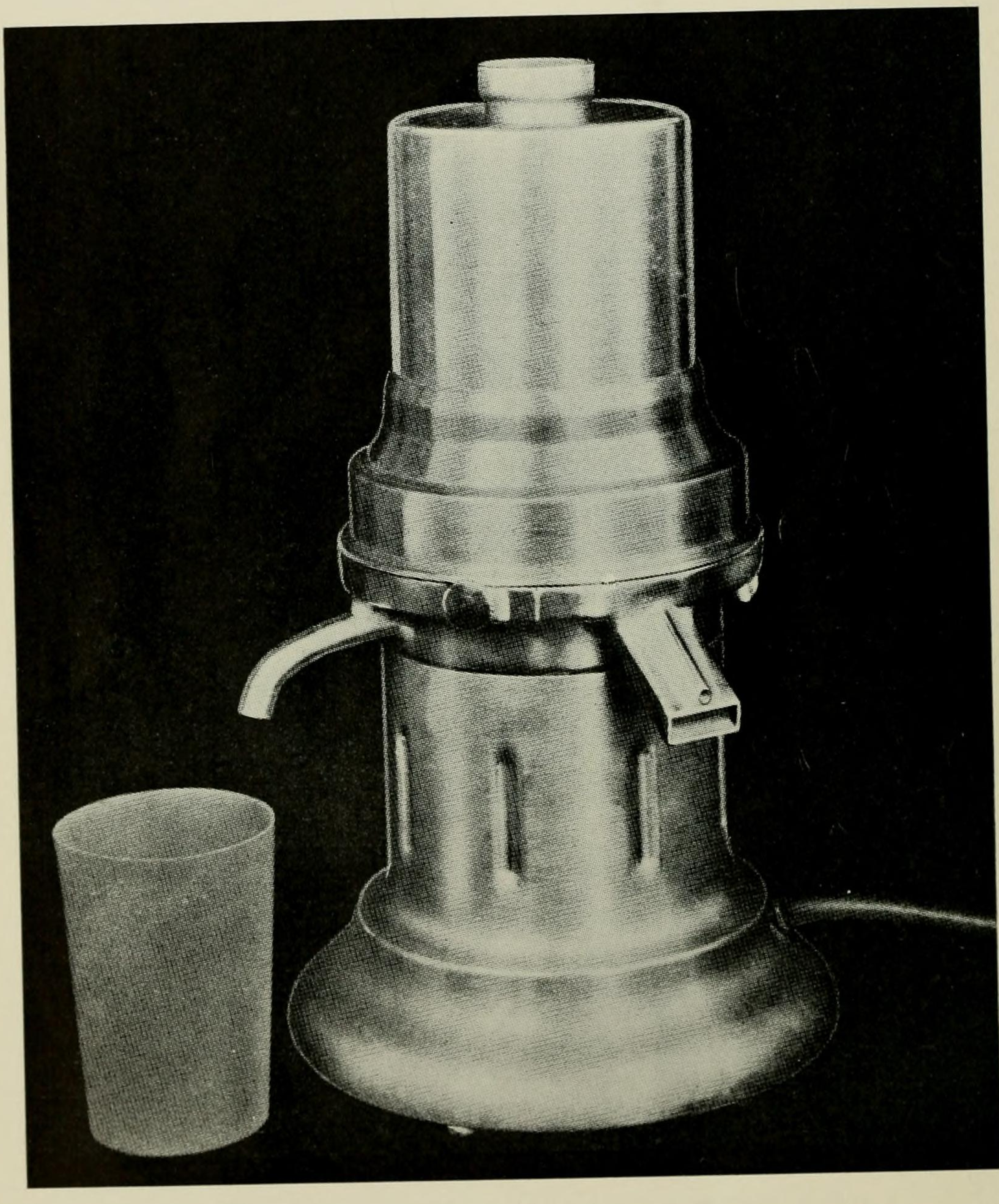

Figure 3. Vegetable and Fruit (non citrous) Juice Extractor.
Courtesy of Brooks L. Jarrett & Co., Pittsburgh, Pa.

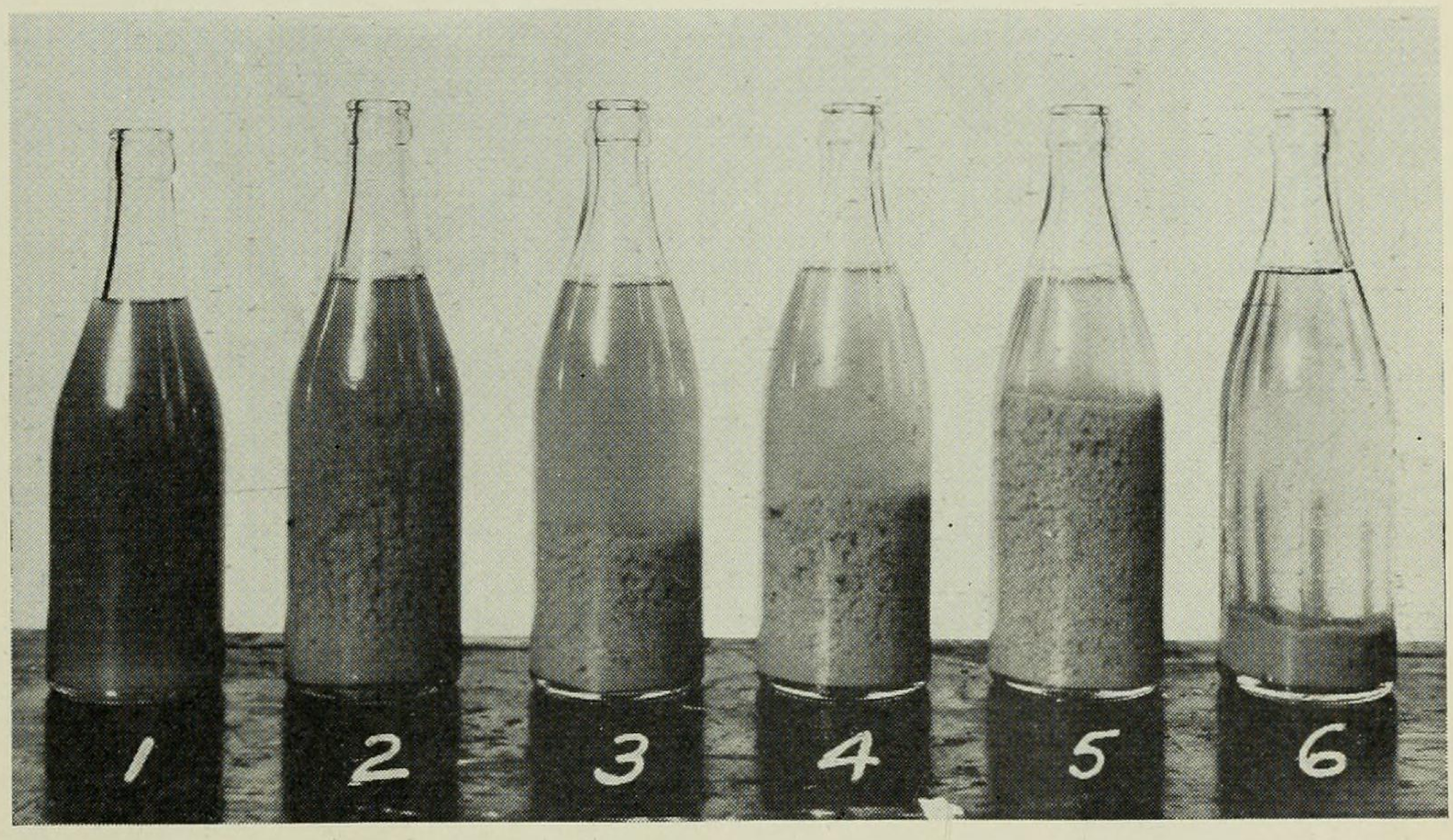

Figure 4. Gelatin-Tannin Treated Cider.

Bottle No. 1 contains untreated cider, No. 6 gelatin-tannin treated cider which has settled for 24 hours. Bottles No. 2 through 5 contain cider treated with gelatin-tannin test solutions in the following amounts per quart: No. 2, 5 cc. gelatin solution and 10 cc. tannin solution; No. 3, 10cc. gelatin solution and 10 cc. tannin solution; No. 4, 15 cc. gelatin solution and 10 cc. tannin solution; No. 5, 20 cc. gelatin solution and 10 cc. tannin solution. Note that the best break and precipitation is in bottles No. 3 and 4, and these bottles therefore would indicate the amounts of gelation and tannin to add to the main batch.

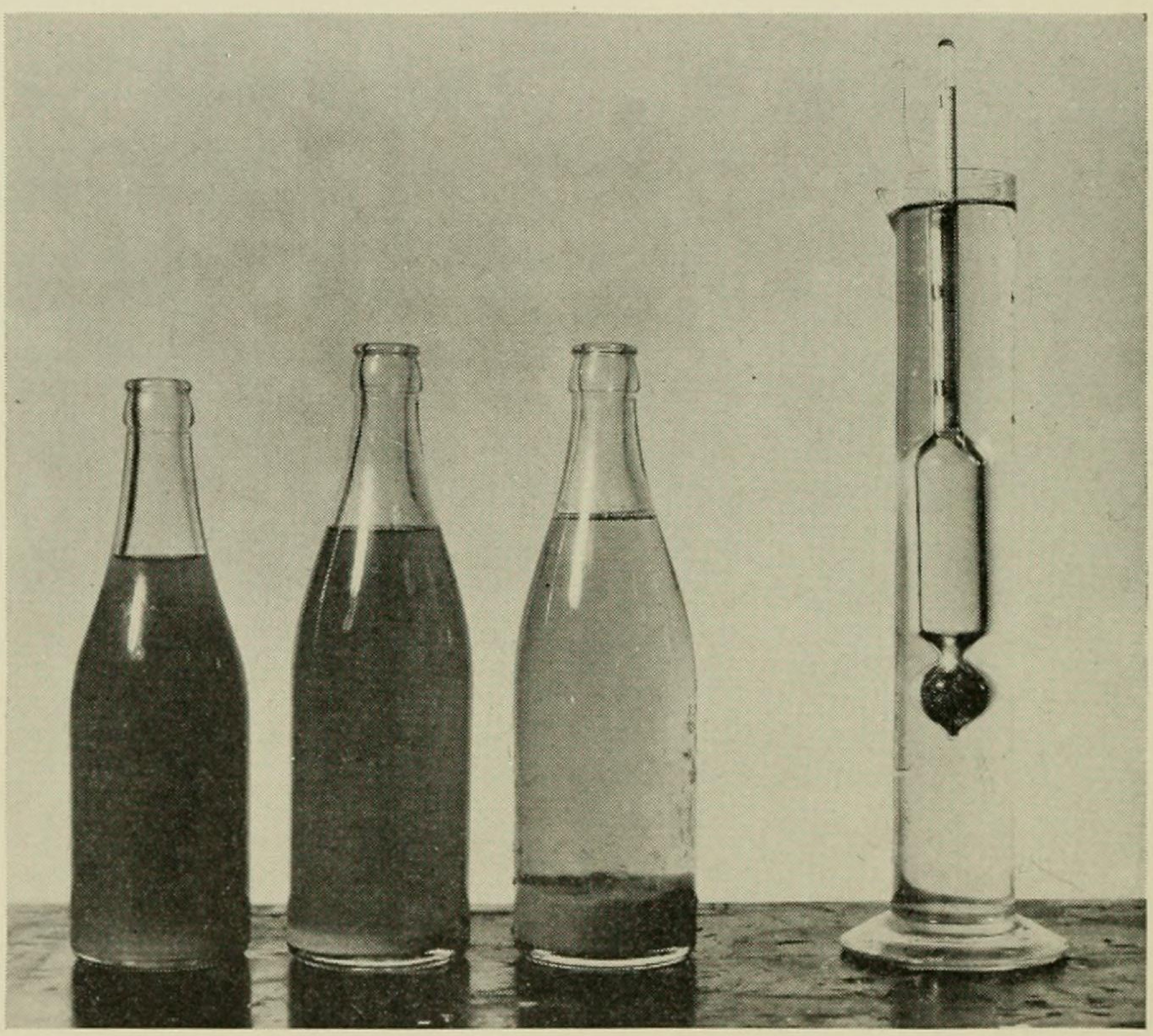

Figure 5. Comparison of Pectinol Treated and Gelatin-Tannin Treated Cider.

On the left is untreated cider; in the middle, Pectinol treated cider; and on the right, gelatin-tannin treated cider. Note how much more compact is the sediment in the Pectinol treated cider. The Brix hydrometer in the cylinder containing gelatin-tannin treated cider shows how clear the treatment renders the cider.

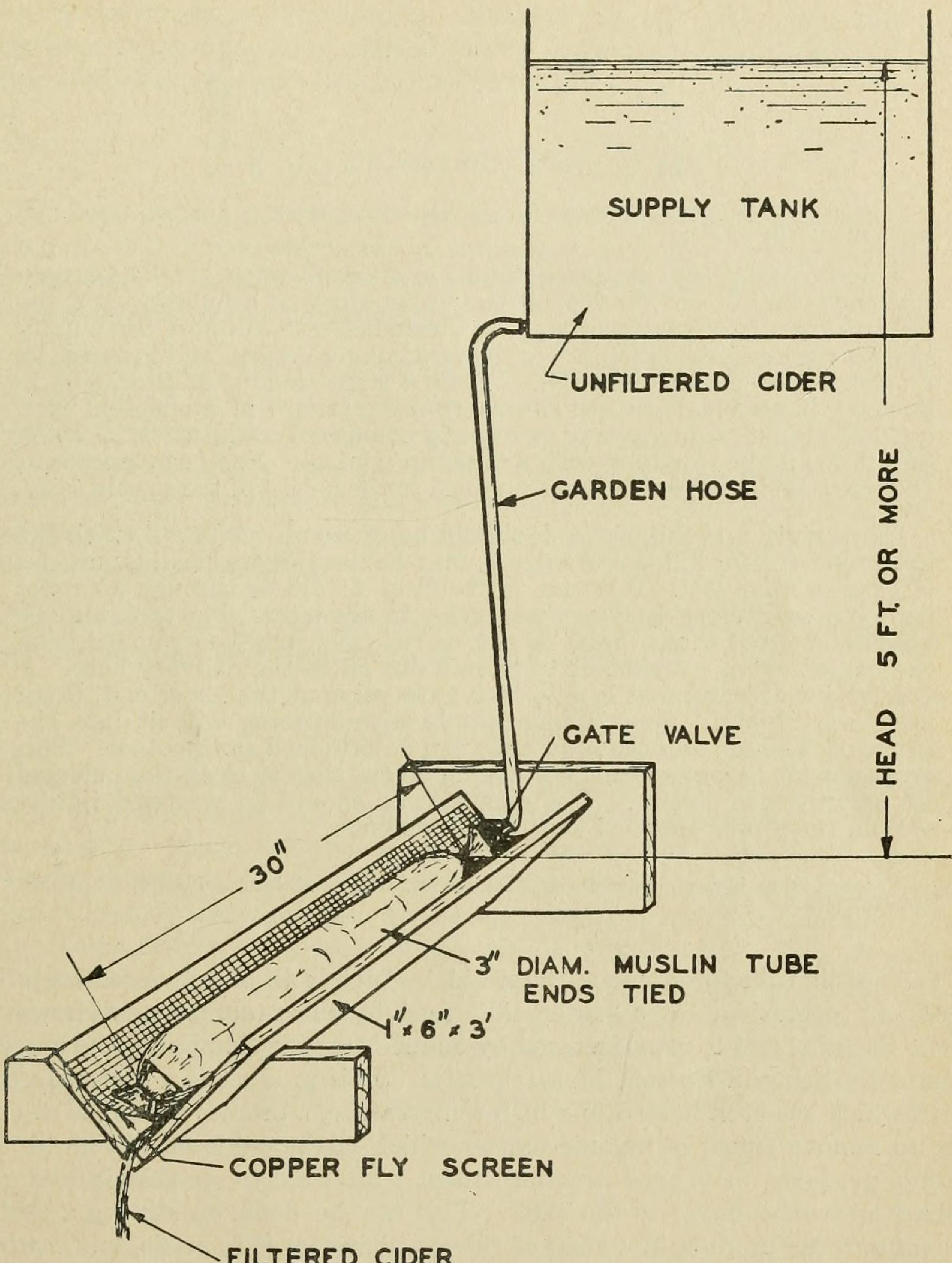

Figure 6. The Essential Elements of the Homemade Filter.

The tube should be supported in the trough by a copper screen. This allows free flow from the trough and makes the entire area of the tube effective in filtering. The copper screen is preferable to iron wire screen because it is less affected by fruit juices.

It is necessary to have a small pressure head on the filter. This can be satisfactorily secured by elevating the supply tank. The greater the elevation the more rapid the flow will be from the filter. The net head should not exceed 15 feet (with muslin tube) and eight feet results in very satisfactory operation. Less head may be used where small quantities are to be filtered, but will necessitate more frequent cleaning of the collector. Tests with cider subjected to enzyme clarification gave the following rates of filtration:

Net Head (Ft.)	Gallons Per Minute*
4	.65
6	1.05
8	1.43
10	1.80
12	2.50
14	3.34

*These were for short runs of about five gallons and rate would be lower for longer runs with thicker filter cakes.

The necessary head may be obtained in different ways: 1. The supply tank may be put on the floor of the upper story of a building and the filter below; 2. a platform may be constructed to support the supply tank at the desired height; 3. or the tank may be raised and lowered by a block and tackle or chain fall. Where a large amount of filtering is to be done, it may be more economical to use a pump† in connection with a storage tank. A pump may be directly connected to the filter, in which case it should be provided with a pressure control. For farm purposes, the cider can be carried or hand-pumped to the height of the supply tank.

The supply and mixing tank should be of wood. A barrel, with the head removed for filling and mixing, may be used where small quantities of cider are handled. Delivery to the filter should be through a rubber garden hose, preferably five-eights inches in diameter. The tank may be bored and fitted with a brass spigot, or the cider may be siphoned from the barrel. It is convenient to have a cut-off in the delivery hose. A convenient arrangement is a ½-inch gate valve at the lower end, fitted with two nipples. One ⅜-inch nipple with bushing will fit into the inside of the hose and the filter tube can be attached to the other. This arrangement is convenient for shutting off the flow to clean the unit and for starting the siphon. The muslin tube should be wrapped tightly around the nipple and tied with a miller's knot.

†Where a pump is used, it should be of bronze and with a minimum of metal in contact with the cider.

The muslin tube filter uses a "filter aid", which is absolutely essential to its successful operation. The "filter aid" used by this laboratory is known as Hyflo Supercel and is manufactured by Johns-Manville Company, the nearest local office being in Boston, Massachusetts. This product is a diatomaceous earth which has been heated to a high temperature, a process known as calcining, to remove traces of organic matter which might cause off-flavors in the filtered product. It is good practice to test a filter aid to see that it does not impart an earthy flavor to the cider. This can be done by stirring a tablespoonful of the product in a glass of cider, waiting for it to settle, and tasting the cider.

As noted under the description of the muslin tube filter, the filter aid is carried down from the supply tank with the cider and forms a cake on the inside of the cloth tube where it acts as a filtering medium by collecting the sediment from the clarified cider. In general one pound of Hyflo Supercel is sufficient for 30 gallons of cider, although as much as one pound for 20 gallons, or as little as one pound for 40 gallons may be necessary, depending upon the condition and extent of clarification of the cider. The filter aid must be mixed thoroughly with the cider before the filter is started and must be stirred during the filtration as otherwise it will settle out.

About two gallons of cider must be run through and returned to the supply tank before any is collected for use, because it takes about that quantity of cider to build up the filter cake. According to the inventors of the muslin tube filter the tube must be cleaned after 20 to 40 gallons have run through where a pressure head of six to eight feet is used, but with more pressure head the filter may be run longer without cleaning. To clean the filter, the tube is untied and the filter aid and sediment shaken out or washed out under running water, after which the tube may be returned to the filter

Filter Presses and Plate Filters

For large installations filter presses are preferred for the production of clear ciders. A list of manufacturers of equipment is given in the appendix. In general, each manufacturer can best give directions for use of his particular type of press and can define its limitations.

Freshly pressed apple cider cannot be economically filtered in a filter press without the use of a filter aid such as asbestos or diatomaceous earth. The colloidal matter present clogs the filters and makes them useless. However, after treatment with a filter aid or with Pectinol or gelatin-tannin, the filter presses are very satisfactory and give a brilliantly clear product. Accessory equipment such as storage tanks, pumps, and sanitary metal tubing is required when filter presses are used.

The so-called germ-proof filters used for sterilizing cider can be utilized only after the cider has been already clarified and pre-filtered.

PERSERVATION OF CIDER

Preservation methods have as their object the elimination or control of undesirable microorganisms. In sweet cider, the esential organisms which must be controlled are yeasts and molds: yeasts, because they ferment the sugars in the cider to alcohol; molds, because they present an unattractive appearance in the cider and also slowly use up the sugar and impart off-flavors to the product. Molds require much more air to carry on their activities than do yeasts, but yeasts are killed more easily by heat treatment and grow less readily at low temperatures than do molds. These points are mentioned because they are important considerations in the preservation of cider.

Preservation methods may be put into four general groups:

1. Germ-proof filtration.
2. Freezing.
3. Pasteurization.
4. Treatment with preservatives

Germ-proof Filtration

In this method, cider after a pre-filtration treatment is run through a filter with openings so small that while the cider can pass through the filter, yeasts and molds are prevented from doing so. After going through the filter the cider is run into sterile bottles; capped with sterile caps, and stored for two weeks or so to be sure fermentation will not take place. It is then ready for distribution. The advantage of the germ-proof filter method is that no heat is required, thus preventing any "cooked" flavor in the cider.

Disadvantages of the germ-proof filter are: (1) Care is required to assure sterility in the bottled juice. (2) The equipment is too expensive for the small manufacturer. (3) Such fine filtration removes much of the color and "body" from the cider.

Freezing

If cider is frozen solid in closed containers and held at a temperature of 10° F. or lower, it may be held from one season to the next without any appreciable change in its flavor.

The container in which the cider is to be frozen, whether it be a barrel, glass, or cardboard container, should not be filled more than three-quarters to four-fifths full, since the cider expands during the freezing process. The container should be covered to prevent the juice from acquiring foreign flavors during freezing.

Freezing does not destroy the yeasts and molds so that after the cider is thawed out it is almost as perishable as freshly pressed cider.

Sufficient time should be allowed for the frozen cider to thaw out after it is removed from storage. If the containers are not too large, they can be set in water and shaken occasionally. Large containers require as long as 24 hours to thaw out.

Cider may be kept fresh for several weeks by simply storing at temperatures of 32° to 36° F. Fermentation ultimately sets in, however, and cold-storage temperatures cannot be relied on to preserve the cider indefinitely. Cider will keep much longer in cold storage if it is chilled immediately after pressing.

Pasteurization

This term is applied to any method of heat treatment in which the food product is heated to a temperature less than the boiling point of water (212° F.).

It must be understood that pasteurization treatment does not always sterilize the product treated. In non-acid products such as milk, the object of pasteurization is to destroy certain disease-producing microorganisms without necessarily eliminating spoilage organisms. In an acid product such as cider or wine, the treatment is employed to destroy or inactivate spoilage organisms such as yeasts and molds, since disease-producing microorganisms are not ordinarily found in acid products.

The temperature employed depends upon the length of time that the product is heated. Heating the product to a high temperature for a short time is called "flash" pasteurization; heating at a low temperature for a longer period, 20 or 30 minutes, is called the "holding" method of pasteurization.

Flash Pasteurization

There is special flash pasteurization equipment made for the dairy industry which can be used to process cider. However, a small coil pasteurizer made from aluminum tubing has been used successfully to flash pasteurize small lots of cider here. The cider is fed by gravity through one coil which is immersed in a tank of water heated to the desired temperature. The juice then flows through a second coil which is surrounded by cold water. A thermometer inserted through an opening in a bronze T-joint joining the two coils indicates the temperature of the cider after it passes through the heated coil. The flow of the cider should be regulated so that the cider is heated to 185° F. before it reaches the cooling coil. The latter should cool the juice down to 140° F. Bottles and caps should be treated to kill any yeasts or molds on them. Boiling the bottles and caps for a minute is a good method of eliminating the spoilage organisms. The bottles should be filled as full as possible when bottled from a flash pasteurizer.

Holding Method of Pasteurization

In this method the clean bottles are filled with cider heated to 130° to 140° F., leaving about one and a half inches to allow for further expansion during the heating process. The caps are then put on all but one bottle. The capped bottles are put on their sides in the pasteurizing tank and covered with water. The uncapped bottle should be kept standing upright with the top one or two inches above the level of the water A thermometer is inserted in this open bottle and heat is applied to the tank. When the thermometer in the open bottle registers 165° F., the temperature is held at this point for 20 minutes. The bottles should then be removed from the vat and slowly cooled.

The size of the pasteurizing tank depends on the amount of cider to be handled. The bottles should not rest on the bottom of the tank but should lie on a platform of wooden slats or screening about one-half inch from the bottom of the tank.

A deposit forms in the bottom of bottles of pasteurized, unclarified cider because of the precipitation of heat-coagulable substances. Unclarified cider also acquires a much more pronounced "cooked" flavor when it is pasteurized.

It is a good practice to aerate pasteurized cider by pouring it from one glass to another just before it is drunk.

Treatment with Preservatives

Sodium benzoate is the chemical compound most commonly used for the preservation of cider. Fellers (14) gives the following practical suggestions for the use of sodium benzoate in fruit juices.:

1. Use only sodium benzoate of high quality that is free from objectionable odor and taste. "U.S.P." grade is better than "Technical" grade. So little is used to preserve beverages, that it is poor economy to use cheap, objectionable preservatives which may ruin the beverage.

2. Do not use salicylic, formic or boric acids. All are prohibited by law in this country.

3. For strongly acid fruit juices which are made from sound stock and are reasonably free from turbidity or sediment, from 0.05 to .075 per cent by weight (3.5–5.5 oz. per bbl.) of sodium benzoate will effectively check alcoholic fermentation. For less sour juices as well as those made from questionable stock, or which are not freshly pressed, from .075 to 0.1 per cent (5.5–7.0 oz. per bbl.) is necessary. After fermentation has started, or in juices of exceptionally heavy body or of low acidity, even more may be necessary.

4. It is very important to add the benzoate to the freshly pressed juice. Yeasts proliferate very rapidly in cider and fruit juices, and delays of even a few hours may seriously impair the efficacy of the preservative.

5. Before filling, clean all receptacles such as bottles, carboys and barrels very thoroughly with steam, hot water, or a 0.02 per cent sodium hypochlorite solution. The latter will not injure the taste of the beverage.

6. A satisfactory way to add the preservative is as follows: Dissolve 1 lb. of sodium benzoate in sufficient water or fruit juice to make exactly 1 gallon. Solution is hastened by heat and stirring. One pint of this solution contains 2 oz. of sodium benzoate. Add as many pints as necessary. Do not add the benzoate in powder form to cider or grape juice through the bung. The preservative is not readily soluble in cold juices and merely settles to the bottom of the barrel. Before the benzoate goes into solution the juice may ferment.

7. Do not expect sodium benzoate to prevent spoilage in non-acid beverages or foods. It is suitable only for acid fruit juices and foods.

8. Benzoate gives the best results, and smaller quantities may be used, if the juice is kept in cool storage.

9. Clarified juices are more easily preserved by benzoate than cloudy juices with sediment.

10. Dirty and partially decayed raw stock produces a juice containing a large number of microorganisms and suspended matter. Such a juice

is unsuitable for preservation with sodium benzoate.

11. Benzoated cider or grape juice will not make good vinegar or wine. However, any alcohol which is present in the juice will change to acetic acid in spite of the preservative. It is therefore useless to attempt to preserve fermented beverages by the use of sodium benzoate.

12. Declare the presence of sodium benzoate and the amount added in per cent by weight, on each container offered for sale.

Experiments with sodium furacrylate and furoic acids showed them to be inferior to sodium benzoate for preserving cider.

Katadyn Treatment

In this method the preservative used is silver in very minute amounts. Equipment is very specialized and is obtainable on a rental basis only.

The general procedure is to pass cider through silver electrodes which are connected to a source of electric current. The cider makes an electrical contact between the electrodes and definite amounts of silver are deposited in the cider depending upon the strength of the current and the quantity of cider passing between the electrodes during any given period of time. Definite information regarding the operation of the Katadyn equipment is provided by the company furnishing the equipment.

Tests made here on a small scale show that the Katadyn process will successfully preserve cider, but it does impart a metallic taste to the product, which decreases during storage. Yeasts are more easily controlled by the method than are molds, so that the Katadyn treatment combined with bottling under a vacuum to inhibit mold growth, was found to be the most satisfactory procedure.

The use of this process in the treatment of cider is comparatively recent in this country, so that no definite statement can be made regarding its practicability for large-scale production.

Canning

Plain cans should be used for canning cider instead of the enameled because the latter perforate badly. The juice is merely filled into the cans, exhausted for 15 minutes at 160° F. or preferably vacuumized to remove air, sealed, and finally pasteurized for 15 minutes at 160° F. The product will keep for several months in a cool place, but should not be held over from one year to the next.

The main problem in the canning of cider is the elimination of oxygen from the juice. It is the combined action of the oxygen and acid in the cider which is believed to be responsible for the unusually corrosive action of cider on tin cans.

A procedure for the canning of cider recommended by Tucker, Marsh and Cruess (25) is as follows: Place the cider in a vacuum tank, preferably glass lined or of stainless steel, and apply a high vacuum of 28 to 29 inches about 20 minutes to remove dissolved and occluded oxygen. Then flash pasteurize the cider for 30 to 60 seconds at 185° F. and run it directly into cans, filling to within one-quarter inch of the top. Seal at once and cool immediately in cold water.

Instead of flash pasteurizing, an alternate procedure would be to fill the cider into cans after the vacuum treatment, leaving a good headspace. Then heat the filled cans in water at 150° F. for about 10 minutes, seal the cans and process at 150° F. for 30 minutes for small cans.

In general, it is more desirable to concentrate the cider by vacuum and preserve in class containers rather than to can the pure cider in tin cans. A somewhat inferior cider concentrate can also be prepared by open-kettle boiling.

Such a product can be preserved by canning either in glass jars, bottles, or tin cans.

CARBONATED CIDER

Carbonation of cider not only produces a sparkling drink much superior to plain cider, but also aids in the preservation of the product. Carbon dioxide gas is the substance responsible for the effervescence and "bite" of carbonated drinks. This gas also exerts an inhibitory action on mold growth so that the pasteurization temperature for carbonated cider may be reduced to 150° F.

There are three general methods of carbonating cider: (1) Use of ordinary soda-water carbonators. (2) Natural carbonation by yeasts. (3) Use of solid carbon-dioxide or "dry-ice."

The use of regular soda-water carbonators can best be explained by the manufacturer of the equipment. Important considerations in the carbonation of cider are:

Carbon-dioxide gas is more soluble in cold cider than in warm; hence during carbonation the temperature should be kept at 40° F. or below.

The amount of gas dissolved at a given temperature is directly proportional to the pressure of the gas.

It is generally agreed that naturally carbonated cider is better than the artificially carbonated product. Carbon dioxide is one of the gaseous products given off during the fermentation of sugar by yeasts. If the fermentation proceeds in a closed container, much of the gas is dissolved in the cider due to the pressure created. Such would be the general process of the natural carbonation of cider. It is by this process that the best champagnes are carbonated and it is also the procedure generally used for carbonating homemade root beer. In the manufacture of champagne, the yeasts which cause the carbonation are removed after they have settled out during storage. This is called disgorging. In homemade root beer as well as in some of the sparkling ciders sold in England, the yeast is left in the bottle, the consumer having become accustomed to the sediment.

Closed Cuvee Method

The closed Cuvee method was developed so that natural carbonation of a juice could be accomplished and the resulting sediment could be removed by filtration rather than by the long settling period and disgorging process. The method was originally used for champagne, but Davis (13) has successfully applied it to the manufacture of sparkling cider. The essential steps in the process are as follows:

1. The cider is partially clarified with a high-speed centrifuge and put into the glass-lined or stainless steel fermenting vat.

2. A pure yeast culture is introduced to start the fermentation and the cider is fermented at a temperature of 70° F. or above until the pressure in the fermenting vat reaches 75 lb. per square inch. This usually requires two to three days with a formation of as little as one-half of one percent of alcohol by volume.

3. As soon as the desired pressure is reached the cider is filtered as it flows from the fermenting vat to the cooling tank. Pressure is first equalized between the two tanks and the filtration is accomplished through gas-tight equipment so that there is very little loss of carbon dioxide.

4. In the cooling tank the cider is cooled to 30° F. so that there will be better absorption of the carbon dioxide gas. It is held in the cooling tank for 48 hours.

5. The cider is then run through a Seitz germ-proof filter into a counter pressure bottling machine where it is bottled in sterile bottles and capped.

By means of the closed Cuvee process either a sparkling sweet or a fermented cider can be produced, depending on the length of time the fermentation is allowed to proceed. The equipment used is expensive, but it is claimed that a very good product can be made by this method.

Dry Ice Method

For carbonation of small lots of cider, Walsh (26) suggests the use of "dry ice" or solid carbon dioxide. The clean bottles are filled with clarified cider cooled to 40° F. or lower. The dry ice is chipped off, accurately weighed, and immediately put into the bottle, which should be sealed as quickly as possible with the crown cap. The bottle is then wrapped loosely with a heavy cloth to prevent injury in case a defective bottle should burst, and shaken until the carbon dioxide is absorbed.

The following table, taken from Walsh, shows the volume of carbonation obtained in an 8-ounce container with different weights of dry ice. For pints and quart bottles proportionate amounts of dry ice and cider are used. A carbonation of about two volumes is recommended for cider.

Amount of Dry Ice Required for Different Volumes of Carbonation

Weight of Dry Ice Grams*	Volume of Juice Fluid Ounces	Volume of Container Fluid Ounces	Volume of Carbonation
1.0	7	8	1.8
1.5	7	8	2.8
2.0	7	8	3.9

*A balance suitable for weighing in grams can be obtained from a scientific supply house such as Central Scientific Company, Cambridge, Massachusetts; Will Corporation, Rochester, New York; Eimer and Amend, New York, N. Y.; W. M. Welch Scientific Company, Chicago, Illinois.

CONCENTRATED CIDER PRODUCTS

Boiled Cider

The simplest and oldest method of concentrating cider is by boiling in an open kettle until the juice has been reduced to approximately one-fourth to one-fifth the original volume. The resulting product is known as boiled cider and is often used in mince meat, apple butter, and for cooking purposes. The color and flavor are distinctly inferior to the vacuum prepared product. After concentration, the cider is strained through a cloth, sedimented by standing for 24 hours, and the clear liquid drawn off into clean containers. Preservation is accomplished by processing the boiled cider in boiling water for 15 minutes.

Other Cider Concentrates

Several methods have been suggested for the manufacture of cider concentrates. Gore (16) concentrated the cider by slow freezing and separation of the ice crystals with a basket centrifuge. With two or three successive freezings and centrifugings, the juice was concentrated so that one gallon was the equivalent of five gallons of the original cider. This method produced a very good product but the process is more expensive than evaporation under a vacuum.

Concentration of cider under a vacuum of 27 to 29 inches is another method of preparing a concentrate which retains color satisfactorily. However, many of the volatile flavoring materials are lost where an ordinary vacuum pan is used. Poore (21) found that practically all of the characteristic volatile flavor came over in the first 9 percent of the distillate when the cider was concentrated in a vacuum pan under a vacuum of 28 to 28.8 inches and a temperature between 96.8° and 123.8° F. When the distillate was redistilled the flavor was found in the first fourth that was recovered and when this was returned to the cider concentrate it had a good flavor.

To prevent the loss of the volatile flavoring constituents the Pfaulder Company of Rochester, New York, have designed a fruit juice concentrator with an ester impregnating unit. Experiments carried out by Carpenter and Smith (7) showed that by this method a concentrate could be made which, when properly diluted, was difficult to distinguish from the original juice.

Cider Syrup

This product differs from other cider concentrates in that part of the acidity is neutralized. Novick (20) in this laboratory, has found the following procedure for the manufacture of cider syrup very satisfactory. Sweet or mildly acid varieties are most suitable for cider syrup manufacture.

1. Clarify the juice with Pectinol and filter.
2. Neutralize the clarified cider to a pH of 5.1 with calcium carbonate or potassium carbonate. The addition of excess alkali causes a dark color and poor flavor, and should be avoided. Normally if approximately three-fourths of the acidity is neutralized a good product will be obtained.
3. Concentrate in a vacuum pan to 68–72 degrees Brix with as high a vacuum as possible, preferably 27 inches. Open-kettle concentration may be used, but the resulting syrup is darker and somewhat inferior in flavor.
4. Filter through cheesecloth, bottle, and pasteurize at 160° F. for 20 minutes. Cool quickly.

Cider syrup may be used as a table syrup in place of maple or blended syrup. It has a characteristic flavor, which while not particularly apple-like, is still very palatable.

Cider Jelly

This product is made by concentrating cider to the jelling point. Since pectin is one of the essential constituents of a jelly, only unclarified cider should be used.

The fresh sweet cider is boiled to 7° to 8° F. above the boiling point of water or until the product flakes off a spoon in the characteristic jelly test. A concentration of seven volumes of cider down to one volume is enough to produce a good jelly. The finished jelly is strained through a single layer of good cheesecloth and poured into clean dry glasses. When the jelly has set, melted paraffin is poured over the surface and the covers are put on or the jelly is capped with an airtight cover. Vacuum sealing after the jelly sets eliminates air and aids greatly in preventing surface growth of molds. Long cooking will darken the color of the jelly and give it a caramel-like flavor, so concentration should be as rapid as possible.

A variation in the older method of cider jelly manufacture consists in adding pectin extract obtained from apple pomace to the fresh cider in sufficient quantity to produce a jelly. For best results the cider should be concentrated to at least one-half its original volume, then the sugar and pomace extract added, and the mixture boiled rapidly to a jelly test. Such a jelly is much less tough and acid than the old-fashioned apple cider jelly. Pectin extracts are easily prepared by boiling pressed pomace with about five times its weight of water for 15 mintes, and straining or filtering the extract. Such pectin extracts may be prepared during the apple season and preserved either by canning or by freezing. A certain degree of concentration, 3 or 4 to 1, is desirable before storing the pectin extract. Of course the pomace may also be dehydrated and stored in the dry state. For the latter, only pomace which has been extracted with water and re-pressed should be used.

Jellies made by the use of pomace extracts (pectin) and cider are somewhat different in character from ordinary heat-extracted apple jelly or from old-fashioned cider jelly. Mint jelly can also be easily made by using pomace extracts, green dye and either mint leaves or extract. Strictly speaking, mint jellies are really not pure apple jellies, although they can be prepared from whole green apples such as Greenings.

USES FOR APPLE POMACE

Approximately 40 percent of the weight of the cider apples remains as pomace after the cider has been pressed out. If left around the cider mill the pomace becomes a breeding ground for yeasts, molds, and vinegar flies. Hence it is very important that it be disposed of as soon as possible.

There is much useful material left in apple pomace. Most of the jelly-making constituent, pectin, still remains in the pomace after pressing. In fact, many of the commercial pectin preparations are made from dried apple pomace. So, if the amount of pomace produced during the season justifies the expense, a pomace drier may be installed. Dried pomace can be stored in a dry place and manufactured later into a pectin preparation or used as stock feed.

As noted in the section on cider jelly, pectin extract may be obtained from the wet pomace and used in the manufacture of jellies. Such jellies must not be labeled "pure apple jelly" unless cider is mixed with the pectin extract at the time of manufacture in amounts which would make the composition of the finished product the same as that of a pure apple jelly.

To make the pectin extract, water to the extent of five times the weight of pomace is mixed with the pomace, the mixture is boiled for 15 minutes, and the liquid drained off and filtered. This pectin extract can then be filled into jars or cans and sealed. Gallon jars may be heated for 20 minutes at 212° F. if filled above 180° F. and stored for future use.

To obtain a clear pectin preparation such as is sold commercially, it is necessary to treat the pectin extract with diastase, a starch-destroying enzyme, to remove the starchy materials and then filter it. Diastase preparations may be bought at most drug stores in the form of extract powder or tablets or they may be purchased in larger quantities directly from the manufacturer (See list of supplies in Appendix). Such preparations as Clarex, Protozyme PX, and malt diastase gave good results in this laboratory. Because of greater ease of filtration, the addition of diastase clarifiers to the unconcentrated extracts is suggested. However, if good filtration equipment is available, the concentrated extracts may be clarified and filtered. Approximately 0.1 percent by weight of diastase clarifier is used. It is best to soak the powder in a small amount of water for an hour to facilitate rapid enzyme action. Approximately 7 ounces per 50-gallon barrel or 0.14 ounce per gallon of pectin extract is used. Directions on commercial enzyme preparations should be followed closely. The optimum temperature is 120° F. and the reaction period should be 90 minutes. However, lower temperatures for a longer period of time may be used. For example, at room temperature the diastase preparation may be left in the cider all night and the filtration accomplished the next morning. General methods for the handling and non-enzymic clarification of pectinous fruit juices have been described by Bell and Wiegand (2).

Results obtained here show that clarified pomace (pectin) extracts retain their jellying power much better than unclarified extracts. Processing methods have been discussed. The canned extract is stored preferably at cold-storage temperatures until ready for use. The pectin extracts also keep well in the frozen condition.

Kertesz and Green (18) showed that stored pomace containing 20 percent or less of moisture, did not actively support the growth of mold. Even at lower moisture contents, however, a gradual loss in pectin quality occurred during storage. These losses were believed not to be of enzymic nature, but rather due to moisture itself.

Apple pomace may also be used as a stock feed. The wet pomace may be stored in a bin, silo, or in a pile, if proper precautions are taken to allow for the weight of the pomace. As mentioned previously, dried pomace may also be used for feeding dry, or soaked with about two and one half times its weight of water. Experiments have shown that apple pomace is approximately equal to good corn silage in feeding value for dairy cows. It is advisable to feed the pomace after milking and to remove the milk from the feeding barn, since otherwise odors from this feed may be absorbed by the milk.

In some states distillers are using apple pomace as a cheap source of alcohol.

LEGAL ASPECTS OF ALCOHOLIC CONTENT OF CIDER

In the Federal Alcohol Administration Act it is stated, "The term 'wine' means (1) wine as defined in section 610 and section 617 of the Revenue Act of 1918, (U.S.C., title 26, secs. 441 and 444) as now in force or hereafter amended and (2) other alcoholic beverages not so defined, but made in the manner of wine, including sparkling and carbonated wine, wine made from condensed grape must, wine made from other agricultural products than the juice of sound, ripe grapes, imitation wine, compounds sold as wine, vermouth, cider, perry and sake; in each instance only if containing not less than 7 per centum and not more than 24 per centum of alcohol by volume, and if for non-industrial use."

However, in the Massachusetts Amendments to the Liquor Control Act the sale of cider containing alcohol is limited as follows:

"This chapter (the Liquor Control Act) shall not apply to the manufacture or storage of alcoholic beverages by a person for his own private use or to sales of cider at wholesale by the original makers thereof, or to sales of cider by farmers, not to be drunk on the premises, in quantities not exceeding in the aggregate the product of apples raised by them in the season of, or next preceding, such sales, or to sales of cider in any quantity by such farmers not to be drunk on the premises if such cider does not contain more than three per cent of alcohol by weight at sixty degrees Fahrenheit; nor shall this chapter apply to sales of cider by the original makers thereof other than such makers and farmers selling not to be drunk on the premises as aforesaid, if the cider does not contain more than three per cent alcohol as aforesaid, not to be drunk on the premises as aforesaid."

The Federal Alcohol Administration Act therefore does not apply to the manufacture or sale of cider unless it contains more than 7 percent of alcohol by volume. Such cider would be easily recognized as "hard" since practically all the sugar of the cider would have to be used up to produce 7 percent of alcohol. Sweet cider would rarely, if ever, attain such an alcoholic content without the addition of sugar.

Apparently no limitations are made by the state on the alcoholic content of cider if sold at wholesale by the original manufacturers, or on cider made by farmers from apples raised by them "in the season of, or next preceding such sales", if the cider is not drunk on the premises. As mentioned in the preceding paragraph, the sugar content of the cider would limit the alcoholic content to 8 percent by weight at the very most. Generally speaking, the alcoholic content of a fully fermented cider is estimated at one-half the percentage of total soluble solids (mostly sugar) in the freshly pressed juice. For example, an apple juice containing 12 percent solids will give a cider containing approximately 6 percent alcohol. Cider manufactured by farmers in Massachusetts from apples other than those produced in their own orchards, or by other manufacturers, must not contain more than 3 percent alcohol by weight. Such cider must not be drunk on the premises.

These regulations do not interfere with the manufacture and sale of sweet cider, since with modern methods of preservation such as pasteurization, cold storage, or use of sodium benzoate, it is easy enough to prevent cider from attaining an alcoholic content of 3 percent. Even if it is desired to produce a sparkling sweet cider, the small amount of alcohol produced in the process of natural carbonation would be much less than the limit set by the State Alcoholic Beverages Control Commission, provided the proper procedure was followed.

SPRAY RESIDUE PROBLEM

Arsenic and lead spray residues often persist on apples after picking. Only a small part of these toxic substances is removed by ordinary fruit washing methods. Commercially, apples are often washed in solutions containing from 0.5 to 1.0 percent hydrochloric acid. This treatment is effective in residue removal. Where visible residue is present on the fruit an acid wash is desirable. Of course only a part of the arsenic and lead passes into the cider. Experimental tests for arsenic on several lots of cider and apple butter manufactured from representative Massachusetts-grown apples showed only traces of this element. However, the U. S. Food and Drug Administration has seized at least one consignment of boiled cider which contained excessive arsenic and lead. The apples were grown in the Pacific Northwest where the spray residue problem is more serious because of scanty rainfall.

In general, except possibly in the case of concentrated apple products, it is not believed that sufficient toxic residue will be present on Eastern-grown apples to constitute a health hazard.

NUTRITIVE VALUE OF CIDER

Apple cider should be sold on its merits as a pleasant, refreshing beverage, not primarily because of its nutritional properites. However, it is deemed advisable to include here such information as is available on the nutritive value of cider.

Smith and Fellers (24) have shown that there is a wide variation in the vitamin C content of 21 varieties of Massachusetts grown apples. Seasonal or other variations, except storage, caused little change in the vitamin C content in any one variety. There is no apparent correlation between the vitamin C content of an apple variety and the chromosome number of that variety.

The daily protective level for guinea pigs varied from 4 grams (84 units per ounce) for Baldwin to over 25 grams (13 units per ounce) for McIntosh. The varieties tested may be conveniently classified as to their vitamin C potency as follows:

Very good (4 to 6.5 grams) (84 to 50 units per ounce): Baldwin, Northern Spy, Ben Davis and Winesap.

Good (7 to 10 grams) (48 to 34 units per ounce): Esopus (Spitzenberg), Rome Beauty, Red Astrachan, King, Roxbury Russet, Rhode Island, and Stayman.

Fair (10.5 to 15 grams) (32 to 22 units per ounce): Arkansas, Gravenstein, Wealthy, Cortland, King David, and Golden Delicious.

Poor (16 to 25 grams) (21 to 13 units per ounce): Jonathan, Delicious, Tolman, and McIntosh.

Cider, immediately after pressing, has just slightly less vitamin C than the apple from which it was made. However, as was shown by Fellers, Cleveland and Clague (15), although cider 24 hours old retained an appreciable amount of vitamin C, benzoated and pasteurized cider over 48 hours old had practically no protective value against scurvy. Titration tests for ascorbic acid on a bottled apple juice preserved by Seitz germ-proof filtration showed that from 2 to 4 quarts of the cider would be required daily to protect a man from scurvy, using the apple juice as the sole source of vitamin C. These bottled ciders contained only 4 to 8 units of vitamin C per ounce.

Apples have been found to contain some vitamin B and 6 to 7 units of vitamin G per ounce, so that cider would also contain these vitamins.

As to other nutrients it might be well to compare cider with milk. Cider contains approximately 0.4 percent protein, about one-eighth as much as whole milk; 0.5 percent fat, about one-eighth as much as milk; 12 percent carbohydrate, over twice as much as milk. It would take about 5.5 ounces of cider or milk to provide 100 calories. The daily energy requirement for a man doing sedentary work is 2,242 calories.

Cider also contains certain essential minerals, but not in the quantity that they would be found in some other foods. According to Sherman (23) there are approximately the following percentages of the various minerals in cider: calcium .007, magnesium .008, potassium .011, phosphorus .012, chlorine .005, sulphur .006, iron .0003. The ash of the apple or its juice is mildly alkaline, the ash from 100 grams being equivalent to approximately 3.7 cubic centimeters of normal alkali.

Unpublished experiments at this laboratory show that the consumption by young men of as much as 800 to 1,000 grams daily of McIntosh apples has no effect whatever on the blood alkali reserve. The urinary acidity was likewise unaffected by the consumption of these large quantities of apples.

GENERAL DISCUSSION

Most of the sweet cider which is manufactured in this country is sold in the fall and early winter, either in the fresh, untreated condition or as benzoated cider. Since simple clarification methods have been developed there is an increasing amount of clarified, filtered cider sold in grocery stores and roadside stands. This clarified cider is not usually preserved but is handled in much the same way as the unclarified cider; that is, benzoated, so it can be held for a few days at room temperature.

If available, freezing storage is the best method of preservation for cider.

For the small manufacturer, the next best procedure is pasteurization, either flash pasteurization with a coil pasteurizer or the holding method.

Carbonation of cider is desirable because it decreases oxidation changes and makes pasteurization at a lower temperature feasible, besides improving the quality of the cider as a beverage. Where large-scale manufacture makes installation of specialized equipment possible, naturally carbonated sweet cider would seem to be the best product to manufacture.

Storage of the bottled, processed cider is almost as important as the preservation treatment. Pasteurization or a similar process does not protect the cider from changes such as are caused by light and high temperatures. The best storage for bottled cider is a cool, dark, storehouse.

If cider is to become more than just a seasonal drink, as much care must be given to its manufacture as would be accorded a good wine. Whether the consumer demand for cider would justify such extra care is problematical, but the large demand for cider in the autumn would indicate that there is a potential year-round market for a good cider beverage.

Improved methods of manufacture make it possible to produce good cider concentrates, but the equipment is too expensive for the small manufacturer. Concentrated cider products such as boiled cider, cider syrup, and cider jelly can be made with simple equipment, but the market for such products is limited.

Apple pomace can be used in the preparation of a pectin extract or for stock feed if fed in combination with foods containing certain essential nutrients. In some states the pomace is used by distillers as a cheap source of alcohol.

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APPENDIX

Partial List of Dealers in Supplies

The following list is included so that cider makers may know where supplies may be purchased. No specific recommendation for any listed firm or product is intended. Equally satisfactory products may often be obtained from other dealers.

Barrels

So many cooperages are located throughout the state that no attempt will be made to list them. The addresses can be found in the telephone directory.

Mail order houses such as Sears Roebuck and Company and Montgomery Ward also sell barrels which are satisfactory for cider storage.

Benzoate of Soda

Heyden Chemical Corp., 50 Union Sq., New York, N. Y.
Hooker Electrochemical Co., 60 East 42nd St., New York, N. Y
Monsanto Chemical Co., St. Louis, Mo.
Seydel Chemical Co., Jersey City, N. J.

Cider Presses and Cider Makers' Supplies

A. B. Farquhar Co., Ltd., York, Pa.
Hydraulic Press Mfg. Co., Mt. Gilead, Ohio
Palmer Bros., Cos Cob, Conn.
Thomas-Albright, Goshen, Ind.

Chemical Supplies and Equipment

Balances, chemicals, hydrometers, thermometers:
- Central Scientific Co., 79 Amherst St., Cambridge, Mass.
- Eimer and Amend, Third Ave., 18th to 19th St., New York, N. Y.
- Fisher Scientific Co., 709–717 Forbes St., Pittsburgh, Pa.
- Arthur H. Thomas, W. Washington Square, Philadelphia, Pa.
- Will Corporation, Rochester, N. Y.

Balances, hydrometers, thermometers:
- Howe and French, Inc., 101 Broad St., Boston, Mass.

Hydrometers, thermometers:
- C. J. Tagliabue Mfg. Co., 525 Old South Building, Boston, Mass.
- Taylor Instrument Co., 141 Milk St., Boston, Mass.

Most wholesale drug and pharmaceutical dealers also carry stocks of chemicals and supplies.

Clarifying Agents and Filter Aids for Cider and Pomace Extracts

Pectinol:
- Hydraulic Press Mfg. Co., Mt. Gilead, Ohio

Protozyme PX:
- Jacques-Wolfe and Co., Passaic, N. J.

Filter-cel:
- Johns-Manville, 75 Federal St., Boston, Mass.

Clarex, malt diastase:
- Takamine Laboratory, Inc., Clifton, N. J.

Dry Ice

Dry Ice Corporation of America, 50 East 42d St., New York, N. Y.
Local ice cream manufacturers can usually supply small quantities of dry ice.

Filters

Alsop Engineering Corp., 39 West 60th St., New York, N. Y.
American Seitz Filter Corp., 31 Union Square, New York, N. Y.
Hydraulic Press Mfg. Co., Mt. Gilead, Ohio
The Independent Filter Press Co., Brooklyn, N. Y.
Karl Kiefer Co., Cincinnati, Ohio
Palmer Bros., Cos Cob, Conn.
Scientific Filter Co., 3 Franklin Square, New York, N. Y.
T. Shriver and Co., Harrison, N. J.
D. R. Sperry and Co., Batavia, Ill.

Vacuum Pans and Special Equipment for the Manufacture of Cider Concentrate and Closed Cuvee Process

Pfaudler Co., Rochester, N. Y.

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Apple Cider

and Cider Products

By J. A. Clague and C. R. Fellers

Greater care in the application of approved known methods in the production >•

and preservation of apple cider and cider products should make for an enlarged

demand for these popular by-products of the fruit industry. This bulletin gives

the results of investigations in this field.

MASSACHUSETTS STATE COLLEGE

AMHERST, MASS.

[Begin Page: Page 2]

APPLE CIDER AND CIDER PRODUCTS

By J. A. Clague, Assistant Professor, and C. R. Fellers, Research
Professor, in Horticultural Manufactures

Production of year-round marketable cider from apples which are below market grade has long been the hope of the apple growers of this country. However, as yet no preserved sweet cider beverage has attained the popularity prophesied for it at the time of its innovation. Some of the reasons for such a condition are: (1) Insufficient care in selection and blending of varieties. (2) Use of immature and unripe fruit; that is, apples picked at the same time as those intended for market and then culled out, rather than tree-ripened fruit. (3) Faulty manufacturing practices due to lack of technical knowledge about the processing and p reservatio n_of apple cider.

To present mformation gathered from experiments on several varieties of Massachusetts apples as well as work done by investigators in other states and countries is the object of this bulletin. It is hoped that the information presented will answer many of the questions confronting fruit growers and others when they consider the manufacture of cider.

COMPOSITION OF THE MORE IMPORTANT MASSACHUSETTS APPLE VARIETIES 1

In this country cider-making quality is not ordinarily considered in the selection of apple varieties for the orchard. In many of the European countries the growing of apples especially for manufacture into cider has been practiced for hundreds of years. This is one reason why in England, for example, the annual consumption of cider is two gallons per capita, while in this country it is not much over one quart per capita.

However, it should be noted that in England the term cider denotes a fermented, usually carbonated or sparkling, apple juice, while in this country cider refers to the unfermented juice unless preceded by the term "hard." An apple variety which might make a good sweet cider would not necessarily be satisfactory for manufacture into sparkling cider, although Davis (12) found that the Baldwin made a good sparkling cider, and here it has proved to be one of the best for sweet cider.

It is generally conceded that the Russet apple is the best single variety for manufacture into cider. However, by judicious blending of cider from two or more varieties, a product can often be made which is better than the juice from any one variety.

This laboratory has rated cider made from some of the more important Massachusetts apples as follows: 1. Roxbury Russet. 2. Baldwin. 3. Northern Spy. 4. Rhode Island Greening. 5. Mcintosh. 6. Ben Davis. 7. King. 8. Wealthy.

The more important physical and chemical characteristics of the ciders listed above were determined during the seasons of 1933 and 1934. Crab-apple cider was also analyzed in 1933. The results obtained, which are shown in Table 1, should be an important aid in the blending of ciders as well as giving a comparison of the composition of a good cider apple such as Russet with that of a poor one such as Wealthy.

Many of the analytical results presented in this section are taken from the master's thesis of

Eunice M. Doerpholz, Mass. State College, 1935.

[Begin Page: Page 3]

Specific Gravity

The determination of specific gravity was made using a hydrometer at a temperature of 21° C. (70° F.). The figure given in the table represents the number of times heavier the cider is than an equal volume of water when both are measured at a standard temperature. Specific gravity may be used as an approximate method of determining the arHount' of alcohol formed during the ^fprj gipritat.irQof cider.^ _A nine-point drop on the hydrometer scale is equal to approximately 1 percent of alcohol by volume, so that a sweet cider with a specfic gravity of 1.050 at the start of the fermentation would have to be fermented to 1.041 to get a 1 percent alcoholic content by volume.

As will be seen from Table 1, the highest specific gravity was found in the Russet and crab-apple ciders, the lowest in the Mcintosh and Wealthy ciders.

Degrees Brix

The Balling or Brix test indicates roughly the percentage of sugar in the juice, or, more exactly, the concentration of a sucrose solution of the same density as the juice being tested.

The determination was made with a hydrometer of the same type as that used for the specific gravity determination, the difference being that the Brix hydrometer has a scale calibrated in degrees from 0° to 30° or 30° to 60°, depending on the sugar concentration of the liquid to be measured. The actual sugar content is usually 1.5 to 2 percent less than the degrees Brix as this reading is influenced by other soluble solid material in the juice such as minerals, acids, pectin, proteins, etc. However, the determination is very simple and rapid and is one that any cider manufacturer will find helpful. The Russet and crab-apple ciders had the highest Brix reading of all the varieties tested.

The Brix reading may also be used to estimate the percentage of alcohol formed during fermentation. A decrease of one degree on the Brix scale indicates that approximately one half of one percent by weight (0.5%) of alcohol has been formed. For example, if the Brix reading was 12° at the start of the fermentation and if at the end of a week the reading had dropped to 6°, the alcohol content of the cider would be roughly 3 percent.

pH Determination

Measurement of pH was made with a quinhydrone electrode during the 1934 season and by the colorimetric method during the 1933 season. This determination is not one that the average cider maker will use, but the pH value is an important factor to be considered in blending ciders. The reason for this is that two ciders might have the same total acid content but because of other constituents in the juice, the "active" acidity or pH might be different. It is the "active" acidity which determines the relative sourness or acid taste of a product. A low pH value indicates a high degree of "active" acidity and vice versa

The results in Table 1 indicate that the pH varies somewhat from season to season and that there is also considerable difference between varieties. Of the ciders made during the 1933 season Mcintosh had the lowest pH and Ben Davis and King the highest. Cider from the two latter varieties also had the highest pH in 1934, while Russet and Wealthy had the lowest.

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Viscosity

The ratio of the rate of flow of cider to the rate of flow of water is a measure of viscosity. The determination must be made at a given temperature in order to have the results comparative. In this study, the time required for cider to pass between two marks on a pipette, divided by the time for the same volume of water to pass between the marks — is the value given as the viscosity. The higher the viscosity, the more "body" the juice will have. The body can be determined approximately by the "feel" of the cider in the mouth, but the method described above gives a more definite basis of comparison.

Viscosity will vary with the quality of the fruit. A hard, ripe fruit usually yields a cider with a low viscosity, while cider made from fruit of the same picking after storage of several months will have a very high viscosity. As the cells break down during storage, the pectin, one of the constituents causing a high viscosity, is more readily extracted with the fruit juice and results in a cider of high viscosity. Because freezing also tends to break the cell walls, cider made from apples which were frozen and subsequently thawed is very oily in consistency and has a high viscosity.

Pectin

The alcohol precipitate method as recommended by the A.O.A.C. (1) was used to determine the pectin content of the ciders. As has been mentioned in the previous section, it is the pectin which is the factor responsible for the "body" of a cider and the pectin content of the apple juice depends to a large extent upon the condition of the fruit at the time of pressing. Although apples are rich in pectin, the amount found in cider is low because the juice is cold pressed and pectin is only sparingly soluble in cold. fruit juices. The lowest pectin content in the ciders examined was 0.08 percent in the Northern Spy and Ben Davis ciders made in 1933; the highest was in the Russet cider made in 1934.

Tannin and Coloring Matter

To determine the exact amount of tannin in a fruit juice would require a very involved procedure. Hence, the method commonly used for the determination of tannin is by titration with a standard potassium permanganate solution using indigo carmine solution as an indicator. Because the potassium permanganate reacts with the coloring matter in the ciders as well as with the tannin, the value obtained is designated as "tannin and coloring matter". The method is given in detail by the A.O.A.C. (1).

Tannin is an important constituent of apple cider in that it contributes the astringent taste which gives so much character to a good cider. Crab-apple cider had the highest tannin content, 0.25 percent, of any of the varieties tested, as might be expected from the astringent taste of the crab-apple. The other ciders had less than one-third the tannin content of the crab-apple, the maximum being 0.08 percent in the Northern Spy, Mcintosh and Baldwin.

Total Acid

This determination was made by diluting 10 cc. of the cider with 100 c.c of distilled water, bringing the solution to a boil, cooling and titrating with 0.1 normal sodium hydroxide solution, using phenolphthalein as an indicator.

Crab-apple cider was found to have the highest total acid content, 0.75 per-cent. Russet was next with a content of 0.61 percent in 1933 and 0.67 percent in 1934. Acidity was calculated as malic acid.

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Ash

From the standpoint of taste and flavor, the ash content of a cider is of little significance. The chief value of an ash analysis is as an indication of the mineral content of the product analyzed.

The determination was made by evaporating 25 grams of cider down to dryness in an electric oven and then burning it to an ash in a muffle furnace at a temperature of 700°-800° C. (1292°— 1472° F.). By weighing the empty container before the cider is put into it and the same container with the ash in it, the percentage of ash can be calculated.

The ash content of the ciders compared favorably with that found in the whole apple. Sherman (23) gives 0.176 as the ash content of apples and in this investigation the ash content varied from 0.12 to 0.38 percent, crab-apple cider having the highest value.

Discussion

Most of the ciders varied in composition from one season to the next. There are so many factors which might be the cause of this variation that it is not feasible to discuss all of them here. Shaw (22) and Caldwell (3, 4, 5, 6,) have shown the effect of climatic and other conditions on the composition of apples and apple juices.

It is interesting to note the composition of the Russet cider, as it was found to be the best for drinking purposes. This cider was higher in sugar content than any of the other ciders tested, with the exception of the crab-apple cider, during both the 1933 and 1934 seasons, and also had the highest total acid content and a fairly high tannin content to give the right "tang" to the juice. The Wealthy cider, on the other hand, had a fairly high acid content, but was low in sugar and tannin. From the standpoint of palatability, this cider was the least desirable of any made in this study.

BLENDING

It is not possible to give any rule for blending ciders that will prove infallible. The most important factors to be considered are the degrees Brix, the tannin content, the pH, and the total acidity.

According to Charley (9), English cider apples are put into three classifications as follows:

1. Sharp juices with a malic acid content greater than 0.45 percent.

2. Sweet juices with a malic acid content less than 0.45 percent, and with a tannin content less than 0.2 percent.

3. Bittersweet juices with a malic acid content less than 0.45 percent, and with a tannin content greater than 0.2 percent.

This classification does not take into account the sugar content of the apples since English cider apples are used chiefly for making a fermented beverage. However, the sugar content of the cider apples is given as 12.5 percent, so on the basis of the grouping shown above, most of the ciders studied in this investigation would be classed as sweet juices.

Since none of the common dessert apples have a high tannin content, and since the so-called bittersweet cider apple is not grown to any extent in this country, the crab-apple would probably have to be used in blending to supply astringency as it has a tannin content of 0.25 percent. Caldwell (5) has shown that French cider varieties are adaptable to conditions in this country and are desirable for blending with American dessert varieties.

[Begin Page: Page 7]

For the benefit of those who might wish to blend ciders with more accuracy than is possible by taste or flavor, the method of Pearson's Square is given.

15.5

9.8

2.2

(Parts of the 15.5 per cent
cider to add)

3.5

(Parts of the 9 . 8 pei cent
cider to add)

Figure 1. Pearson's Square

The procedure in using the square is best illustrated with an example If a cider containing 12 percent sugar is desired as the finished product, the figure 12 is put in the center of the square, as illustrated in Figure 1. The two ciders available are, say, a 15.5 percent cider and a 9.8 percent cider. Then the figure 15.5 is put in the upper left-hand corner and the figure 9.8 in the lower left-hand corner. The results obtained by substracting the figures in the corners from the center figure (always subtracting the less from the greater) are placed diagonally opposite from the original figure on the right-hand side. In the example given, 12 would be subtracted from 15.5 giving 3.5 as the result, and 9.8 would be subtracted from 12 giving a result of 2.2. So, to get a cider with a sugar content of 12.0 percent, 2.2 parts of the 15.5 percent cider should be mixed with 3.5 parts of the 9.8 percent cider. "Parts" may refer to quarts, gallons, or barrels of cider depending on the quantity at hand, or the method of measuring available. It would not be possible to use the method for calculating the amount of dry sugar to add without making other allowances. Pearson's Square may also be used in the manner given above for adjusting the acid or tannin content of ciders by blending. It is also a convenient tool for adjusting the acid content of vinegar.

PRESSING

According to Chenoweth (11) the yield of cider depends principally upon four factors:

1. The variety of apple.

2. The condition of the fruit.

3. The type of equipment.

4. The method of manipulation.

Yields of cider obtained from several varieties of apples pressed at different seasons of the year are shown in Table 2. Pressings were all made on a power press so that variations in the yield of cider caused by the type of equipment and method of manipulation were reduced to a minimum

The highest yield of cider, 4.4 gallons per bushel, was obtained from Baldwin apples pressed in October. The lowest yield, 2.4 gallons per bushel, was obtained from Russet apples pressed in April.

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Table 2. Effect of Variety and Date of Pressing on the Yield of Cider

It should be noted, however, that the next year Russet apples gave a yield of 3.9 gallons to the bushel when pressed in March, the highest yield of any variety pressed at that time of year. Ben Davis apples gave the lowest average yield, but the pressings were all made late in the season so that the figures do not give a true indication of the yield which might be obtained in the fall of the year.

Baldwin, Russet, Northern Spy, Rhode Island Greening, and Mcintosh all retained their cider-making qualities well into the February following the autumn they were picked, when they were held under good storage conditions. Aside from the increased yield obtained when sound, ripe fruit is used, the aroma and quality of the cider is also a factor to be considered.

Type of Equipment

Manufacturers of cider-making equipment have various types of mills from small hand mills with a capacity of 60 to 90 gallons a day to large power mills capable of producing more than 6,000 gallons of cider in a 10-hour day.

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Although formerly the less efficient hoop or barrel type of press was used in the hand mills, now the rack and cloth press is standard equipment for practically all the mills.

Method of Manipulation

Increased yields of cider may be obtained by proper care in grating the fruit, building the cheese and applying the pressure. The grater type of pulper is better than the crusher for grinding the fruit. Grinders as supplied by the manufacturers are usually efficient.

The layers of the cheese should be of uniform thickness equal to the depth of cheese frame. The pulp must be packed into all corners and should be of the same density throughout to insure uniform pressure. The pressure should be applied slowly and should be maintained for at least 10 minutes at the maximum pressure.

A deeper-colored cider and a higher yield can also be obtained if the ground apple pulp is allowed to stand for several hours before it is pressed.

Other Factors to be Considered in Pressing

1. Washing. It is recommended that the apples be dipped for 5 minutes in a diluted acid wash followed by thorough rinsing in running water to remove the bulk of any spray residue and to decrease the amount of dirt and number of spoilage organisms on the fruit. Even washing the apples in water, while not as good as the acid wash, greatly improves the keeping qualities of the cider.

2. Iron is dissolved by prolonged contact with either the ground pulp or the cider, and under certain conditions is apt to cause blackening of the cider. Hence, all contact with iron should be reduced to a minimum.

3. Care of the cloths. Satisfactory press cloths may be obtained from a cider mill supply house. They should be thoroughly washed, boiled, and rinsed before using and, if possible, after each day's pressing. When used dry the cloths are apt to impart an undesirable flavor to the cider, so that it is advisable to soak the cloths overnight in clean cold water before a pressing is to be made with them.

4. Containers for the cider should be absolutely clean and free from any odors.

5. Unless cider is to be clarified with Pectinol (discussed later), it should be chilled as soon after pressing as possible. A temperature of 32° F. or below is the best storage temperature, but cider has been held for as long as a month at 40° F. without appreciable fermentation.

Action of Apple Juice and Cider on Metals

The acids in cider have a corrosive action on certain metals. The extent of this action on some of the more common metals, is given in the following list prepared by Charley (9) :

Iron — Strong action with formation of green and brown tannates.

Tin — Slight action.

Copper — Badly attacked.

Aluminium — Slight action.

Zinc — Badly attacked.

Lead — Badly attacked.

Stainless steels — No action.

[Begin Page: Page 10]

Proper selection of the metal equipment to be used in cider manufacture would not only be more economical over a period of years, but would also eliminate any danger of health hazards such as might occur if lead were exposed to the cider for any length of time. Off flavors and colors would also be developed if an excess of metals such as zinc, copper, and iron were dissolved in the cider.

A Small-Scale Apple-Juice Extractor

A machine for extracting apple juice on a small scale has been developed by Dr. Jenkins of Keene, New Hampshire. The purpose of the extractor is to enable soda-fountain operators and solt-drink dispensers to extract juice from fresh apples directly mto a glass. The machine consists essentially of (1) a motor-driven disk covered with teeth which grinds the apple to a pulp, (2) a filter chamber containing a permanent non-clogging, metallic filter screen. The finely pulped apple is thrown by centrifugal force into the filter chamber and the juice is filtered through the metallic screen and led through a small pipe into the container. The solids automatically discharge through a separate pomace spout. (See Fig. 3.)

The juice extracted by this machine should not be classed as cider but rather as apple juice since it does not have the flavor or color of cider However, it is very palatable and should prove popular as a soda-fountain drink. Apple juice made by this extractor and sold in the same way as fresh orange juice should lead to an increased consumption of apples. Moreover, the fresh apple juice made by this machine was found to be as rich in vitamin C as the apple from which it was made, if consumed immediately, whereas pasteurized cider or cider held for a few days in storage was deficient in vitamin C.

Treatment of Containers

Cider can be spoiled very easily by storage for a few hours in a foul barrel. Several methods are available for the cleaning and sweetening of barrels.

Where live steam is available, thorough washing with hot water followed by treatment with live steam and a cold-water rinse is good procedure. Of course, use of hot water and steam removes paraffin from paraffin-lined barrels, and after such treatment it would be necessary to reline the container.

A moldy barrel should have the head removed and all the mold scraped off as well as the layer of wood underneath. Hot 5 percent soda ash 'sodium carbonate) solution should then be scrubbed around the inside of the barrel after which it should be steamed or rinsed with several changes of hot water. Used barrels that appear to be sound should also be given the treatment with the hot soda ash solution.

Another method of sterilizing and deodorizing moldy or sour containers is to fill them with a solution of sodium hypochlorite (available at any drug store), or chloride of lime containing 500 parts per million of available chlorine, repeating the treatment until the container smells sweet. Thorough and repeated rinsing is necessary after this treatment.

Burning of sulphur in empty barrels before they are stored helps to keep them in good condition from one season to the next. Sulphur strips can be obtained from a cider makers' supply house.

Emphasis has been placed on the cleaning of barrels because they are so difficult to clean. Whenever possible it is better to keep cider in glass containers which can be kept clean and sterile with little trouble.

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CLARIFICATION

The object of clarification of cider is to make the juice more easily filterable. Substances in the cider tend to form a slimy film on the filtering surface and slow down the speed of filtration. Hence, the clarification methods have as their object the breaking up of the viscous suspension so that the filter-clogging material is precipitated to the bottom of the container. The three best methods are given below.

Flash Heating Method

Carpenter and Walsh (8) suggest coagulating the suspended colloidal material by heating the cider to 180° F. for 20 seconds and cooling immediately. This method is satisfactory but requires flash pasteurization equipment.

Gelatin-Tannin Method

Numerous precipitating agents such as tannin and gelatin, white of egg, isinglass and blood, have been suggested as a means of clarifying cider. Of these the tannin-and-gelatin treatment is the most satisfactory for cider.

Addition of gelatin and tannin to the cider causes a fluffy precipitate to form which gradually settles to the bottom leaving the upper part of the liquid clear. Apparently the precipitate is caused by a combination of the pectin, gelatin and tannin. Apple cider ordinarily contains enough tannin to react with the gelatin, but to take care of the loss by precipitation additional tannin is added so that the taste will not be changed.

Since ciders differ in composition, it is necessary to test any given lot of cider to determine the amount of gelatin and tannin to add. For this purpose the following test solutions are made up. The description of the process is taken from Walsh (26). (See Figs. 4. and 5.)

Solution 1. Dissolve \i ounce of tannin in 5.95 fluid ounces of 95 per cent alcohol. Then add 23.8 fluid ounces of water and mix thoroughly.

Solution 2. Dissolve % ounce of gelatin in 23.8 fluid ounces of water and add 5.95 fluid ounces of 95 per cent alcohol. Heat a portion of the water and add the powdered gelatin slowly, stirring continuously. Then add the rest of the water and dissolve the gelatin by heating in a pan of hot water or double boiler and stirring. Add the alcohol and mix well.

These solutions should be kept in separate stoppered glass containers and may be used as needed, the alcohol acting as a preservative in both cases. In some cases the gelatin solution will jell when cold, but it can be liquefied when needed by putting the container in hot water.

Four white glass quart bottles should then be filled up to the neck with cider and numbered 1, 2, 3, and 4. Then add to each bottle the following amounts of solution 1 (tannin) and solution 2 (gelatin) :

	Bottle No. 1	Bottle No. 2	Bottle No. 3	Bottle No. 4
Sol. 1 cubic centimeters....	10	10	10	10
Sol. 2 cubic centimeters....	5	10	15	20

(Note: A measuring cylinder or pipette, graduated in cubic centimeters may be purchased from a drug store or from a chemical supply or cider supply house. The test solutions could also be made up at a drug store.)

Measure and add the amounts of solution shown to each bottle, adding the tannin solution first in all cases and shaking well after the addition of each solution. Let the bottles stand 10 minutes and the bottle which shows the most clear juice is the one to which the proper proportions of tannin and gelatin were added.

[Begin Page: Page 12]

The quantity of gelatin and tannin to use for 100-gallon batches of cider is then found by referring to Table **. For smaller amounts of cider, proportionate amounts of tannin and gelatin are used. For example, if bottle No. 3 showed the greatest amount of clear juice at the end of the 10 minute period, 1.25 ounces of tannin and 4.2 ounces of gelatin should be added to 100 gallons of cider; for 50 gallons, one-half these amounts, or 0.63 ounce of tannin and 2.1 ounces of gelatin should be added to the cider.

Table ** Amounts of Gelatin and Tannin to be Used for 100 Gallons of Cider Based on Different Tests

	Bottle No. 1	Bottle No. 2	Bottle No. 3	Bottle No. 4
Tannin, ounces	1.25	1.25	1.25	1.25
Gelatin, ounces	1.50	3.00	4.20	6.00

When the correct amounts of gelatin and tannin have been determined, the proper amount of tannin is dissolved in about 2 quarts of hot water (for a 100-gallon batch) and is then poured into the container of juice in a thin stream, stirring constantly. Ten minutes after the tannin has been put in the juice, the gelatin solution prepared by dissolving powdered gelatin in hot water as described for the test solution is added in like manner, with constant stirring. If the correct amounts of gelatin and tannin have been used, the juice starts to clear at once, and if left undisturbed, will be ready for filtration after standing 16 to 24 hours.

Disadvantages of the gelatin and tannin method are: (1) the cider is bleached by the treatment; (2) the precipitate is not as compact as with the Pectinol treatment; (3) the procedure is more complicated than the Pectinol method.

Advantages of the gelatin and tannin treatment are: (1) no heating is required during the treatment; (2) there is not as much loss of viscosity, unless the cider is subsequently filtered through a very fine filter. (3) The precipitation can be accomplished at a lower temperature than is possible with the Pectinol treatment.

Pectinol Method

The simplest method of clarifying cider is with Pectinol, an enzyme preparation made from certain molds with sugar as the vehicle. Pectinol breaks the soluble pectin in the cider down into simpler substances some of which are insoluble and settle out. As the insoluble material precipitates out it carries down other turbid colloidal matter which has lost the protective influence of the pectin.

The length of time required for the enzyme to clarify the cider depends on the temperature of the cider and the concentration of the enzyme. The following table taken from Hickok and Marshall (17), shows the quantities of Pectinol which are required to clarify cider under varying conditions of time and temperature. These figures are approximate since ciders vary in their composition.

Ounces of Pectinol Required to Clarify 100 Gallons of Cider under Certain Specified Conditions of time and Temperature

Temperature Time allowed for action of Pectinol

(Fahr.) 5 hours 15 hours 30 hours 48 hours

40° 30 15 10

60° 54 18 9 6

100° 14 5

[Begin Page: Page 13]

The manufacturers recommend adding the Pectinol as soon after pressing as possible, using one pound for every 100 gallons of juice. The Pectinol should be sifted directly into the juice with gentle stirring and the juice permitted to stand overnight at room temperature (70° F.). There is no appreciable fermen-tation when the cider is held at room temperature for the time recommended, provided the juice is filtered and processed immediately after the clarification treatment.

Pectinol-treated cider must be heated at 140° F. for 10 minutes after clarification is complete to stop the enzyme action, as otherwise the pectin remaining in the juice is gradually broken down during storage and forms a deposit in the container. Pasteurization of the cider at any temperature above 140° F. will, of course, also stop the enzyme action.

Centrifuge Method

High speed centrifuges which are now on the market have been used to clarify cider, but we have never seen cider treated by this method and cannot say how satisfactory it is. Tests conducted on a small scale with cream separator and basket type centrifuges were unsatisfactory.

However, according to Marston (19) the super centrifuge is used extensively in the manufacture of sparkling fermented cider in England. Charley (9, 10) reports that such ciders are more fruity and mellow than filtered ciders. Fermentation can be practically stopped by centrifuging. In the early stages, this treatment caused a small reduction in the fermentation rate, but when fermentation had gone far enough for the specific gravity to be down to about 1.025 it was stopped almost completely. The drawback to the use of this method is the slight haze permeating the cider. To get a brilliantly clear cider it is usually necessary to filter after centrifuging.

Effect of Clarification by Gelatin-Tannin and Pectinol on the Composition of Ciders

Samples of cider made from eight varieties of apples were clarified by the Pectinol and the gelatin-tannin methods and filtered. The filtered ciders as well as an untreated portion from each lot were then tested for ash, pectin, total acid, tannin and coloring matter, viscosity, pH, specific gravity, and degrees Brix. Results of this test are shown in Table 3.

The viscosity was much lower in the Pectinol-treated cider than in the gelatin-tannin and the untreated ciders. This is in agreement with the organoleptic test, since the gelatin-tannin treated cider has much more "body" than the Pectinol-clarified product.

While the pectin content is apparently decreased to the same extent by both methods of clarification, it must be remembered that the alcohol precipitate method was used in the determination. The alcohol would precipitate some of the decomposition products of the pectin which would show in the table as pectin. However, the decomposition products would be of such a nature that they would not affect viscosity as much as the pectin found in the untreated juice or in the gelatin-tannin treated product.

The pH of the various juices was affected but slightly by the clarification treatment.

The average of the total acidity values would indicate that the Pectinol treatment slightly increases and the gelatin-tannin treatment decreases the total acid content of cider. The increase in acidity in the Pectinol-treated

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juice is probably due to some of the decomposition products of pectin, such as pectic acid, which are formed by the action of Pectinol, but is so slight as to be of doubtful significance. Some of the slight decrease in the gelatin-tannin treated juice might be ascribed to the loss of tannin or tannic acid.

The clarified ciders had a lower specific gravity and Brix value than the untreated ciders, Pectinol causing more of a decrease in both instances than gelatin-tannin. Loss of pectin would be one factor responsible for the decrease in specific gravity and Brix value, but more important would be the small loss in sugar content through fermentation during the required settling period.

The average content of tannin and coloring matter was lowered more than a half by treatment with gelatin-tannin, but only a little less than a third by the Pectinol treatment. Since the gelatin-tannin treated cider is much lighter in color than the Pectinol treated, it is not surprising to find such a variation in the amount of tannin and coloring matter as determined chemically.

Ciders clarified with Pectinol had a higher ash content than did the gelatin-tannin treated juices.

FILTRATION

Much of the cider produced is not filtered, but experience shows that a clear cider is much preferred by the consumer. Small cider manufacturers often press the cider and store it in tanks overnight to settle. By siphoning the cider from the upper levels of the tanks, a fairly clear product can be obtained. Too long storage must be avoided or fermentation will occur and defeat the purpose of the tank clarification. In this state the semi-clarified juice may be filtered through a cloth filter or even through a filter press though a filter-aid is necessary if the latter is used. This process is best carried on in cool weather.

The muddy residue can be used for vinegar stock.

Muslin Tube Filter

A simple homemade filter has been developed at Michigan State College by Hickok and Marshall (17.) (See Fig. 6.) Their description of the muslin tube fruit juice filter and its operation follows:

The set-up for performing the filtering operation consists of three principal parts:

1. A mixing and supply tank.

2. Elevation of the supply tank to provide a pressure head on filter unit.

3. The collecting or filtering unit.

The collecting unit is the novel and most essential part of the outfit. It is a long, slender, cloth tube, closed at one end, with the other end connected to a rubber hose extending from the supply tank. This tube is laid in a horizontal position in a trough. When the mixture of cider and filter aid is fed into the closed tube, the pressure swells the tube to its full dimensions. The cider is forced out rather uniformly over the entire surface of the tube and the filter aid forms a cake of uniform thickness on the inside. The trough is given a slight slope so that the clear juice runs out of one end into a receptacle.

The cloth tube is made of unbleached muslin, sewed to give a diameter of approximately three inches. A tube of a larger diameter will not support the filter cake satisfactorily and subsequent cracking and breaking of the cake may cause cloudiness in the filtered cider. A tube one yard long is most convenient. It cleans easily, coats evenly in a short time, and is the usual cloth width sold. It is recommended that both ends of the tube be left open to facilitate cleaning. In use, the dead end should be folded back, carefully gathered and tied, preferably with a single miller's knot.

[Begin Page: Page 17]

Figure 2. Hydraulic Press in the Food Manufacturing Laboratory

Small size with a capacity of 2 ' 2 bushels to a pressing.

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Figure 3. Vegetable and Fruit (non citrous) Juice Extractor.

Courtesy of Brooks L. Jarrett & Co., Pittsburgh, Pa.

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Figure 4. Gelatin-Tannin Treated Cider.

Bottle No. 1 contains untreated cider, No. 6 gelatin-tannin treated cider which has settled for 24 hours. Bottles No. 2 through 5 contain cider treated with gelatin-tannin test solutions in the following amounts per quart: No. 2, 5 cc. gelatin solution and 10 cc. tannin solution; No. 3, lOcc. gelatin solution and 10 cc. tannin solution; No. 4, 15 cc. gelatin solution and 10 cc. tannin solution; No. 5, 20 cc. gelatin solution and 10 cc. tannin solution. Note that the best break and precipitation is in bottles No. 3 and 4, and these bottles therefore would indicate the amounts of gelation and tannin to add to the main batch.

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Figure 5. Comparison of Pectinol Treated and Gelatin-Tannin Treated Cider.

On the left is untreated cider; in the middle, Pectinol treated cider; and on the right, gelatin-tannin treated cider. Note how much more compact is the sediment in the Pectinol treated cider

The Brix hydrometer in the cylinder containing gelatin-tannin treated cider shows how clear the treatment renders the cider.

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3' DIAM. MUSLIN TUBE

ENDS TIED

COPPER FLY SCREEN

FILTERED CIDER

Figure 6. The Essential Elements of the Homemade Filter.

The tube should be supported in the trough by a copper screen. This allows free flow from the trough and makes the entire area of the tube effective in filtering. The copper screen is preferable to iron wire screen because it is less affected by fruit juices.

It is necessary to have a small pressure head on the filter. This can be satisfactorily secured by elevating the supply tank. The greater the elevation the more rapid the flow will be from the filter. The net head should not exceed 15 feet (with muslin tube) and eight feet results in very satisfactory operation. Less head may be used where small quantities are to be filtered, but will necessitate more frequent cleaning of the collector. Tests with cider subjected to enzyme clarification gave the following rates of filtration:

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Net Head (Ft.)	Gallons Per Minute*
4	.65
6	1.05
8	1.43
10	1.80
12	2.50
14	3.34

These were for short runs of about five gallons and rate would be lower for longer runs with thicker filter cakes.

The necessary head may be obtained in different ways : 1. The supply tank may be put on the floor of the upper story of a building and the filter below; 2. a platform may be constructed to support the supply tank at the desired height; 3. or the tank may be raised and lowered by a block and tackle or chain fall. Where a large amount of filtering is to be done, it may be more economical to use a pumpf in connection with a storage tank. A pump may be directly connected to the filter, in which case it should be provided with a pressure control. For farm purposes, the cider can be carried or hand-pumped to the height of the supply tank.

The supply and mixing tank should be of wood. A barrel, with the head removed for filling and mixing, may be used where small quantities of cider are handled. Delivery to the filter should be through a rubber garden hose, preferably five-eights inches in diameter. The tank may be bored and fitted with a brass spigot, or the cider may be siphoned from the barrel. It is convenient to have a cut-off in the delivery hose. A convenient arrangement is a J4-inch gate valve at the lower end, fitted with two nipples. One %-inch nipple with bushing will fit into the inside of the hose and the filter tube can be attached to the other. This arrangement is convenient for shutting off the flow to clean the unit and for starting the siphon. The muslin tube should be wrapped tightly around the nipple and tied with a miller's knot.

tWhere a pump is used, it should be of bronze and with a minimum of metal in contact with the cider.

The muslin tube filter uses a "'filter aid", which is absolutely essential to its successful operation. The "filter aid" used by this laboratory is known as Hyflo Supercel and is manufactured by Johns-Manville Company, the nearest local office being in Boston, Massachusetts. This product is a diatomaceous earth which has been heated to a high temperature, a process known as calcin- ing, to remove traces of organic matter which might cause off-flavors in the filtered product. It is good practice to test a filter aid to see that it does not impart an earthy flavor to the cider. This can be done by stirring a table-spoonful of the product in a glass of cider, waiting for it to settle, and tasting the cider.

As noted under the description of the muslin tube filter, the filter aid is carried down from the supply tank with the cider and forms a cake on the inside of the cloth tube where it acts as a filtering medium by collecting the sediment from the clarified cider. In general one pound of Hyflo Supercel is sufficient for 30 gallons of cider, although as much as one pound for 20 gallons, or as little as one pound for 40 gallons may be necessary, depending upon the condition and extent of clarification of the cider. The filter aid must be mixed thoroughly with the cider before the filter is started and must bestirred during the filtration as otherwise it will settle out.

About two gallons of cider must be run through and returned to the supply tank before any is collected for use, because it takes about that quantity of cider to build up the filter cake. According to the inventors of the muslin tube filter the tube must be cleaned after 20 to 40 gallons have run through where a

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pressure head of six to eight feet is used, but with more pressure head the filter may be run longer without cleaning. To clean the filter, the tube is untied and the filter aid and sediment shaken out or washed out under running water, after which the tube may be returned to the filter

Filter Presses and Plate Filters

For large installations filter presses are preferred for the production of clear ciders. A list of manufacturers of equipment is given in the appendix. In general, each manufacturer can best give directions for use of his particular type of press and can define its limitations.

Freshly pressed apple cider cannot be economically filtered in a filter press without the use of a filter aid such as asbestos or diatomaceous earth. The colloidal matter present clogs the filters and makes them useless. However, after treatment with a filter aid or with Pectinol or gelatin-tannin, the filter presses are very satisfactory and give a brilliantly clear product. Accessory equipment such as storage tanks, pumps, and sanitary metal tubing is required when filter presses are used.

The so-called germ-proof filters used for sterilizing cider can be utilized only after the cider has been already clarified and pre-filtered.

PERSERVATION OF CIDER

Preservation methods have as their object the elimination or control of undesirable microorganisms. In sweet cider, the esential organisms which must be controlled are yeasts and molds: yeasts, because they ferment the sugars in the cider to alcohol; molds, because they present an unattractive appearance in the cider and also slowly use up the sugar and impart off-flavors to the product. Molds require much more air to carry on their activities than do yeasts, but yeasts are killed more easily by heat treatment and grow less readily at low temperatures than do molds. These points are mentioned because they are important considerations in the preservation of cider.

Preservation methods may be put into four general groups:

1. Germ-proof filtration.

2. Freezing.

3. Pasteurization.

4. Treatment with preservatives

Germ-proof Filtration

In this method, cider after a pre-filtration treatment is run through a filter with openings so small that while the cider can pass through the filter, yeasts and molds are prevented from doing so. After going through the filter the cider is run into sterile bottles; capped with sterile caps, and stored for two weeks or so to be sure fermentation will not take place. It is then ready for distribution. The advantage of the germ-proof filter method is that no heat is required, thus preventing any "cooked" flavor in the cider.

Disadvantages of the germ-proof filter are: (1) Care is required to assure sterility in the bottled juice. (2) The equipment is too expensive for the small manufacturer. (3) Such fine filtration removes much of the color and "body" from the cider.

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Freezing

If cider is frozen solid in closed containers and held at a temperature of 10° F. or lower, it may be held from one season to the next without any appreciable change in its flavor.

The container in which the cider is to be frozen, whether it be a barrel, glass, or cardboard container, should not be filled more than three-quarters to four-fifths full, since the cider expands during the freezing process. The container should be covered to prevent the juice from acquiring foreign flavors during freezing.

Freezing does not destroy the yeasts and molds so that after the cider is thawed out it is almost as perishable as freshly pressed cider.

Sufficient time should be allowed for the frozen cider to thaw out after it is removed from storage. If the containers are not too large, they can be set in water and shaken occasionally. Large containers require as long as 24 hours to thaw out.

Cider may be kept fresh for several weeks by simply storing at temperatures of 32° to 36° F. Fermentation ultimately sets in, however, and cold-storage temperatures cannot be relied on to preserve the cider indefinitely. Cider will keep much longer in cold storage if it is chilled immediately after pressing.

Pasteurization

This term is applied to any method of heat treatment in which the food product is heated to a temperature less than the boiling point of water (212° F.).

It must be understood that pasteurization treatment does not always sterilize the product treated. In non-acid products such as milk, the object of pasteurization is to destroy certain disease-producing microorganisms without necessarily eliminating spoilage organisms. In an acid product such as cider or wine, the treatment is employed to destroy or inactivate spoilage organisms such as yeasts and molds, since disease-producing microorganisms are not ordinarily found in acid products.

The temperature employed depends upon the length of time that the product is heated. Heating the product to a high temperature for a short time is called "flash" pasteurization; heating at a low temperature for a longer period, 20 or 30 minutes, is called the "holding" method of pasteurization.

Flash Pasteurization

There is special flash pasteurization equipment made for the dairy industry which can be used to process cider. However, a small coil pasteurizer made from aluminum tubing has been used successfully to flash pasteurize small lots of cider here. The cider is fed by gravity through one coil which is immersed in a tank of water heated to the desired temperature. The j uice then flows through a second coil which is surrounded by cold water. A thermometer inserted through an opening in a bronze T-joint joining the two coils indicates the temperature of the cider after it passes through the heated coil. The flow of the cider should be regulated so that the cider is heated to 185° F. before it reaches the cooling coil. The latter should cool the juice down to 140° F. Bottles and caps should be treated to kill any yeasts or molds on them. Boiling the bottles and caps for a minute is a good method of eliminating the spoilage organisms. The bottles should be filled as full as possible when bottled from a flash pasteurizer.

Holding Method of Pasteurization

In this method the clean bottles are filled with cider heated to 130° to 140° F.,

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leaving about one and a half inches to allow for further expansion during the heating process. The caps are then put on all but one bottle. The capped bottles are put on their sides in the pasteurizing tank and covered with water. The uncapped bottle should be kept standing upright with the top one or two inches above the level of the water A thermometer is inserted in this open bottle and heat is applied to the tank. When the thermometer in the open bottle registers 165° F., the temperature is held at this point for 20 minutes. The bottles should then be removed from the vat and slowly cooled.

The size of the pasteurizing tank depends on the amount of cider to be handled. The bottles should not rest on the bottom of the tank but should lie on a platform of wooden slats or screening about one-half inch from the bottom of the tank.

A deposit forms in the bottom of bottles of pasteurized, unclarified cider because of the precipitation of heat-coagulable substances. Unclarified cider also acquires a much more pronounced "cooked" flavor when it is pasteurized.

It is a good practice to aerate pasteurized cider by pouring it from one glass to another just before it is drunk.

Treatment with Preservatives

Sodium benzoate is the chemical compound most commonly used for the preservation of cider. Fellers (14) gives the following practical suggestions for the use of sodium benzoate in fruit juices. :

1. Use only sodium benzoate of high quality that is fiee from objectionable odor and taste. "U.S. P." grade is better than "Technical" grade. So little is used to preserve beverages, that it is poor economy to use cheap, objectionable preservatives which may ruin the beverage.

2. Do not use salicylic, formic or boric acids. All are prohibited by law in this country.

3. For strongly acid fruit juices which are made from sound stock and are reasonably free from turbidity or sediment, from 0.05 to .075 per cent by weight (3.5-5.5 oz. per bbl.) of sodium benzoate will effectively check alcoholic fermentation. For less sour juices as well as those made from questionable stock, or which are not freshly pressed, from .075 to 0.1 per cent (5.5-7.0 oz. per bbl.) is necessary. After fermentation has started, or in juices of exceptionally heavy body or of low acidity, even

more may be necessary.

4. It is very important to add the benzoate to the freshly pressed juice. Yeasts proliferate very rapidly in cider and fruit juices, and delays of even a few hours may seriously impair the efficacy of the preservative.

5. Before filling, clean all receptacles such as bottles, carboys and barrels very thoroughly with steam, hot water, or a 0.02 per cent sodium hypochlorite solution. The latter will not injure the taste of the beverage.

6. A satisfactory way to add the preservative is as follows: Dissolve 1 lb. of sodium benzoate in sufficient water or fruit juice to make exactly 1 gallon. Solution is hastened by heat and stirring. One pint of this solution contains 2 oz. of sodium benzoate. Add as many pints as necessary. Do not add the benzoate in powder form to cider or grape juice through the bung. The preservative is not readily soluble in cold juices and merely settles to the bottom of the barrel. Before the benzoate goes into solution the juice may ferment.

7. Do not expect sodium benzoate to prevent spoilage in non-acid beverages or foods. It is suitable only for acid fruit juices and foods.

8. Benzoate gives the best results, and smaller quantities may be used, if the juice is kept in cool storage.

9. Clarified juices are more easily preserved by benzoate than cloudy juices with sediment.

10. Dirty and partially decayed raw stock produces a juice containing

a large number of microorganisms and suspended matter. Such a juice

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is unsuitable for preservation with sodium benzoate.

11. Benzoated cider or grape juice will not make good vinegar or wine. However, any alcohol which is present in the iuice will change to acetic acid in spite of the preservative. It is therefore useless to attempt to preserve fermented beverages by the use of sodium benzoate.

12. Declare the presence of sodium benzoate and the amount added in per cent by weight, on each container offered for sale.

Experiments with sodium furacrylate and furoic acids showed them to be inferior to sodium benzoate for preserving cider.

Katadyn Treatment

In this method the preservative used is silver in very minute amounts. Equipment is very specialized and is obtainable on a rental basis only.

The general procedure is to pass cider through silver electrodes which are connected to a source of electric current. The cider makes an electrical contact between the electrodes and definite amounts of silver are deposited in the cider depending upon the strength of the current and the quantity of cider passing between the electrodes during any given period of time. Definite information regarding the operation of the Katadyn equipment is provided by the company furnishing the equipment.

Tests made here on a small scale show that the Katadyn process will successfully preserve cider, but it does impart a metallic taste to the product, which decreases during storage. Yeasts are more easily controlled by the method than are molds, so that the Katadyn treatment combined with bottling under a vacuum to inhibit mold growth, was found to be the most satisfactory procedure.

The use of this process in the treatment of cider is comparatively recent in this country, so that no definite statement can be made regarding its practicability for large-scale production.

Canning

Plain cans should be used for canning cider instead of the enameled because the latter perforate badly. The juice is merely filled into the cans, exhausted for 15 minutes at 160° F. or preferably vacuumized to remove air, sealed, and finally pasteurized for 15 minutes at 160° F. The product will keep for several months in a cool place, but should not be held over from one year to the next.

The main problem in the canning of cider is the elimination of oxygen from the juice. It is the combined action of the oxygen and acid in the cider which is believed to be responsible for the unusually corrosive action of cider on tin cans.

A procedure for the canning of cider recommended by Tucker, Marsh and Cruess (25) is as follows: Place the cider in a vacuum tank, preferably glass lined or of stainless steel, and apply a high vacuum of 28 to 29 inches about 20 minutes to remove dissolved and occluded oxygen. Then flash pasteurize the cider for 30 to 60 seconds at 185° F. and run it directly into cans, filling to within one-quarter inch of the top. Seal at once and cool immediately in cold water.

Instead of flash pasteurizing, an alternate procedure would be to fill the cider into cans after the vacuum treatment, leaving a good headspace. Then heat the filled cans in water at 150° F. for about 10 minutes, seal the cans and process at 150° F. for 30 minutes for small cans.

In general, it is more desirable to concentrate the cider by vacuum and preserve in class containers rather than to can the pure cider in tin cans. A somewhat inferior cider concentrate can also be prepared by open-kettle boiling.

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Such a product can be preserved by canning either in glass jars, bottles, or tin cans.

CARBONATED CIDER

Carbonation of cider not only produces a sparkling drink much superior to plain cider, but also aids in the preservation of the product. Carbon dioxide gas is the substance responsible for the effervescence and "bite" of carbonated drinks. This gas also exerts an inhibitory action on mold growth so that the pasteurization temperature for carbonated cider may be reduced to 150° F.

There are three general methods of carbonating cider: (1) Use of ordinary soda-water carbonators. (2) Natural carbonation by yeasts. (3) Use of solid carbon-dioxide or "dry-ice."

The use of regular soda-water carbonators can best be explained by the manufacturer of the equipment. Important considerations in the carbonation of cider are:

Carbon-dioxide gas is more soluble in cold cider than in warm; hence during carbonation the temperature should be kept at 40° F. or below.

The amount of gas dissolved at a given temperature is directly proportional to the pressure of the gas.

It is generally agreed that naturally carbonated cider is better than the artificially carbonated product. Carbon dioxide is one of the gaseous products given off during the fermentation of sugar by yeasts. If the fermentation proceeds in a closed container, much of the gas is dissolved in the cider due to the pressure created. Such would be the general process of the natural carbonation of cider. It is by this process that the best champagnes are carbonated and it is also the procedure generally used for carbonating homemade root beer. In the manufacture of champagne, the yeasts which cause the carbonation are removed after they have settled out during storage. This is called disgorging. In homemade root beer as well as in some of the sparkling ciders sold in England, the yeast is left in the bottle, the consumer having become accustomed to the sediment.

Closed Cuvee Method

The closed Cuvee method was developed so that natural carbonation of a juice could be accomplished and the resulting sediment could be removed by filtration rather than by the long settling period and disgorging process. The method was originally used for champagne, but Davis (13) has successfully applied it to the manufacture of sparkling cider. The essential steps in the process are as follows:

1. The cider is partially clarified with a high-speed centrifuge and put into the glass-lined or stainless steel fermenting vat.

2. A pure yeast culture is introduced to start the fermentation and the cider is fermented at a temperature of 70° F. or above until the pressure in the fermenting vat reaches 75 lb. per square inch. This usually requires two to three days with a formation of as little as one-half of one percent of alcohol by volume.

3. As soon as the desired pressure is reached the cider is filtered as it flows from the fermenting vat to the cooling tank. Pressure is first equalized between the two tanks and the filtration is accomplished through gas-tight equipment so that there is very little loss of carbon dioxide.

4. In the cooling tank the cider is cooled to 30° F. so that there will be better absorption of the carbon dioxide gas. It is held in the cooling tank for 48 hours.

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5. The cider is then run through a Seitz germ-proof filter into a counter pressure bottling machine where it is bottled in sterile bottles and capped.

By means of the closed Cuvee process either a sparkling sweet or a fermented cider can be produced, depending on the length of time the fermentation is allowed to proceed. The equipment used is expensive, but it is claimed that a very good product can be made by this method.

Dry Ice Method

For carbonation of small lots of cider, Walsh (26) suggests the use of "dry ice" or solid carbon dioxide. The clean bottles are filled with clarified cider cooled to 40° F. or lower. The dry ice is chipped off, accurately weighed, and immediately put into the bottle, which should be sealed as quickly as possible with the crown cap. The bottle is then wrapped loosely with a heavy cloth to prevent injury in case a defective bottle should burst, and shaken until the carbon dioxide is absorbed.

The following table, taken from Walsh, shows the volume of carbonation obtained in an 8-ounce container with different weights of dry ice. For pints and quart bottles proportionate amounts of dry ice and cider are used. A carbonation of about two volumes is recommended for cider.

Amount of Dry Ice Required for Different Volumes of Carbonation

*A balance suitable for weighing in grams can be obtained from a scientific supply house such as Central Scientific Company, Cambridge, Massachusetts; Will Corporation, Rochester, New York; Eimer and Amend, New York, N. Y.; W. M. Welch Scientific Company, Chicago, Illinois.

CONCENTRATED CIDER PRODUCTS

Boiled Cider

The simplest and oldest method of concentrating cider is by boiling in an open kettle until the juice has been reduced to approximately one-fourth to one-fifth the original volume. The resulting product is known as boiled cider and is often used in mince meat, apple butter, and for cooking purposes. The color and flavor are distinctly inferior to the vacuum prepared product. After concentration, the cider is strained through a cloth, sedimented by standing for 24 hours, and the clear liquid drawn off into clean containers. Preservation is accomplished by processing the boiled cider in boiling water for 15 minutes.

Other Cider Concentrates

Several methods have been suggested for the manufacture of cider concentrates. Gore (16) concentrated the cider by slow freezing and separation of the ice crystals with a basket centrifuge. With two or three successive freezings and centrifugings, the juice was concentrated so that one gallon was the equivalent of five gallons of the original cider. This method produced a very good product but the process is more expensive than evaporation under a vacuum.

Concentration of cider under a vacuum of 27 to 29 inches is another method of preparing a concentrate which retains color satisfactorily. However, many of the volatile flavoring materials are lost where an ordinary vacuum pan is used. Poore (21) found that practically all of the characteristic volatile flavor came over in the first 9 percent of the distillate when the cider was concentrated in a vacuum pan under a vacuum of 28 to 28.8 inches and a temperature between 96.8° and 123.8° F. When the distillate was redistilled the flavor was found in the first fourth that was recovered and when this was returned to the cider concentrate it had a good flavor.

To prevent the loss of the volatile flavoring constituents the Pfaulder Company of Rochester, New York, have designed a fruit juice concentrator with an ester impregnating unit. Experiments carried out by Carpenter and Smith (7) showed that by this method a concentrate could be made which, when properly diluted, was difficult to distinguish from the original juice.

Cider Syrup

This product differs from other cider concentrates in that part of the acidity is neutralized. Novick (20) in this laboratory, has found the following procedure for the manufacture of cider syrup very satisfactory. Sweet or mildly acid varieties are most suitable for cider syrup manufacture.

1. Clarify the juice with Pectinol and filter.

2. Neutralize the clarified cider to a pH of 5.1 with calcium carbonate or potassium carbonate. The addition of excess alkali causes a dark color and poor flavor, and should be avoided. Normally if approximately three-fourths of the acidity is neutralized a good product will be obtained.

3. Concentrate in a vacuum pan to 68-72 degrees Brix with as high a vacuum as possible, preferably 27 inches. Open-kettle concentration may be used, but the resulting syrup is darker and somewhat inferior in flavor.

4. Filter through cheesecloth, bottle, and pasteurize at 160° F. for 20 minutes. Cool quickly.

Cider syrup may be used as a table syrup in place of maple or blended syrup. It has a characteristic flavor, which while not particularly apple-like, is still very palatable.

Cider Jelly

This product is made by concentrating cider to the jelling point. Since pectin is one of the essential constituents of a jelly, only unclarified cider should be used.

The fresh sweet cider is boiled to 7° to 8° F. above the boiling point of water or until the product flakes off a spoon in the characteristic jelly test. A concentration of seven volumes of cider down to one volume is enough to produce a good jelly. The finished jelly is strained through a single layer of good cheesecloth and poured into clean dry glasses. When the jelly has set, melted paraffin is poured over the surface and the covers are put on or the jelly is capped with an airtight cover. Vacuum sealing after the jelly sets eliminates air and aids greatly in preventing surface growth of molds. Long cooking will darken the color of the jelly and give it a caramel-like flavor, so concentration should be as rapid as possible.

A variation in the older method of cider jelly manufacture consists in adding pectin extract obtained from apple pomace to the fresh cider in sufficient quan-

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tity to produce a jelly. For best results the cider should be concentrated to at least one-half its original volume, then the sugar and pomace extract added, and the mixture boiled rapidly to a jelly test. Such a jelly is much less tough and acid than the old-fashioned apple cider jelly. Pectin extracts are easily prepared by boiling pressed pomace with about five times its weight of water for 15 mintes, and straining or filtering the extract. Such pectin extracts may be prepared during the apple season and preserved either by canning or by freezing. A certain degree of concentration, 3 or 4 to 1, is desirable before storing the pectin extract. Of course the pomace may also be dehydrated and stored in the dry state. For the latter, only pomace which has been extracted with water and re-pressed should be used.

Jellies made by the use of pomace extracts (pectin) and cider are somewhat different in character from ordinary heat-extracted apple jelly or from old-fashioned cider jelly. Mint jelly can also be easily made by using pomace extracts, green dye and either mint leaves or extract. Strictly speaking, mint jellies are really not pure apple jellies, although they can be prepared from whole green apples such as Greenings.

USES FOR APPLE POMACE

Approximately 40 percent of the weight of the cider apples remains as pomace after the cider has been pressed out. If left around the cider mill the pomace becomes a breeding ground for yeasts, molds, and vinegar flies. Hence it is very important that it be disposed of as soon as possible.

There is much useful material left in apple pomace. Most of the jelly-making constituent, pectin, still remains in the pomace after pressing. In fact, many of the commercial pectin preparations are made from dried apple pomace. So, if the amount of pomace produced during the season justifies the expense, a pomace drier may be installed. Dried pomace can be stored in a dry place and manufactured later into a pectin preparation or used as stock feed.

As noted in the section on cider jelly, pectin extract may be obtained from the wet pomace and used in the manufacture of jellies. Such jellies must not be labeled "pure apple jelly" unless cider is mixed with the pectin extract at the time of manufacture in amounts which would make the composition of the finished product the same as that of a pure apple jelly.

To make the pectin extract, water to the extent of five times the weight of pomace is mixed with the pomace, the mixture is boiled for 15 minutes, and the liquid drained off and filtered. This pectin extract can then be filled into jars or cans and sealed. Gallon jars may be heated for 20 minutes at 212° F. if filled above 180° F. and stored for future use.

To obtain a clear pectin preparation such as is sold commercially, it is necessary to treat the pectin extract with diastase, a starch-destroying enzyme, to remove the starchy materials and then filter it. Diastase preparations may be bought at most drug stores in the form of extract powder or tablets or they may be purchased in larger quantities directly from the manufacturer (See list of supplies in Appendix). Such preparations as Clarex, Protozyme PX, and malt diastase gave good results in this laboratory. Because of greater ease of filtration, the addition of diastase clarifiers to the unconcentrated extracts is suggested. However, if good filtration equipment is available, the concentrated extracts may be clarified and filtered. Approximately 0.1 percent by weight of diastase clarifier is used. It is best to soak the powder in a small amount of water for an hour to facilitate rapid enzyme action. Approximately 7 ounces per 50-gallon barrel or 0.14 ounce per gallon of pectin extract is used. Directions on commercial enzyme preparations should be followed closely. The optimum

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temperature is 120° F. and the reaction period should be 90 minutes. However, lower temperatures for a longer period of time may be used. For example, at room temperature the diastase preparation may be left in the cider all night and the filtration accomplished the next morning. General methods for the handling and non-enzymic clarification of pectinous fruit juices have been described by Bell and Wiegand (2).

Results obtained here show that clarified pomace (pectin) extracts retain their jellying power much better than unclarified extracts. Processing methods have been discussed. The canned extract is stored preferably at cold-storage temperatures until ready for use. The pectin extracts also keep well in the frozen condition.

Kertesz and Green (18) showed that stored pomace containing 20 percent or less of moisture, did not actively support the growth of mold. Even at lower moisture contents, however, a gradual loss in pectin quality occurred during storage. These losses were believed not to be of enzymic nature, but rather due to moisture itself.

Apple pomace may also be used as a stock feed. The wet pomace may be stored in a bin, silo, or in a pile, if proper precautions are taken to allow for the weight of the pomace. As mentioned previously, dried pomace may also be used for feeding dry, or soaked with about two and one half times its weight of water. Experiments have shown that apple pomace is approximately equal to good corn silage in feeding value for dairy cows. It is advisable to feed the pomace after milking and to remove the milk from the feeding barn, since otherwise odors from this feed may be absorbed by the milk.

In some states distillers are using apple pomace as a cheap source of alcohol.

LEGAL ASPECTS OF ALCOHOLIC CONTENT OF CIDER

In the Federal Alcohol Administration Act it is stated, "The term 'wine' means (1) wine as defined in section 610 and section 617 of the Revenue Act of 1918, (U.S.C., title 26, sees. 441 and 444) as now in force or hereafter amended and (2) other alcoholic beverages not so defined, but made in the manner of wine, including sparkling and carbonated wine, wine made from condensed grape must, wine made from other agricultural products than the juice of sound, ripe grapes, imitation wine, compounds sold as wine, vermouth, cider, perry and sake; in each instance only if containing not less than 7 per centum and not more than 24 per centum of alcohol by volume, and if for non-industrial use."

However, in the Massachusetts Amendments to the Liquor Control Act the sale of cider containing alcohol is limited as follows:

"This chapter (the Liquor Control Act) shall not apply to the manufacture or storage of alcoholic beverages by a person for his own private use or to sales of cider at wholesale by the original makers thereof, or to sales of cider by farmers, not to be drunk on the premises, in quantities not exceeding in the aggregate the product of apples raised by them in the season of, or next preceding, such sales, or to sales of cider in any quantity by such farmers not to be drunk on the premises if such cider does not contain more than three per cent of alcohol by weight at sixty degrees Fahrenheit; nor shall this chapter apply to sales of cider by the original makers thereof other than such makers and farmers selling not to be drunk on the premises as aforesaid, if the cider does not contain more than three per cent alcohol as aforesaid, not to be drunk on the premises as aforesaid."

The Federal Alcohol Administration Act therefore does not apply to the manufacture or sale of cider unless it contains more than 7 percent of alcohol by volume. Such cider would be easily recognized as "hard" since practically all the sugar of the cider would have to be used up to produce 7 percent of alcohol. Sweet cider would rarely, if ever, attain such an alcoholic content without the addition of sugar.

Apparently no limitations are made by the state on the alcoholic content of cider if sold at wholesale by the original manufacturers, or on cider made by farmers from apples raised by them "in the season of, or next preceding such sales", if the cider is not drunk on the premises. As mentioned in the preceding paragraph, the sugar content of the cider would limit the alcoholic content to 8 percent by weight at the very most. Generally speaking, the alcoholic content of a fully fermented cider is estimated at one-half the percentage of total soluble solids (mostly sugar) in the freshly pressed juice. For example, an apple juice containing 12 percent solids will give a cider containing approximately 6 percent alcohol. Cider manufactured by farmers in Massachusetts from apples other than those produced in their own orchards, or by other manufacturers, must not contain more than 3 percent alcohol by weight. Such cider must not be drunk on the premises.

These regulations do not interfere with the manufacture and sale of sweet cider, since with modern methods of preservation such as pasteurization, cold storage, or use of sodium benzoate, it is easy enough to prevent cider from attaining an alcoholic content of 3 percent. Even if it is desired to produce a sparkling sweet cider, the small amount of alcohol produced in the process of natural carbonation would be much less than the limit set by the State Alcoholic Beverages Control Commission, provided the proper procedure was followed.

SPRAY RESIDUE PROBLEM

Arsenic and lead spray residues often persist on apples after picking. Only a small part of these toxic substances is removed by ordinary fruit washing methods. Commercially, apples are often washed in solutions containing from 0.5 to 1.0 percent hydrochloric acid. This treatment is effective in residue removal. Where visible residue is present on the fruit an acid wash is desirable. Of course only a part of the arsenic and lead passes into the cider. Experimental tests for arsenic on several lots of cider and apple butter manufactured from representative Massachusetts-grown apples showed only traces of this element. However, the U. S. Food and Drug Administration has seized at least one consignment of boiled cider which contained excessive arsenic and lead. The apples were grown in the Pacific Northwest where the spray residue problem is more serious because of scanty rainfall.

In general, except possibly in the case of concentrated apple products, it is not believed that sufficient toxic residue will be present on Eastern-grown apples to constitute a health hazard.

NUTRITIVE VALUE OF CIDER

Apple cider should be sold on its merits as a pleasant, refreshing beverage, not primarily because of its nutritional properites. However, it is deemed advisable to include here such information as is available on the nutritive value of cider.

Smith and Fellers (24) have shown that there is a wide variation in the vitamin C content of 21 varieties of Massachusetts grown apples. Seasonal or other variations, except storage, caused little change in the vitamin C content in any one variety. There is no apparent correlation between the vitamin C content of an apple variety and the chromosome number of that variety.

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The daily protective level for guinea pigs varied from 4 grams (84 units per ounce) for Baldwin to over 25 grams (13 units per ounce) for Mcintosh. The varieties tested may be conveniently classified as to their vitamin C potency as follows:

Very good (4 to 6.5 grams) (84 to 50 units per ounce) : Baldwin, Northern Spy, Ben Davis and Winesap.

Good (7 to 10 grams) (48 to 34 units per ounce): Esopus (Spitzenberg), Rome Beauty, Red Astrachan, King, Roxbury Russet, Rhode Island, and Stay man.

Fair (10.5 to 15 grams) (32 to 22 units per ounce): Arkansas, Gravenstein, Wealthy, Cortland, King David, and Golden Delicious.

Poor (16 to 25 grams) (21 to 13 units per ounce): Jonathan, Delicious* Tolman, and Mcintosh.

Cider, immediately after pressing, has just slightly less vitamin C than the apple from which it was made. However, as was shown by Fellers, Cleveland and Clague (15), although cider 24 hours old retained an appreciable amount of vitamin C, benzoated and pasteurized cider over 48 hours old had practically no protective value against scurvy. Titration tests for ascorbic acid on a bottled apple juice preserved by Seitz germ-proof nitration showed that from 2 to 4 quarts of the cider would be required daily to protect a man from scurvy, using the apple juice as the sole source of vitamin C. These bottled ciders contained only 4 to 8 units of vitamin C per ounce.

Apples have been found to contain some vitamin B and 6 to 7 units of vitamin G per ounce, so that cider would also contain these vitamins.

As to other nutrients it might be well to compare cider with milk. Cider contains approximately 0.4 percent protein, about one-eighth as much as whole milk; 0.5 percent fat, about one-eighth as much as milk; 12 percent carbo-hydrate, over twice as much as milk. It would take about 5.5 ounces of cider or milk to provide 100 calories. The daily energy requirement for a man doing sedentary work is 2,242 calories.

Cider also contains certain essential minerals, but not in the quantity that they would be found in some other foods. According to Sherman (23) there are approximately the following percentages of the various minerals in cider: calcium .007, magnesium .008, potassium .011, phosphorus .012, chlorine .005, sulphur .006, iron .0003. The ash of the apple or its juice is mildly alkaline, the ash from 100 grams being equivalent to approximately 3.7 cubic centi-meters of normal alkali.

Unpublished experiments at this laboratory show that the consumption by young men of as much as 800 to 1,000 grams daily of Mcintosh apples has no effect whatever on the blood alkali reserve. The urinary acidity was likewise unaffected by the consumption of these large quantities of apples.

GENERAL DISCUSSION

Most of the sweet cider which is manufactured in this country is sold in the fall and early winter, either in the fresh, untreated condition or as benzoated cider. Since simple clarification methods have been developed there is an increasing amount of clarified, filtered cider sold in grocery stores and roadside stands. This clarified cider is not usually preserved but is handled in much the same way as the unclarified cider; that is, benzoated, so it can be held for a few days at room temperature.

If available, freezing storage is the best method of preservation for cider.

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For the small manufacturer, the next best procedure is pasteurization, either flash pasteurization with a coil pasteurizer or the holding method.

Carbonation of cider is desirable because it decreases oxidation changes and makes pasteurization at a lower temperature feasible, besides improving the quality of the cider as a beverage. Where large-scale manufacture makes installation of specialized equipment possible, naturally carbonated sweet cider would seem to be the best product to manufacture.

Storage of the bottled, processed cider is almost as important as the preservation treatment. Pasteurization or a similar process does not protect the cider from changes such as are caused by light and high temperatures. The best storage for bottled cider is a cool, dark, storehouse.

If cider is to become more than just a seasonal drink, as much care must be given to its manufacture as would be accorded a good wine. Whether the consumer demand for cider would justify such extra care is problematical, but the large demand for cider in the autumn would indicate that there is a potential year-round market for a good cider beverage.

Improved methods of manufacture make it possible to produce good cider concentrates, but the equipment is too expensive for the small manufacturer. Concentrated cider products such as boiled cider, cider syrup, and cider jelly can be made with simple equipment, but the market for such products is limited.

Apple pomace can be used in the preparation of a pectin extract or for stock feed if fed in combination with foods containing certain essential nutrients. In some states the pomace is used by distillers as a cheap source of alcohol.

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APPENDIX

Partial List of Dealers in Supplies

The following list is included so that cider makers may know where supplies may be purchased.
No specific recommendation for any listed firm or product is intended. Equally satisfactory prod-

ucts may often be obtained from other dealers.

Barrels

So many cooperages are located throughout the state that no attempt will be made to list them. The addresses can be found in the telephone directory.

Mail order houses such as Sears Roebuck and Company and Montgomery Ward also sell barrels which are satisfactory for cider storage.

Benzoate of Soda

Heyden Chemical Corp., 50 Union Sq., New York, N. Y.

Hooker Electrochemical Co., 60 East 42nd St., New York, N. Y

Monsanto Chemical Co., St. Louis, Mo.

Seydel Chemical Co., Jersey City, N. J.

Cider Presses and Cider Makers' Supplies

A. B. Farquhar Co., Ltd., York, Pa.

Hydraulic Press Mfg. Co., Mt. Gilead, Ohio

Palmer Bros., Cos Cob, Conn.

Thomas-Albright, Goshen, Ind.

Chemical Supplies and Equipment

Balances, chemicals, hydrometers, thermometers:

v Central Scientific Co., 79 Amherst St., Cambridge, Mass.

Eimer and Amend, Third Ave., 18th to 19th St., New York, N. Y.

Fisher Scientific Co., 709-717 Forbes St., Pittsburgh, Pa.

Arthur H. Thomas, W. Washington Square, Philadelphia, Pa.

Will Corporation, Rochester, N. Y.

Balances, hydrometers, thermometers:

Howe and French, Inc., 101 Broad St., Boston, Mass.

Hydrometers, thermometers:

C. J. Tagliabue Mfg. Co., 525 Old South Building, Boston, Mass.

Taylor Instrument Co., 141 Milk St., Boston, Mass.

Most wholesale drug and pharmaceutical dealers also carry stocks of chemicals and supplies.

Clarifying Agents and Filter Aids for Cider and Pomace Extracts

Pectinol:

Hydraulic Press Mfg. Co., Mt. Gilead, Ohio

Protozyme PX :

Jacques-Wolfe and Co., Passaic, N. J.

Filter-eel:

Johns-Man ville, 75 Federal St., Boston, Mass.

Clarex, malt diastase:

Takamine Laboratory, Inc., Clifton, N. J.

Dry Ice

Dry Ice Corporation of America, 50 East 42d St.. New York, N. Y.

Local ice cream manufacturers can usually supply small quantities of dry ice.

Filters

Alsop Engineering Corp., 39 West 60th St., New York, N. Y.

American Seitz Filter Corp., 31 Union Square, New York, N. Y.

Hydraulic Press Mfij. Co., Mt. Gilead, Ohio

The Independent Filter Press Co., Brooklyn, N. Y.

Karl Kiefer Co., Cincinnati, Ohio

Palmer Bros., Cos Cob, Conn.

Scientific Filter Co., 3 Franklin Square, New York, N. Y.

T. Shriver and Co., Harrison, N. J.

D. R. Sperry and Co., Batavia, 111.

Vacuum Pans and Special Equipment for the Manufacture of Cidei Concentrate and

Closed Cuvee Process

Pfaudler Co., Rochester, N. Y.

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