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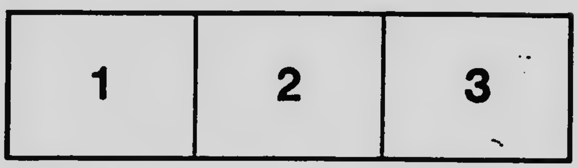

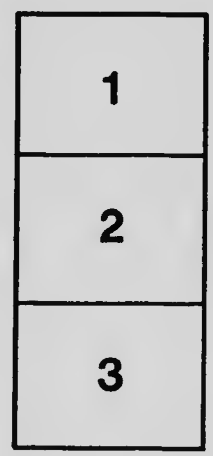

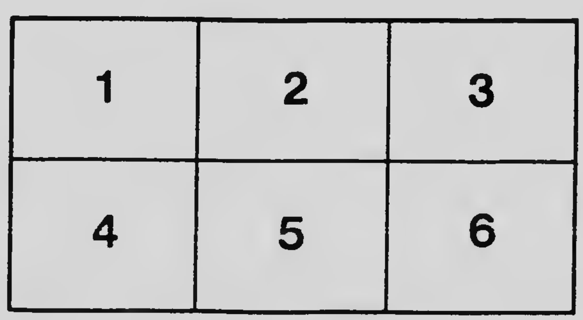

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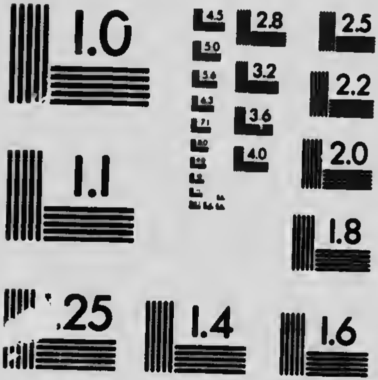

1912.

BULLETIN 200.] [A

Ontario Department of Agriculture

FRUIT BRANCH

Fruit Juices

By L. Meunier.

PREFACE.

Our experiments on fruit have a treble aim: First, to be useful to the fruit-grower by giving him divers ways of getting a big profit from his

Experimental Station at Jordan Harbor.

surplus crop or from cull fruit. Second, to put on the market natural non-alcoholic drinks made out of apples, grapes, etc., so supplying the people with beverages that will suit their taste without injuring their health. The hygienic properties of the unfermented apple-juice and grape juice are well known and generally recommended to the consumer. And lastly, we have considered the question of turning to profit the by-products of the juice industries (such as lees and pressed fruit, pomace, etc.) by making vinegar, food for cattle and hogs, etc. So, our work may be of interest not only to the fruit-grower, but to a . farmer of this Province who has a surplus of inferior fruit.

PART I.—ON APPLE JUICE AND ITS FERMENTATIONS.

This will be devoted to Chemistry and Biology as connected with apple-juice, cider, and vinegar making.

We shall consider the composition of apples and their juice, and look into the causes and conditions of the alcoholic fermentation that turns the juice into cider. The acetous fermentation that makes the vinegar will also be explained.

The Apple.

What is an apple composed of from a chemical point of view?

The average composition of ripe apples is:

Water	82.70
Sugars	11.00
Protein	0.50
Pectin	2.00
Acids, Ash, etc.	0.80
Crude fibre	3.00
	100.00

The crude fibre is quite insoluble, and a great part of the protein, pectin, and ash is not very soluble. The remainder consists of water and very soluble compounds. So there is about 95 per cent. juice in the apple and 5 per cent. other materials that are practically insoluble.

The apple is an aggregate of very small cells, the walls of which are insoluble, and these cells are filled with juice.

By grating the fruit the walls are broken and the liquid is easily crushed out by pressing.

The percentage of juice that one obtains depends upon the variety of apple, and also on the way of grating, and especially on the method used for the pressing.

The composition of the juice which is crushed out is the same, no matter what process has been employed.

The Apple Juice.

The average composition of the juice is:

Water	87.00
Sugars	11.60
Protein	0.10
Pectin	0.50
Acids and tannin	0.60
Ash	0.20
	100.00

The composition of the apple juice varies to a great extent according to the variety and state of ripeness of the fruit. For instance, the percentage of the total sugar may vary from 8 to 20, that of the pectin from 0.3 to 1.2.*

In any case the percentage of water is the highest, and that of the total sugar comes next. The sum of all the others (pectin, protein, acids, ash) is about one-tenth of the sugar.

So the sugar is, by far, the predominant substance that is dissolved in the juice. Consequently the specific gravity of the liquid depends chiefly

Thermometer and hydrometer.

Hydrometer and gauge.

Taking the Specific Gravity.

upon the amount of sugar, and it is possible to figure that amount roughly when the gravity is known.

The specific gravity is taken by the means of an hydrometer that is dipped into a gauge which is full of juice. The deeper the hydrometer

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*** The figures referring to the composition of apples and apple-juice are the results of analyses made in England and France, where a very extensive work has been undertaken to know something about the chemistry of the apple and its products (juice, cider, vinegar, etc.).**

plunges the lighter the juice is and also the poorer in sugar. There is a scale on the rod of the hydrometer, and the figure that is on the scale and just above the level of the liquid indicates the specific gravity.

There are tables that give the percentage of sugar according to the gravity, and also the quantity of alcohol which may be obtained from a gallon of cider.

The specific gravity of a juice containing 11.6 per cent. sugar is about 1.054.

If the alcoholic fermentation takes place in a juice the sugar is turned into alcohol and carbonic gas little by little, and as the fermentation advances the specific gravity decreases until it reaches about 0.999. Then the sugar has been completely transformed.

This shows how to use the hydrometer in order to know the stage of the fermentation ir a cider.

The Alcoholic Fermentation.

Why and in what conditions does a juice undergo the alcoholic fermentation?

Three conditions are necessary: the presence of yeast, a suitable temperature and a proper composition of the liquid.

Yeast. On the skin of the ripe fruit there are microscopic cells that have the shape either of eggs or lemons.

Their length is a little less than 1-100 of a millimeter; that is to say, 1-200 of a line.

As a rule, when the apple is grated and pressed many of these (yeast cells) are mixed up with the juice. Under favorable circumstances they multiply and, at the same time, turn the sugar into alcohol and carbonic gas. This is called "fermentation." If in the open air, the production of carbonic gas gives rise to a lot of small bubbles that rise to the surface of the liquid and burst there, making the liquid look as if it were boiling. Generally the fermentation goes on as long as there is sugar in the juice, and, when completed, the liquid is then undisturbed and settles quickly. The yeast cells sink to the bottom of the vessel that contains the cider and forms a granulated sediment called "yeast."

The yeast-cells are little plants and so have all the properties of vegetal protoplasm. So they are destroyed by high temperature, that of boiling water (212° F.), for instance.

They want air (or rather oxygen) to grow and multiply, and are killed by the use of preservatives, or at least become inactive under the influence of a certain proportion of an antiseptic.

Temperature. The fermentation cannot take place at any temperature. The yeast cells work only from 30° F. (—1° C.) to 95° F. (+35° C.). And between these extremes the intensity of the fermentation varies greatly. The quantity of sugar that is transformed during an hour is hardly detectable at 30° F. That quantity increases as the temperature becomes higher, and does so until it reaches about 75° F. At a still higher degree the intensity of the fermentation is less. That decreases quickly as the mercury goes up, and, above 95° F. there is no fermentation at all.

So it is at 75° F. that the sugar is turned most quickly into alcohol, and if the temperature becomes higher or lower the rapidity of the fermentation decreases, and the presence of yeast becomes void either under 30° F. or above 95° F.

Composition of the Liquid. Water, sugar, acids, combined nitrogen and various salts are necessary to the proper action of the yeast.

These principles are, as a rule, in the right proportions in the apple juice, so that it shall u dergo fermentation if yeast cells are present there and the temperature suitable. And yet (even under these circumstances) the fermentation is sometimes very slow. This seems to be due to the poverty of the apple juice in nitrogen. When this is the case the addition of a very slight proportion of ammonium phosphate favors a quicker fermentation.

Some people put preservatives into the liquid in order to check the fermentation. That is a simple way to make "unfermented cider," but it is not to be commended. The preservatives kill the yeast cells, or, at least, render them unable to cause fermentation; but the action of preservatives on human protoplasm is about the same as on yeast protoplasm, so preservatives are "poisons" more or less dangerous to the human body.

Consequently the use of salicylic acid, benzoate of soda, etc., should be completely prohibited, the more so that it is possible to preserve the cider through other means.

Practical Conclusions. When the juice is intended for vinegar or brandy, the quicker the fermentation the better.

Consequently it is very important to know how to obtain the quickest fermentation available.

We have seen that the yeast is necessary to the fermentation. No fermentation can take place if there is no yeast cell in the juice. Besides, the rapidity of the fermentation increases as the number of yeast cells becomes larger. Therefore it is advisable to put a culture of yeast in the juice intended for quick fermentation. That culture may be obtained as follows:

Into a tub (or any other vessel of same shape) pour some apple juice and about 1 per thousand ammonium phosphate (neutral). The tub should be placed in a room of which the temperature is about 75° F.

Owing to the heat, combined nitrogen and oxygen of the air, the yeast cells multiply very quickly and a boisterous fermentation takes place. After a couple of days the liquid (yeast culture) is fit for use. Then the yeast culture is poured into the tanks or vats that contain the bulk of the juice. The addition of one per cent. of that culture is plenty as a rule.

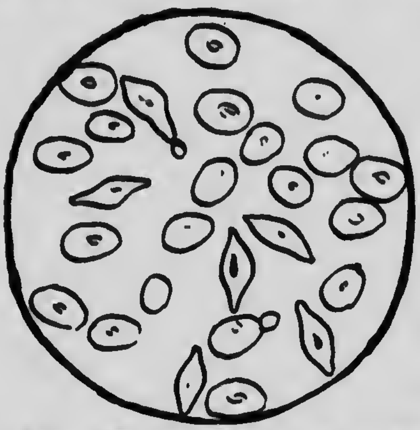
We remember that the yeast works best when the temperature is around 75° F, so if a quick fermentation is wanted one should try to maintain the juice at a temperature close to 75° F.

In the large factories the tanks should be provided with coils heated by steam; this is the cheapest way to control the temperature of the juice.

Let us now consider an opposite case: the making of sweet cider or unfermented apple juice. Then the aim of the maker is either to get a very slow fermentation or to check it completely.

As yeast cells and fit temperature are both needed for the fermentation there are two ways to make the action of the yeast void.

The yeast cells may be removed or killed by racking, filtering, heating, etc., or the juice may be cooled right off the press and put into cold storage at a temperature slightly under 30° F.



1. *Yeast.* Saccharomyces mali (egg-shaped cells) and Saccharomyces apiculatus (lemon shape).

2. *Bacteria.* Separate cells and chains of Mycoderma aceti.

To get a cider absolutely free from alcohol, but keeping its sweetness for months, allow a few yeast cells to remain in the liquid. And, instead of keeping the juice under 30° F., let the temperature go up to freezing point. So the keeping of sweet cider is possible in ordinary cold storages cooled by ice.

These various considerations show how useful scientific knowledge is to the cider maker. It gives him a complete control over the alcoholic fermentation and enables him either to check the work of the yeast or to obtain a slow or quick fermentation.

The Acetous Fermentation.

Let us now consider the vinegar question.

In many cases, the juice that has undergone the alcoholic fermentation becomes sour shortly after.

What is the reason for this?

Bacteria (called *Mycoderma aceti* by the scientist) grow on the surface of the cider, and there form a thin veil known as the "mother."

Thanks to these bacteria the oxygen of the air is combined with the alcohol, forming an acid, viz., acetic acid, which gives its peculiar flavor to the vinegar.

Four conditions are necessary to turn the cider into vinegar.

These are:

1st. The presence of acetous bacteria.

2nd. The contact of oxygen.

3rd. A favorable temperature.

4th. A fit composition of the cider,

The acetous ferment is a microscopic plant such as the alcoholic ferment (yeast).

That acetous bacterium is much smaller than a yeast cell. Its length is about 3-2000 of a line.

Every bacterium gives, by growing, a chain of cells of equal size. The chains spread in all directions on the surface of the cider, intermingle, and make a sort of woven cloth, that is, "the mother."

The oxygen is absolutely necessary to transform the alcohol into acetic acid after the formula:

$$\underset{\text{alcohol}}{\underline{C^2H^5.OH}} + \underset{\text{oxygen}}{\underline{O^2}} = \underset{\text{acetic acid}}{\underline{CH^3.COOH}} + \underset{\text{water}}{\underline{H^2O}}$$

The oxygen used by the bacteria is that of the air. If contact between the air and liquid is avoided, acetous fermentation is not possible. That is the reason why one pours oil (olive oil or pure liquid vaseline) into the cider, in order to keep it from getting sour. In some large English and French factories the cider tanks are completely closed and there is in the vat no gas but carbonic anhydride. Therefore the acetous fermentation cannot set in and the cider does not become sour, no matter how long it is kept in these tanks.

There is no possible action of the acetous ferment either under 50° F. or above 110° F. From 50° F. to 82° F. the intensity of the acetous fermentation increases, but above the latter degree that intensity decreases. So the most suitable temperature for the acetous bacteria is 82° F., and the production of acetic acid is lessened as it becomes warmer or cooler.

As to the right composition, let us say that water, alcohol, nitrogen and salts are needed and must be in the liquid in suitable proportions. That is generally the case with cider. The presence of preservatives would check the acetous fermentation or lessen its activity.

The above scientific facts should guide the vinegar maker.

In order to turn the cider into vinegar as quickly as possible one should:

1st. Provide the cider with good mother.

2nd. Get a very large surface of contact of the cider and air, 3rd. Maintain the liquid at a temperature close to 82° F.

As the acetous fermentation is advancing the specific gravity of the liquid increases.

By the use of an hydrometer and a table it is possible to know the percentage of acetic acid.

When acetous fermentation is completed the percentage of acid is the same as that of the alcohol which was contained in the cider.

So, owing to the use of an hydrometer and two tables it is easy to know when all the alcohol has been turned into acetic acid. As the vinegar is sold according to its richness in acid this fact is of great interest to the manufacturer.

We shall give more details when considering vinegar making from a practical point of view.

As to the present, we have reached our aim; that is, to show how Chemistry and Biology will assist the cider and vinegar makers.

PART II.—HOW TO MAKE UNFERMENTED SPARKLING APPLE JUICE.

There are many ways to do so, but we only give a full description of the process that we have used at the Horticultural Experiment Station, Jordan Harbor.

The process we refer to is such that the use of heat or preservatives is not necessary to keep the juice unfermented. The sparkling does not come from natural fermentation but from artificial carbonation.

To understand the reason of every step in the making of that cider, we must remember some facts of paramount importance, i.e.:

1. The yeast (that is to say, the necessary agent of the fermentation) is *on* the skin of the fruit, and not inside the apples.

2. Practically, the yeast does not work at a temperature lower than 30° F. That yeast will give more and more alcohol as the temperature becomes higher, and so until the mercury has reached 80° F.

3. The intensity of the fermentation is in proportion to the quantity of yeast, or rather to the number of yeast cells contained in the liquid. So the fewer the cells, the less the fermentation.

4. When the juice deposits, nearly all the yeast cells are in the sediment or lees.

5. On any apparatus used in a cider factory there are yeast cells, bacteria or mould germs. They are dangerous to the cider as liable to set in the fermentation or to give a disagreeable taste to the liquid.

6. The contact of the juice with the air (or any gas containing oxygen) gives rise to a multiplication of the yeast cells, and besides, that contact may alter the color and flavor of the cider.

Now let us consider the various stages of the making. One can sum them up as follows:

1. Sterilizing the premises, apparatus, vats.
2. Washing the fruit.
3. Grinding the apples.
4. Pressing the pulp.
5. Putting the juice in tanks in a cold storage.
6. Racking to separate the sediment.
7. Filtering.
8. Carbonating.
9. Bottling.

There are two by-products: the pomace and the lees (sediment). Both can be used; we will show how later on.

Sterilizing the Factory.

Before the start, the ceilings, walls and floors should be "sprayed" with a solution of a strong antiseptic. Formalin at 1 per thousand will answer the purpose.

All the apparatus has to be sterilized in the same way, or, better, by the use of boiling water. If formalin is used it will be necessary to rinse carefully after.

The grinder and the press (including racks and cloths) should be rinsed and scalded every day as soon as the work is over.

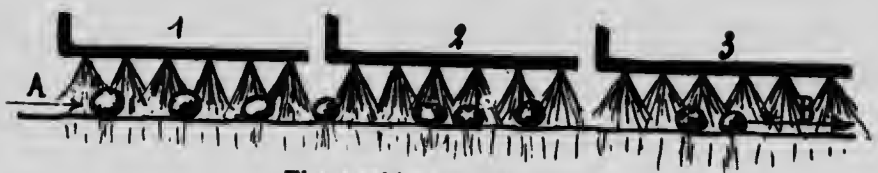
The floors must be washed also every day and kept in perfect cleanliness.

Washing the Fruit.

This operation is intended for getting rid of the yeast, bacteria and moulds which are on the skin of the apples. Just a dipping into water would do good; but a dip into an antiseptic solution will be much more effectual. In that case the antiseptic compound must be washed off afterwards, so that no preservative shall remain on the apples when the grinding takes place.

In our small factory at the Horticultural Experiment Station, we did the washing as follows: Three tubs were filled with water and one of them received 5 per thousand formalin. The fruit was put into large baskets and dipped successively into water, formalin solution, and water again. The liquid of the first and third tubs (which are filled with water only) must be changed very often, while the formalin solution can be used for several days. The apples were dipped into the solution for one minute.

This process, useful on a small scale, would not be practical in a large factory. There the apples could be washed as shown in the following figure.



The washing of the fruit.

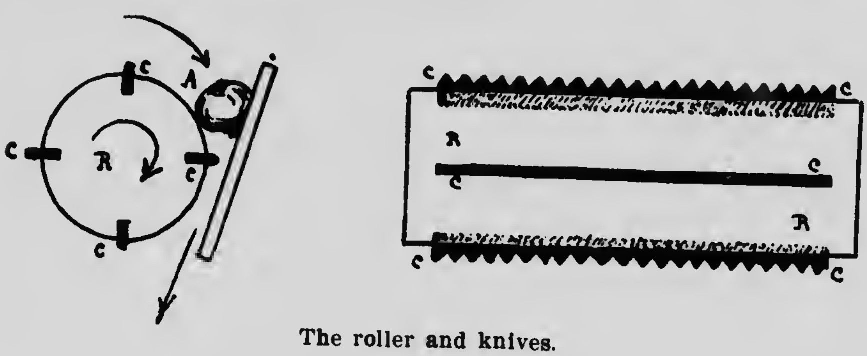
The apples are carried on a chain belt from A to B, and as they proceed they are washed by jets of water. The pipes 1 and 3 sprinkle the fruit with ordinary water, and from pipe 2 flows the formalin solution, that can be collected and used again many times.

The formalin water used in this case should be a 2 per cent. solution, and the fruit should remain a quarter of a minute under the formalin jets.

Grinding.

From the washer the apples are carried to the grinder, and there they are crushed or divided into small pieces. It is necessary to obtain as much juice as possible at the first pressing, so it is advisable to grind very finely when cloths are used for the pressing.

There are many kinds of grinders. As a rule they are made of two rollers between which the apples are crushed. But the finest pulp is obtained with only one roller provided with cutters. These are placed around the roller as shown in our drawing.



The roller and knives.

Each cutter (or knife) slightly protrudes, and, owing to its fine teeth, acts like a grater.

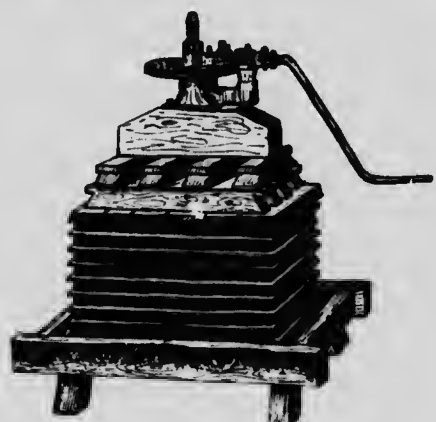
It must be remembered that the rollers of the grinder are generally made of cast iron, which is easily attacked by the juice. The iron gives to the liquid a slight but unpleasant taste. When the rollers become rusted the quantity of iron dissolved in the juice may be so great that it gives to the liquid a dark color. This must be avoided by a thorough daily cleansing of the grinder, after which the rollers should be oiled with "pure liquid vaseline."

The grinding must differ according to the way of pressing. When the latter is done with the use of racks and cloths, the finer the pulp is, the better. But it would be nonsense to crush finely the apples when they are to be pressed into a cylinder of latticework. If one tried to do so all the pulp would pass between the laths, and any attempt to separate the juice from the crude fibre would be a failure. When the primitive process of the lattice cylinder is to be used for pressing it is necessary to grind the apple very coarsely.

PRESSING.

The pressing of the pulp must be done after the grinding as soon as possible, so that the few yeast-cells, which may remain on the fruit-skins, shall have no time to multiply and cause the fermentation of the liquid.

The old way.



The up-to-date method.

What kind of press should be used?

As a rule small presses worked by a screw are utilized on the farms, and hydraulic presses are used in large cider factories. They are both good in their place. The hydraulic presses give quickly a strong pressure and a great percentage of the apple juice, but the smallest hydraulic press is too dear for the farmer who intends to make cider on a very small scale, for his own use, for instance.

In that case the cheap ordinary screw press costing about $20.00 is sufficient. But it will be necessary to replace the lattice cylinder by a set of racks and cloths as shown on the pictures.

Our experiments at the Horticultural Experiment Station have proved that the lattice cylinder should be removed from the cider factory to some museum for tools of the past ages.

We have pressed the same quantity of apples in both ways, that is to say in the old way, and, on the other hand, with racks and cloths. The pressing was done by the same man with the same press and during the same time (half an hour). Through the lattice cylinder, we obtained 15 per cent of the juice, and with a set of racks and cloths, we have crushed out 55 per cent. of the juice.

As many farmers do not know the process of pressing by use of cloths, we will explain that method in a few words.

For an ordinary home press are wanted: A form, a dozen racks and half a dozen cloths.

We have made all that in the cheapest way. As cloths, we have used ordinary sack canvas cut in squares 30 inches wide. The racks and form have been made out of laths 1½ inches wide, and half an inch thick. A rack is a lattice work composed of laths crossing each other at right angles and nailed together. Our racks are square and 17 inches wide.

Form, rack and cloth.

There are 5 laths on one side and 7 on the other. A form is something like a square box without any top or bottom. It is made of four pieces of laths nailed together. Each side is 16 inches long.

We have taken a photograph that shows a form, a rack and a cloth used in our experiments.

Cloths, racks and form being so prepared we proceed as follows:

A rack is laid on the pressure platform and the form is placed on that rack, and covered with a cloth. The latter is carefully put in such a way that it closely lines the form.

And now the form is filled up with apple pulp. Then the cloth is folded upon the pulp and the form is pulled off. Another rack is put on the pulp and another layer of crushed apples is placed on the second rack just in the same way as on the first one. Three or four layers are put up in this way and on the last layer is placed the rack and beams. It is then pressed by working the screw in the way used to press the pulp in the lattice-tub.

In the making of unfermented apple juice it is very important to press quickly. The juice should be crushed out not later than two hours after the grinding. This is very easily done—either with ordinary or hydraulic press—when the press is properly fed by the grinder. Half an hour pressing is plenty when the hydraulic press is used and one hour is enough with the ordinary press fitted with racks and cloths.

Cold Storage of the Juice.

As soon as the juice is crushed out of the apples it should be put into a cold cellar, or better, into a regular cold storage. It is possible to check the fermentation for a few weeks at a temperature as high as 40° F., but it will be safer to run the cold storage at 30° F. That is a little under freezing point, but the apple juice freezes only at a still lower degree.

The apple juice is stored in vats or tanks. These tanks should be slightly tapering so that no sediment can stick to the walls. As a rule, the larger the tank is, the better. A big factory should use vats holding 10,000 gallons at least. In a very large tank, there is practically no loss through evaporation, no sensible change of temperature (even if that of the storage goes up for a while) and, besides, the cost of the storage of a gallon becomes smaller as the size of the tank increases.

The vats are made of oak, white pine or cypress. Oak tanks are dear. White pine vats are liable to give a nasty taste to the juice. Cypress should be preferred.

The outside of the tanks should be washed twice with linseed oil and the inside coated with shellac varnish.

Fill the tank up with water as long as it is not quite tight. After the drawing off of that water a scalding of the tank wall is required.

Then pour some pure liquid vaseline into the vat. That is intended to cover the apple juice later on. The liquid vaseline used must be refined so that there is no taste and no flavor in it. The right kind of oil must be secured as the cider would very easily take any bad taste or odor. The quantity of oil to pour into the tank should not be less than 5 ounces to the square foot of open surface. From the press to the vat the juice should be pumped or drawn through a rubber hose used as a siphon, the lower end of this being at the bottom of the tank.

When the tank is filled up, a cover should be put on the top in order to avoid the falling of any dirt or germs into the vat.

Racking.

Notwithstanding the precautions which have been taken, the juice would undergo fermentation after a month or two if the liquid was not carefully separated from the few yeast and bacteria cells which are still therein.

Fortunately the juice will *naturally* become clear within two or three weeks, and a sediment, a few inches thick, will sink to the bottom of the vat. That sediment is called "lees." The liquid above the lees will become very clear, and then practically all the germs (yeast and bacteria) are in the sediment. If we separate the lees from the clear liquid, the

Filling a barrel from a tank.

latter will not undergo fermentation as the yeast is necessary to do that work.

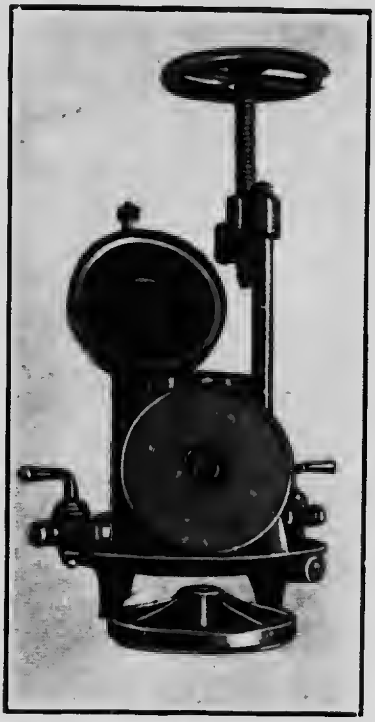
So, let us watch carefully the juice stored in the tanks and see how it settles by taking a little liquid every day. As soon as the lees have settled to the bottom of the tank the liquid juice must be drawn off (or racked).

Sterilize a pump and an empty tank and pour some liquid vaseline into the tank intended for the clear juice. This must be preserved all the time from contact with the air, when flowing from one tank to another under the oil.

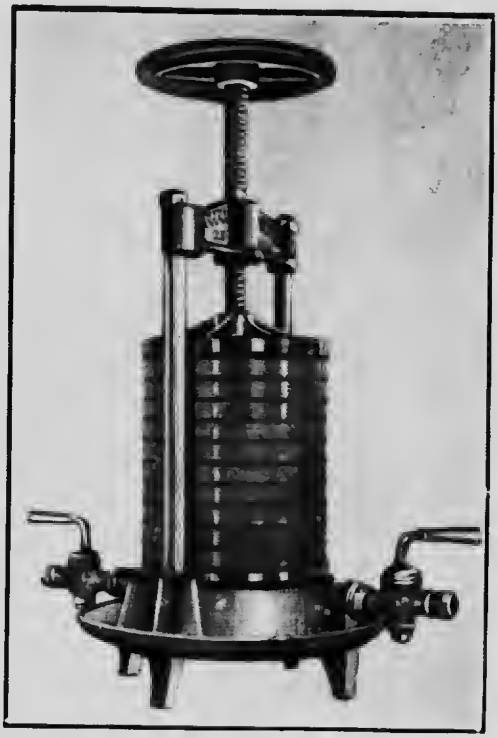
The liquid will very often deposit again and a second racking must take place within a month, after which the juice is very clear and contains so very few yeast cells that it cannot undergo any appreciable fermentation when kept undisturbed in the cold storage.

This apple-juice is ready for marketing, as unfermented sweet cider.

One can draw it from the tanks into sterilized barrels (see our picture), bung them down and ship them a short distance safely. And



The filter.
Showing the disc plates.



The filter.
Ready for work.

yet, after the opening of the barrel this cider will begin to ferment within a week or two if not kept in a cold place.

So, unfermented apple-juice intended for selling at any time of the year should be put into bottles instead of barrels, as it is the safest way to keep cider in good order.

To be a quite attractive drink, the juice sold in bottles must be of a bright color and sparkling. The brightness will be obtained by filtering, and the sparkling by means of carbonic gas.

Filtering.

Filtering is largely used to make wines and beers brighter.

We have filtered apple-juice in order to obtain the same result and also to complete the removal of any germ from the cider.

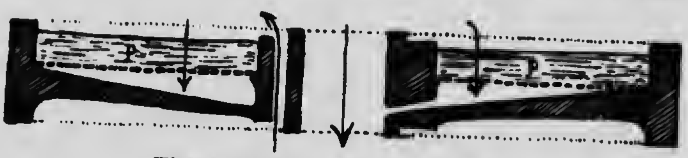
We used the Karl Kiefer filter which did good work. Other filters can be employed as long as the filtering is obtained by straining the juice through materials not liable to alter the quality of the cider and besides retaining any solid particle that may be in the liquid.

The pictures show the filter we have utilized at the Station. That filter is made of a frame and 10 round plates of same size and shape.

We have drawn the cut of a plate in order to make the filtering process comprehensible.

The liquid flows as the dashes show. It goes up through small holes and spreads on the layers of paper-pulp that are laid on a wire-screen. The pressure (given by a pump) forces the juice through the filtering paper. Then the liquid flows towards the centre of the plate and by the means of small openings enters the large central conduit.

Nearly all the common metals are attacked by the acids of the juice, so, all inside parts of the filter should be tin-lined or silver-plated.



The section of a plate of filter.

A good filter is expensive. That used in our experiments is worth $100.00 and the silver-plating cost $10.00. It cannot filter more than 200 gallons a day. So, the filter needed in a big factory should be much larger and more expensive. And yet the use of such a filter is to be commended as the best way to completely check the fermentation by removing all germs from the juice and to give an unrivalled brightness to the liquid.

Many people think that it is not possible to filter the cider when sweet. That is quite wrong. When the juice has settled, the clear liquid is very easily filtered, no matter how rich in sugar. It is not the sugar that makes the filtering difficult, but the pectinous matters and solid particles which are eliminated with the lees when the work is properly done.

Carbonating.

People are very fond of carbonated drinks. The beverages which have the largest consumption contain a certain amount of carbonic gas that is dissolved in the liquid. Such are most of the soft-drinks and beers.

When they are poured into the glass the carbonic gas gives rise to a multitude of bubbles which form a nice froth. The apple juice must be presented in the same way. So we have to carbonate it before the bottling.

I have been told many times that it is not possible to carbonate apple-juice properly.

That may be right in some cases, for instance, when the liquid is not clarified beforehand.

Carbonator. Gas drum and connections.

But our experiments have proved that the carbonating of apple-juice is not only possible, but very easily done. After it has been clarified and filtered the cider is easier to carbonate properly than water.

As the carbonating is quite unknown to most of the farmers and cider-makers, we shall describe that operation.

The necessary implements are: 1st, a cider pump; 2nd, a carbonator; 3rd, some gas drums. The picture shows them and how they are connected.

The juice, coming from the filter, is pumped into the carbonator; it flows in the pipe that is seen on the right. The liquid goes down the long cylinder of the carbonator, making a cascade on the balls that fill that cylinder. So the cider has a great surface of contact with the carbonic gas that is in the carbonator. When the juice reaches the lower part of the apparatus it is saturated with carbonic gas. (The height of the carbonated juice collected in the barrel is shown owing to a glass tube placed on the side of the carbonator.) A pipe goes up from the bottom to the tap that is seen on the right between the barrel and the long cylinder. The liquid flows up in that pipe, and, through a rubber hose, it goes from the tap to the bottling machine that is on the left.

The black cylinder is a gas drum which contains the carbonic anhydride. The drum is connected to the carbonator by a thin copper tube. The pressure and the flow of the gas entering the carbonator are regulated by the means of taps and a gauge showing the pressure to the square inch.

Like the filter, the carbonator is expensive, but necessary to obtain unfermented sparkling apple-juice of good quality.

The carbonator used at the Station is not a very large one and yet its cost is $250.00. This is convenient for a small plant, but a larger size would be needed in a big factory.

The carbonic gas is sold at 8c. a pound.

When the daily work is over water must be run through the filter and carbonator.

Tin and rubber are the only materials coming in contact with the juice during the carbonating process. The carbonator is thickly tin-lined, and all the connecting conduits intended for the cider are tin-pipes or rubber hose.

The pressure used in our experiments was 50 lbs. to the square inch. The result has been quite satisfactory.

Bottling.

The next operation is the bottling.

What kind of bottles and corks should be used?

As to the bottles, the size that seems to suit the trade best is the pint. Of course the glass must be transparent in order to show how clear and bright the juice is.

With regard to the corks, the crown is probably the best one.

The advantages of the crown cork are many. It is easy to put on and easy to take off. The crown makes a pretty fitting by itself and so it is not necessary to put any foil on the neck of the bottle. And, lastly, the crown cork is cheaper than any other cork.

The only drawback to the use of the crown is that special bottles (called crown-cork bottles) are required, and these are costly.

Nevertheless, crown-corking is used more and more and should be used for cider in most cases. And yet there will be a market for any high grade of apple juice presented in the same way as champagne. A drink of that kind could easily be sold at 15c. a pint, so giving a very good return to the maker. That will be considered later. For the present, let us explain ho to use the crown corks.

The corking machine is seen in the photograph.

Bottling machine.
The crown-cork machine.

The carbonated juice arrives into the head of the machine through the rubber hose that is shown on the figure.

Let us also see how to fill and cork the bottles.

The machine, bottles and corks are first sterilized by the means of a formalin solution (5 per thousand). Of course the formalin must be removed by rinsing with pure water. The operator washes his hands carefully and sterilizes them by a dip into formalin water. One puts some bottles on the little table seen on the left of the machine and a lot of crown corks in the large cup.

A crown is taken and slipped up into a hole (throat) that is at the lower end of the head. The cork is held in the throat by means of four catches.

Then a bottle is placed as shown on the picture. The neck of the bottle is just under the throat, which is provided with a rubber ring.

The operator turns up the handle that is on the right, so narrowing the central hole of the rubber ring. By putting one's foot on the treadle—

Bottle in place for the filling.

that is in front of the machine—one draws the head down so that the rubber ring will make a joint on the top of the bottle.

Then the handle shown on the left is pushed forward until it opens a valve giving way to the flow of the carbonated juice into the bottle. When that is half full one pushes the left handle forward in order to open another valve that will let out the air contained in the bottle. Then by pulling the handle to him the operator reopens the first valve we spoke of, that allows the liquid to flow again and fill the bottle up. The handle is taken back to its first position and one gives a strong, firm pressure down on the treadle. That puts the crown on the top of the bottle. The right handle is then turned down and the operator takes his foot off the treadle so that the head goes up. The bottle is taken off (see the picture) and put on the table shown on the right.

It takes much longer to explain the work than to do it. After some days' practice just a few seconds will be required to fill and cork a bottle.

The crown-cork machine we have used is worth $100.00, and is made by the Aluminum & Crown Stopper Co. Limited, Toronto.

The top of the crown should be decorated with an apple or bear the words apple-cider. Attractive labels, adorned with fruit or apple blooms, should also be pasted on the bottles.

It pays to present the drink in an attractive form.

When labelled the bottles should be placed in a cold storage

Shipping and Selling.

"Cold is the friend of the cider," the Norman says. We must remember that and keep the drink in cold storage as much as possible.

One should use refrigerators for shipping, and every grocer dealing in cider should have an ice box to put the cider in.

Instructions should be given to the retailers asking them to put the cider in a cool place and not in the window as they too often do, so spoiling the beverage.

The bottles shown in the windows should be left there as an advertisement, but never sold.

PART III.—COST OF A PLANT AND PROFIT.

The cost of a cider plant will be very small on any farm provided with a cold storage.

The fruit should remain there until the winter. Then the grinding takes place and the juice can be stored in any room of which the temperature is about freezing point.

The bottling will be done early in the spring and the bottles taken back to the cold storage.

So. the only large expense will be the machinery.

The cost of that which I would use for a 5,000-gallon plant is:

Grater and press	$100
Tanks for 5,000 gallons	150
Filter and pump	150
Carbonator	250
Bottling machinery	100
Various implements	50
	$800
Building	400
	$1,200

By using this small plant it is possible to make a success of the business by the selling of 50,000 bottles a year at 7½c. a pint. bottle—that would be sold at 10c. a piece by the retailer.

50,000 pints can be obtained from 5,000 gallons crushed out of 500 barrels fruit.

If we figure the cost per bottle as follows:

Glass	**2c.**
Gas, cork, label	**1c.**
Interest and labor	**1½c.**
Total	**4½c.**

That gives a profit of 7½—4½=3c. a bottle, or $1,500 for 500 barrels fruit, that is to say $3.00 a barrel.

So, the culls could pay nearly as well as the No. 1 fruit.

It is needless to say that much larger profits should be obtained by putting up cider factories on a co-operative basis.

PART IV.—THE BY-PRODUCTS.

The return given by the cider-industry can be much increased if the by-products are properly utilized.

These by-products are the pomace and the lees.

What to do with the Pomace.

The pressed apples (pomace) are very often considered as a nuisance and thrown away.

And yet this pomace could be used in many ways.

It could be soaked in water and pressed again, so giving a certain amount of juice. That would not be so rich as the juice obtained from the first pressing, but still fit for making ordinary cider vinegar or brandy.

We do not advocate the use of the pomace in that way. We think that the pomace should be utilized for feeding purposes.

However rich in crude fibre, the pomace is a valuable food owing to its content of carbohydrates and protein.

The greatest part of the apple-protein is not soluble, so it remains in the pomace.

The percentage of protein contained in the apple is less than 0.50 on the average.

In the pomace that percentage is 1.37 according to Lechartier and 1.40 after Wolf.

Therefore, the pomace is about three times richer in protein than the apple. Hence, as a flesh builder, this pomace is about three times more valuable than the apple. Therefore, the pressed apples should never be thrown away, but should be utilized as a food for cows or hogs.

The pomace can be used when soft, but it must be dried for shipping or using after some months. This drying could be done easily and cheaply by the means of kilns.

If intended to obtain a food richer in carbohydrates, one could mix up molasses with the pomace. Besides beans might be used to increase the protein percentage.

At the Horticultural Experiment Station we have mixed up soft pomace and molasses (half and half) and moulded the mixture in "forms" of the same size as that used to make the cheese of apple pulp. (See Pressing.) The "cakes" so obtained were allowed to dry for some weeks. Then we fed some to a cow that took it greedily. A sample analyzed by Prof. R. Harcourt, O.A.C., contained:

Moisture	34.8
Protein	4.0
Fat	3.5
Ash	6.5
Crude fibre	10.6
Soluble carbohydrates	40.6
	100.0

Molasses for feeding purposes is worth about $20.00 a ton at the sugar factory.

How to use the Lees.

In Europe they make brandy out of the lees.

That is not to be commended; we think the lees should be turned into vinegar. Therefore, we shall explain how to make vinegar on a small scale, that being likely what most of the farmers will require.

The lees should first ferment completely, that is until the specific gravity is around 0.999.

If the fermentation is slow a yeast culture and also heat and ammonium phosphate might be used to get a dry cider quicker.

That cider will be turned into vinegar by the means of casks (or barrels) prepared as shown in the picture.

Every barrel is provided with a tap (T) and a funnel (F) fitted up with a rubber tube (R).

Two openings (O and O') are intended for circulation of air.

One starts preparing a culture of *Mycoderma aceti*. One pint of cider and one-third of a pint of ordinary vinegar are poured into some flat vessel which is then placed in a room at a temperature close to 80° F. After a few days a "mother" will grow on the surface of the liquid.

As soon as that mother is secured, the vinegar barrel is half-filled with cider mixed with one-tenth of vinegar. (That is to check the growth of any microbe but the right bacterium, *Mycoderma aceti.*)

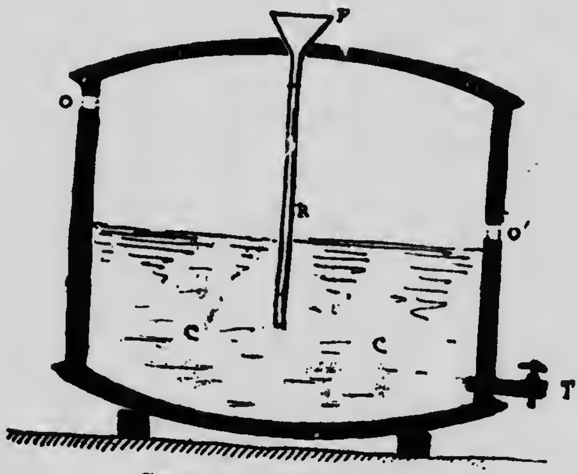
Pieces of "mother" are put on the liquid, through the holes.

At a proper temperature a quick acetous fermentation sets in. Within a fortnight the alcohol is transformed into acetic acid, and, then, one draws off one-third of the liquid by opening the tap (T). When that is done one pours slowly into the funnel the same quantity of cider as that of drawn-off vinegar. Owing to the rubber tube the cider flows under the mother without doing it any harm.

And now, from week to week, a third of the vinegar is taken out of the barrel and replaced by cider.

The vinegar so obtained should be filtered as soon as possible and stored either in barrels or in bottles.

By this process it is easy to make a high grade of vinegar.



Cask for vinegar making.

APPENDIX.

We shall give here the results of some experiments that we have carried on at the Horticultural Experiment Station.

They will illustrate what we have previously stated about the causes of, and conditions necessary to the fermentation.

The parts of the yeast, temperature and nitrogen will be clearly shown.

Our researches have also thrown into light the influence of the variety as to the quality of the cider.

The last part of this Appendix is devoted to the concentration of the juice by freezing it.

YEAST AND LEES.

The yeast-cells are the necessary agents of the alcoholic fermentation. The more numerous they are, the quicker the fermentation of the juice.

When the apple juice settles, most of the yeast-cells are in the sediment.

So, by separating the clear liquid from the lees, the latter will ferment much more quickly than the limpid juice.

The following results of our experiments show the accuracy of the above hypothesis.

Some juice of "Greening" was put in bottles and stored in a cold room. After some days the juice settled. Then the clear liquid was drawn off from some bottles and poured into clean ones, whereas the lees was gathered together.

That was on the 6th of March.

Thence, from time to time, the gravity has been taken with a Beaumé's hydrometer.

The following are the figures that represent the degrees Beaumé at various stages of the fermentation.

Date.	Clear Juice.	Juice.	Lees.
6, 3, '11	6°.3 B.	6°.3 B.	6°.3 B.
15, 3, '11	6°.3	6°.3	6°.2
22, 3, '11	6°.2	6°.0	4°.4
8, 4, '11	6°.1	4°.7	2°.3
12, 5, '11	2°.9	0°.4	0°.3

In the space of one month, the clear juice has only lost 0°.2, whereas the juice (not set apart from the lees) lost 1°.6 and the lees 4°.0, and, a month later, the juice and lees were nearly dry (completely fermented) when the clear juice was just half fermented.

That shows the importance of the "rackings" used in order to check the fermentation.

TEMPERATURE.

We have stated that the intensity of the alcoholic fermentation is closely connected with the temperature.

In order to prove this, we filled up some bottles with clear juice of Greening and divided the experimental bottles in three lots. One of them was placed in the cellar, the second on the first floor of the cider factory and the third in the greenhouse. The mean temperature of the cellar has been about + 5° C. and those of the first story and greenhouse + 10° C. and + 20° C. respectively.

The gravity was taken in each place the same day, from week to week.

Date.	Cellar (5°C.)	First Floor (10°C.)	Greenhouse (20°C.)
6, 3, '11	6°.3 B.	6°.3	6°.3
15, 3, '11	6°.3	6°.3	6°.0
22, 3, '11	6°.2	6°.0	4°.8
8, 4, '11	6°.1	5°.1	0°.4
12, 5, '11	2°.9	0°.2	0°.2

That table shows the great advantage of a low temperature to check the fermentation. Hence the use of cold storages for the making of unfermented apple juice.

As to the cold storage of apple juice, experiments have already been undertaken by Mr. H. C. Gore, of the United States Department of Agriculture. The cold storage was at 0° C. (freezing point). The juice of the varieties tried fermented at that low temperature; nevertheless, the rapidity of the fermentation was much less than under the ordinary circumstances.

So the use of a common cold storage is not enough to avoid any fermentation—at least with the juice of a great many varieties.

That is the reason why the yeast must be taken away by means of rackings, and filterings, if necessary.

NITROGEN.

The yeast cells need nitrogen to multiply.* If they do not find that in the juice, there is no multiplication, and they may be so very few that no fermentation takes place, no matter how favorable the temperature is.

Here are two examples of that influence of nitrogen.

In order to clarify a sample of apple juice a little casein was added to a part of the liquid. The casein, bringing nitrogen into the juice, quickened the fermentation.

* The cells cannot use nitrogen in every form. Soluble compounds of certain classes only are usable.

Date.	Without Casein.	With Casein.
14, 3, '11 13, 5, '11	7°.7 B. 4°.7 B.	7°.7 B. 7°.1 B.

The other instance was given by adding ammonium phosphate to some apple juice, which did not ferment, though at a proper temperature.

What was the reason of that? Want of yeast or poverty in some necessary principle?

The addition of ammonium phosphate determined a quick fermentation. As other phosphates did not cause the same result the role of the nitrogen is obvious.

There are two practical conclusions:

1. Nitrogen compounds should not be employed to refine the juice that is to be sold as unfermented. Therefore the use of casein, isinglass, gelatine, etc., should be rejected.

2. Nitrogenous substances could be added to the juice to quicken its fermentation, if wanted. That is generally the case when the cider is intended for vinegar or brandy. Then neutral ammonium phosphate should be used to prepare a yeast culture.

PROPERTIES OF EACH VARIETY.

The composition of the apple juice varies according to the variety.

Consequently the qualities of the cider vary accordingly, as well as the ways of its clarification and fermentation.

In Europe hundreds of varieties of apples have been analyzed, especially by Mr. A. Truelle in France and Mr. F. J. Lloyd in England. Both have done much for the "Chemistry of the Apple."

But, from a practical point of view, the most interesting feature is probably the work of Dr. B. T. Barker, Director of the National Fruit and Cider Institute (Long Ashton, England).

He completely gave up the old way of making cider with any variety, or rather with unknown varieties mixed up in unknown proportions. He treated separately each variety.

We have just begun to apply the same method to the Canadian apples, and already obtained some useful results.

Three varieties (Baldwin, Greening and Spy) have been compared with regard to their qualities as to the making of cider and unfermented apple juice.

Here are some notes referring to that subject:

CLARIFICATION. The apple juice, as we have previously stated, has the property to settle and form a sediment that contains the solid particles which were in the primitive juice. In other words, the juice becomes clear by giving a deposit of lees.

That takes place whenever the juice is placed in a very cold room. But the clarification becomes impossible as soon as the fermentation sets in; that is due to the disturbance caused by the rising of bubbles.

The juices of the three varieties were placed in a cellar, the mean temperature of which was about freezing point.

That was in March, and the fruit used had been kept in a cold storage. The juices have been watched every day.

The natural clarification took place as follows:

Baldwin	after..............	4 days.
Greening	"	10 "
Spy	"	19 "

Clarification was perfect in every case.

FERMENTATION. Let us now compare the varieties as to their fermentation.

The table further on shows the results obtained by placing Greening and Spy juices under the same conditions:

Date.	Greening.	Spy.
6, 3, '11	6°.3 B.	7°.7 B.
15, 3, '11	6°.3	7°.7 B.
22, 3, '11	6°.0	7°.5.
8, 4, '11	4°.7	7°.2
12, 5, '11	0°.4	6°.0

(The Baldwin juice ferments as quickly as that of Greening.)

The very slow fermentation of the Spy juice is striking. It shows the possibility of making unfermented apple juice (or, at least, very sweet cider) just by the use of proper varieties.

Any farmer could make a success of that.

The Spy apples should be crushed when the mean temperature of the day keeps under freezing point. The juice—stored in tanks, in a cold room—would settle and give, within a month, a very clear liquid. That should be drawn off into another tank, and then, if possible, put in bottles. By so doing the juice could be sold as unfermented many months after the making. We have kept samples from March until June that did not ferment.

This remarkable property of the Spy juice seems to be due to the lack of nitrogen. The addition of ammonium phosphate (or albuminous substances) to the liquid gives rise to a quick fermentation.

We have mixed up Spy and Greening juices (half and half); the fermentation set in and became nearly as quick as that of pure Greening juice.

JUICE AND CIDER. The peculiarities of the clarified juices were:

Baldwin—

1. Pale yellow color.
2. Sweet and slightly astringent taste.
3. Nice flavor.

Greening—

1. Very pale greenish-yellow color.
2. Sweet and agreeably acid taste.
3. Pleasant, delicate flavor.

Spy—

1. Yellow, a little brownish.
2. Very sweet and slight, peculiar, rather unpleasant taste.
3. Very strong apple flavor.

We have made various kinds of cider with each variety, and we sum up here the results of our investigations.

Baldwin.—Makes good cider of any kind, but especially fit for "Champagne cider." Not suitable for unfermented apple juice if no cold storage can be used.

Greening.—Gives a delicious middle-sweet cider that reminds one of the famous "Devonshire cyders." Cold storage needed to prepare unfermented juice. Not very good when dry.

Spy.—Most suitable for "unfermented sparkling apple juice" and sweet "Norman cider." Not good when completely fermented.

That shows how important the choice of the varieties is, and the value of a careful study of Canadian apples with regard to cider making.

FROST AND CONCENTRATION.

The concentration of the apple juice seems to have a great future. So we shall relate an experiment that might be of great interest to the makers of concentrated juice.

First, what is concentration?

We have seen that the juice is (on the average) composed of

Water	87
Other substances	13
	100

One concentrates the juice whenever one takes a part of the water off. That concentration may be obtained by evaporating the water.

In the evaporating plants the juice is heated and "boiled down" long enough to get a thick syrup.

This concentrate juice does not ferment. Moreover, its weight is less than one-fourth of that of the primitive apple juice.

The concentrate juice is stored in barrels and shipped saf[illegible] cheaply even to remote parts of the Old Country. There it is used in various ways: jellies, jams, syrups, cider and brandy making.

Let us now consider another method available to concentrate the apple juice.

If some juice is cooled down at a lower temperature than 30° F. (—1° C.) it partly freezes.

The icicles that appear at first are almost pure water. So, if one takes away these icicles as they are formed, the juice becomes more and more concentrated.

On March 3rd a pailful of juice was placed outside at a temperature of about 10 degrees Fahr. below freezing point.

After some hours the ice was separated from the juice and melted. It gave a liquid of which the gravity was 4°.7, Beaumé scale. The juice that remained in the pail showed a density of 14°.7 B., and the original juice 7°.7 B.

So it is possible to concentrate the juice in that way—to a certain extent, at least.

The peculiar properties of both liquids obtained by freezing are of interest.

The concentrate juice (14°.7 B.) is very sweet, very acid, and deep in color. That means it is very rich in sugars, acids and tannins.

On the other hand, the liquid from the icicles (4°.7 B.) seems to lack anything but flavor, as if the icicles had included the flavoring essences of the fruit.

Moreover this liquid of pleasing taste and flavor ferments very slowly. (That is probably because nearly all the yeast and nitrogenous principles are in the concentrate juice.)

Hence the idea of treating the liquid obtained from the icicles in the same way as apple juice in order to make a sparkling unfermented drink.

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2. Dr. B. T. Barker. *Bulletins of the National Fruit and Cider Institute.* (Long Ashton, near Bristol, England.)

3. From the U. S. Department of Agriculture. Bureau of Chemistry. *H. W.* Wiley, Chief.)

   A. Bulletin 71. *A Study of Cider Making.* By William B. Alwood. (1903).

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   C. Bulletin 129. *Enological Studies.* By William B. Alwood. (1909.)

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