

THE PREPARATION OF UNFERMENTED APPLE JUICE.

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An inexpensive method of preserving apple juice so that the product will be free from objectionable sediment and a pronounced "cooked" taste, and can be kept in closed containers without the use of chemical preservatives, has apparently never been devised. Experimental work was undertaken with a view to developing such a method, and it is believed that a satisfactory procedure has been evolved. The main problems were: (1) The clarification of the juice; (2) the sterilization of the juice; (3) the carbonation of the juice; and (4) the question as to the best containers for the sterilized product.

THE CLARIFICATION OF THE JUICE.

Fresh apple juice contains notable quantities of solid matter, which will settle out on prolonged standing, forming a bulky deposit. In the case of raw juice this consists of dirt particles, starch grains, fragments of the cell walls of the apples, and, finally, albuminous matter, yellow-brown in color and very bulky. The albuminous matter composes by far the greater part of the sediment. The character of this sediment when heated to 140° to 158° F. (60° to 70° C.) remains about the same, except that the starch grains are no longer apparent, the starch being wholly or partly gelatinized.

This sediment is very objectionable, since its presence seriously detracts from the appearance of the finished juice after sterilizing by heat. In the finished juice the albuminous matter forms slimy particles, yellow to dark brown in color, which very readily mix with the juice when agitated, and are slow to settle. The product looks as though the most uncleanly methods had been used in its preparation, whereas the reverse may have been the case. The removal of the materials which form the sediment is, therefore, one of the most important steps in the preparation of a marketable product.

The methods at present used for this purpose are two: (1) Filtration, and (2) sedimentation of the sterilized juice in large casks.

Filtration is expensive and slow, and, while a product of great brilliancy is obtained, the cost of the plant and the operation of the process will undoubtedly prevent its extended use. Paper pulp is

ordinarily employed for the filter material, and the albuminous matter in the juice quickly forms a dense layer over the surface. The ensuing filtration is very slow, and a large filtering surface is required for practical use.

Sedimentation by gravity of juice heated to 140° to 158° F. (60° to 70° C.), and then allowed to cool in closed casks, is very slow. Unheated juice can not, of course, be used, owing to the fact that fermentation soon sets in. A period of five to seven days is required to produce a juice relatively free from sediment. At this time as much as possible of the supernatant juice is withdrawn from the sediment. The objections to this method lie in (1) the difficulty of keeping the juice sterile during the sedimentation period; (2) the large amount of coopeage required for any considerable output of juice, and (3) the fact that, owing to the bulk of the sediment, considerable quantities of juice can not be drawn off. The juice left with the sediment is then only suitable for vinegar stock. In addition only partial clarification is secured. These objections to sedimentation are the result of numerous tests with barrel lots of juice.

A method of clarification which is free from the above objections, and is also cheap and may be applied on a small or large scale, is clarification by use of a cream separator. Repeated trials have shown that a cream separator can successfully clarify the juice, leaving only traces of sediment in the product. Absolute clearness of the juice is not produced by use of the machine, but practically all sediment can be removed by this process. In the experimental work to be described a hand-power cream separator of the disk type was employed. The first trial of the method indicated that a satisfactory clarification of apple juice could readily be obtained by use of the separator, and many further trials have confirmed these early indications. The suspended matter in the juice collects in the bowl of the separator, while the clean juice runs out through the milk and cream screws. After a run of the juice through the machine, the heavier particles originally present—the starch grains and any soil or dirt particles, together with some albuminous matter—are to be found tightly packed in the lower part of the tubular shaft in the bowl of the machine, while a heavy layer of albuminous material is invariably packed on the inner side of the bowl and a lighter layer on the inner side of the bowl cover. The disks remain quite free from sediment. When the space between the disks and the sides of the bowl is quite filled with sediment, the flow from the milk screw ceases and the flow from the cream screw is much increased. At this time the machine should be stopped and the bowl cleaned. The juice from the milk screw is invariably considerably clearer than that from the cream screw. The reason for this is not apparent; the fact, however, was always observed. The juice from the cream screw is, in turn, much clearer than the untreated juice.

An extended series of tests established the following facts with regard to the method of clarifying by passing through a separator, using unfermented juice and a machine of the size indicated:

First. The amount which may be run through the machine before it is necessary to stop and clean the bowl is from 25 to 40 gallons, depending on the quantity of sediment present in the juice.

Second. The rate at which the juice passes through the machine is about 45 gallons per hour, where a delivery tube of 450 pounds per hour (for milk) is employed. On fitting the separator with a delivery tube of 750 pounds capacity per hour, less perfect clarification was effected than when the smaller delivery tube was used.

Third. But very little increase in the degree of clarification or capacity for sediment was secured when juice heated to 140° to 158° F. (60° to 70° C.) was run through.

Fourth. When heated juice was allowed to stand over night and to cool and settle before passing through the separator, the supernatant juice contained much less sediment than the original juice and two to three times as much could be passed through the machine before cleaning became necessary than when unseparated juice was used.

Fifth. Two separations are necessary when working with a separator of the size employed. The first treatment removes the bulk of the sediment, and the second takes out nearly all of the remainder.

Sixth. Running the juice more than twice through the separator improves the character of the product but little, as only very small amounts of the suspended matter in the juice are removed.

Seventh. The best conditions, as worked out by experiment, for clarifying apple juice, are as follows, working with a hand machine with a capacity for milk of 450 pounds per hour.

(a) The juice must be freshly expressed and, to be of high quality, should be prepared from sound, well-ripened fall or winter apples.

(b) It should be received in a clean barrel or cask, which must not contain any fermentation residues. This point is very important, as experience has shown that the very fine deposit formed in fermenting juice can not be successfully removed by the separator, and this deposit is difficult to clean from the sides and bottoms of fermentation casks.

(c) The juice is then passed through the separator, using the necessary precautions as to oiling and starting the machine, and turning the crank at the rate of 45 turns per minute. Twenty-five to forty gallons of fresh juice can be run through before the capacity of the bowl for sediment is reached. The juice which comes through the milk screw is collected separately.

(d) As soon as the milk screw becomes clogged the machine is stopped and the bowl is cleaned.

(e) The juice collected from the milk screw is passed through again and the juice then coming from the milk screw is collected as before.

The clarification of 25 gallons of juice, using one machine of the capacity indicated and a juice containing sediment in such quantity that a run of that amount would fill the space between the disks and the sides of the bowl with sediment, requires about one hour and a quarter, the juice passing through the bowl twice.

THE STERILIZATION OF THE JUICE.

As soon as the juice is clarified by the separator, it must be sterilized in closed containers. The points which have been carefully determined in this work have been the lowest safe temperature and the shortest period of heating for bottles and for cans.

If the juice is not to be packed and shipped, glass fruit jars, or bottles with patent stoppers, may be employed, but to stand shipping well, sealed cans or cork-stoppered bottles must be used.

STERILIZATION IN BOTTLES.

In the work with bottles, quart bottles of the champagne type were used. These were filled with clarified juice, some air space being left to allow for expansion of the liquid on heating. The bottles were placed upright and entirely submerged in water in a tank which could be heated by a jet of steam. About fifteen minutes were required to bring the water in the tank up to the temperatures employed in the several sets of experiments, namely, 140°, 149°, and 158° F. (60°, 65°, and 70° C.). After the bottles were placed in the tank from twenty-five to thirty minutes were required for the contents of the bottles to attain the temperature used. One-half hour was, therefore, allowed before beginning to count time in these tests—fifteen minutes to bring the bath up to the temperature, and fifteen minutes holding at this temperature for the juice in the bottle to attain the bath temperature. The bottles were withdrawn at intervals and set away on their sides in baskets, being kept in a warm room whose temperature was quite constant day and night, between 70° and 75° F. The bottles were agitated and notes taken on them from day to day.

The results show that a temperature of 149° F. (65° C.) for one hour will give good results and that 158° F. (70° C.) for one-half hour also gives good results. Only a very slight cooked taste is given to the juice by heating at 158° for one hour—slightly more, however, than is given by heating at 149° for the same period.

STERILIZING IN CANS.

One-gallon packers' cans were employed. These were first carefully rinsed with water, filled, sealed (rosin dissolved in alcohol being used as flux), and then heated in the same manner as the bottles. The juices employed were thoroughly typical and were clarified by passing twice through the separator. A full half hour was found by a careful test to be necessary for heating the contents of the can up to the bath when the water in the bath was cold to start with, and this period was only slightly shortened when the bath was hot at the time the cans were placed in it.

Unfortunately, the periods of heating were not short enough nor the temperatures used low enough to indicate unsafe conditions, since none of the cans spoiled; but proper treatment was found to be very readily given at low temperatures and for brief periods. It was expected that the cans which were only heated up to 149° F. (65° C.) in the hot water and then removed would surely spoil. These cans remained sound, however, and thus the period of heating indicated as sufficient for canning is unexpectedly short. When the cans were removed, they were cooled over night and allowed to stand in the same room as that in which the bottles were held. Owing to the large bulk of juice in the cans of the size employed (1 gallon), it is evident that the juice was maintained at a sterilizing temperature longer than if bottles or small-sized cans had been used. This fact must be kept in mind if the results here obtained are applied to other sizes than gallon cans.

THE CARBONATION OF THE JUICE.

In addition to experimental work on clarifying and on heating the juice, investigations were made on carbonating it with a view to disguising the slight cooked taste which it is impossible entirely to avoid. Carbonating also increases the palatability of the juice in the opinion of many persons. The method used consisted in carbonating the juice under slight pressure and then heating in bottles or cans, and no difficulty was encountered. In the simple experiments devised and carried on in connection with this work, the carbon dioxid (carbonic-acid gas) was secured from a firm handling soda-water supplies. It was obtained in liquid form in a steel cylinder furnished with a reduction valve and a gauge and delivery tube, so as to deliver at pressures up to 30 pounds.

After clarification, the juice was carbonated by pouring it into a clean keg and running in the gas up to a pressure of 15 pounds. The keg was provided with a thick pine bung, through the middle of which was bored a half-inch hole, which received the rubber delivery tube from the cylinder of compressed gas. The bung was soaked in

water for a few minutes before use, so that it could be driven in to make a tight joint, and was so fitted that it projected beyond the surface of the keg and could be readily loosened when carbonation was finished. About 12 gallons of juice were poured into the keg. Carbon dioxide was admitted before driving the bung in air-tight in order to expel the air which fills the space in the keg not occupied by the juice. The bung was then driven in by tapping with a hammer and more gas admitted. The keg was vigorously rocked so as to thoroughly agitate the juice and so accelerate the absorption of the gas.

The gauge was watched, and in these experiments the pressure was not allowed to go beyond 15 pounds per square inch. The juice used in the carbonating work was quite cool, ranging from 48° to 68° F. (9° to 20° C.) in the different experiments. As the carbonating of liquids is apparently well understood, no attempts were made to correlate the pressure, temperature, and amount of gas which could be dissolved in the juice. In these experiments the juice was carbonated at a pressure not exceeding 15 pounds until a sample was drawn tasting distinctly of the gas, this being the amount of carbonation desired. Working under these conditions in the different trials, from fifteen minutes to one-half hour was required to carbonate 12 gallons of juice. The stream of gas was then stopped, the bung cautiously loosened, the contents of the keg poured out, and the juice bottled or canned.

The gas remains for some time in the juice when under atmospheric pressure and only gradually diminishes in quantity, so that great haste in sealing the juice is not necessary. If the carbonated juice is to be sterilized in cans they must be heated in stout frames to prevent distortion of the can while hot and consequent bursting. The finished canned product bulges the ends of the cans to some extent, but not enough to cause permanent bending. The juice must not be too highly charged with the gas nor removed from the frames while still hot, or such bending, with consequent weakening of the soldered joints and bursting of the can, may occur.

THE BEST CONTAINERS FOR STERILIZED JUICE.

In the work with juice treated as above described, bottles and cans have been used as containers. The other containers which might have been tried were barrels or kegs, and jugs. Owing to the great liability to leakage and consequent infection of juice when treated in barrels and kegs, these containers are considered impracticable when the juice is to be kept indefinitely. Jugs are considered to be too cumbersome and at the same time too fragile to be handled readily in comparison with cans.

For bottles, sound corks, well soaked in hot water, should be used. These can be wired in before the bottles are heated; or tin cork holders, which may be bought on the market, may be used. The exposed end of the cork should be dipped in hot paraffin or hot grafting wax after heating, to prevent the cork from drying out with consequent serious danger of infection of the bottled juice.

No trouble was experienced in sealing the cans. As previously noted, standard 1-gallon packers' cans were employed. These had a $2\frac{1}{16}$ -inch opening and were filled to within about one-quarter inch of the opening. The can was then wiped and the flux, consisting of rosin dissolved in alcohol, was applied. Hemmed caps were employed for sealing— that is, the tin cover which fitted over the opening in the can was fitted with a rim of solder. For sealing the can, a capping steel and soldering copper are required, also a gasoline furnace for heating the steel and copper, and a supply of flux, solder, and sal ammoniac.

Barrels and kegs can be successfully used as containers for sterilized juice when it is desired to keep the juice sweet for a limited period of a few days or weeks. The cask must be thoroughly cleaned and well steamed, and filled with the juice heated to between 149° and 158° F. (65° and 70° C.). The cask can then be bunged, but considerable contraction takes place on cooling, with resulting strain on the cask and consequent increase in the danger of leakage. It is a much better procedure to close with a clean cotton plug, and when the cask and contents are cool to remove the plug and quickly insert a wooden bung which has been sterilized by soaking in alcohol. Two experiments were carried on with success with 50-gallon barrels, following this procedure. This juice kept for ten days without showing fermentation. At this time the barrels were emptied and used for other purposes.

In the experiments with barrels, and in all other work in which the juice was heated except in bottles and cans, a pasteurizer (fig. 4) designed by Mr. Given, of the Bureau of Chemistry, was employed. It proved to be a very useful machine and was capable of heating the juice with perfect control of temperature at any desired rate up to several hundred gallons per hour.

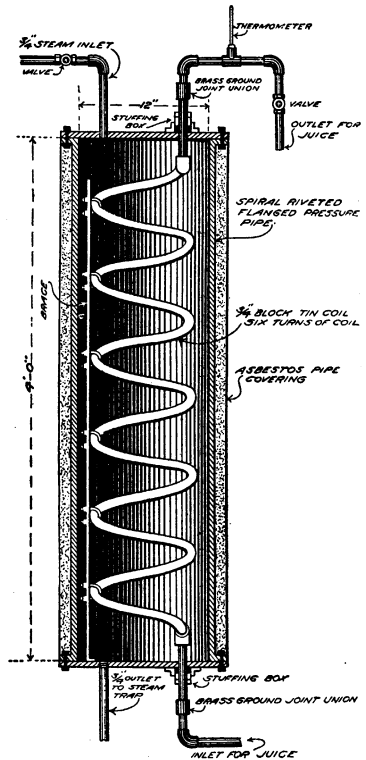


FIG. 4.—Pasteurizer for apple juice.

The cost of handling apple juice when it can be obtained perfectly fresh in clean barrels is slight. The only expense of separating the juice is for the labor, and if a small steam generator be used in connection with a turbine separator this cost can probably be lessened. Bottles of the champagne type cost from 3 to 5 cents each, and gallon cans cost from 4 to 5 cents each in lots of 1,000. On account of the acid nature of apple juice, the cans employed should be made of a high grade of tin plate and, as with other canned products, the juice should not be allowed to stand in the can after opening. With a view to lessening the action of the juice on the walls of the can, lacquering the inside of the can with a vegetable gum was tried. Considerably less action of the juice on the tin was noted when the lacquered can was used.

Sterilizing requires a tank of water which can be heated by steam or in any other way so that it can be easily maintained at the desired temperature. The apparatus for carbonating is simple and cheap, and the method is easy of application.

The chemical work in connection with the experiment has been to determine the composition of the juices employed and the effect of the treatment on the composition of the juice. The results of this work show that the chemical composition is practically unchanged by the treatment of clarifying, carbonating, and heating.