Rate of Heat Penetration During the Pasteurization of Cucumber Pickle[1][2]

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Introduction

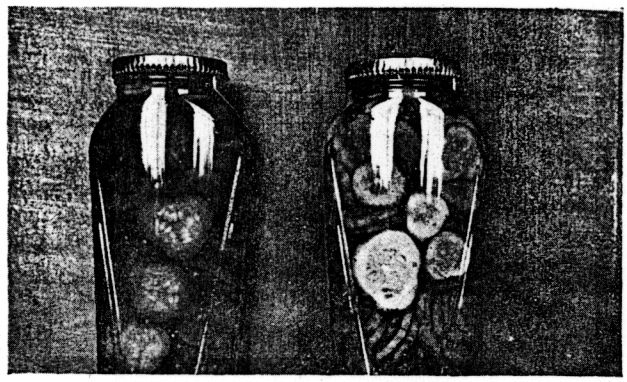
WHEN pasteurization can be safely employed in the preservation of certain fruit products it may not only serve to prevent deterioration due to changes brought about by microorganisms, but may also be used, when properly controlled, to prevent changes brought about by excessive temperatures which result in discoloration, "off" and "cooked" flavors, and physical changes in the structure of the fruit itself.

Of the various types of pickle products manufactured, at least one may be classified as a pasteurized product, wherein both the preservation brought about by heat and the influence of heat upon the physical structure are of prime importance. The style of pickle referred to is that prepared from sliced, green cucumbers and commonly called fresh cucumber pickle, old fashioned pickle or bread and butter pickle.

During the phase of manufacture of this type of pickle, that dealing with pasteurizing, it is highly important to know the rate of heat penetration to the center of the jar or container during the rise in temperature up to and including the holding temperature period. The amount of heat employed must be such as to destroy all microbial life responsible for spoilage and yet allow retention of the maximum amount of natural crispness in the cucumber slices. At the conclusion of the holding period, prompt cooling must prevent continued "cooking" if a product of the highest quality is to be obtained.

Some of the phases that must be considered before adopting a pasteurizing temperature are: (1) firmness of the green cucumbers, (2) brining of the cucumber slices, (3) numbers and types of microorganisms to be killed, (4) pre-heating of the slices and liquor prior to pasteurizing and finally (5) the size of the jar or container to be pasteurized.

The effectiveness of pasteurization in the preservation of the quality and appearance of fresh cucumber pickle is illustrated in Figure 1. The unpasteurized jar contains a clear, flabby, unpalatable product which has lost all of its fresh texture and appearance. The pasteurized jar retains the fresh characteristics over a period of several months' storage.



Unpasteurized Pasteurized

Fig. 1. The effect of pasteurization in preserving the quality and appearance of fresh cucumber pickle.

The material presented will be more or less confined to the experimental studies on the pasteurization procedure in regard to fresh cucumber pickle. Particular emphasis will be placed on the rate of heat transmission into the center of the glass jars and the rate of heat loss during the subsequent cooling process.

Experimental Procedure

THE temperatures chosen for pasteurization, as well as the holding periods, were arrived at through the aid of careful bacteriological analyses. These studies were made on all of the various stages of the manufacture of the pickle.

The pickle to be pasteurized was packed in 24 oz. jars, the ratio of slices to liquor being approximately 5-to-3. The jars were placed in rectangular wooden crates, constructed so as to provide ample circulation of water and capable of holding 18 jars.

To permit the recording of temperatures by the use of thermocouples, a small groove was filed on the neck of the jar, a thermocouple inserted to the center of the jar, and the jar closed by a 70 mm. Halyard Crown Cap. Jars so provided were distributed throughout the pasteurizing tank. Temperatures were read by a potentiometer which was scaled to read in degrees Fahrenheit. In those cases where temperatures were determined by use of mercury thermometers, these latter were inserted into the centers of the test jars through

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holes punched in the caps. The thermometer in each case was insulated from the metal by a cork stopper bored to fit the thermometer. Jars so equipped were placed at the top and bottom levels of the tank. A strong cord fastened around the necks of the jars served as the method for raising and lowering.

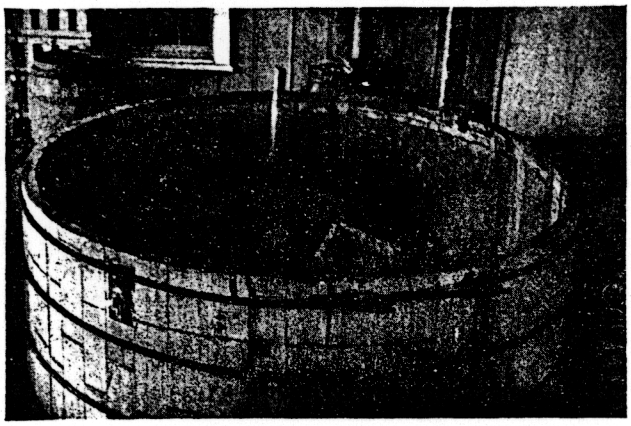

Fig. 2. Showing pasteurization tank with "V" circulating baffle in foreground.

One of the tanks used for pasteurizing (Figure 2) had the following specifications and equipment: A wooden tank 8 feet in diameter with a capacity of approximately 1,500 gallons. The water was heated by steam, a one-inch open end pipe being run down the side of the tank and across the floor to within about 2 feet of a wooden circulation baffle, the latter being made of two boards 1 inch thick and 12 inches wide each, set at an angle of 45 degrees and mounted to the side of the tank. The "V" baffle was notched where it came in contact with floor of the tank so as to allow introduction of water for cooling through a hose line run down the inside of the baffle. Two holes were bored on opposite sides of the tank for draining and were supplied with long plugs that could be easily reached from the top of the tank.

On the floor of the tank pine 2 x 4's were put down parallel to the steam line, being placed in such a manner as to serve as circulating channels for the water during pasteurization and cooling, as well as keeping the crates on the bottom tier from too close contact with the steam line.

The tank was loaded in the following manner. The first tier of crates was arranged on the edges of the parallel 2 x 4's in such a manner as to allow free circulation of water and the subsequent tiers were then added. The tank when loaded held approximately 100 crates, this number making 5 tiers, bringing the top tier to within about 6 inches from the top of the tank.

After the crates of pickle were properly placed in the tank, the draining holes were plugged and the tank filled with water. Steam was allowed to enter during the filling, being admitted as soon as there were a few inches of water visible in the bottom of the tank.

For the experimental runs where the jars were cooled rapidly, water was added through a hose line which was run down the inside of the baffle to within 6 inches of the bottom of the tank. The object was to add the water slowly at first, at the bottom of the tank, and to cool the jars by upward displacement of the hot water by cold.

Discussion of Results

IN Figure 3, curves are shown for the recorded temperatures as indicated by the thermocouples placed in the center of the jars, the jars being at different levels throughout the tank. The five different levels represent the tiers of jars in which the thermocouples were located as shown in the diagram (lower right, Figure 3).

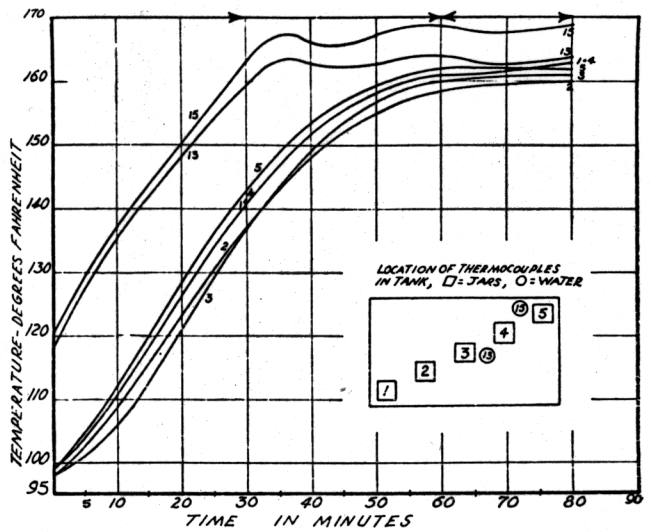

Fig. 3. Rate of heat penetration to the center of 24 oz. jars of cucumber pickle as indicated by thermocouples during the pasteurization at 160° F. for 20 minutes.

It will be noted that there is but one curve for thermocouples Nos. 1 and 4, the reading being identical during the course of the heating. Examination of the curves show that the water reached 160° F. in about 30 minutes, the jars reaching the same temperature in approximately 60 minutes, indicating a definite lag, this being fairly consistent during the approach of the jars to 160° F. As the jars approached the pasteurizing temperature the steam had to be reduced to avoid heating the water to too high a temperature, which would also advance the temperature in the jars to above that which was desired, the effect of which is shown by the gradual manner in which the thermocouple curves smoothed out between 150° F. and 160° F.

The curves for the recorded temperatures of the water at the top of the tank as well as those of two jars located at two levels of the tank are shown in Figure 4. In general the rise in temperature of the jars and that of the water is similar to that described in the explanation of Figure 3. The same consistent temperature lag in the jars as compared to water is noted as 160° F. is approached. At the conclusion of the holding period water was added from the bottom of the tank, the downward trend of the curves shows the cooling effect. After

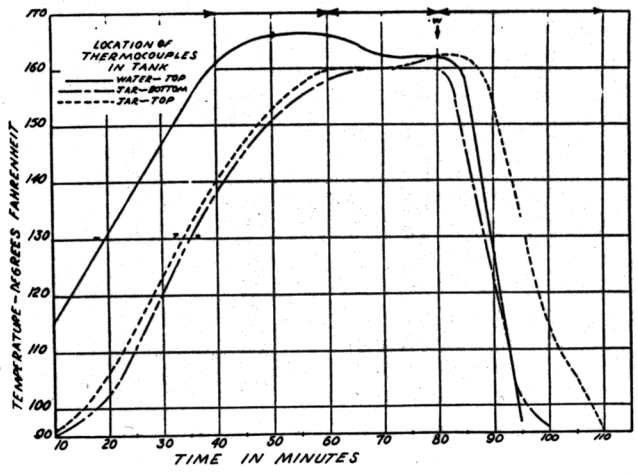

Fig. 4. Rate of heat penetration to the center of 24 oz. jars of cucumber pickle during pasteurization at 160° F. for 20 minutes and the heat loss upon subsequent cooling.

about 25 minutes all of the jars were considered to be below 110° F. which can be said to be safe from continued heating changes.

Figure 5 shows the temperature recordings of an experimental run where mercury thermometers were used in place of thermocouples, the former being more adaptable for routine plant procedure. Curves are shown for water temperatures taken at the top of the tank, also jar temperatures taken at the top and bottom levels of the tank. It will be noted the water reached approximately 160° F. in 50 minutes and the jars in 70 min-

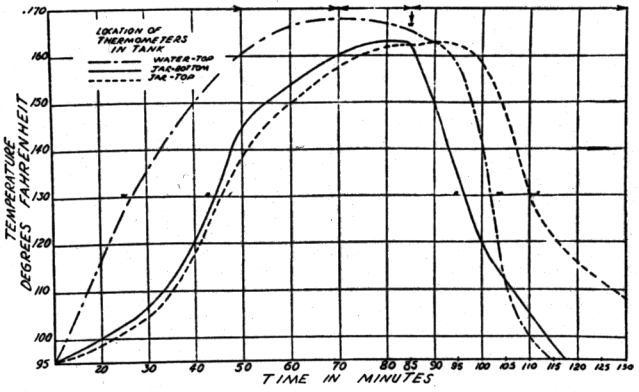

Fig. 5. Rate of heat penetration to the center of 24 oz. jars of cucumber pickle during the pasteurization at 160° F. for 15 minutes and the heat loss upon subsequent cooling.

utes. Slowness in raising the jars to the pasteurizing temperature in this run may be partly explained as due to demands on the steam pressure at other outlets about the plant. A consistent temperature lag is shown during the approach to the 160° F. in the jars as compared to the water temperature. At the conclusion of the holding period, water was added as previously described and the sharp decline of the curves shows the cooling effect of the water. In 20 minutes the lower jars were sufficiently cooled to avoid deterioration due to continued heating. The top level of jars reached the safe range in 35 minutes. As would be expected, there was a lag in the rate of cooling in the top level of jars as compared to the bottom level of jars.

Since the formula used by another firm might not be the same as that used in these studies no recommendations are offered. The temperatures and holding periods given do not necessarily apply where the acidity, salt and sugar content and certain phases of manufacture are different. Trial runs should be made before a definite procedure is adopted.

Summary and Conclusions

IN conclusion it may be said that in the pasteurization of cucumber pickle in accordance with the equipment and procedure described there is a definite lag period in the jar temperature as compared to the water temperatures while approaching the 160° F. pasteurizing temperature. While the time in minutes for the jars and water respectively to reach 160° F. may vary somewhat for different runs, the lag period between the two remains more or less constant while arriving at different temperature levels.

The data indicate that the circulation afforded by the steam pressure directed at the "V" baffle is adequate to give a relatively even temperature throughout different tank levels. Minor temperature differences encountered may be attributed to the following: changes in steam pressure, lack of free circulation of water due to improperly placed crates, individual errors of one or two degrees in thermocouples and finally, the difficulty of placing jars with inserted mercury thermoetmers in any other place but the bottom of the tank directly in contact with the water as it leaves the baffle.

The addition of cold water (76° F.) at the conclusion of the holding period was found satisfactory in cooling the jars in sufficient time to avoid changes in the pickle attributed to "cooking."

Acknowledgment

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