HIGH-TEMPERATURE SHORT-TIME PASTEURIZATION OF ICE CREAM MIX

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The desire of many ice cream manufacturers in recent years to use a HTST method for pasteurizing ice cream mix has presented public health officials with the problem of determining proper time and temperature standards for use in such a process. Such standards must not only insure the destruction of pathogenic bacteria which might be present, but should provide for the destruction of other bacteria present, to an extent comparable to that for the holder process. The standard for this process is 155°F for 30 minutes, as stipulated in the U. S. Public Health Service Ordinance and Code for Frozen Desserts (1940). The interest of the industry to use a HTST process for ice cream mix leaves little doubt of its probable adoption generally, particularly by larger companies. The absence of any standard for the HTST process until 1948 has undoubtedly delayed the adoption of such processes in areas operating under the U. S. Public Health Service Ordinance and Code for Frozen Desserts.

Present Status

In 1943 Dowd and Anderson used an Electro-pure unit for the HTST pasteurization of ice cream mix. Portions of mixes were pasteurized at 180°F for 19 seconds in the HTST unit and at 160°F for 30 minutes in a vat pasteurizer. Averages of the standard plate count indicated that the HTST process was just as efficient as the holder process in reducing the total number of bacteria in the mix. Phosphatase determinations also showed that this HTST procedure adequately pasteurized the mix.

In discussing the dual use of the Vacreator for condensing milk and pasteurizing ice cream mix, Wilster in 1945 reported the total counts of mix obtained by this process. In these studies the first chamber was controlled to heat the mix to 198-200°F, in the second chamber it was cooled to about 161°F, and to 100°F in the third. At one installation studied the mix from the Vacreator gave counts of bacteria per ml from 0 to 300, while at a second, counts from 200 to 1200 were obtained. Phosphatase tests on all mixes so pasteurized were negative. Unfortunately, there were no comparisons with pasteurization at 155°F for 30 minutes.

Speck in 1946 conducted plant experiments to ascertain the destruction of the normal flora of bacteria in ice cream mix by HTST pasteurization. A plate heater normally used to preheat mix for holder pasteurization was fitted with a holding tube, the cold mix being heated directly to the pasteurization temperature without any preheating, such as is obtained in a regenerator. Although the pasteurizer was of 1000 gallon per hour capacity, the volumes processed, and thus the time of pasteurization, were varied by means of a Reeves Vari-Speed Moto drive connected to a Waukesha sanitary pump. The unit was timed for the various holding times by injecting saturated salt solution into water being pumped through the unit. The salt was injected at a valve located on the holding tube, 26 inches from the heater, and its appearance at a sampling valve located 5 inches from the flow diversion valve was detected by a Sol-u-bridge.

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After sterilization of the equipment, usually two different mixes were pasteurized at varying temperatures for a given holding time. Pasteurization temperatures from 165°F to 180°F, at 5°F intervals, were used for holding times of 25, 26.5, 29.5, 32.5, and 37.5 seconds. Approximately 10-ml samples were collected from the sampling valve on the holding tube located just ahead of the flow diversion valve, and cooled in ice water. In addition samples of the unpasteurized mix were collected for determining the total and coliform counts. A 5-ml portion of each raw mix was laboratory pasteurized at 160°F for 30 minutes, this time and temperature being used as a basis of comparing the effectiveness of the HTST pasteurization experiments, since it is the usual pasteurization treatment used in the industry. The results showed that HTST pasteurization by this plant equipment using 175-180°F for 25 seconds gave bacterial destruction equivalent to laboratory pasteurization at 160°F for 30 minutes. Longer times at 175°F and 180°F did not increase the bacterial kill significantly. Although coliform bacteria were present in all the raw mixes, none survived any of the plant HTST pasteurization treatments or the laboratory pasteurization.

The foregoing study indicated quite definitely that HTST pasteurization of ice cream mix at 175-180°F for 25 seconds should kill any pathogenic bacteria present, as based on its effectiveness of bacterial kill equivalent to the holder process which has a wide margin of safety for such purposes. It was felt by a number of persons, however, that more direct information should be available on the minimum times and temperatures required to insure the destruction of pathogens in HTST pasteurization of ice cream mix. In order to obtain such information Speck studied the times and temperatures required to kill Micrococcus freudenreichii (No. MS66) in mix. This organism was used after unsuccessful efforts were made to locate the heat-resistant *Escherichia coli* (No. 3U), a culture which had somewhat greater heat resistance than *Mycobacterium tuberculosis* and *Brucella abortus*, and which had been used by previous investigators as an index of safe pasteurization and sterilization procedures. Fortunately, *Micrococcus freudenreichii* (No. MS66) possessed practically the same degree of heat resistance in milk as reported for *Escherichia coli* (No. 3U), and in addition could be grown with the selective medium desoxycholate lactose agar (BBL) on which it formed small red colonies in 48 hours at 37°C. The technique used in the laboratory HTST pasteurization studies was modeled somewhat after the one used by Fuchs, who eliminated the effect of heating-up times in similar studies on milk by inoculating a tube of tempered milk with a drop of test culture. The method developed consisted of placing 5 ml of mix, obtained by melting vanilla ice cream, in a sterile 120 x 20 mm glass vial plugged tightly with a rubber sleeve stopper. A series of tubes so prepared were tempered to the temperature under test. Then tubes were inoculated singly for given holding times with a suspension of the test culture, which had been grown on agar slants of a yeast extract-proteose peptone medium, suspended in sterile water, then shaken and filtered through sterile filter paper to eliminate clumps-of cells. This suspension contained about 500 million cells per ml. Then 0.05 ml of the suspension was inoculated into the tempered mix through the rubber stopper by means of a 1-ml tuberculin syringe fitted with a 2-inch 20-gauge hypodermic needle. This permitted instantaneous inoculation and mixing of the test culture in the mix, and gave 1-2 million cells of the culture per ml of mix. After the desired holding period the tube was cooled rapidly in ice water. The pasteurized inoculated mix, as well as controls of unpasteurized inoculated mix and pasteurized uninoculated mix, were plated on desoxycholate lactose agar (BBL).
and incubated at 37° C for 48 hours. The red colonies of *M. freudenreichii* (No. MS66) were then counted. The results showed that 99.99 percent destruction of the culture was effected in the ice cream mix at 150° F in 15 minutes, at 155° F in 2 minutes, at 160° F in 45 seconds, at 165° F in 12.5 seconds, and at 170° F in 1 second. Thus the U.S.P.H.S. standard of 155° F for 30 minutes and the suggested 180° F for 19 seconds or the 175° F–180° F for 25 seconds appeared to have quite large margins of safety for the destruction of pathogens in ice cream mix.

In 1948 Minthorn 4 described a commercial installation for the HTST pasteurization of ice cream mix, using a special heater for rapid heating and agitation of the mix during passage through the heater. In this operation the mix was pasteurized at 175° F for 23 seconds. By this treatment the author reported that the total count was low, coliform bacteria were destroyed, and phosphatase was inactivated.

The work of Sanders and Sager 5 on the heat inactivation of phosphatase in ice cream mix showed that 155° F for 30 minutes, or the 2 suggested HTST standards of 175–180° F for 25 seconds or 180° F for 19 seconds, would produce a safe product with a large margin of safety, based on the destruction of this enzyme as an index of safety. Thus in their studies phosphatase was destroyed at 155° F in 5 minutes, at 161° F in 60 seconds, or at 165° F in 21 seconds.

In view of the desire of a number of ice cream manufacturers to use HTST pasteurization, Mr. A. W. Fuchs, 8 of the U. S. Public Health Service, suggested that in areas operating under the *Ordinance and Code for Frozen Deserts*, a temporary standard of 175° F for 25 seconds be adopted until further research indicated any necessary change. This time and temperature combination appeared to be equivalent to 155° F for 30 minutes in bacterial destruction, based on the data available, but the need for further information regarding this proposed standard was recognized. Although there may be some question regarding its bactericidal equivalence to the standard for the holder process, there can be no doubt regarding the adequacy of the temporary HTST standard in eliminating pathogens.

**QUESTIONS STILL CONFRONTING THE USE OF HTST PASTEURIZATION OF ICE CREAM MIX**

The primary bacteriological problem remaining is the determination of time and temperature combinations equally as destructive to bacteria harbored in ice cream mix as is 155° F for 30 minutes. Although the present tentative standard presumably fulfills this requirement, more confirming data is desirable, and data should be available also on times required at higher temperatures. A process for which the latter data would be applicable, for instance, would be in plants where pasteurization is done by the Vacreator. Furthermore, as HTST pasteurization of ice cream mix becomes more generally adopted, it is very possible that pasteurizers different from the ones now available will be introduced. Such new equipment conceivably may be designed to operate at times and temperatures different from the present tentative HTST standard. Such developments could be expedited by having advance knowledge concerning the requirements of the times, at a series of temperatures, for the proper destruction of bacteria in ice cream mix.

Another problem of possible importance in the pasteurization of ice cream mix is the effect of varying concentrations of certain ingredients in different mix formulate. This question has received no attention previously. Even though the total solids concentration of mix may not vary markedly, the fat and solids-not-fat components are varied. It is the latter that may be expected to have a measurable effect on the destruction of bacteria present. In the pasteurization of chocolate milk,
Speck et al. found that increasing the added sugar concentration from 5 percent to 8 percent, or the addition of 3 percent non-fat-milk-solids tended to prolong the time for the destruction of Micrococcus freudenreichii (No. MS66) at 143° F, 145° F, and 150° F. No effect was found by increasing the stabilizer from 0.0555 percent, the preferable concentration, to 0.07 percent the maximum usable without getting coagulation and wheying-off. In this connection, the work of Sanders and Sager showed the probable effect of solids-not-fat on the destruction of phosphatase. Thus, skim milk required only 0.7° F less, and 20 percent or 40 percent cream required only 0.7° F more than the temperature required to inactivate phosphatase in 4.0 percent milk. However, ice cream mix required about 4.5° F more and sherbet 5.7° F more than the temperature required to inactivate phosphatase in milk. Butterfat concentration evidently had relatively small effect, but the solids other than fat had a very pronounced effect on phosphatase destruction. Studies are now in progress in the writer’s laboratory to gain information on these and similar problems concerned with the HTST pasteurization of ice cream mix.

The determination of holding times in HTST pasteurization of ice cream mix presents another problem. When the difficulties encountered in timing milk in HTST pasteurizers are considered, it is obvious that ice cream mix presents greater ones. For example, the viscosity of mix offers more opportunity for “coring” effects in the conventional holding tubes, which makes the customary timing by water of questionable value for use in ice cream mix pasteurization. Timing is concerned primarily with the shortest time required for the fastest moving bacterium to pass through a holding tube or chamber, yet laminations of mix formed on the sides of the tube or chamber conceivably could cause faster movement of the mix at the center. It is essential, therefore, that timing measurements should be of this fastest moving portion. In establishing standards of holding times at different temperatures, however, it would be reasonable to expect that consideration be given to lethal temperatures present during the heating-up and cooling periods which are usually obtained in plant installations.

Aside from the bacteriological considerations of HTST pasteurization of ice cream mix, there are those concerned with the general operational program of manufacturing plants, the selection and use of stabilizers, and the effect of this type of pasteurization on the various characteristics of the finished ice cream. These manufacturing problems will undoubtedly receive more attention as the HTST methods are accepted from the public health viewpoint.

REFERENCES