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Food Science and Technology Notes

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TIME-TEMPERATURE CONSIDERATIONS IN THE PASTEURIZATION OF ICE CREAM MIXES

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The mix pasteurization methods have received a great deal of attention in recent years, the interest growing chiefly out of the desire to reduce processing costs and increase the production capacity. The efforts have been directed primarily toward systems of continuous pasteurization which have proven their efficiency in related industries. There are certain problems, however, which are peculiar to the processing of ice cream mixes and for that reason deserve careful consideration.

The Purpose of Mix Pasteurization

In the eyes of the general public, the principal function of pasteurization is that of destruction of pathogenic microorganisms. Pasteurization standards set up by the U. S. Public Health Service as well as those of State and local public health regulatory agencies, are formulated with this purpose in mind. Actually, the standards are sufficiently high to provide a significant safety margin over the time and temperature actually required to destroy the pathogens. As a consequence, a mix processed in conformity to these standards will have its total bacterial content drastically reduced which carries with it the beneficial effect of improving its keeping quality.

Pasteurization also destroys some naturally occurring, though undesirable, enzymes in milk. Thus, if ice cream were made from a raw mix, it would be almost certain to develop a rancid flavor as a result of the action of the enzyme lipase.

Additional functions of pasteurization are related to the actual mix making process. The application of heat is required to dissolve the sweetening agents, some flavoring materials such as chocolate liquor or cocoa, ingredients such as frozen cream or frozen eggs, and stabilizers and emulsifiers. For proper

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homogenization, the mix should be homogenized at an elevated temperature, preferably 140°F or higher. The body and texture of ice cream is influenced by the heat treatment given to the mix. As the processing temperature of the mix is increased, there will be a tendency toward a smoother texture and a drier body in the ice cream.

It can be seen that heat treatment of the mix is an important processing step. The ice cream manufacturer would want to heat the mix even if regulations did not require it.

The Present Standards

The U. S. Public Health Service pasteurization requirements are 155°F for 30 minutes and 175°F for 25 seconds for the batch and high-temperature short-time processes, respectively. Approval has also been given specifically to a process in a unit called the Vacreator in which the mix is heated to 194°F for 0.75 seconds and another unit called the Roswell Heater in which heating to 200°F for 3 seconds is employed. Variations from these requirements may be encountered in some localities, such as the batch pasteurization standard of 160°F for 30 minutes in Chicago and elsewhere.

The pasteurization requirements for ice cream mixes are significantly higher than those for milk. One reason for this is that the higher solids content protects both bacteria and enzymes from the destructive effects of heat. Since the composition of ice cream mixes and related products may vary widely in fat, serum solids, and sugar content, it is important that the standards provide an adequate safety margin even under conditions when the microorganisms receive maximum protection from the solids. All of the solids in the mix contribute to the protective effect, but it has been demonstrated that the enzyme phosphatase, whose inactivation is used as a test for the adequacy of pasteurization, derives considerably more protection from increasing nonfat solids in the mix than from the fat. In spite of these considerations, indications are that the safety margin afforded by the ice cream mix pasteurization standards is greater than that provided by the milk pasteurization standards.

How Are Bacteria Destroyed

It is generally accepted that when bacteria are subjected to a heat treatment they are destroyed in a predictable manner. The rate of destruction at any given temperature will vary with different species of bacteria. Some organisms are killed slowly and these are called thermophilic or heat resistant bacteria. Some bacteria belonging to the spore forming group are not killed by pasteurization at all and require heating to about 240°F for 15 minutes for complete destruction. Sterilization of evaporated milk, for instance, depends on the destruction of these most heat resistant organisms.

The time required for complete or practically complete destruction of any organism at different temperatures also generally follows a predictable pattern. This can best be seen graphically. If the logarithm of the time interval is plotted against the temperature, a straight line is obtained connecting all points. The slope of this line is characteristic of the organism tested and will vary with different organisms.

This regularity in which bacteria are killed by heat, in a sense, had made it possible to establish pasteurization standards. If the destruction rate followed an unpredictable pattern, one could never be sure that a product was free of undesirable organisms. Our present pasteurization standards, therefore, give a very high degree of assurance that their time and temperature combinations are more than adequate to destroy any known disease producing organism which may be found in an ice cream mix.

Evolution of the HTST Standards

A great deal of experimental work has preceded the establishment of the present HTST standards for ice cream mix. In some of the early studies, investigators were comparing the destruction of the natural flora of the mixes when processed by both the batch and HTST procedures. Since a possibility existed that the organisms present in these mixes may have been largely of the nonresistant types, later investigations were conducted with known heat resistant test organisms. The most widely used test organism was *Micrococcus* sp. MS 102. It is extremely heat resistant as evidenced by the fact that it is able to survive heating to 155°F for 30 minutes in significant numbers. It was only after the evidence from a number of these studies was evaluated that a standard of 175°F for 25 seconds was established.

Several types of equipment were used in the experimental work on HTST pasteurization. They included tubular, plate, film, and vacuum heat exchangers. Before any particular heat exchanger may be used commercially, it requires the approval of the Public Health regulatory agency which exercises jurisdiction in a given geographic area. The design of each type of equipment is carefully scrutinized to insure that it complies with sanitary construction requirements and is so engineered that every drop of mix is at all times subjected to the prescribed time and temperature exposure. Safety devices must be incorporated which will automatically prevent unpasteurized mix from leaving the heater under such adverse conditions as a power or steam failure.

Since the HTST pasteurization standards for milk (161°F for 15 seconds) differ from those of ice cream mixes, some complications arise when the same equipment is to be used for processing both products. In the extreme case, it may be necessary to install dual controls and separate holding tubes, although the problem may at times be solved in a simpler way. If the processor were willing to pasteurize milk at 175°F for 25 seconds and found the flavor of that milk acceptable for his purposes, this would be the simplest solution.

Pasteurization standards designate the minimum heat treatment required to insure public safety. The processor may use higher temperatures and longer holding times at his option. Some processors heat vanilla mixes to 165°F for 30 minutes or 220°F for 25 seconds to improve the body and texture of the ice cream. Chocolate mixes may require heating to 175°F for as long as 30 minutes to bring out the desirable flavor of the chocolate. Continuous pasteurization using properly designed equipment offers a great deal of flexibility in the selection of the desired pasteurization temperature.

Technological Considerations

Continuous processing has the inherent potential of higher production capacity and lower production cost. It facilitates the employment of the regeneration principle which results in savings on both the heating and cooling requirements. It also provides for a more efficient utilization of floor space.

Certain routine mix making procedures have to be modified when the mix is pasteurized continuously. To effect maximum economy, the ingredients should be introduced in readily dispersible form, and the mixture must be thoroughly agitated. When it is necessary to use ingredients which do not disperse readily, a pre-solution system may be readily designed in which these mix constituents are dissolved in a minimum amount of water by applying heat. The correct amount of water needed should be determined by actual trial and taken into account in calculating the mix composition.

The mix may be homogenized either before or after final heating, following passage through a part or all of the raw or pasteurized side of the regenerator, respectively. The choice depends on the circumstances encountered in any given installation and is based on such factors as emulsion stability, viscosity control, sanitation, and, all factors being equal, convenience.

With few exceptions, the mix formula does not need to be modified when changing from batch to HTST pasteurization. Ordinarily, there would be no reason to change the fat, serum solids, and sweetener concentration. The amount of stabilizer used will depend on the pasteurization time and temperature. With the minimum required process of 175°F for 25 seconds the body and texture of the ice cream would be inferior to that made from a batch pasteurized mix, unless the stabilizer content is increased. It may be necessary to use as much as 1.2 lbs. of stabilizer for every 1 lb. needed in a batch pasteurized mix.

As the pasteurization temperature is increased, the stabilizer requirements are gradually lowered until, at some point, they become equal for both the batch and the HTST pasteurized mixes. A further increase in the pasteurization temperature may actually permit a slight reduction in the stabilizer content over that in batch pasteurization. This point is generally reached at above 215°F for 25 seconds or above 230°F for 3 seconds, as under these conditions the hydration of milk constituents effectively augments the stabilizer activity. Under favorable conditions, it may be possible to reduce the stabilizer by 10-20%. It is wise, however, to proceed with caution when reducing the amount of stabilizer because an excessive reduction may result in poor heat-shock properties and reduced storage life.

When the mix is pasteurized at 175°F for 25 seconds, the flavor of the resulting vanilla flavored ice cream should be as good as or better than that made from a batch pasteurized mix. As the processing temperature is increased, a cooked flavor is imparted to the mix, much of which, however, dissipates after freezing. The intensity of the flavor is somewhat related to the composition of the mix and the relative freedom from "burn-on" on the heating surfaces. Under most conditions it does not become significantly objectionable.

With a little experience, processors can find the best conditions for pasteurizing their mixes. Each product may have its own optimum conditions. A sherbet mix, for instance, would not need to be processed at the same temperature as an ice cream mix. Different heating conditions may also be found desirable for such products as ice milk mixes, soft-serve mixes, and milk shake mixes. Because of the inherent flexibility of continuous processing, temperature adjustments may usually be made without impairing the production capacity and efficiency of operation.