THE CONDENSATION PROCESS OF PREPARING AN ICE CREAM MIX

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The general lack of uniformity in the use of materials and the methods of manufacture is responsible for the great variation in the standards and quality of ice cream found on the market. In the present method of manufacture of commercial ice cream, whole milk, sweet cream, plain (superheated) condensed milk, sugar, gelatin, and the desired flavoring usually form the ingredients. Evaporated milk, sweetened skim condensed milk, or milk powder and butter may be substituted for the above lacteal materials. A balanced supply of the different ingredients must be kept on hand at all times, and mixed together as needed. The mix is standardized to conform to a state requirement or a desired composition. In some cases the cream or the entire mix is pasteurized; and in a few plants the mix is homogenized. This must be followed by aging to insure the desired yield.

Within the last year the use of the condensation process of preparing an ice cream mix has greatly increased. This method consists essentially of combining sugar and the different lacteal substances in the proper proportions, evaporating to the desired composition, homogenizing, and cooling. The main purpose is to utilize merely milk and butter as the basis of the milk solids and butterfat. In the present methods of manufacture, however, it is impossible to use only milk and butter because the content of milk-solids-not-fat would be insufficient.

This paper is the report of a study which was made of the methods of preparation and standardization, and the bacterio-

1 This work was carried on under the supervision of Dr. M. J. Prucha and Dr. O. R. Overman, and with the cooperation of Dr. H. A. Ruehe, Dairy Department, University of Illinois, Urbana, Illinois.
 logical factors concerned in the condensation process. Part I deals with the preparation, and part II takes up a study of the bacteria in the condensed mix.

**I. PREPARATION OF THE CONDENSED MIX**

*Apparatus required*

In the preparation of the condensed mix the essential equipment is some form of concentrating apparatus. The ordinary "vacuum condensing pan" is the most efficient for this purpose. This consists of a copper retort with a steam-jacketed bottom, steam coils inside, and some form of condenser. A large, steam-driven, vacuum pump makes possible the evaporation of water under reduced pressure, at a temperature of about 130°F., thus promoting rapidity and economy of evaporation.

The ingredients are mixed in a large open kettle, commonly known as the "forewarmer." Any vat could be utilized for the purpose. Heat may be applied by means of coils, or by introducing live steam directly into the mixture. While the latter method introduces some water, it is more rapid and serves to agitate the milk while being heated.

A Baumé hydrometer, or a Westphal balance, may be used to indicate the point of proper concentration. Either a homogenizer or a viscolizer must be utilized in order to thoroughly emulsify the fat in the mix. This prevents the rise of butterfat during storage, and increases the viscosity of the mix. An efficient means of cooling must be provided. The ordinary upright open-faced cooler answers the purpose. This type of cooler also permits the drawing off of the mix directly into clean, dry cans. The mix may be pumped into large, insulated storage tanks and held until needed.

*Materials used*

Fresh whole milk is the best and cheapest source of the milk-solids-not-fat. This provides a clean, fresh-milk flavor which is not destroyed in the process. Economy is obtained by con-
TRACTING FOR MILK DIRECTLY FROM THE PRODUCERS. EVEN IF MILK IS PURCHASED FROM DISTRIBUTORS, IT IS STILL THE CHEAPEST SOURCE OF MILK SOLIDS. SKIM MILK MAY BE USED TO ADVANTAGE, ESPECIALLY IF AN OUTLET FOR THE SWEET CREAM IS AVAILABLE.

UNSALTED BUTTER IS NECESSARY TO ADD TO THE MIX IN ORDER TO SUPPLY THE PROPER AMOUNT OF BUTTERFAT. SWEET CREAM MAY BE USED, BUT THE USE OF IT TENDS TO INCREASE THE COST OF THE MIX, UNLESS THERE IS NO OTHER OUTLET FOR THE SWEET CREAM. IF SWEET CREAM IS USED, ADVANTAGE IS TAKEN OF THE SOLIDS-NOT-FAT IN THE CREAM IN THE PROCESS OF STANDARDIZING.

EITHER CANE OR BEET SUGAR MAY BE USED FOR SWEETENING.

Process of Manufacture

/General Procedure. 1. Examine the milk to make sure that it is fresh, clean, and sweet. Test a representative sample of the milk and of the cream (if cream is to be used) for percentage of butterfat and total solids, calculating the solids-not-fat by difference. The percentage of butterfat in the butter should also be determined.

2. Calculate the quantity of each ingredient to use:
   a. It is necessary to first decide upon the percentage composition desired in the finished mix. Butterfat, milk-solids-not-fat, sugar, gelatin, and total solids must be taken into consideration.
   b. Such amounts of the different ingredients are used as will give the desired proportion of butterfat, milk-solids-not-fat, sugar, and gelatin in the finished mix. No further standardizing will then be required unless the batch is overcondensed, in which case pure water only is needed.
   c. When a definite quantity of mix is desired, the amount of milk required is ascertained by multiplying the percentage of milk-solids-not-fat in the mix by the pounds of mix, and dividing by the percentage of solids-not-fat in the milk. The amount of butter required is found by multiplying the percentage of fat in the mix by the pounds of mix desired, subtracting the product of the percentage of fat in the milk times the pounds of milk, and dividing by the percentage of fat in the butter.
d. When a given quantity of milk is used, the yield of mix is found by multiplying the percentage of solids-not-fat in the milk by the pounds of milk, and dividing by the percentage of milk-solids-not-fat in the desired mix. The butter is then calculated as in (c) above.

e. If cream is used, the ratio method of standardizing may be conveniently applied, advantage being taken of the solids-not-fat in the cream. Special tables have been prepared for a mix of a definite composition, which greatly simplify these calculations.

3. Weigh, or carefully measure, the required quantities of each ingredient into the forewarmer. The gelatin is added after condensing, either before homogenizing, or before freezing.

4. Heat the mixture in the forewarmer to 160°–170°F. This pasteurizes the mix, facilitates the melting of the butter and the solution of the sugar, and increases the rapidity of evaporation in the condensing apparatus.

5. Remove the excess water by evaporating under a vacuum of about 24 inches, at a temperature of 130°F. The batch is "struck" when the proper reading is obtained on the Baumé hydrometer, or Westphal balance.

6. Transfer the condensed mix to a vat with an efficient agitator. If this vat is mounted on scales, the mix may be weighed. Otherwise the full yield is obtained by measuring the volume and adding the necessary water to secure the proper yield.

7. Homogenize or viscolize the warm condensed mix, under a pressure of about 2000 pounds per square inch.

8. Cool the mix as rapidly as possible to a low temperature, preferably from 40° to 45°F.

9. Store the prepared mix at as low a temperature as possible, without freezing.

10. Retest the finished condensed mix, and restandardize if necessary.
The ingredients named under "materials" are placed in the forewarmer, resulting in a mixture having the composition shown in the second column. The excess water (510.5 pounds) is removed by condensing. When the desired composition is reached, the Baumé reading will be 10.3° at a temperature of 130°F. The final test is shown in the third column.

The mixture may be condensed slightly heavier than necessary, and made up to exactly 100 gallons by adding pure water. With the addition of flavoring, and gelatin if it has not been added previously, the mix is ready for freezing at any time.

Conclusions

1. A uniformly prepared ice cream mix may be made by the condensation process, using milk, butter or cream, sugar, and gelatin.

2. The condensed mix is easily standardized to a uniform composition by having the butterfat, milk-solids-not-fat, sugar, and gelatin in the proper proportion before condensing. A definite yield is thus obtained.
II. A BACTERIOLOGICAL STUDY OF THE CONDENSATION PROCESS

Since bacteria in ice cream are of importance from a sanitary as well as an economic point of view, a bacteriological study was made of the mix prepared by the condensation process.

Counts were made by the plate method, using standard lactose agar as media. An incubation period of four days at 30°C. was used. In all cases the counts given are the averages of the two plates made for each sample.

Source of bacteria

The lacteal substances used are the chief source of bacteria in the ice cream mix. Since milk and cream are ideal media for the growth and development of bacteria, it is to be expected that such products will greatly increase the bacterial count of the finished product. The sugar and gelatin are usually of minor importance, but utensils are a very prolific source of contamination.

The number of bacteria in the mix will vary according to the care that the milk products have received prior to their use, and according to the plant procedure. At the Iowa Experiment Station the number of bacteria in thirteen samples of ice cream was found to range from 130,000 to 40,850,000 per cubic centimeter (1). The United States Department of Agriculture found the average number of bacteria in 94 samples to be 37,859,907 per cubic centimeter. The maximum was 510,000,000, and the minimum 120,000 (2). The extremely high counts in ice cream are no doubt due to the fact that many manufacturers do not pasteurize their mix, nor take the proper precautions to avoid recontamination.

Efficiency of pasteurization of the condensing process

In order that ice cream may be a safe product for human consumption, and in order that the danger of souring may be reduced to a minimum, the mix should be subjected to some form of pasteurization. In the condensing process the mix is heated to 160°–170°F., in the forewarmer, and then condensed at a tem-
temperature around 130°F. The efficiency of pasteurization of this process is shown by the following tabulation:

<table>
<thead>
<tr>
<th>BATCH NUMBER</th>
<th>MIX BEFORE HEATING IN FOREWARMER</th>
<th>DIRECT FROM PAN</th>
<th>DESTRUCTION</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Actual count</td>
<td>Comparative count*</td>
<td>per cent</td>
</tr>
<tr>
<td>1</td>
<td>9,600,000</td>
<td>800</td>
<td>480</td>
</tr>
<tr>
<td>2</td>
<td>2,260,000</td>
<td>20,000</td>
<td>12,000</td>
</tr>
<tr>
<td>3</td>
<td>21,600,000</td>
<td>2,400</td>
<td>1,440</td>
</tr>
<tr>
<td>4</td>
<td>7,600,000</td>
<td>7,200</td>
<td>4,320</td>
</tr>
<tr>
<td>5</td>
<td>51,000,000</td>
<td>27,200</td>
<td>16,320</td>
</tr>
<tr>
<td>6</td>
<td>12,250,000</td>
<td>3,560</td>
<td>2,136</td>
</tr>
<tr>
<td>7</td>
<td>3,660,000</td>
<td>3,750</td>
<td>2,250</td>
</tr>
</tbody>
</table>

* The comparative count represents the number of bacteria per cubic centimeter that would be in the mix if the original volume had been retained, allowance being made for the decrease in volume, due to condensing. It is obtained by multiplying the actual count by 0.6.

These data show the completeness of pasteurization brought about by the heat in the forewarmer and condenser. In most cases the count of the condensed mix was quite low, the minimum being 800 and the maximum 27,200. Five of the seven batches run had a count of less than 7,500 per cubic centimeter.

The tendency of the unpasteurized mix to have extremely high counts is indicated by the number of bacteria per cubic centimeter found before heating it in the forewarmer. If ice cream is to be safely and economically produced, the mix must be subjected to some process that will greatly decrease the bacteria.

**Number of bacteria at different stages of manufacture**

To determine the relative importance of each step in the manufacture of the mix, counts were made of two batches after the completion of each step in the process. Care was taken to clean each utensil before it was used, by rinsing it with scalding water.

<table>
<thead>
<tr>
<th>BEFORE HEATING IN FOREWARMER</th>
<th>DIRECT FROM PAN</th>
<th>DIRECT FROM HOMOGENIZER</th>
<th>AFTER ADDITION OF GELATIN</th>
<th>PROSEN ICE CREAM</th>
</tr>
</thead>
<tbody>
<tr>
<td>9,600,000</td>
<td>800</td>
<td>1,400</td>
<td>1,450</td>
<td>2,600</td>
</tr>
<tr>
<td>2,260,000</td>
<td>20,000</td>
<td>26,200</td>
<td>26,250</td>
<td>31,000</td>
</tr>
</tbody>
</table>
These results indicate that after the mix is drawn from the pan the subsequent steps in the operation will result in the addition of only a very small number of bacteria if ordinary precautions are taken against recontamination. The increase after homogenizing and freezing is probably due, for the most part, to the breaking up of the bacterial clusters, which results in a higher count by the plate method.

The number of bacteria added by the gelatin will depend upon the grade of gelatin and the temperature to which it is heated. The temperature used in this experiment was 160°F., which was sufficient to kill most of the bacteria without injuring the jelling qualities of the gelatin. It may therefore be seen that with proper care there will be only a slight increase in the bacteria in the frozen ice cream over the number in the mix as it comes from the pan.

**Keeping qualities of the mix**

It often becomes necessary to store either the milk products or the mix for several days before freezing. It was found that condensed mix could be kept in a very good condition at a temperature of 32°-35°F for a period of two weeks. Some was kept a month and then frozen into ice cream which contained no noticeable off-flavors.

<table>
<thead>
<tr>
<th>Mix stored in 10-gallon can at 32°-35°F.</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>DAYS</strong></td>
</tr>
<tr>
<td>0</td>
</tr>
<tr>
<td>5</td>
</tr>
<tr>
<td>14</td>
</tr>
<tr>
<td>23</td>
</tr>
<tr>
<td>32</td>
</tr>
</tbody>
</table>

As might be expected from the bacterial count, very little difference could be detected in the taste of the mix during the first two weeks of storage. It was not until the third week that a slight off-flavor began to develop. Thirty-two days after it was put into storage, the mix was frozen into ice cream, and al-
though it contained large numbers of bacteria, no off-flavor could be detected in the finished product. If the condensed mix is properly made and handled, the ice cream manufacturer should have no trouble in storing it for two weeks at a temperature of about $32^\circ$ F.

Conclusions

1. From this experiment it may be concluded that it is possible to prepare an ice cream mix by the condensation process that contains a very small number of bacteria.

2. The number of bacteria in the mix as it comes from the pan approximately represents the number that will be in the frozen product, providing ordinary care is taken.

3. The mix will keep for two or three weeks when stored at a temperature of $32^\circ$–$35^\circ$ F.

REFERENCES