Ice Cream.

4

637.4 International Cooperation Administration.
I61 Office of Industrial Resources. NTIS
Ice Cream. May 1958.
24 p.
Prepared by John Crerar Library, Chicago.
IR 15586 PR.
Technical Inquiry No. 15.

1. Ice cream industry. 2. Industrial plants. I. Title.
II. Technical Inquiry No. 15.

TECHNICAL I

PN-AAS-161

# ICE CREAM

MAY 1958

Technical Aids Branch
Office of Industrial Resources
INTERNATIONAL COOPERATION ADMINISTRATION
Washington 25, D. C.

Reference Center
Room 1656 NS

# FOREWORD

The Technical Inquiry Service answers inquiries from overseas on factory or commercial establishment, operation, management, and engineering. This brochure is one of a series based on these technical inquiries.

This report is designed to provide only a general picture of the factors that must be considered in establishing and operating a factory of this type. In most cases, plans for actual installations will require expert engineering and financial advice in order to meet specific local conditions.

Mention of the name of any firm, product, or process in this report is not to be considered a recommendation or endorsement by the International Cooperation Administration, but merely a citation that is typical in its field.

Industrial reports prepared for ICA under special contract are customarily reviewed and edited before publication. This report, however, like other technical inquiry replies, has not been reviewed; it is the sole responsibility of the firm that prepared the report.

This brochure was prepared in January 1957 by the John Crerar Library, Chicago, Illinois

For further information and assistance, readers should contact their local Productivity Center, Industrial Institute, Servicio, or United States Operations Mission.

May 1958

A

TABLE OF CONTENTS


| | Page |
|---|---|
| Introduction | 1 |
| Receiving Room Operations | 7 |
| Mix Preparation | 8 |
| First Freezing | 11 |
| Final Freezing or Hardening | 11 |
| Packaging and Delivery | 12 |
| Records and Plant Costs | 12 |
| Equipment Manufacturers | 20 |
| References | 22 |


B

INTERNATIONAL COOPERATION ADMINISTRATION
OFFICE OF INDUSTRIAL RESOURCES

# TECHNICAL INQUIRY SERVICE

IR 15586 PR

## ICE CREAM

### I. Introduction

Ice cream varies in its composition to a more marked degree than any other dairy product. The possible combinations of the various ingredients are very wide, local preferences vary, and the various state and local laws and ordinances vary, so that there is no single definition for the product. The one ingredient most widely considered essential to ice cream is butterfat. Next in importance are the non-fat solids in milk, and sugar. These three ingredients, plus water, when whipped and frozen will make ice cream. Other ingredients are added to improve flavor, body, palatability, appearance, keeping quality, and to give other desired characteristics.

Most U.S. states specify minimum fat content, minimum solids content, and minimum weight per gallon as legal requirements for sale of the ice cream product in the respective states. The weight requirements refer to the frozen product. The composition standards are also in per cent by weight. Where weight requirements are mentioned, it is to control the amount of air in the product, the overrun. The ice cream requirements in effect in 1956 in the various states are given in Table I.

In the process of freezing, the mix is whipped to incorporate air, and the volume of the finished product is therefore substantially greater than the volume of the unfrozen mix. This increase in volume is known as overrun and is the ratio between the amount of the increase and the original volume, expressed as a percentage. The proper and exact control of overrun is important because of the effect on the quality of the ice cream, the yield obtained, and the profit. Too little air in the product will make it soggy and heavy and unpalatable. Too much air will make it frothy, snowy and flaky in texture. Since high overrun will materially increase the yield from a given quantity of mix, it is often a temptation to exceed the limits of quality, but this is unwise and is not common practice because of the adverse effect on quality and sales.

Although the percentage of each ingredient may show considerable variation, the total solids will usually remain between 38% and 41%. Fat, non-fat milk solids, and sugar constitute the bulk of the solids. Other sources of solid material are stabilizers, eggs, flavors, colors, fruits, nuts, etc.

TABLE I

1956 ICE CREAM STANDARDS BY STATES

| State | Min. Fat: Plain ice Cream | Min. Fat: Fruit, Nut, Chocolate | Min. Milk Solids | Max. Milk Solids, Milk Sherbets | Weight in Pounds per Gallon |
|---|---|---|---|---|---|
| Alabama | 10% | 8% | 18% TMS | 8% | 1.6 TFS |
| Arizona | 10% | 8% | 30% TFS | | |
| Arkansas | 10% | 8% | 18% TMS | 4% Min. Milk Sherb. | 1.6 TFS |
| California | 10% | 8% | | 4% Max. BF | 1.6 TFS |
| Colorado | 12% | 10% | | | |
| Connecticut | 10% | 8% | 36% TFS | 3% Max. BF Sherb.<br>3% Min. BF Ice Milk | 1.6 TFS |
| Delaware | 12% | Choc. 12%<br>Fruit, nut<br>8% | | 3% | |
| Florida | 10% | 8% | 18% TMS plain<br>14% fruit, etc. | 4% Min. | 1.6 TFS |
| Georgia | 10% | 8% | | | 4.5 |
| Idaho | 12% | 10% | 18% TMS | 4% Min. | 1.6 TFS<br>4.25 total wt. |
| Illinois | 12% | Choc. 10% | | | 100% overrun max. |
| Indiana | 10% | 8% | 18% TMS | 3% Max. BF<br>4% Min. MS | 1.6 TFS<br>4.25 total wt. |
| Iowa | 12% | 10% | 20% TMS | 4% Min. MS | 18 oz/qt at factory |
| Kansas | 10% | 10%* | 20% TMS | | |
| Kentucky | 10% | 10% | 18% TMS | | |
| Louisiana | 10% | 8% | 20% TMS plain<br>18% fruit, etc. | 10% MS | 1.6 TFS<br>4.5 total wt. |
| Maine | 11% | 9% | | | 1.6 TFS<br>4.5 total wt. |

| State | Min. Fat: Plain Ice Cream | Min. Fat: Fruit, Nut, Chocolate | Min. Milk Solids | Max. Milk Solids, Milk Sherbets | Weight in Pounds per Gallon |
|---|---|---|---|---|---|
| Maryland | 12% | 8% | 20% TMS | 1% Min. BF | 1.6 TFS<br>4.5 total wt. |
| Massachusetts | 10% | 8% | 18.5% TMS plain<br>16.5% fruit, etc. | 4% Min. MS | 4.5 |
| Michigan | 12% | 10% | | 2.5% Max. BF | 1.6 TFS<br>4.25 total wt. |
| Minnesota | 12% | 10% | 20% TMS | 4% Min. | 4.5 |
| Mississippi | 10% | Fruit-nut<br>8% | | 6% Max. TMS | 1.6 TFS<br>4.5 total wt. |
| Missouri | 8% | 8% | | | |
| Montana | 10% | Fruit 9% | 20% TMS | 5% Max. | 1.6 TFS<br>4.5 total wt. |
| Nebraska | 12% | 10% | 20% | 8% Max. | 4.5 |
| Nevada | 14% | 12% | | 8% Max. | 4.5 |
| New Hampshire | 14% | 12% | | 4% Min.<br>8% Max. | 4.5 |
| New Jersey | 10% | 8% | | 5% | 4.5 |
| New Mexico | 12% | 10% | 20% TMS | | |
| New York | 10% | 8% | 18% TMS plain<br>14% fruit, etc. | 5%; no MS allowed in ice sherbets | 1.6<br>4.5 total wt. |
| North Carolina | 10% | 8% | 35% TS | 4% Min. | 1.6 TFS<br>4.5 total wt. |
| North Dakota | 12% | 10% | | 4% Min. MS | 4.5 |
| Ohio | 10% | 8% | 18% TMS | 4% Min. | 4.5 |
| Oklahoma | 10% | 8% | 18% TMS | 5% Max. | 1.6 TFS<br>4.5 total wt. |
| Oregon | 12% | 10% | 20% TMS | | 4.5 |
| Pennsylvania | 10% | 8% | | 5% | 1.8 TFS<br>4.75 total wt. |

TABLE I (contd)

| State | Min. Fat: Plain Ice Cream | Min. Fat: Fruit, Nut, Chocolate | Min. Milk Solids | Max. Milk Solids, Milk Sherbets | Weight in Pounds per Gallon |
|---|---|---|---|---|---|
| Rhode Island | 10% | 8% | 20% TMS | 8% Max. | 1.6 TFS<br>4.5 total wt. |
| South Carolina | 10% | 8% | 18% TMS plain<br>16% fruit, etc. | 4% Min.<br>6% Max. | 1.6 TFS<br>4.25 total wt. |
| South Dakota | 12% | 10% | | 5% Min. Fat | 4.5 |
| Tennessee | 10% | 8% | 18% TMS | 4% | 1.6 TFS |
| Texas | 8% | 6% | | | 4.5 |
| Utah | 12% | 9% | 28% TFS | 4% Min. MS | 1.6 TFS |
| Vermont | 10% | 8% | | 1% Min. BF | 1.6 TFS<br>4.5 total wt. |
| Virginia | 10% | 8% | 35% TFS | 3% Fat | 4.5 |
| Washington | 10% | 10% | 20% TMS | | |
| West Virginia | 8% | 8%* | 10% non-fat MS | | |
| Wisconsin | 13% | 11% | | 2% Min. | 4.5 |
| Wyoming | 10% | 8% | 18% TMS | 10% Max. | 1.6 TFS<br>4.25 total wt. |

TMS = Total Milk Solids; TS = Total Solids; TFS = Total Food Solids; BF = Butter Fat
* With deductions due to addition of fruit, etc.

Stabilizers, such as gelatin, are used in ice cream to enhance the quality and appearance of the ice cream. They give the product a smooth texture, body, and proper melting resistance. Gelatin has a particular affinity for water, so that when used in the right proportions and added at the correct temperature, it will tend to "soak up" the free water in the ice cream mix, thus deterring the formation of large ice crystals. It increases the viscosity of the mix, producing a better body. The resulting ice cream will also retain its shape better when melting. Too much gelatin must not be used because of the adverse effect on the appearance of the melted ice cream. Other common stabilizers are sodium carboxymethylcellulose (cellulose gum) and "Dariloid", or sodium alginate.

Eggs are sometimes used in ice cream, both for mechanical reasons and because the flavor is sometimes thought desirable. Although whole eggs are often used, only the yolk provides the desired qualities. The mechanical benefit derived is that the egg yolk improves the whipping quality of the mix, improves the texture of the product, and to a certain extent helps to stabilize the mix. The whipping quality imparted by the egg yolk is of more benefit in batch freezers than in continuous freezers. Eggs are used in the mix in approximately the same proportion as a stabilizer -- usually less than half of one percent.

Flavors and colors are usually not considered a part of the basic mix. Liquid flavors are usually added to the mix just prior to freezing, solid flavors after freezing. Fruits, nuts, candies, etc., are also added after freezing. Chocolate, however, is usually added along with the basic ingredients. The amount of flavoring used depends on the strength of the flavoring material, the intensity of flavor desired, and the type of flavor. Coloring, if used, is usually added after the basic mix is processed, and just before freezing.

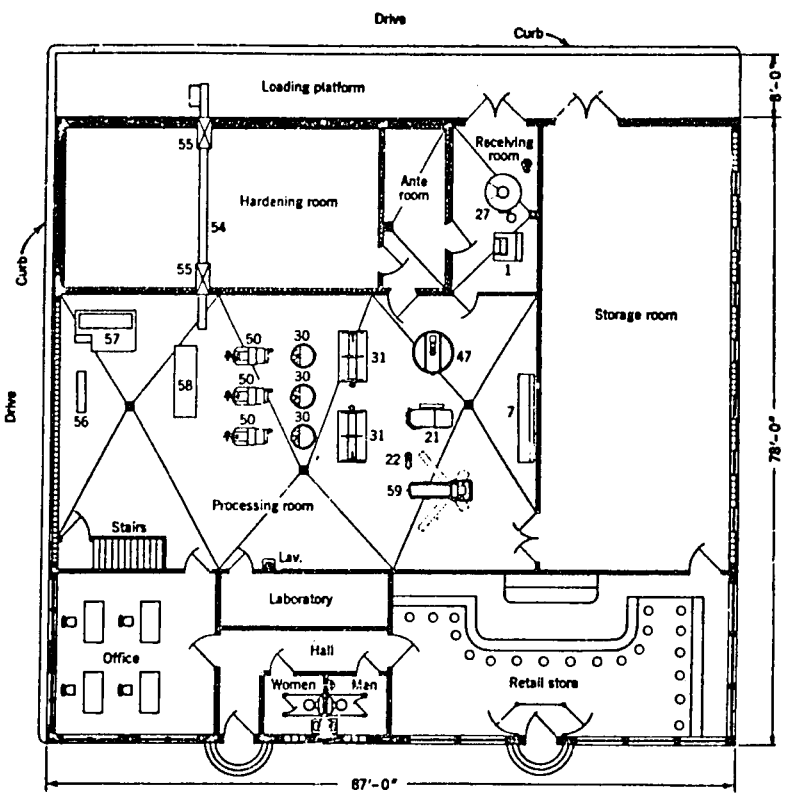
For many years commercially produced ice cream was packaged in bulk only. Later, consumer-size packages of pints, quarts and half gallons came on the market. Recently, the production of the so-called novelties, or individual portions, has constituted an increasing proportion of the ice cream products made in the U.S. One class of these, known as stick novelties, includes coated ice cream bars on a stick and water ices on a stick. Other novelties are ice cream sandwiches (a bar of ice cream between two cookies), factory-made ice cream cones with coatings, cake-ice cream rolls, etc. Production of such novelties requires the use of special equipment, most of which is patented and rather expensive.

In general, the manufacturing processes in a plant producing ice cream fall into four major groups: (1) receipt of raw ingredients; (2) mix preparation; (3) first freezing; (4) final freezing, or hardening. Each of these groups will be discussed separately. The equipment used for all operations involved in these groups depends on a number of factors, including the volume of production desired. Choice of equipment is best made by consultation with equipment manufacturers such as those listed at the end of this report. One equipment manufacturer has suggested the following basic list of equipment for an ice cream plant producing approximately 300 gallons per day:

1 40 quart batch ice cream freezer
1 5 x 5 ammonia compressor with two-speed 20 H.P. motor
1 Hardening room, fiberglass insulated, 9 feet x 15 feet x 8 feet
1 Hardening room blower
1 Ammonia high temperature blower unit
1 Evaporative condenser for ammonia
1 Package filler
1 Stainless steel top work table
1 Two compartment wash sink
1 Lot of various refrigeration control items

The price of the above items would be approximately $11,500. The hardening room capacity is between 900 and 1200 gallons, allowing three to four days storage.

Figure 1 shows a suggested plant layout for an ice cream plant producing 200,000 gallons of ice cream per year. The major equipment for this plant is also given.




*Courtesy of the Cherry Burrell Corp.*

Plan for 200,000-Gallon-a-Year Ice-Cream Plant.

*Note:* Boiler room, refrigeration equipment, and locker room are located in basement. *Equipment list:* 1, receiving and dumping unit; 7, sanitary wash sink; 21, homogenizer; 22, pump; 27, can washer; 30, vat; 31, storage vat; 47, round processor; 50, freezer; 54, ice-cream can conveyor; 55, ice-cream can pass door; 56, chocolate dip tank; 57, popsicle brine tank; 58, work table; 59, cooler.

FIGURE I

## II. Receiving Room Operations

Whereas a milk plant generally receives only one product, liquid milk, the ice cream plant will receive many ingredients in several forms (dry, liquid, frozen, etc.) and packaged in various ways (barrels, tank trucks, cans, bags, bottles, etc.) Each plant should be set up and organized to handle any product needed in any form. Failure to be so organized may often make it impossible to take advantage of fluctuations in the market, and make the purchase of economical quantities or variations of a particular product unduly difficult.

The incoming raw material in an ice cream plant is not necessarily processed on the same day. Receiving operations may therefore be conducted throughout the day, and need not start before the other plant operations in the morning. Because the whole receiving operation is conducted all day, the rate of operation can be somewhat slower, and relatively lower capacity equipment can be used. This, however, depends to a large extent upon the individual plant and its operating schedule, having due regard to the manpower expended and the possibly higher cost of having a man or crew working at less than peak efficiency.

More and more U.S. plants are adopting a mix-assembly procedure which is continuous and semi-automatic, and as a result, liquid ingredients are receiving a growing emphasis. Such a system can be used to the greatest advantage where all incoming ingredients are already liquid, so that no time is lost or extra vats required in which the solid ingredients are blended into the liquids. In an all-liquid plant, the usual ingredients to be handled in large volume are liquid, sugar, cream and condensed skim milk. The liquid sugar normally arrives in a tank truck, from which it is pumped directly to the storage tanks. Weight is determined either by the seller at the time of filling the truck or by a truck scale at the receiving platform. At the time of delivery the truck is connected through a section of pipe to a positive pump which pumps the liquid sugar to a storage tank, from which it is pumped, or flows, directly to the mix-assembly vat. Other liquid products, such as cream and milk, are handled the same way. Provisions must be made for any tests to be made, such as determination of butterfat and solids content of cream and milk. If the cream is received in cans rather than trucks, a conveyor system can be set up to handle both the incoming full cans and the outgoing empty cans, with weight scales incorporated into the conveyor system for checking weight.

Dry ingredients usually arrive in bags or barrels. These are neither weighed nor sampled, but moved directly into the dry storage room. On account of the miscellaneous ingredients received, the volume of which may be substantial, it is necessary to have three major divisions of facilities at the receiving dock. One is pipe and pump connections to unload tank trucks. The second is an ordinary loading dock to handle bulk containers such as bags and barrels, The third is a can conveyor, scales, weigh cans, can washers and the usual milk plant receiving room equipment.

Several types of storage of the various ingredients are required, pending their use. Bulk liquids are pumped directly to storage tanks in or near the processing room. These tanks may or may not be refrigerated. Frozen products are taken to a cold storage room, or the hardening room may be used. Frozen products may be thawed before mixing, or they may be broken in a comminutor into small pieces which will thaw easily in the mixing operation.

Provision must be made for handling the packaging containers. As mentioned previously, most of the containers now used by the ice cream industry in the U.S. hold small quantities. They come in a wide variety of shapes and sizes. Some are shipped flat and assembled at the plant; some are already assembled when received. Plans must be made for storage and movement of these containers.

## III. Mix Preparation

The step in ice cream production known as mix preparation covers all operations subsequent to receipt of the raw material until the complete mixture enters the first freezer. The object is to prepare a mix ready for freezing, containing all ingredients in proper proportion and homogeneous in form, of the optimum temperature and viscosity, and freezing of which will produce a product with all desired properties. The major steps in this process are assembly of major ingredients in a vat or tank, pasteurization, homogenization, cooling and storage. Minor ingredients, such as colors, flavors and stabilizers, are added at different stages, depending on their characteristics. Other procedures involve determination of acidity and its control, standardization of composition, filtering and sometimes aging. Mixing may be done in batches or in a continuous operation.

A. Batch Mixing. Usually, the vat in which the ingredients are assembled is also used for pasteurization. The liquid ingredients are placed in the vat first, and heating and agitation is started at once. Dry ingredients are added after all the liquid ingredients are in the vat and under agitation.

Certain dry ingredients do not go into solution easily, and precautions must be taken to avoid lumping. One method is to add the dry material slowly while the mix is still cool and with maximum agitation. Powdered non-fat milk solids are particularly difficult to add without lump formation. Prior solution in cold water is sometimes used. Gelatin is generally added with the sugar before the mix becomes too warm. It may also be dissolved in hot water and added to the mix when both gelatin and mix are about 145°F. Liquid or soluble dry flavors are added at this stage. Solid flavors such as fruits, nuts, and candies, are inserted after freezing.

B. Continuous Mixing. Continuous mix assembly is based on the use of liquid ingredients and is most efficient where the mix is pumped directly to a separate pasteurizer, rather than to a storage tank. The ingredients are kept in storage tanks near the assembly area and are assembled in a weigh can mounted on a scale. The

order of assembly is the same as for batch mixing. The amount of each item in the mix is predetermined and is measured by weight added in the weigh can.

Although the plant must make up its mix in accordance with a predetermined formula, occasionally the final mix does not contain the exact proportions desired. For this reason, most plants test each mix before pasteurization. Where continuous assembly is used, testing must also be continuous. High acidity of the ice cream can interfere with quality and processing operations, since it results in precipitation of the protein, inefficient homogenization, poor whipping qualities, and deterioration of body and flavor. Acid mixes are corrected by adding a neutralizer such as sodium bicarbonate or calcium hydroxide. Over-correction must be avoided.

C. Pasteurization. Ice cream mix is pasteurized in exactly the same way and for the same reasons as is milk. Since the mix is higher in viscosity, heavier agitators are required in the pasteurizers for batch mixes. "Shortime" pasteurizers used in continuous assembly operations will require calculations for increased pressure, number of plates required and their arrangement, and horsepower and capacity of the pump required. Ice cream mixes need more intense heat treatment than milk. Standards of pasteurization are not uniform in the U.S., being governed by local laws and ordinances. Generally, however, it is recognized that 160°F for 30 minutes for the batch system, or 175°F for 25 seconds for the continuous system, meets the qualifications. Pasteurization is done after all dairy ingredients have been added, but before addition of material harmed by heat, such as flavors, fruits, nuts, etc.

D. Homogenization. It is always advisable to filter the mix, even though the individual ingredients may each have been filtered previously. Filtration is done to prevent lumps in the final product, to remove any extraneous matter that may have accidentally been introduced, and to prevent damage to equipment, most of which is built to operate on very close tolerances. The process is really "straining" since metal screens are used instead of filter cloths. Following filtration, the mix is homogenized, a practice universal in the U.S.

Homogenization is done to obtain a product uniform throughout the container, to reduce curd tension, and to produce an apparent creaminess and richness. Whipping is easier in the freezer following homogenization, and the butterfat has less tendency to separate and freeze onto the blades and cylinder walls of the freezer. It is commonly done at the same time as pasteurization, since it should be done at temperatures of 145°F or higher. However, it may also be done in a separate container following pasteurization but before cooling.

Pressure used in homogenization varies from plant to plant, but it is commonly recognized that pressures should diminish somewhat as fat content increases and also should be lower for chocolate mixes. In a two-stage homogenizer, the pressure in the second stage remains fairly constant at about 500 psi, and for the most plain mixes of average fat content at about 2400 psi total. Higher pressures result in a drier ice cream with a tendency toward fat-clumping, and with greater whipping ability in the

freezer. However, too great a pressure will actually reduce whipping ability. Too low a pressure will not produce the desired reduction in fat particle size, the desired emulsion will not result, body and texture will suffer, and the ice cream may have a tendency to be icy. Homogenization also makes possible the use of butter, dry butter-fat, butter oil, and frozen cream, since agitation alone will not permit proper incorporation of these substances into the mix.

E. Cooling and Aging. It is particularly important in ice cream products to cool the mix rapidly, especially through the range of 50-30°F, to prevent bacterial growth and to prevent an increase in viscosity. The final temperature of the mix should be about 36°F, and should be stored prior to freezing at not over 40°F. Cooling is usually done on a surface cooler of the cabinet type, though sometimes a plate cooler is used. One of the big advantages of a plate cooler, when operated in conjunction with the pasteurizer, is the possibility of large savings in heat, since the hot mix heats and is cooled by the incoming cold raw mix.

Aging (storing) of ice cream mix is not uniform in the U.S.; some plants do not age the mix at all, and some age it for as long as 48 hours. It is generally believed that not more than 24 hours is necessary to obtain the benefits from aging, and many plant operators limit the period to 4 hours. Aging permits the protein and gelatin in the mix to soak up free water, which then cannot form ice crystals. In addition, crystallization of fat globules occurs, which decreases the load on the freezer and permits freezing to a stiffer consistency. Aside from aging, the cooled mix is usually stored for a certain period of time, since freezing rate is seldom exactly matched to the rate of mix preparation. Storage tanks must, of cource, be refrigerated. Storage in the form of the finished ice cream is always preferable to extended storage before freezing.

F. Flavoring and Coloring. As stated previously, most flavors are added just before the mix is ready to be frozen and some, such as fruits and nuts, are added after freezing. In some plants it is found practical to make a standard basic mix containing no flavors, from which any variety of ice cream may be produced by addition of the appropriate flavor. Flavor is added to the mix in a mix-flavor tank in the freezing room and as an integral part of the freezing operation. The tank varies in size from 30 to 200 gallons capacity, depending upon the number and size of freezers drawing mix from it. The tanks have agitators to distribute the flavor evenly in the mix. To insure continuity of operation, particularly with continuous freezers, there are usually two mix flavor tanks per freezer, or they are arranged so that each freezer can draw mix from one of several tanks. Thus, one tank is being emptied while the other is being filled and flavor incorporated.

Artificial coloring is often added either to enhance the natural color, to make it more uniform, or to provide color not furnished by the flavoring. It is usually added to the mix with the flavoring in the mix flavor tank.

## IV. First Freezing

The first freezing operation is done to freeze the produce partially and to incorporate air into the ice cream. As mentioned previously, the mix is whipped at the same time, and the increase in volume due to the air is called the overrun. Just as for mix preparation, freezing can be done either in batches or continuously.

Batch freezers usually range between 8 and 160 quarts in capacity. Continuous freezers are usually equipped to handle a much greater volume -- up to 300 gallons per hour. Direct expansion of ammonia is most often used for refrigerating, but brine freezers are still in use in some plants. Both types of freezers have inherent advantages and disadvantages. Internal design varies from manufacturer to manufacturer.

Freezer speed should be such that maximum freezing rate and whipping are obtained. The manufacturer of a given freezer usually can specify the rate at which his freezer obtains optimum results. Ordinarily, freezing time should run between 10 and 12 minutes per batch. The mix is usually drawn from the freezer when 15% to 30% of the total water has frozen to ice. With the continuous freezer, as much as 50% of the water may be frozen. If freezing is too fast and too great, the desired overrun cannot be obtained, and the ice cream becomes too stiff to discharge from the freezer rapidly enough. Whipping to obtain overrun is done in the freezer. In batch operations, the mix is frozen to the desired consistency, the refrigeration system is turned off, and whipping is carried out in the freezer to the point where the overrun limit is reached. In the continuous freezer, whipping is done with air being incorporated under pressure, which apparently brings about the smoother texture of the ice cream produced by the continuous system.

The temperature at which the ice cream is drawn from the freezer usually ranges from $24^{o}$ to $26^{o}$F in the case of the batch freezer and from $20^{o}$ to $22^{o}$F in the case of the continuous freezer. However, stiffness rather than temperature is the usual criterion for determining when the mix should be removed. When the ice cream is drawn from the freezer, it should be placed in the hardening room as soon as possible. A coarse texture results if the ice cream melts partially. Partial melting is particularly a problem where the ice cream is transferred to packaging machines for filling small containers, and a coarse texture often results from this operation. This may be overcome to a large extent by subjecting the small packages to an air blast at $-30^{o}$F to $-50^{o}$F to freeze them very rapidly. The continuous system eliminates most of this problem, since the packaging operation can be geared directly to the freezer itself, and the temperature of the mix coming from the continuous freezer is somewhat lower.

## V. Final Freezing, or Hardening

The hardening operation completes the freezing of the approximately 50% total water in the mix left unfrozen by the freezer. Actually, the ice cream is somewhat more palatable as it comes from the freezer, but marketing the ice cream in

this form is seldom practical. Hardening the freezer ice cream and storing it at a low temperature is necessary for varying periods of time prior to customer purchase.

The freezing accomplished in the hardening room ordinarily proceeds at a slower rate than in the freezer, but this introduces the problem of formation of large ice crystals. Hardening rooms are usually operated so that marketing is possible within 24 hours after hardening begins. Their construction will depend on the requirements of the particular hardening operation. Generally speaking, they should be so built and refrigerating equipment installed so that the temperature maintained falls between -25°F and -10°F. Lower temperatures do not justify the additional costs for most plants. Whatever temperature is chosen to be maintained, it should not be allowed to fluctuate; automatic control is desirable.

## VI. Packaging and Delivery

The following factors must be considered in choosing the container: cost; sanitary features; ease of handling; effect on ice cream quality; appearance; storage; weight per volume of product; consumption point in relation to factory location; unit size desired. Bulk containers are made of both paper and metal, and smaller quantities are packaged primarily in paper, and recently, in plastics. Both bulk and package containers are filled before hardening, and the continuous system permits filling directly from the freezer. Batch operations require the use of special filling machines.

Refrigerated trucks are the usual means of delivery from the hardening room to the retail store. This equipment is usually quite expensive and is subject to rapid deterioration, so that consideration must be given to its selection and care. The use of solid carbon dioxide (dry ice) for refrigeration of the trucks is quite wide in the U.S., because of its convenience, cleanliness and sometimes savings in refrigeration costs. Certain precautions must be taken in its use, but its advantages are great. Another type of refrigerated truck uses cold salt brine in overhead and wall tanks. While operating costs are low, deterioration of the body and chassis of such a truck is very rapid, due to the corrosive effect of the brine. This method is almost completely obsolete in the U.S. Trucks used for long distance hauling or for continuous use may have complete mechanical refrigerating systems installed, but the expense of this method prohibits its use except under limited conditions.

## VII. Records and Plant Costs

Total costs and distribution of costs naturally will vary with variations of the individual components of the costs. Even two plants in the same area will not have the same costs for several reasons. Also, ice cream is a seasonal product, and unit cost will be greater in the winter months. Plant design and layout will have a strong effect on costs because of their effects on labor requirements and machine

utilization. Table II shows the approximate distribution of total cost for ice cream manufacture in the U.S. The manufacturing and delivery costs in the table contain allowances for equipment depreciation but not for initial investment. Initial investment and return on the investment must be calculated separately and used in determining retail price of the finished product.

TABLE II

ICE CREAM COST DISTRIBUTION

| Cost Item | % of Total |
|---|---|
| Ingredients | 50 |
| Manufacturing | 20 |
| Selling and Advertising | 10 |
| Delivery | 15 |
| Administrative | 5 |

Some sort of cost accounting system is vitally necessary to the manufacturer, no matter how small his business. Many systems can be used to obtain the necessary information. For convenience, the accounting may be divided into that of mix manufacturing cost and frozen product manufacturing cost. Each of these may be further subdivided into the following areas: raw materials; labor; expenses (packaging and maintenance supplies, fuel, power, repairs, etc.); and fixed charges and overhead (depreciation, taxes, insurance, administrative costs, etc.) Further segregation is of course, possible and usual.

The records kept for cost accounting will be determined by the particular system devised. Such records are necessary for efficient plant operation, but they must not be so elaborate or numerous as to be excessively time-consuming. Figures 2 through 12 show typical record forms used in ice cream plants in the U.S.

ICE CREAM FREEZING-ROOM REPORT

Date_____

Flavor_____

Reported by_____

Gallons mix used_____

Per cent fat in mix_____

Mix batch number_____

Gallons finished:

Bulk_____

Packaged_____

Total_____

Materials used for flavoring and coloring:

| Product | Amount | Unit Cost | Total Cost |
|---|---|---|---|
| | | | |
| | | | |
| | | | |
| | | | |
| | | | |

Cost of flavoring and coloring per gallon of ice cream_____

FIGURE 2

DAILY LABORATORY REPORT

Date_____ Reported by_____

| Mix No. | Per Cent Fat | Per Cent T.S. | Per Cent Acid | *E. coli* | Bacteria |
|---|---|---|---|---|---|
| | | | | | |
| | | | | | |
| | | | | | |
| | | | | | |
| Ice cream | | | | | |
| | | | | | |
| | | | | | |
| | | | | | |
| | | | | | |
| Milk products | | | | | |
| Cream | | | | | |
| Condensed | | | | | |

FIGURE 3

SPECIALTIES REPORT

Date_____

| Materials Used | Molds | Pies | Cakes | Fancy | Total | Production | |
|---|---|---|---|---|---|---|---|
| | | | | | | Item | Quantity |
| Cream | | | | | | Molds | |
| Ice cream mix | | | | | | Pies (large) | |
| Ice cream | | | | | | Pies (small) | |
| Strawberries | | | | | | Cakes | |
| Pecan nuts | | | | | | 1-layer (serves 8) | |
| Sugar, powdered | | | | | | 2-layer | |
| | | | | | | 3-layer | |
| | | | | | | Log Roll | |
| | | | | | | Puddings | |
| | | | | | | Special | |
| Labor | | | | | | | |
| | | | | | | | |
| | | | | | | | |
| | | | | | | | |
| | | | | | | | |

FIGURE 4

## DAILY MIX BATCH REPORT

Mix Made_____ _____Per Cent Fat

_____ _____19____

| Gallons | Pounds | Per Cent B.F. | Description | Pounds S.N.F. | Per Cent S.N.F. | Pounds B.F. |
|---|---|---|---|---|---|---|
| | | | Milk | | | |
| | | | Mix | | | |
| | | | | | | |
| | | | | | | |
| | | | | | | |
| | | | | | | |
| | | | | | | |
| | | | 40% Cream | | | |
| | | | | | | |
| | | | | | | |
| | | | | | | |
| | | | | | | |
| | | | Skim condensed—plain | | | |
| | | | | | | |
| | | | | | | |
| | | | Corn sirup | | | |
| | | | Corn sugar | | | |
| | | | Sugar | | | |
| | | | Stabilizer | | | |
| | | | | | | |
| | | | Pectin | | | |
| | | | Egg yolk | | | |
| | | | | | | |
| | | | | | | |
| | | | Cocoa | | | |
| | | | Chocolate | | | |
| | | | Vanilla | | | |
| | | | | | | |
| | | | Citric acid | | | |
| | | | Rerun | | | |
| | | | Water | | | |
| | | | | | | |
| | | | | | | |
| | | | Butter | | | |
| | | | | | | |
| | | | | | | |
| | | | TOTAL TO ACCOUNT FOR | | | |
| | | | LOSS IN PRODUCTION | | | |
| | | | GAIN IN PRODUCTION | | | |
| | | | MIX PRODUCED | | | |
| | | | TOTAL BUTTERFAT USED | | | |

FIGURE 5

PLANT INVENTORY

Date_____ Reported by_____

| Flavor | Bulk | | | | Packaged | | Bricks | |
|---|---|---|---|---|---|---|---|---|
| | 5 | 3 | 2½ | 1 | Quart | Pint | Quart | Pint |
| Vanilla | | | | | | | | |
| New York | | | | | | | | |
| Chocolate | | | | | | | | |
| Strawberry | | | | | | | | |
| Banana | | | | | | | | |
| Burnt almond | | | | | | | | |
| Butterscotch | | | | | | | | |
| Butter pecan | | | | | | | | |
| Caramel | | | | | | | | |
| Chocolate chip | | | | | | | | |
| Black walnut | | | | | | | | |
| Fudge ripple | | | | | | | | |
| Raspberry ripple | | | | | | | | |
| Nesselrode | | | | | | | | |
| Mint stick | | | | | | | | |
| Orange ice | | | | | | | | |
| Lime ice | | | | | | | | |
| Raspberry ice | | | | | | | | |
| Pineapple ice | | | | | | | | |

| Novelties | Dozen |
|---|---|
| Cups | _____ |
| Pies | _____ |
| Popsicles | _____ |

FIGURE 6

FACTORY-FILLED PACKAGE AND BRICK PACKAGE REPORT

Code No. Date_____19__

| *Factory-Filled Package* | Quarts | Pints | Gallons Mix Used | Gallons Fruits and Flavors | |
|---|---|---|---|---|---|
| Vanilla | | | | | |
| New York | | | | | |
| Chocolate | | | | | |
| Strawberry | | | | | |
| | | | | | |
| | | | | | |
| | | | | | |
| Total | | | | | |
| *Brick Package* | | | | | |
| Neapolitan | | | | | |
| Chicago | | | | | |
| Pineapple nut | | | | | |
| Palmer House | | | | | |
| New York cherry | | | | | |
| | | | | | |
| | | | | | |
| | | | | | |
| | | | | | |
| Total | | | | | |

FIGURE 7

DAILY DISTRIBUTION OF LABOR REPORT

ICE CREAM PRODUCTION

Date_____19__

| Employee's Name | Total Hours | Receiving and Mix Making | Bulk | Package | Choco-Rip | Scotch-Rip | Popsicle | Dixie Cups | Big-Shot Cones | Special Pies | Fancy | Fruits and Flavors | Cooler | Cleaning | Nuts |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | |

FIGURE 8

BULK FREEZING REPORT

Code No. Date 19

| *Ice Creams* | Production | | | | | | Gallons Mix Used | Gallons Flavor and Fruits | |
|---|---|---|---|---|---|---|---|---|---|
| | 5 | 3 | 2½ | 1 | | Total | | | |
| Vanilla | | | | | | | | | |
| New York | | | | | | | | | |
| Chocolate | | | | | | | | | |
| Strawberry | | | | | | | | | |
| Maple nut | | | | | | | | | |
| | | | | | | | | | |
| | | | | | | | | | |
| | | | | | | | | | |
| | | | | | | | | | |
| | | | | | | | | | |
| | | | | | | | | | |
| | | | | | | | | | |
| Total | | | | | | | | | |
| *Ices* | | | | | | | | | |
| Orange | | | | | | | | | |
| Pineapple | | | | | | | | | |
| Raspberry | | | | | | | | | |
| | | | | | | | | | |
| | | | | | | | | | |
| Total | | | | | | | | | |

FIGURE 9

SUMMARY OF PRODUCTION

Date 19

| | Gallons Produced | Overrun |
|---|---|---|
| Bulk ice cream | | |
| Brick ice cream | | |
| Factory-filled ice cream | | |
| Total bulk and packaged | | |
| Novelties | | |
| Total ice cream production | | |
| Bulk sherbet | | |
| Packaged sherbet | | |
| Novelty sherbet | | |
| Total production of ice cream and sherbet | | |
| Yield per pound coating used | | |

NOVELTY LABOR STATISTICS

| Novelty | Dozens Produced | Man-Hours | Production per Man-Hour | Girl-Hours | Production per Girl-Hour | Total Hours | Total Production per Hour |
|---|---|---|---|---|---|---|---|
| Cups | | | | | | | |
| Cones | | | | | | | |
| | | | | | | | |
| | | | | | | | |
| | | | | | | | |

FIGURE 10

MONTHLY INVENTORY OF SUPPLIES

Month_____ Reported by_____

| Item | Quantity on Hand | Amount Needed to Order |
|---|---|---|
| Sugar | | |
| Corn sugar | | |
| Sirup | | |
| Washing powder | | |
| Sterilizing powder | | |
| Scrub brushes | | |
| Filter cloths | | |
| Neutralizer | | |
| Egg yolk | | |
| Stabilizer | | |
| Pectin | | |
| Pecans | | |
| Pistachio | | |
| Maple | | |
| Caramel | | |
| Strawberries | | |
| Peaches | | |
| Raspberries | | |
| Pineapple | | |
| Rum pudding | | |
| Nesselrode | | |
| Fudge sirup | | |
| Raspberry sirup | | |
| Coloring | | |
| Red | | |
| Orange | | |
| Yellow | | |
| Green | | |
| Pink | | |
| Extract | | |
| Vanilla | | |
| Orange | | |
| Lime | | |
| Pistachio | | |
| Coffee | | |
| Packages | | |
| Quarts | | |
| Pints | | |
| Cups | | |
| Containers | | |
| 5 gal | | |
| 2½ gal | | |
| 1 gal | | |
| Citric acid | | |
| Popsicle units | | |
| Creamside units | | |
| Cones | | |
| Straws | | |
| Dippers | | |
| Spoons | | |
| Uniforms | | |
| Women | | |

FIGURE 11

MILK PRODUCTS REPORT

ICE CREAM DEPARTMENT

Date received_____

Received from_____

Hauled by_____

| | Cans | Gross Weight | Tare | Net Weight | Shippers' Test | Our Test | Pounds B.F. | Pounds M.S.N.F. | Acidity |
|---|---|---|---|---|---|---|---|---|---|
| Cream | | | | | | | | | |
| | | | | | | | | | |
| | | | | | | | | | |
| Condensed | | | | | | | | | |
| | | | | | | | | | |

Received by_____

Remarks_____

FIGURE 12

## VIII. Equipment Manufacturers

There are a number of companies in the U.S. manufacturing equipment for ice cream plants. Generally, they fall into two categories: those producing equipment for making ice cream in bulk quantities, and those producing equipment for making novelties, or individual portions. Some companies produce both types of equipment. Most of these companies offer consulting and engineering development services to purchasers of their equipment. Any company must receive detailed information as to the projected operation before advice and recommendations can be made. A list of representative U.S. manufacturers of equipment is given below.

| | |
|---|---|
| 1. Cherry-Burrell Corporation<br>427 West Randolph Street<br>Chicago 6, Illinois | (Complete plants) |
| 2. Mojonnier Brothers Company<br>4601 West Ohio<br>Chicago, Illinois | (Complete plants) |
| 3. Creamery Package Manufacturing Company<br>1243 West Washington Boulevard<br>Chicago 7, Illinois | (Complete plants) |
| 4. Burgess, Smith and Rodgers, Incorporated<br>330 West 42nd Street<br>New York, New York | (Complete plants) |
| 5. Triangle Package Machinery Company<br>Bagby Division<br>6646 West Diversey Avenue<br>Chicago 35, Illinois | (Individual portions) |
| 6. Anderson Brothers Manufacturing Company<br>Rockford, Illinois | (Fillers and cappers) |
| 7. Tekni-Craft<br>Rockton, Illinois | (Small automatic freezers for retail stores) |
| 8. Union Standard Equipment Company<br>Lafayette and Houston Streets<br>New York, New York | (Re-built equipment) |

## REFERENCES

1. Sommer, H.H.
The theory and practice of ice cream making
Madison, Wisconsin, The Author, 1946; 5th edition. 704pp.

2. Turnbow, G.D., Tracy, P.H. and Raffetto, L.A.
The ice cream industry
New York, Wiley, 1947; 2nd edition. 654pp.

3. Farrall, A.W.
Dairy engineering
New York, Wiley, 1953; 2nd edition. 477pp.

4. Frandsen, J.H. and Nelson, D.H.
Ice creams and other frozen desserts
Amherst, Massachusetts, The Author, 1950. 318pp.

Mention of the name of any firm, product or process in this report is not to be construed as a recommendation or endorsement but merely as a citation that is typical in its field. Commercial directories generally list names of additional companies and products.

NOTE: To obtain copies of any catalogs, bulletins and other reference material mentioned in this report, please write directly to the indicated source of issue or supply.

## ACKNOWLEDGMENT

A large part of the information contained in this report was obtained through the courtesy of the Cherry-Burrell Corporation, Chicago, Illinois.

## TECHNICAL INQUIRY SERVICE REPORTS

Information relating to establishment of a manufacturing plant has been furnished by the Technical Inquiry Service in the following reports:

### CHEMICAL AND RELATED PRODUCTS

Fermentation Ethyl Alcohol
Furfural
Laundry and Milled Toilet Soap
Pharmaceutical Products
Potash
Salicylic Acid
Small Fertilizer Plant
Sulphuric Acid
Vinyl Floor Tiles

### FOOD PROCESSING

Candy and Confectionary
Carob Molasses
Crude Olive Oil
Dehydrated Molasses
Fish Meal
Fish and Shrimp Processing
Ice Cream
Molasses
Orange Juice
Rice
Rice Bran Oil
Salted Peanuts
Slaughtering and Meat Packing Plant
Soybean Processing
Starch
Unfermented Grape Juice
Wheat Flour
Wheat Milling

NOTE: Additional plant requirements data have also been published in longer plant operations and plant requirements reports, for industries listed in the Technical Aids Branch "Industrial Reports and Publications" bulletins.

METALS

Aluminum Architectural Specialties
Bicycles
Coil Springs
Copper Tubing
Copper Wire - Drawing and Insulating
Fluorescent Lamp Ballast
Fractional and Small Horsepower Electric Motors and Direct Starters for Squirrel-Cage Motors
Galvanized Steel Pipe
Latch Needles
Manganese
Metal Spinning
Mineral Wool
Ornamental Ironwork
Porcelain Enamelware
Primary Hardware
Radios
Recovery of Zinc
Rice Paddy Cultivators
Shallow Well Hand Pumps
Small Steel Melting Plant
Small Steel Rolling Mill
Split Gib-Head Keys and Solid Taper Pins
Stainless Steel Utensils
Storage Bins
Surgical Instruments
Tungsten Carbides
Wire Products

MISCELLANEOUS

Adhesive Tape
Automobile Batteries
Block Ice Making
Dry Cleaning
Souvenirs and Small Jewelry

RUBBER AND LEATHER

Camelback
Children's Shoes
Men's Dress Shoes
Rubber Cement
Rubber Floor Tiles
Rubber Soling
Rubberized Fabric
Small Leather Tannery
Tire Cord Bonding
V-Belts
Women's Shoes

TEXTILES

Cotton Crochet and Knitting Yarns
Cotton Yarn
Hooked Rugs
Jute Yarn
Nylon Hosiery
Surgical Cotton
Wool Scouring
Woolen Yarn
Worsted Yarns

STONE, CLAY AND GLASS

Asphalt Floor Tiles
Cement
Chalk Whiting

WOOD AND PAPER

Brooms
Boxes and Shooks
Creosoted Wood Products
Flush Doors
Hardwood Parquet Flooring
Lead Pencils
Paper Bags
Plywood
Refrigerated Walk-In Coolers
Sensitized Papers
Wood Wastes