FORMULATION OF ICE CREAM AND OTHER FROZEN DESSERTS

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Effective quality control demands that products be made to exact specifications to insure, among other criteria, a uniform composition from day to day. There are several factors which influence the selection of the composition of a particular product, the more important being ingredient cost, quality, legal requirements, and efficiency of operation.

A premium grade ice cream may differ from the regular run product in that it may have a higher fat content, use more expensive flavoring, have a lower overrun, or be made from better quality dairy products. In all instances the difference represents an increase in cost which the manufacturer hopes will guarantee an improved quality. To do so, however, several other requirements must be met: the dairy products must be of the highest quality, the proportion of fat to serum solids and sweetening agents must be such as to bring out the best possible flavor and body and texture and provide adequate protection against heat-shock damage and sandiness; the mix must be correctly stabilized, heat processed and homogenized; the correct quantity of a high quality flavoring must be incorporated; the ice cream must be frozen to a stiff consistency (21-22.5°F) with the desired amount of overrun and quickly hardened, preferably, to a temperature of -15°F; the package should not only be attractive but also provide protection against moisture and air movement; and the ice cream should be moved through the normal channels of commerce with the least possible temperature fluctuations and in the minimum possible time.

While it would be highly desirable to have a minimum delay between production and consumption of ice cream, such an ideal situation is seldom encountered. In most situations, the ice cream is subjected to considerable abuse before it is actually consumed, and the mix formulation must provide for some degree of protection against excessive damage.

When the storage temperature of ice cream is allowed to fluctuate, a certain amount of melting takes place followed by refreezing. Large ice crystals grow at
the expense of small ones, and eventually, the ice cream becomes coarse textured. Obviously, the greater the fluctuation in temperature, the more rapidly will the heat-shock damage proceed, and the more severe will be its effects. Some protection against heat-shock damage is obtained by reducing the amount of free water in the ice cream mix. This may be accomplished by more stabilizer, more intense heat treatment of the mix and increasing the total solids content of the mix.

Unless special milk solids with a reduced lactose content are used, it is not feasible to increase the serum solids content of an ice cream mix appreciably. Because of its limited solubility, an increased lactose concentration may partially crystallize and impart a sandy texture to the ice cream. The sugar content may be increased effectively by substituting a sweetening agent which is not as sweet as beet or cane sugar (sucrose) for a portion of the sugar. The most common sweetening agents used for this purpose are the various products made by the hydrolysis of starch. They are classified according to Dextrose Equivalent (D.E.) which expresses numerically the extent to which the starch has been converted to simpler sugars. The D. E. of various corn syrups varies from 36 D. E. for a low conversion syrup to 62 D. E. for a high conversion syrup. The former syrup is somewhat less than half as sweet as sucrose while the high conversion syrup is two-thirds as sweet. It is, thus, possible to increase the sweetener content without making the ice cream too sweet.

Corn syrups are available in liquid form as low, regular, intermediate, and high conversion syrups. They may also be obtained in blends with sucrose syrup. The regular and low conversion syrups and dextrose (corn sugar), the product of complete starch hydrolysis, are also sold in dry form. The choice of the particular corn sweetener will depend on the properties which are desired, cost, and convenience. In general, the more viscous, lower D. E. products will produce a more resistant body in the ice cream and impart somewhat more heat-shock protection. They have a tendency, however, the mask certain flavors in ice cream, and if used in excessive amounts impart a "syrupy" flavor. The high D. E. syrups also impart some heat-shock protection and produce a body and flavor which is more like that of an ice cream which contains only sucrose as the sweetening agent.

An ice cream containing 10% fat and requiring at least a moderate protection against heat-shock, should have 37.5-38.5% total solids, a sweetening level equivalent to 14-15% sucrose, and good stabilization. A number of good stabilizers consisting of various combinations of carboxymethyl cellulose, algin, locust bean gum, carrageenin, guar gum, gelatin, and emulsifiers are available from various commercial sources. Since the required quantity of stabilizer varies with different types, the manufacturer's directions should be carefully consulted.

In all of the suggested formulations which follow, the proportion of sweetener is given as an amount equivalent to a given percentage of sucrose. Appropriate substitutions with corn sweeteners may be made to attain the desired total solids content.

**Formulation for Plain Ice Cream**

<table>
<thead>
<tr>
<th>Fat (%)</th>
<th>10</th>
<th>12</th>
<th>14</th>
<th>16</th>
</tr>
</thead>
<tbody>
<tr>
<td>Serum Solids (%)</td>
<td>11</td>
<td>11</td>
<td>10</td>
<td>9</td>
</tr>
<tr>
<td>Sweetness as sucrose (%)</td>
<td>14-15</td>
<td>14-15</td>
<td>14-15</td>
<td>14-15</td>
</tr>
<tr>
<td>Stabilizer and emulsifier</td>
<td>Follow manufacturer's directions</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total solids (%)</td>
<td>37.5-38.5</td>
<td>38.5-39.5</td>
<td>39-40</td>
<td>40-41</td>
</tr>
</tbody>
</table>
Formulations for a Chocolate Ice Cream Mix

A chocolate ice cream of excellent quality may be produced from a specially prepared mix flavored with chocolate liquor. While cocoa or a blend of cocoa and chocolate liquor may also be used, a somewhat harsher chocolate flavor would be obtained than with straight chocolate liquor.

<table>
<thead>
<tr>
<th></th>
<th>Butterfat (%)</th>
<th>Serum Solids (%)</th>
<th>Sweetness as Sucrose (%)</th>
<th>Chocolate liquor (%)</th>
<th>Cocoa (%)</th>
<th>Stabilizer according to manufacturer's directions</th>
<th>Total Solids (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>10</td>
<td>8.5-9</td>
<td>17-18</td>
<td>5</td>
<td>0</td>
<td></td>
<td>41-42</td>
<td>40.5-42</td>
</tr>
</tbody>
</table>

Formulation for a Mix for Fruit Ice Cream

In order to impart a typical flavor, a rather high proportion of certain fruits must be incorporated into the ice cream. In the case of a 2 to 1 frozen strawberry pack (2 parts berries to 1 part sugar), the addition of 2 lbs. of frozen berries to 8 lbs. of ice cream makes a desirable combination. Assuming that a finished product is desired containing 10% butterfat, 11% serum solids, 15% sweetness in terms of sucrose, 0.3% stabilizer and emulsifier, and 20% of a 2 to 1 strawberry pack, the unflavored mix would have to be of the following composition:

12.5% butterfat
13.5% serum solids
10.4% sweetness as sucrose
0.375% stabilizer and emulsifier

The sweetness level of this mix may appear low at first glance, but it should be remembered that the strawberries in this example contain 33% sugar and an allowance is made for that in calculating the fruit mix. On the other hand, the stabilizer content may appear too high, but 80 lbs. of mix must contain sufficient stabilizer to stabilize 100 lbs. of ice cream. If the viscosity of the mix should become excessively high for efficient handling, the stabilizer content should be reduced to the optimum level. Under such conditions consideration may be given to stabilizing the fruit, particularly, if iciness becomes a problem.

Formulations for Ice Milk Mixes

Hard and soft frozen ice milks must be considered separately because their formulations differ in the sweetness level and total solids content. Soft-served ice milk does not require protection against heat-shock, because for the most part, it is sold and consumed directly from the freezer. Its refreshing qualities, in fact, are enhanced by a relatively low total solids content. Hard ice milk, on the other hand, must receive all the protection possible to improve its storage life.

The use of corn sweeteners as replacement for a portion of the sucrose is particularly desirable in the case of hard frozen ice milk. Special advantage may be taken of the good bodying properties of the low D. E. products.
Formulations for Sherbets and Ices

While there may be differences in opinion as to the type of body most desirable for sherbets, it appears that a body similar to that of ice cream has wide acceptance. To obtain this type of body a relatively high total solids content and good stabilization are required. The Federal Standards place a ceiling on the total permissible milk solids in a Fruit Sherbet at 5% and the butterfat content at 2%. Also required is a minimum fat content of 1% and a total milk solids content of 2%. Incorporation of the maximum permissible milk solids would have a beneficial effect on the body and texture of the sherbet but, at the same time, might result in a masking of the fruit flavor. For this reason a total milk solids content of from 2-4% may be preferable.

Careful consideration should be given to the fruit flavoring used in sherbets and ices. The Federal Standards specify that the quantity of fruit ingredients in relation to the weight of the finished product shall be not less that 2% in the case of citrus fruits, 6% in the case of berries, and 10% for other fruits. If artificial flavors are used, certain labeling provisions must be complied with; this also applies when artificial coloring is present.

When an ice cream mix is used to supply the necessary milk solids to a sherbet, its sugar content (which will generally be equivalent to 15% sweetness expressed as sucrose) should be taken into account in calculating the remainder of the sweetener requirements. Some fruit preparations also contain added sugar which should be taken into account. The acid content of different fruit preparations varies which makes it necessary to determine the required amount of additional citric acid. Lemon juice, for instance, contains considerably more acid than orange juice, so if this is the form of flavoring used, the additional citric acid requirements would be substantially lower for the lemon sherbet. The levels of milk solids and sugar in the sherbet also affect the additional acid requirements. Generally, somewhat less acid would be required with a low milk solids or low sugar content. Since water ices contain no milk solids, they require less acid than sherbets.

The final degree of acidity in a sherbet is a matter of personal preference and varies from 0.4% to 0.65% expressed as lactic acid. (The reason for expressing the acidity as % lactic acid is because this is the usual way of determining acidity in dairy products.) The desired pH will generally be between pH 3.0 - 4.0.
Formulations of Mixes for Milk Shakes

A direct-draw milk shake mix is usually prepared unflavored or chocolate flavored. It is frozen without the addition of any other ingredients, except flavoring in the case of the unflavored mix, in a special freezer designed to dispense it with a correct milk shake consistency. A hard frozen milk shake base, on the other hand, is frozen in the same manner as ice cream, and a milk shake is produced by blending it with a quantity of milk and flavoring on a spindle type mixer. The formulations of these two products are, consequently, different.

<table>
<thead>
<tr>
<th>Hard Frozen Milk Shake Base</th>
<th>Direct Draw Milk Shake Mix</th>
</tr>
</thead>
<tbody>
<tr>
<td>3.5-4.5 Fat (%)</td>
<td>3.5-6</td>
</tr>
<tr>
<td>11-14 Serum Solids (%)</td>
<td>11-14</td>
</tr>
<tr>
<td>10-14 Sucrose (%)</td>
<td>7-9</td>
</tr>
<tr>
<td>3-8 Corn Sweetener (%)</td>
<td>0-4</td>
</tr>
<tr>
<td>14-15 Total Sweetness as Sucrose (%)</td>
<td>9</td>
</tr>
<tr>
<td>0 Cocoa (%)</td>
<td>0</td>
</tr>
<tr>
<td>33-38 Total Solids (%)</td>
<td>24-32</td>
</tr>
</tbody>
</table>

Stabilizer according to manufacturer's directions

The total solids content of milk shake mixes should be carefully selected as it is related to the body of the finished product which may be produced from it. As would be expected, a higher total solids content will produce a heavier body. The type of body desired depends on consumers' demands.

Other Frozen Desserts

In some states it is permissible to make a Mellorine type frozen dessert which has a composition similar to ice milk or ice cream, except that a substitute fat is used in place of butterfat. Acceptability of such a product is affected by the physical properties, blandness, and flavor stability of the fat used. A number of fats especially formulated for Mellorine are available to the trade.

Special Dietetic Frozen Desserts are also permitted in some areas. Some may have a reduced total caloric content while others may have only a lower caloric content derived from carbohydrates. In the latter case, it is customary to use sorbitol in place of sugar and saccharin or sucaryl as a sweetener. The serum solids content is also reduced to keep the lactose concentration at a low level. The ice cream manufacturer is urged to consult all pertinent regulations applicable to the production and marketing of these types of products so that strict compliance with all legal requirements is assured.

Still-frozen water ices are popular items particularly during the warm season. The mix usually contains from 13-17% total sugar solids derived mainly from sucrose.
(11-14%) and corn sweeteners (2-5%), flavoring, color, and stabilizer. Manufacturer's directions should be followed in regard to the amounts and types of ingredients to be used.

**General Considerations**

The formulations presented should only serve as guides in determining the desired composition of a product. Factors which influence the final decision are: (1) product quality desired; (2) heat-shock protection needed; (3) ingredient cost; (4) consumer's preference; and (5) compliance with all applicable legal requirements. There are many satisfactory formulations for all of the products discussed. In most cases the concentrations of constituents were given as ranges of values to emphasize the fact that many combinations are possible. It is also recognized that in some cases the desired concentration of a particular constituent may be found outside of these ranges, particularly, in the case of the sweetening agents. The only firm requirement, in fact, is compliance with legal requirements. These apply not only to composition, but also the permissible ingredients, flavorings, color, weight of finished product, and labeling.