Food Science and Technology Notes

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The Total Solids Content of Ice Cream

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The total solids content is related to nearly all of the organoleptic properties, that is, flavor, body and texture and melt-down and it is also a vital factor in determining the shelf life and heat-shock properties of ice cream. In actual practice, the total solids content may be varied between the extremes of 36 and 42% at the option of the ice cream maker to achieve one of the following objectives: (1) make an ice cream with the desired level of heat-shock resistance; (2) make a premium grade, high fat containing product; (3) make a chocolate ice cream mix; (4) make an ice cream with the desired level of flavor release; (5) make an ice cream with the desired ingredient cost; (6) make a "home-style," low solids containing product; (7) make a product with the desired type of body and texture and (8) possibly to duplicate the characteristics of a competitor's product.

Of course, changes in the total solids content are not the only means available to the ice cream maker for influencing the characteristics of his product. Heat treatment of the mix, homogenization pressure and temperature, variations in type, quantity and composition of stabilizer and emulsifier, amount of overrun incorporation, type and quantity of flavoring used, method of freezing and method of hardening are are other means by which the characteristics of the finished product may be altered. However, the total solids content will in all cases play a dominant role and any other changes which may be made in an effort to impart a certain property to the ice cream will be influenced by the total solids content and the results must be interpreted in terms of the treatment as well as the total solids content.

The total solids content is made up of milk solids, sweetening agents and stabilizers and emulsifiers. The various types of solids differ in their effects on the organoleptic properties of ice cream and it is not possible to indiscriminately substitute one type of solids for another. In the case of the stabilizer th legal limit of 0.5% concentration by weight is actually higher than most ice cream manufacturers would choose to use.

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The Milk Solids

The minimum milk solids content is prescribed by the Federal Standards for a number of frozen desserts. The minimum for vanilla ice cream are 10% fat, 6% milk solids not fat, and 20% total milk solids; for bulky flavored ice cream such as chocolate and fruit, 8% fat and 16% total milk solids; for ice milk, 2% fat (7% fat maximum and 11% total milk solids); and sherbets, 1% fat (2% fat maximum) and 2% total milk solids (5% maximum). The minimum standards for bulky flavored ice cream are dependent on the actual amount of flavoring used and may be higher than the minimum permissible concentrations of 8% fat and 16% total milk solids.

It is generally accepted that the butter fat content is extremely important in determining the organoleptic properties of the ice cream. When supplied by high quality dairy products butter fat not only contributes an excellent and widely acceptable flavor, but also body characteristics which would be difficult to duplicate by other ice cream constituents. Except for premium products, however, the fat content is limited in most cases by economic and competitive considerations and the ice cream maker's problem resolves itself into making the best possible ice cream with a given fat content which is usually at the minimum legally permissible level.

The non-fat milk solids provide three major classes of constituents which contribute to the organoleptic properties of ice cream - lactose, proteins and minerals. The proteins are particularly important because, in a sense, they provide the frame work around which the body of ice cream is built. The minerals assist in this job to the extent that they affect the properties of proteins which includes direct chemical interaction with proteins and the control of pH which in turn affects the properties of proteins.

A reasonable range for non-fat milk solids in ice cream appears to be between 9 and 12%. The lower limit is prescribed by the Federal Standards and the upper limit is governed by such considerations as cost, mix viscosity, danger of lactose crystallization resulting in a sandy texture, and the possibility of imparting "milk solids" flavor which may detract from the refreshing qualities of the finished product. While the flavor of skim milk is rather bland, many consumers do not find it particularly pleasant-tasting. Increasing the skim milk solids concentration beyond a reasonable limit may, therefore, be undesirable.

The Federal Standards recognize a large number of optional dairy ingredients which supply the necessary milk solids. The list includes cream, dried cream, plastic cream, butter, butter oil, milk, concentrated milk, evaporated milk, sweetened condensed milk, super heated condensed milk, dried milk, skim milk, concentrated skim milk, evaporated skim milk, condensed skim milk, sweetened condensed part skim milk, non-fat dry milk, sweet cream buttermilk, skim milk that has been concentrated and from which part of the lactose has been removed by crystallization, skim milk in concentrated or dried form which has been modified by treating the concentrated skim milk with calcium hydroxide and disodium phosphate, concentrated cheese whey, and dried cheese whey. The standards should be consulted for other specifications pertaining to buttermilk and whey products.

The choice of the milk products to use is based on availability, cost, any special properties desired, and quality. In evaluating the quality of milk products, all known criteria should be considered including flavor, physical and mechanical properties, pH and acidity, chemical composition, bacteriological quality and freedom from extraneous matter. Generally speaking, the quality of the finished ice cream can be no better than that of its ingredients.

Certain specific objectives are sought in the use of some of the milk products. Thus, skim milk products with a reduced lactose content could be used to incorporate a higher than usual non-fat milk solids content because the danger of lactose crystallization has been reduced. Super-heated condensed milk products have a beneficial effect on the body and texture and heat-shock properties of the ice cream.

Caseinates are not recognized by the standards as milk products but their use is permitted, providing the mix contains 20% total milk solids. The various casein preparations may include those made by precipitation with gums, ammonium, calcium, potassium or sodium caseinate.

Sweetening Agents

Along with milk solids, ice cream must contain one or more sweetening agents. In addition to the obvious function of providing sweetness, these agents also serve to lower the freezing point, help build the body and texture, and help in providing additional heat shock resistance when required.

The Federal Standards recognize the following optional sweetening ingredients: Sucrose (cane or beet sugar), dextrose, Invert sugar, corn sirup (dried corn sirup, glucose sirup, dried glucose sirup), maple sirup, honey, brown sugar, malt sirup (maltose sirup, malt extract), dried malt sirup (dried maltose sirup, dried malt extract), refiner's sirup, molasses (other than blackstrap), lactose, and fructose. These materials contain various degrees of sweetness and, in some cases, characteristic flavors of their own. Thus, if honey or maple sirup were used as sweetness, a honey or maple flavored ice cream, respectively, would be produced.

The most commonly used sweeteners are sucrose and a variety of corn sirups differing in the degree and mode of starch hydrolysis from low acid conversion to high enzyme conversion. Products hydrolyzed by a combination of acid and an enzyme treatment are also available. Sucrose possesses a characteristic sweet flavor which is not complicated by any other side flavors. With respect to intensity of sweet flavor, sucrose is generally assigned a value of 100, even though some sugars, such as fructose are actually sweeter. Corn sirup solids vary in sweetening power from 40 to 70 compared to that of sucrose, depending on the degree of starch hydrolysis.

The quantity of sweetening agents to be used in ice cream is not prescribed by the standards and may be varied at the option of the ice cream maker as long as the ice cream contains not less than 1.6 lbs of total solids per gallon and weighs not less that 4.5 lbs to the gallon. Since 1.6 lbs is 35.55% of 4.5 lbs, a non-bulky flavored ice cream which contains only the minimum 20% total solids, no additional optional eggs or caseinates and is whipped to the maximum permitted overrun would have to contain at least 15.55% sweetening agents and stabilizer. However, a total solids content of 35.55% would be considered too low for most commercial ice cream.

The composition of different corn sirups varies with the degree of conversion and so do the properties which are imparted to the ice cream. The corn sirup processors deserve much credit for their success in refining the sirups to such an extent that very bland-flavored products are produced and marketed. This has made it possible to use larger concentrations of corn sirups in ice cream with less danger of imparting an undesirable "unnatural sweetener" flavor.

When formulating an ice cream mix, the ice cream maker should have a clear understanding of the type of product and its properties that he is striving to produce. Some specific points which he should consider are the type of body, i.e.

the degree of resistance, shortness, gumminess, etc.; degree of heat-shock protection needed; sweetness level of the ice cream - best expressed as sweetness equivalent to that of pure sucrose; flavoring to be used; and inevitably, cost. Let us assume that it is desired to produce a body with medium resistance, comparatively little gumminess, some heat-shock protection, a sweetness level of 14 to 15% expressed as sucrose, in an ice cream containing 10% fat. These specifications suggest a mix containing in the neighborhood of 38% total solids and a 20 to 25% replacement of corn sirup solids for sucrose. A possible formulation would be 10% fat, 11% serum solids, 12.75% beet or cane sugar, 4.25% 36DE or 42DE corn sirup solids and a quantity of stabilizer as recommended by the particular product's manufacturer. Another possible formulation would be 11% fat, 11% serum solids, 12.8% cane or beet sugar, 3.2% 65DE corn sirup solids and the appropriate quantity of stabilizer.

Stabilizers

Stabilizers, while contributing insignificantly to the total weight of solids in ice cream, on a pound for pound basis, have by far the greatest effect on the body and texture of any of the other constituents. Stabilizers vary not only in their effectiveness as promoters of a desired body and texture, but also in such properties as solubility, dispersibility, effect on whipping ability, effect on melt-down characteristics, viscosity and cost.

The maximum quantity of stabilizer permitted by the standards is 0.5% by weight of the finished ice cream. Any pectin or other gum which may have been used to stabilize fruit ingredients must be included in calculating the total permitted weight of the stabilizer. This should create no hardship as most stabilizers are quite effective in much lower concentrations. Proprietary, commercial stabilizers are frequently blends of two or more gums with an admixture of dextrin, propylene glycol, or glycerin. It is well to determine the required, correct concentration of stabilizer, bearing in mind that it will be related to the concentration of the other solids. Understabilization may result in a weak, coarse body with poor resistance to heat shock. Overstabilization, on the other hand, may produce a heavy, gummy body with poor melting properties.

The following optional stabilizing ingredients for ice cream are listed in the standards: Agar-agar, algin (sodium alginate, propylene glycol alginate) gelatin, calcium sulfate, gum karaya, gum acacia, guar seed gum, locust bean gum, oat gum, gum tragecanth, carrageenan, salts of carrageenan, furcelleran, salts of furcelleran, lecithin, psyllium seed husk and sodium carboxymethylcellulose. In addition to these, the list for fruit sherbets also includes egg white, hydroxypropyl methylcellulose and pectin.

Emulsifiers

The only remaining solids which may be used in ice cream, other than those used for flavoring, are substances generally referred to as emulsifiers and drying agents. Specifically, they are monoglycetides or diglycerides, or both of the fat forming fatty acids which may be used up to a level of 0.2% of the weight of the finished ice cream and polyoxyethylene (20) sorbitan tristearate, polysorbate 80, or both, which may be used up to a level of 0.1% of the weight of the finished product. Egg and egg yolks are also permitted providing the concentration of egg yolk solids is less than 1.4% by weight of the finished product in regular ice cream and not less than 1.4% in French ice cream or frozen custard.

Emulsifiers are effective in promoting a smoother textured ice cream and a drier appearing product as it leaves the freezer. Excessive amounts of emulsifiers may cause churning of the fat with an attendant greasy mouth feel. In addition to their emulsifing properties, eggs may also impart a characteristic flavor to the product.