ICE-CREAM & FROZEN DESSERTS

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Module 3. Ingredients in ice cream and frozen desserts

Lesson 8
STABILIZERS AND EMULSIFIERS – SELECTION, MECHANISM OF ACTION, INFLUENCE ON MIX AND ICE CREAM, PROPRIETARY STABILIZER BLENDS

8.1 Introduction

The stabilizers are a group of compounds, usually polysaccharides that are responsible for adding viscosity to the unfrozen portion of water and thus holding this water so that it cannot migrate within the product. This results ice cream that is firmer to the chew. Without stabilizers, the ice cream would become coarse and icy very quickly due to the migration of the free water and growth of existing ice crystals. Although excellent ice cream products can be made with only the natural stabilizing and emulsifying materials present in milk such as milk proteins and phosphates, additional stabilizers and emulsifiers have potential benefits.

Emulsifiers aid in the production of drier ice cream upon extrusion with smoother body and texture and good stand up or melt resistance. The emulsifying agents commonly used in ice cream are mono and diglycerides and polysorbate-80, polyoxyethylene sorbitan monooleate. Milk also contains some naturally emulsifying compounds that aid in the manufacture of ice cream. These include milk proteins, phosphates and citrates. Egg yolks may also be used as an emulsifier as they are high in lecithin.

8.2 Stabilizers

Major functions performed by stabilizer in ice cream include contributing to body or ‘substance’ and creaminess, imparting a smooth texture and providing melting resistance to ice cream. Excessive use of stabilizers, however, may result in gumminess, poor meltdown and interfere with flavour release. The most important functions of stabilizers is to ‘stabilize’ the product texture i.e. to prevent or minimize detrimental effect of heat shock during storage and distribution.

8.2.1 Selection

The following factors are important in choosing a stabilizer:

- Ease of incorporation in mix
- Effect on viscosity and whipping properties in mix
- Ease of dispersibility in cold and hot mix
- Type of body produced in the ice cream
- Effect on meltdown characteristics
- Ability to retard ice crystal growth
- Amount required to produce the stabilization
- Cost
- Perception as natural
- Effect on flavour perception

8.2.2 Mechanism of action

Capable of imbibing large quantities of water while still remaining dispersed in water and forming colloidal solutions, stabilizers are functionally also termed as hydrocolloids. These viscogenic compounds are primarily polysaccharides although, gelatin a well known stabilizer is a protein in nature. The most apparent effect of stabilizers is the increased viscosity of the continuous liquid phase. The effect of stabilizers on viscosity exhibits considerable interaction with milk constituents. For instance, the basic viscosity of stabilizer solution is generally not affected by heat treatment in the absence of milk solids, but in their presence, within creasing total solids, the effect of stabilizer on heat induced increase in viscosity of the system becomes more pronounced.

Upon hardening, the water content of ice cream falls considerably with a concomitant increase in the concentration of stabilizer in the liquid phase. The increased stabilizer concentration together with decreased temperature greatly increases the viscosity, there by substantially reducing diffusion and mobility of the liquid in the frozen product. Also, gel formation induced by stabilizer in the mix is believed to effect, considerably, immobilization of the liquid. The movement of water is hindered partly by the ability of hydrocolloids to form hydrogen bonds, too. Thus, refreezing of water that originated from melting of ice due to temperature fluctuations would not permit the formation of large ice crystals. It should, however, be noted that merely by increasing the viscosity the desired stabilization of ice structure may not be achieved. Increasing the viscosity of a 36% TS mix by addition of 5% polyethylene glycol had no effect on ice crystal size in the frozen dessert.

Certain stabilizers such as guar gum are effective thickening agents with no gelling ability. Further, the way stabilizers influence the body and texture perception in frozen ice cream could be related to their molecular structure and orientation besides their gel forming or viscosity building ability. However, extrapolation of results from model systems to ice cream is difficult as the later is a complex system with high concentrations of salt, sugar and stabilizers, which interact with other molecules, e.g. protein.

8.2.3 Influence on mix and ice cream

1. Effect on texture

The most profound involvement of stabilizers in promoting smoothness through control of ice crystal size begins after initial freezing and hardening. Once the ice crystals are formed, the influence of stabilizers is to do exactly what it implies… stabilize the size of the ice crystals against growth as a result of temperature fluctuation (heats hock). There is an increase in mean ice crystal size each time the temperature fluctuates. Stabilizers help create a situation where a higher proportion of water which changes state during temperature rise recrystallizes as small crystals. This is thought to occur through the formation of a system (with high viscosity and /or a gel structure) which immobilizes the melted water, thereby reducing the degree to which it can migrate to existing ice crystals and deposit on them when it refreezes. The net effect is to slow the rate of ice crystal growth whenever heat shock occurs.

2. Effect on body characteristics

This is a major function at the time the product is drawn, during hardening and at the time of consumption. It involves the participation of the stabilizer ingredients in determining the cohesiveness of the product, particularly those aspects described by such adjectives as chewy, sticky, weak, gummy, etc.

3. Effect on whipping and overrun retention

The structure which is established as water freezes and stabilizer and its complexes are concentrated also play a role in providing strength to the air cell wall. Stabilizer are therefore involved in the amount of air which is incorporated and the degree to which the air cells are stable.

4. Effect on melting rate and properties of melted product

The structure which results from the interaction of gums with water and other ingredients has a direct bearing on the rate of melting and appearance of the melted product. The meltdown appearance function is outcome to the role of stabilizer with respect to protecting against serum separation and fat destabilization in that by reducing the degree of destabilization of fat and protein, stabilizers canavoid the development of curdy appearance in melted product.

5. Effect on sandiness

Sandiness is caused by lactose,the defect was more prevalent 50-60 years ago and is rarely seen today. This is because of the type of stabilizers used these days (CMC, natural gums,carrageenan, etc.), which functions in a manner similar to control of ice crystal size through decreasing the mobility of unfrozen water during heat shock. The supersaturated stages in which sugars responsible for sandiness are prone to crystallize in frozen desserts are reached at temperature associated with a high stabilizer concentration. This encourages the distribution of the crystallizing lactose over a large number of small crystals rather than a lesser number of larger crystals which ultimately grow to a size where they can be perceived. Microcrystalline cellulose is particularly effective in this function, probably by providing an additional seeding function which encourages the development of small crystals.

6. Effect of stabilizer during ageing

Ageing of ice cream mix is an important processing step with regard to stabilizer action. Hydration of stabilizer is the most obvious effect of ageing, although not all stabilizers require ageing for complete hydration. The effects of ageing are more pronounced with gelatin stabilizers, and improvements in ice cream and freezing performance becomes more evident as the ageing time increases from 4 to 12 h or more . Even mixes containing stabilizers which require no ageing for complete activation benefit from a certain minimum ageing due to milk protein hydration and fat crystallization.

8.2.4 Proprietary stabilizer blends

Most ice cream manufacturers use blends of several stabilizer ingredients to achieve the desired characteristics which cannot be provided by a single ingredient. It is not possible to produce ice cream with desired characteristics by using a single stabilizer. For instance, a short chewy body of ice cream is associated with the use of CMC. Use of guar gum results in ice cream having a gummy body. Sodium alginate produces a light bodied ice cream. Typical stabilizer combinations are: guar gum and xanthan gum, locust bean gum, and xanthan gum; locust bean gum and carrageenan; alginates and pectin. For example, to make an ice cream which is somewhat short and chewy, but not to the extent which would be produced by using CMC, it is necessary to select a combination of CMC and alginate or CMC and guar gum to provide the desired properties.

Blending of colloids can also be done to reduce the cost of stabilizer. However, indiscriminate change in stabilizer composition might prove counter productive since noticeable changes might occur in frozen dessert properties. Thus, while selecting a blend of stabilizers, functionality rather than the cost should be the overriding factor.

8.3 Emulsifires

Emulsifier are surface active agents known to improve the sensory quality of ice cream by aiding the whipping process, improving air cell distribution and enhancing the products heat shock resistance. They also impart a dry appearance and stiffness or ‘stand up’ property to the product being extruded from the freezer. These effects are brought about by the inter facial properties of emulsifiers. Their ability to reduce surface tension seems to promote development of smaller but numerous air cells.

The primary effect of emulsifiers in ice cream is related to their ability to de-emulsify the fat globule membrane formed during homogenization. This de-emulsifications arising from the disruption of the fat globule membranes during freezing, facilitates the agglomeration and coalescence of fat globules,leading to partial churning out of the fat phase. The agglomerated fat globules stabilize air cells. Thus, emulsifiers are used to improve the whipping qualities of ice cream by producing smallerice crystals and smaller air cells, resulting in a smoother ice cream texture and drier, stiffer ice cream. Generally, a mixture of high and low hydrophile-lipophile balance (HLB) emulsifiers, such as mono- and diglycerides and polysorbate 80 are used. HLB concept was put forth by Griffin in the year 1949. HLB number ranges from 0 to 20. The HLB number is derived by calculating the proportion of the molecular weight of the emulsifier molecule represented by the hydrophilic portion and dividing that value by 5. The HLB system can be useful in describing an emulsifiers general characteristics; however, it is not precise enough to be applied as a tool in identifying an exact HLB number which will exactly match a specific emulsion need.

8.3.1 Selection

The following criteria are used in choosing an emulsifier

- Fat percentage of mix
- Type of frozen dessert
- Effect on flavour of product
- Cost
- Composition of fat in mix
- Compatibility with stabilizer used
- Type of freezer used
- Method of processing – homogenization
- Formulation – effect of other ingredients
- Legal standards

8.3.2 Mechanism of action

The two phase emulsion is stabilized by casein micelles adsorbed at the fat globule serum interface in the homogenized ice cream mix. But when an emulsifier such as a monoglycerideis used, the fat globules are covered with an emulsifier layer and the milk proteins form an outer layer. Monoglycerides effectively compete with protein if they form crystals at the interface. Hence, the outer protein layer tends to be repelled from the fat globules. As a result, the emulsion is prone to destabilization by mechanical action during freezing. This destabilizing effect, in conjunction with other processing factors, is considered to be primarily responsible for development of the desired product structure.

The dry appearance of ice cream coming out of the freezer is believed to be caused by several phenomena, one of which is an emulsifier induced clustering of fat globules at the liquid air interface. Also, more air cells of smaller size foaming on account of presence of emulsifiers appear to provide more surface with the available liquid, which implies that the liquid is spread over a larger area.

The de-emulsification effect of emulsifiers is related not only to the quantity of emulsifiers used but also to the fat content of the product. With increasing emulsifier concentration, fat de-emulsification is enhanced and beyond a certain limit, greasy texture and short body result due to butter formation in the freezer. Higher fat levels magnify this de-emulsification phenomenon. Thus, an emulsifier level just enough to provide the correct amount of ‘partial churning’ is necessary, and less emulsifier is required in a high-fat ice cream than in a low fat one. Excessive emulsifier may promote slow melting and curdy meltdown.

8.3.3 Influence on mix and ice cream

1) Effect of type of an emulsifier

Different emulsifiers differ structurally, and so their action in ice cream differs, too. Obviously, therefore, the quantity of emulsifier required varies with the type of emulsifier used. Mono- and diglycerides are often used in combination, although the former is more effective. When unsaturated fatty acids such as oleic acid are present in the molecule, these emulsifiers promote better dryness at drawing from the freezer.The fat destabilization responsible for stiffness of the frozen mix is in the decreasing order for mono laurate,monooleate, and mono stearate in that sequence used at 0.1-0.2%, mono- and diglycerides are less likely to cause churning. However, their drying and whipping ability is somewhat limited as compared to polysorbates which are water soluble components of sorbitol. Tween 80 or polysorbate 80 (polyoxyethylene sorbitan monooleate) has a high drying power and aids in heat shock resistance, but the unsaturated fatty acid may undergo auto oxidation to develop an off flavour,particularly when a certain level is exceeded. Used usually at 0.02 to 0.06%,Tween 80 in excess may cause churning especially in soft serve and high fat ice creams. Another polysorbate, Tween 65 (polyoxyethylene sorbitan tristearate) has a little lower drying power as compared to Tween 80 but has excellent whipping properties. Because of its flavour stability, Tween 65 can be used at higher levels (e.g. 0.1%) without any adverse effect on the products flavour. The fat destabilizing ability of different polysorbates is in the order Tween 80> Tween 40 (polyoxyethylene sorbitan monopalmitate) > Tween 60 (polyoxyethylene monostearate)> Tween.

2) Mix processing in relation to emulsifier action

It is necessary that for an emulsifier to be effective in ice cream mix, the latter has to be homogenized. While milk protein, casein in particular helps achieve size reduction of fat globules by homogenization,presence of emulsifiers promote greater size uniformity as, for example, mix containing a monoglyceride displays upon homogenization, a very narrow band of size distribution (about 1µ) as compared to mix without monoglyceride (1-5 µ).While homogenization of ice cream mix helps to stabilize the oil-in-water emulsion, it is this stabilizing effect in conjunction with the destabilizing effect of the emulsifier that results in the desirable texture quality. The greatly decreased fat globule size coupled with controlled de-emulsification caused by emulsifiers, in essence, brings about the development of the right kind of structure and corresponding texture in ice cream.

During ageing of ice cram mix, milk fat crystallizes, much of crystallization taking place during the first hour. Presence of emulsifiers leads to more extensive fat crystallization. The emulsifier caused protein desorption from fat globules is time dependent and takes place during ageing. Further, the initial desorption from the surface of the fat globules, in the presence of emulsifiers, occurs as the removal of a coherent protein layer rather than individual casein particles. The process of deemulsificaiton continues into the freezer to yield the desired body and texture.

Emulsifiers and stabilizers contribute to a great extent, to the desired body and texture characteristics of ice cream and frozen desserts. The mechanisms of their actions have been studied extensively in recent times and their role in conjunction with various processing steps have been delineated by various workers. It is well recognized that individual compounds vary considerably in their emulsifying/ stabilizing effects and often a single compound is not entirely satisfactory. Thus, a mixture of two or more emulsifiers/ stabilizers is generally preferred to overcome the drawbacks of individual compounds.