

ICE-CREAM & FROZEN DESSERTS



Jump to...



B. Tech. (Dairy Technology) ► DT-3 ► Resources ► Lesson 18. EFFECT OF PROCESSING ON PHYSICO-CHEMICAL PROPERTIES: CONTROL OF WHIPPING ABILITY OF MIXES

Module 6. Physico-chemical properties of ice cream mixes and ice cream

Lesson 18

EFFECT OF PROCESSING ON PHYSICO-CHEMICAL PROPERTIES: CONTROL OF WHIPPING ABILITY OF MIXES

18.1 Introduction

Incorporation of air in ice cream is necessary to produce ideal body and texture. The amount of air that can be whipped into the mix will be influenced by the regulations and by the composition of the mix. As a guide, maximum overrun should be 2.5 to 3 times the total solids content to avoid possible defects in the finished ice cream.

18.2 Whipping Ability of Ice Cream Mixes

The mix and air in-flow and ice cream out-flow rates determine the time that the mix spends inside the barrel (known as the residence time, typically 30-60 s), the overrun, the pressure inside the barrel (typically 5 atm.) and the throughput (which can be as much as 3000 lh^{-1} in a large industrial freezer). All of these, together with the dasher rotation speed (typically 200 rpm), determine the outlet temperature. Modern factory freezers are computer-controlled, allowing easy monitoring and control of the process parameters. Air is injected into the barrel through a system of filters to ensure that it is clean, dry and free from microbiological contamination. Initially the air forms large bubbles. It is essential to create (and maintain) a dispersion of small air bubbles to obtain good quality ice cream. The beating of the dasher shears the large air bubbles and breaks them down into many smaller ones: the larger the applied shear stress, the smaller the air bubbles. Long residence times also lead to small air bubbles. It is easier to whip air into a foam that consists of a large volume fraction of liquid and a small volume fraction of air than vice versa. The high pressure inside the barrel reduces the volume of the air that has been introduced, and therefore makes it easier to aerate further.

In a standard ice cream formulation, sufficient partial coalescence occurs to enable a stable air cell structure to be maintained at overruns up to about 120%. It can be difficult to obtain overruns of more than about 60% in products where fat and protein are not present, or only present in small quantities, such as sorbets. Similarly it is difficult to obtain high overruns if there is insufficient shear (for example because of a very short residence time) to produce partially coalesced fat. Extra shear, and hence increased de-emulsification, can

be produced either by increasing the dasher speed or by using a closed dasher. Whilst the mix is aerated, it is simultaneously frozen.

18.3 Factors Affecting Whipping Ability of Mix

The factors affecting whipping ability of mix (not so important in continuous freezers but of great importance in batch freezing)

18.3.1 Total solids

Total solids replace water in the mix, thereby increasing the nutritive value and mix viscosity and improving the body and texture of the ice cream. Increasing the percentage of total solids up to a certain extent decreases the percentage of frozen water and permits a higher overrun in ice cream. A heavy soggy product may result when the total solids content is too high i.e. above 40-42%.

18.3.2 Butter fat

If butter is used with emulsifier, there is a positive influence on whipping ability of mix. Limitations on excessive use of fat in a mix include cost, a hindered whipping ability, decreased consumption due to excessive richness, and high caloric value

A partially crystalline fat droplet is necessary for clumping to occur. This has been attributed to the protrusion of crystals into the aqueous phase, causing a surface distortion of the globule. The crystal protrusions can then pierce the film between two globules upon close approach. As the crystals are preferentially wetted by the lipid phase, clumping is thus inevitable. This phenomenon may account for partial clumping of globules under a shear force. The clusters thus formed actually hold the ice cream serum in their interstices, resulting in the observed dryness. These fat globule chains may also envelop the air cells, thus improving overrun, but fat crystals are also known to impair overrun development in whipped cream.

In an experiment, a portion of milk fat in ice cream was substituted with safflower oil, a highly unsaturated oil, in an attempt to lower the saturated fatty acid content of the final product. The authors reported that increasing concentration of safflower oil decreased overrun but had little effect on the extent of fat destabilization at lower substitution levels

18.3.3 Serum solids

Milk solids-not-fat (MSNF) or serum solids improve the texture of ice cream, aid in giving body and chew resistance to the finished product, are capable of allowing a higher overrun without the characteristic snowy or flaky textures associated with high overruns, and may be a cheap source of total solids

Proteins contribute much to the development of structure in ice cream, including emulsification, whipping, and water holding capacity. The interfacial behavior of milk

The loss of stearic stability from the globule, which was contributed from micellar adsorption, accounts for its greater propensity for partial coalescence during shear. Partial coalescence is responsible for establishing a three-dimensional aggregation of fat globules that provide structural integrity. This is especially important if such integrity is needed when the structural contribution from ice is weaker (i.e., before hardening or during melting).

Milk proteins are well known for their foaming properties and during the manufacture of ice cream, air is incorporated to about 50% phase volume. Thus it should not be surprising that milk proteins contribute to stabilizing the air interface in ice cream. This air interface is very important for overall structure and structural stability. Loss of air can lead to a defect known as shrinkage, the occurrence of which is fairly common and very significant for quality loss and unacceptability of the product

The proteins ,which make up approximately 4% of the mix, contribute much to the development of structure in ice cream including:

- Emulsification properties in the mix
- Whipping properties in the ice cream
- Water holding capacity leading to enhanced viscosity and reduced iciness

a) Citrate, phosphate, calcium and magnesium

These ions decrease tendency for fat coalescence (Sodium citrate, Disodium Phosphate). They prevent churning in soft ice cream for example, producing a wetter product. These salts decrease the degree of protein aggregation. Calcium and magnesium ions have the opposite effect, promote partial coalescence. Calcium sulfate, for example, results in a drier ice cream. Calcium and magnesium increase the degree of protein aggregation. Salts may also influence electrostatic interactions. Fat globules carry a small net negative charge, these ions could increase or decrease that charge as they get attracted to or repelled from the surface.

b) Sugar

Depresses freezing point and prolongs whipping.

c) Stabilizers

During the freezing process, as more and more water freezes, the stabilizer and its complexes get concentrated, and these also provide strength to the air cell wall. Therefore, the amount of air which is incorporated and the degree to which the air cells are stable is influenced by stabilizers. However, increased viscosity may prolong whipping time under certain circumstances.

d) Emulsifiers

Emulsifiers which are used in ice cream are usually integrated with the stabilizers in proprietary blends, but their function and action is very different from the stabilizers. They are used for improvement of the whipping quality of the mix, for production of a drier ice cream to facilitate molding, fancy extrusion, and sandwich manufacture, for smoother body and texture in the finished product, for superior drawing qualities at the freezer to produce a product with good stand-up properties and melt resistance, and for more exact control of the product during freezing and packaging operations. Their mechanism of action can be summarized as follows: they lower the fat/water interfacial tension in the mix, resulting in protein displacement from the fat globule surface, which in turn reduces the stability of the fat globule to partial coalescence that occurs during the whipping and freezing process, leading to the formation of a fat structure in the frozen product that contributes greatly to texture and meltdown properties. The extent of protein displacement from the membrane, and hence the extent of dryness achieved, is a function of the emulsifier concentration.

Egg yolk solids, like sweet cream buttermilk solids improve the whipping ability and shorten the freezing time.

18.3.4 Pasteurization

Higher temperature enhances whipping.

18.3.5 Homogenization

Mixes up to 10% fat content are subjected to homogenization to achieve optimal fat structuring and ice cream meltdown (Fig. 4.5). The net effects of homogenization are in the production of a smoother, more uniform product with a greater apparent richness and palatability, and better whipping ability. Homogenization also decreases the danger of churning the fat in the freezer and makes it possible to use products that could not otherwise be used, such as butter and frozen cream. **(Fig. 18.1), and (Fig. 18.2: Effect of homogenization pressure on fat globules)**

18.3.6 Ageing

An aging time of 4 h or greater is recommended following mix processing prior to freezing. This allows for hydration of milk proteins and stabilizers (some viscosity increase occurs

The whipping qualities of the mix are usually improved with aging. Aging is performed in insulated or refrigerated storage tanks, silos, etc. Mix temperature should be maintained as low as possible ($\leq 5^{\circ}\text{C}$) without freezing.

Depresses freezing point if they contain high sugar, hence prolong whipping.

Batch freezing processes differ slightly than the continuous systems. The barrel of batch swept surface heat exchanger is filled to about one half volume with the liquid mix. The freezing unit and agitators are then activated and the product remains in the barrel for such time so as to achieve the proper degree of overrun and stiffness. Whipping is not controlled but cannot exceed that which will fill the barrel with product i.e. 100% overrun when starting half full.

In a continuous scraped surface freezer, numerous processes take place that ultimately influence the overall quality of the ice cream. One of the most important steps, of course, is freezing water into ice. At the same time as ice is being formed, there is also air incorporation, leading to development of air cells and the desired overrun.

ÉÁÇì ëÉëKÇáÉëKÇáLã çç ÇÁLã çÇLÉëÇì ëÁÉÚ ÁÈ KÜè\ aÇZPMUP

Last modified: Wednesday, 19 December 2012, 03:37 PM

DT-3