Consortium for Educational Communication

Module on

Ice Cream

By

Umar Zahoor

Research Associate

Department of Food Technology

University of Kashmir

9596122406

Text

No one knows exactly when ice cream was first produced. Ancient manuscripts tell us that the Chinese liked a frozen product made by mixing fruit juices with snow – what we now call water ice. This technique later spread to ancient Greece and Rome, where the wealthy in particular were partial to frozen desserts. After disappearing for several centuries, ice cream in various forms reappeared in Italy in the Middle Ages, most probably as a result of Marco Polo returning to Italy in 1295 after some 17 years in China, where he had acquired a liking for a frozen dessert based on milk. From Italy, ice cream spread through Europe during the 17th century, long remaining a luxury product for the royal courts. Industrial ice cream production began at the end of the 19th century when the first mechanical refrigerators were pioneered. Ice cream, a milk-based product, is a major product of the dairy industry and has become a dominant consumer product for large segments of the population. Ice cream is sold both in a package form (cups, cones and cartons) and in 'open' containers at retail outlets or ice cream parlours, which is distributed manually in scoops, cones or sundaes (Warke et al., 2000). According to U.S. standards, ice cream must contain at least 10% milk fat, before the addition of bulky ingredients, and must weigh a minimum of 4.5 pounds to the gallon that is soft frozen just before serving on the premises, so the formulas differ from hard-frozen products. The fat content of soft-serve mixes is in the range of 4–12%, and the serum solids vary inversely from 11 to 14% with fat content (Marshall et al., 2003). Ice cream and related products are members of the "frozen dairy desserts family" and are defined in the Code of Federal Regulations (CFR) Title 21 Part 135. These frozen desserts are defined as follows:

Ice cream is basically defined as that food produced as a result of freezing, while stirring, a pasteurized mix, followed by homogenized and

Freezing.

''Reduced fat'' ice cream contains at least 25% less total fat than the referenced product (either an average of leading brands or the company's own brand).

''Light'' ice cream contains at least 50% less total fat or 33% fewer calories than the referenced product (the average of leading regional or national brands).

''Low-fat'' ice cream contains a maximum of 3 g of total fat per serving (1/2 cup).

''Nonfat'' ice cream contains less than 0.5 g of total fat serving.

Ice cream can be divided into a number of categories. As legislation varies from one country to another, the following should be regarded as a guideline only. The fat content of ice cream typically determines the category to which it belongs. In some countries fat content has to exceed 9 % to" qualify" for the ice cream category. Below this level, the product is typically called milk ice, whereas ice cream with more than 12 – 13 % fat is often categorized as either luxury or premium.

"The fat can be either of animal or vegetable origin. If the latter, legislation in a number of countries dictates that the product cannot then be called ice cream, but must be labelled, for example, non-dairy ice cream. In Denmark the special term "ermol" has to be used."

General composition of Ice cream

Milk fat: 10% - 16% (greater than 10%by legal definition and usually between 10% and as high as 16% fat in some premium ice cream)

Milk solid not fat (SNF): 9% - 12% (also called as serum solids, contains the proteins (Caseins and Whey protein) and carbohydrates (lactose) found in milk The SNF contains on average dry weight basis, 38% protein, 54% lactose and 8% ash (including Ca 1.38%, P 1.07%, K 1.22%, Na 0.7%).

Sweeteners: 10% - 14% (usually a combination of sucrose and glucose based corn syrup sweeteners

Emulsifiers and Stabilizers: 0.5% - 0.25%

Water: 55% - 64%

Fat

Fat makes up about 10 – 15 % of an ice cream mix and may be milk or vegetable fat. Milk fat or fat in general, including that from non dairy sources is important to ice cream for the following reasons:

- Increases the richness of flavor in ice cream
- Produces a characteristic smooth texture by lubricating
- Helps to give body due to its role in fat destabilization
- Aids in good melting properties due to its role in fat destabilization
- Aids in lubricating the freezer barrel during manufacturing during manufacturing (Non-fat mixes are extremely hard on the freezing equipment

Milk fat is used in the form of whole milk, cream, butter or anhydrous milk fat (AMF). Where the milk fat is replaced by vegetable fat, hydrogenated (hardened) coconut oil and palm kernel oil are most commonly used. The blends of oils are often used in ice cream manufacture, selection to take into account physical characteristics, flavor, availability, stability during storage and cost. The use of vegetable fat in ice cream is regulated by legislation in many countries. During freezing of ice cream the fat emulsion which exists in the mix will partially destabilize or churn as a result of the air incorporation, ice crystallization and high shear forces of the blades. This partial churning is necessary to set up the structure and texture in ice cream which is very similar to the structure in whipped cream. Emulsifiers are used to promote this destabilization process. The triglycerides in milk fat have a wide melting range (+40^0 C to – 40^0 C) and thus there is always a combination of liquid and crystalline fat. Alteration of this solid: liquid ratio can affect the amount of fat destabilization that occurs. Duplicating this structure with other sources of fat is difficult. In various parts of the worlds (UK, Europe, America) vegetable fat are used extensively as fat sources in ice cream.

While selection of the fat following factors should be kept into consideration

- Crystal structure of the fat
- The rate at which the fat crystallizes during dynamic temperature conditions
- The temperature dependent melting profile of the fat (at chilled and freezer temperatures)
- The content of high melting triglycerides which can produce a waxy, greasy mouth feel
- Flavor and purity of the oil

The limitations of the excessive use of butterfat includes

Cost

Hindered whipping ability

Decreased consumption due to excessive richness

High caloric value

Solid not fat (SNF) SNF consist of proteins, lactose and mineral salts derived from whole milk, skim milk, condensed milk, milk powders and/or whey powder. In addition to its high nutritional value, SNF helps to stabilise the structure of ice cream due to its water-binding and emulsifying effect. The same effect also has a positive influence on air distribution in the ice cream during the freezing process, leading to improved body and creaminess. The quantity of MSNF should always be in proportion to the water content. The optimal level is 17 parts MSNF to 100 parts water:

%SNF = 17 (100 – other solids in percentage) / 117

SNF ingredients have following beneficial reasons

- Improves the texture of ice cream due to the protein functionality
- Helps to give body and chew resistance to the finished product
- Capable of allowing a higher overrun without the characteristic snowy or flaky textures associated with high overrun, due also to the protein functionality
- May be a cheap source of total solids, especially whey protein

The limitations on their use includes off flavors which may arise from some of the products, and an excess of lactose which can lead to the defect of sandiness prevelant when the lactose crystallizes out of solution. Excessive concentration of lactose in the serum phase may also lower the freezing point of the finished product to an unacceptable level.

The best sources of the serum solids include sweetened condensed whole or skimmed milk, frozen condensed skimmed milk, buttermilk power or condensed buttermilk, condensed whole milk, or dried or condensed whey. Superheated condensed skimmed milk with high viscosity is sometimes used as stabilizing agent. Further the proteins which make up approximately 4% of the mix contribute much to the development of structure in ice cream are emulsification properties in the mix, whipping properties in the ice cream, water holding capacity leading to enhanced viscosity and reduced iciness. The lactose crystallization due to a decrease in temperature favours slow crystallization inso far as it increases the viscosity reduces the kinetic energy of the particles and decreases the rate of transformation from beta to alpha lactose. Supersaturated state can exist, however, due to extreme viscosity, and it is likely that much of the lactose in ice cream is non-crystalline. Stabilizers help to hold lactose in supersaturated state due to viscosity enhancement. Fruits, nuts, candy - add crystal centers and may enhance lactose crystallization. Nuts pull out moisture from ice cream immediately surrounding the nut thus concentrating the mix

Sweeteners

Sugar is added to increase the solids content of the ice cream and give it the level of sweetness consumers prefer. Ice cream mix normally contains between 12 – 20 % sugar. Many factors influence the sweetening effect and product quality, and many different types of sugar can be used, such as cane and beet sugar, glucose, dextrose and invert sugar (a mixture of glucose and fructose). The consistency of the ice cream can also be adjusted by selecting different types of sugar..In the production of sugar-free ice cream, sweeteners are used to replace sugar. Aspartame, sorbitol and glycerol or manitol are the most commonly used sweeteners and are applied in conjunction with a bulking agent such as malto-dextrin. Sweeteners improve the texture and palatability of the ice cream, enhance flavors, and are usually the cheapest source of total solids. In addition, the sugars, including the lactose from the milk components, contribute to a depressed freezing point so that the ice cream has some unfrozen water associated with it at very low temperatures typical of their serving temperatures, -15° to -18° C. Without this unfrozen water, the ice cream would be too hard to scoop. Sucrose is the main sweetener used because it imparts excellent flavour. Sucrose is a disaccharide made up of glucose (dextrose, cerelose), and fructose (levulose). Sucrose is dextrorotatory - meaning it rotates a plane of polarized light to the right, +66.5°.With hydrolyzed sucrose the plane of polarization is to the left, "inverted" -20°. An acid, plus water, plus heat treatment, at concentrations above 10%, yields invert sugar and increases the sweetness. It has become common in the industry to substitute all or a portion of the sucrose content with sweeteners derived from corn sugar. This sweetener is reported to contribute a firmer and chewier body to the ice cream, is an economical source of solids, and improves the shelf life of the finished product.

Emulsifiers and stabilizers

Emulsifiers and stabilizers are typically used as combined products at dosages of 0,5 % in the ice cream mix. Traditionally, these products were produced by dry blending, but nowadays integrated products are preferred due to their high performance and improved storage stability Emulsifiers are substances that assist emulsification by reducing the surface tension of liquid products. They also help stabilise the emulsion during the homogenisation process by creating smaller, more uniform fat globules. The emulsifiers are a group of compounds in ice cream that aid in developing the appropriate fat structure and air distribution necessary for the smooth eating and good meltdown characteristics desired in ice cream. Since each molecule of an emulsifier contains a hydrophilic portion and a hydrophobic portion they reside at the interface between fat and water. As a result they act to reduce the interfacial tension or the force which exists between the two phases of the emulsion**.** This causes a desorption of protein from the fat droplet surface, which promotes a destabilization of the fat emulsion (due to a weaker membrane) leading to a smooth, dry product with good meltdown properties (see diagram on the right). Their action will be more fully explained in the structure of ice cream section

The original ice cream emulsifier was egg yolk, which was used in most of the original recipes.

Today, two emulsifiers predominate most ice cream formulations.

1. Mono and di glycerides

They are derived from the partial hydrolysis of fats or oils of animal or vegetable origin

2. Polysorbate 80

A sorbitan ester consisting of a glucose alcohol (sorbitol) molecule bound to a fatty acid, oleic acid, with oxyethylene groups added for further water solubility. Other possible sources of emulsifiers include buttermilk, and glycerol esters. All of these compounds are either fats or carbohydrates, important components in most of the foods.

A stabiliser is a substance that has the ability to bind water when dispersed in a liquid phase. This is called hydration and means the stabiliser forms a matrix that prevents the water molecules from moving freely. Generally speaking there are two types: protein in the form of gelatine, and carbohydrates, including seaweed colloids, hemi-cellulose and modified cellulose compounds. Stabilisers are used in ice cream production to increase the viscosity of the mix and create body and texture. They also control the growth of ice crystals and improve melting resistance

The functions of stabilizers in ice cream are

- In the mix: To stabilize the emulsion to prevent creaming of fat and, in the case of carrageenan, to prevent serum separation due to incompatibility of the other polysaccharides with milk proteins, also to aid in suspension of liquid flavours.

- The ice cream at draw from the scraped surface freezer: To stabilize the air bubbles and to hold the flavourings, e.g., ripple sauces, in dispersion,

- In the ice cream during storage: To prevent lactose crystal growth and retard or reduce ice crystal growth during storage also to prevent shrinkage from collapse of the air bubbles and to prevent moisture migration into the package (in the case of paperboard) and sublimation from the surface

- In the ice cream at the time of consumption: To provide some body and mouthfeel without being gummy, and to promote good flavor release.

Limitations of the stabilizers include production of undesirable melting characteristics due to too high viscosity, excessive mix viscosity prior to freezing, contribution to a heavy or chewy body

The stabilizers in use today include

Locust Bean Gum

Soluble fibre of plant material derived from the endosperm of beans of exotic trees grown mostly in Africa (Locust bean gum is a synonym for carob bean gum, to the beans of which were used centuries ago for weighing precious metals.

Guar Gum

From the endosperm of the bean of the guar bush, a member of the legume family grown grown in India for centuries and now grown to a limited extent in Texas.

Carboxymethyl cellulose (CMC)

Derived from the bulky components, or pulp cellulose of plant material and chemically derivatized to make it water soluble.

Xanthan gum

This gum produced in culture broth media by the microorganism Xanthaomonas campestris as an exopolysaccharide, used to a lesser extent

Sodium alginate

It is an extract of seeweed, brown kelp, also used to a lesser extent

Carrageenan

Carrageenan an extract of Irish Moss or other red algae, originally harvested from the coast of Ireland, the village of Carragheen but now most frequently obtained from Chile and the Phillipines. Each of the stabilizers has its own characteristics and often, two or more of these stabilizers are used in combination to lend synergistic properties to each other and improve their overall effectiveness. Guar, for example, is more soluble than locust bean gum at cold temperatures, thus it finds more application in HTST pasteurization systems. Carrageenan is not used by itself but rather is used as a secondary colloid to prevent the wheying off of mix which is usually promoted by one of the other stabilizers. Gelatin**,** a protein of animal origin, was used almost exclusively in the ice cream industry as a stabilizer but has gradually been replaced with polysaccharides of plant origin due to their increased effectiveness and reduced cost.

Colours

Natural or artificial colours are added to the mix to give the ice cream an attractive appearance. Local legislation exists in most countries regarding the use of colors in food.

Other ingredients

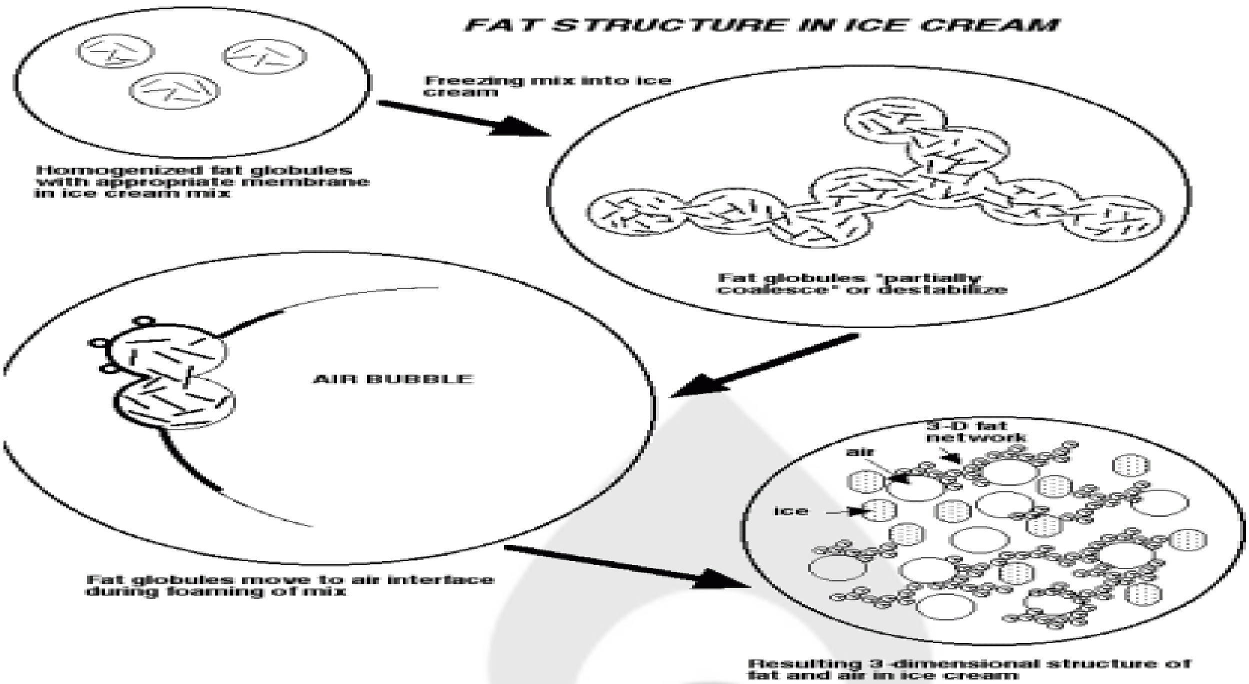
Many moulded and extruded ice cream products are coated with chocolate. Generally speaking, two types of chocolate coatings are used real chocolate and chocolate compound, the latter containing cocoa powder instead of cocoa mass and cocoa butter, and vegetable fat such as coconut or palm kernel oil. Ripples (sauces) are incorporated in ice cream for taste and appearance. They can also be applied for pencil filling and top decoration. Dry ingredients are added through an ingredient feeder. A great variety of products are used: chocolate, nuts, dried fruit pieces, candies, cookies, Smarties, caramel pieces, etc.

Ice cream Structure

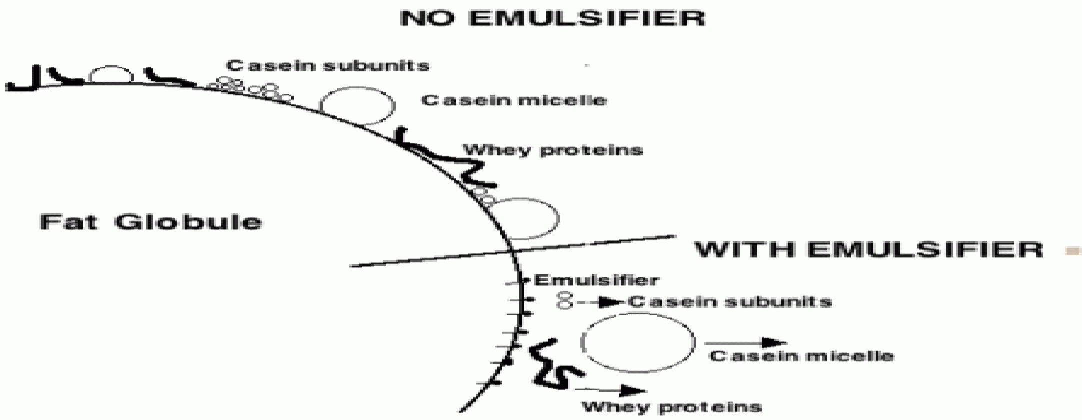
Ice cream is both fascinating and confusing. The texture of the ice cream when we consume it (smooth, coarse, etc.) is based on its structure and thus the structure is probably one of its most important attributes.

1. Colloidal aspect of ice cream structure
2. Ice cream meltdown
3. Structure from ice cream

1. **Colloidal aspect of ice cream structure**



Ice cream is both an emulsion and a foam. The milk fat exists in tiny globules that have been formed by the homogenizer. There are many proteins that act as emulsifiers and give the fat emulsion its needed stability. The emulsifiers are added to ice cream to actually reduce the stability of this fat emulsion by replacing proteins on the fat surface (shown on the right), leading to a thinner membrane more prone to coalescence during whipping. When the mix is subjected to the whipping action of the barrel freezer, the fat emulsion begins to partially break down and the fat globules begin to flocculate or destabilize. The air bubbles which are being beaten into the mix are stabilized by this partially coalesced fat. If emulsifiers are not added the fat globules would have so much ability to resist this coalescing, due to the proteins being adsorbed to the fat globule that the air bubbles would not be properly stabilized and the ice cream would not have the same smooth texture



Ice cream Meltdown

one of the important manifestations of ice cream structure is its melt-down. When you put ice cream in an ambient environment to melt, Two events occur the melting of the ice and the collapse of the fat stabilized foam structure. The melting of the ice is controlled by the outside temperature and the rate of heat transfer. However even the ice cream melt, the ice cream does not melt until the fat stabilized foam structure collapses and that is a function of the extent of fat destabilization/ partial coalescence which is controlled mostly by the emulsifier concentration.

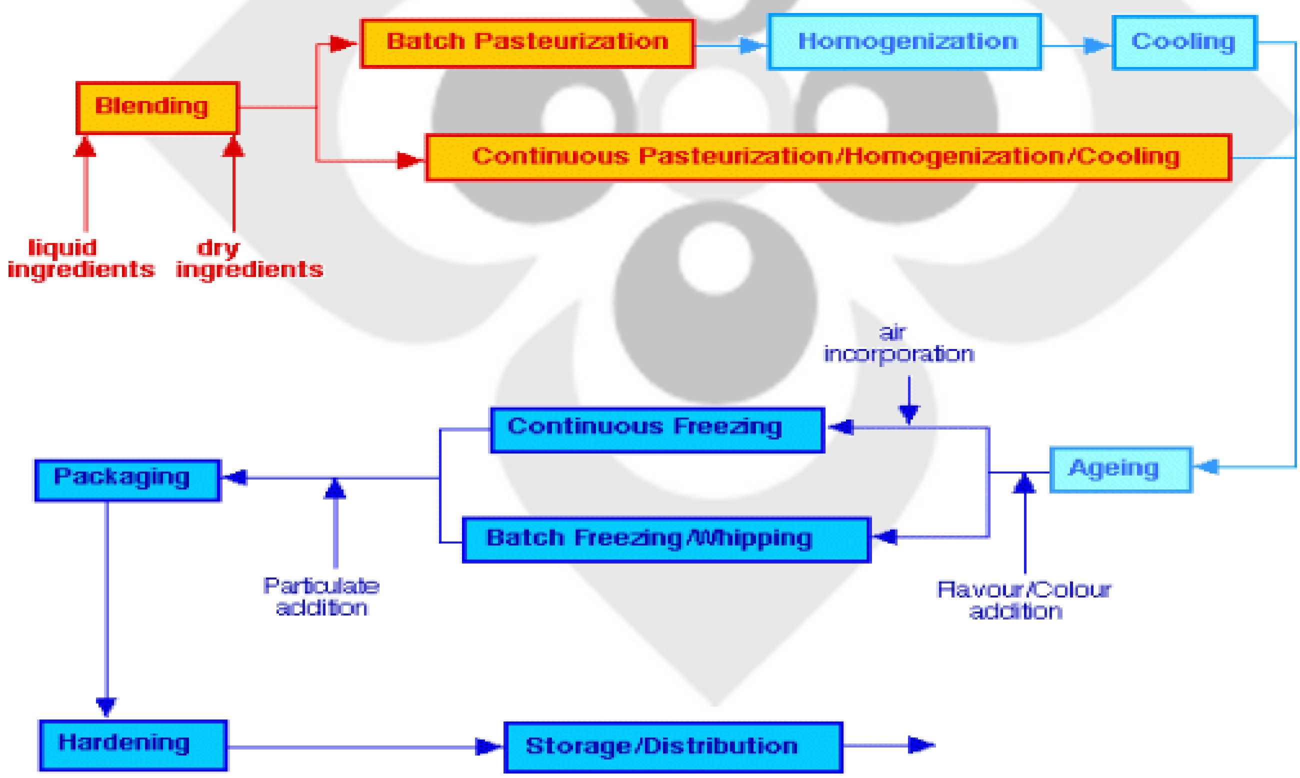
Structure from the ice crystals

Adding structure to the ice cream is the formation of the ice crystals. Water freezes out of a solution in its pure form as ice. In a sugar solution such as ice cream the initial freezing point of the solution is lower than 0^0C due to these dissolved sugars (freezing point depression). This is mostly a function of sugar content of the mix. As the ice crystallization begins and water freezes out in its pure form, the concentration of the remaining solution of sugar is increased due to water removal and consequently the freezing point is lowered. This process of freeze concentration continues to a very low temperature.

Ice cream Manufacture

The basic steps in the manufacturing of ice cream are generally as follows:

1. Blending of the mix
2. Pasteurization
3. Homogenization
4. Ageing of the mix
5. Freezing
6. Packaging
7. Hardening

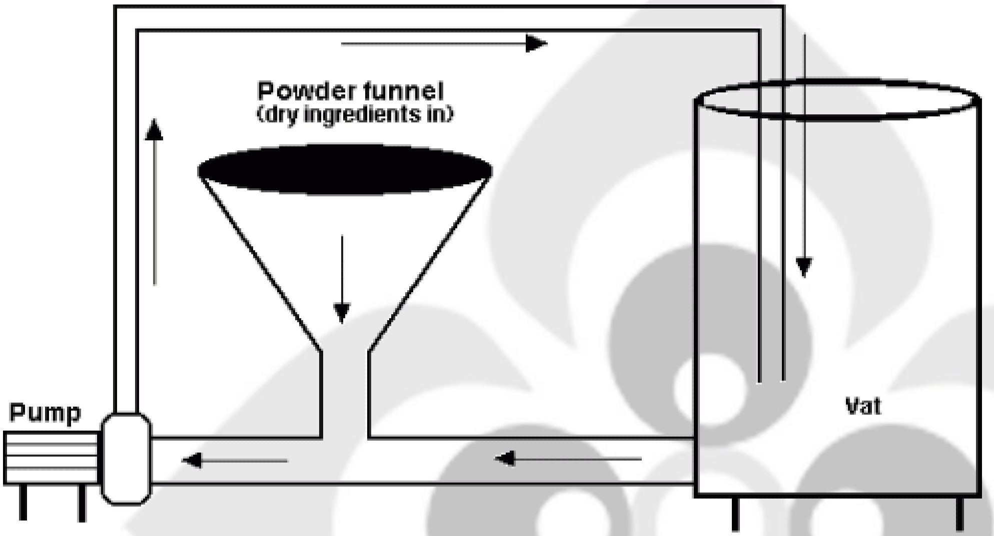


Process flow diagram for ice cream manufacture

(Red section represents the operations involved raw, unpasteruization mix, Pale blue section represents the operations involved pasteurized mix, Dark blue section represents the operations involved frozen ice cream).

1. Blending of the Mix:

First the ingredients are selected based on the desires formulation and the calculation of the recipe from the formaulation and the ingredients chosen. The ingredients are weighed and blended together to produce what is known as the "ice cream mix". Blending requires rapid agitation to incorporate powders and often high speed blending are used. Generally the hopper devices are used for the blending of ice cream.

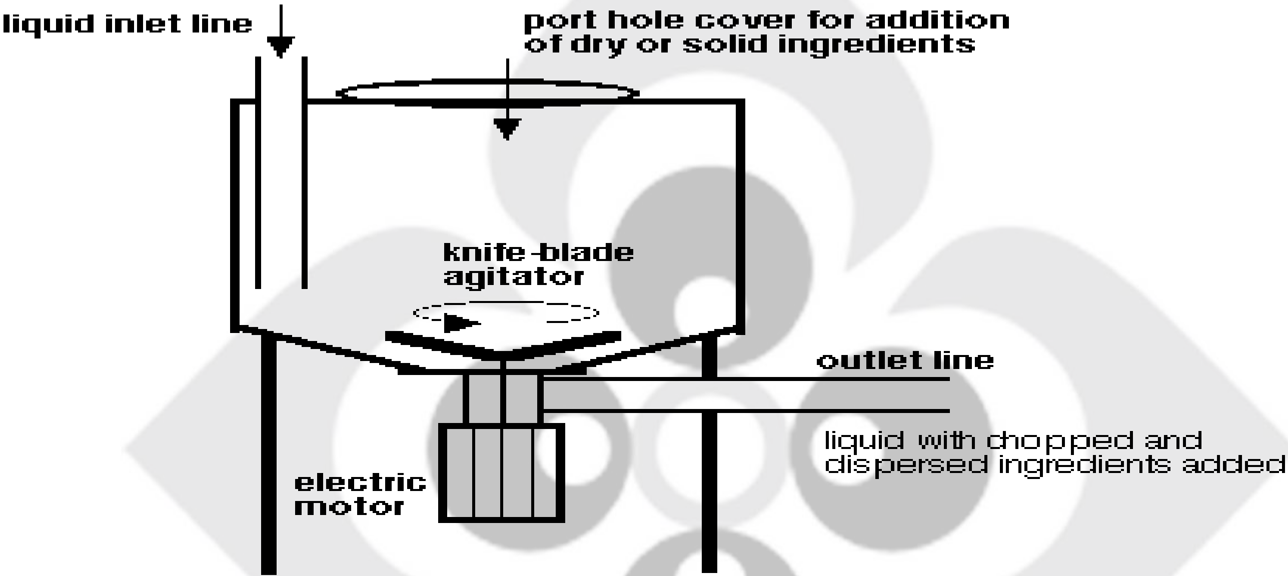


Simple hopper device for incorporating dry ingredients into recirculating liquids

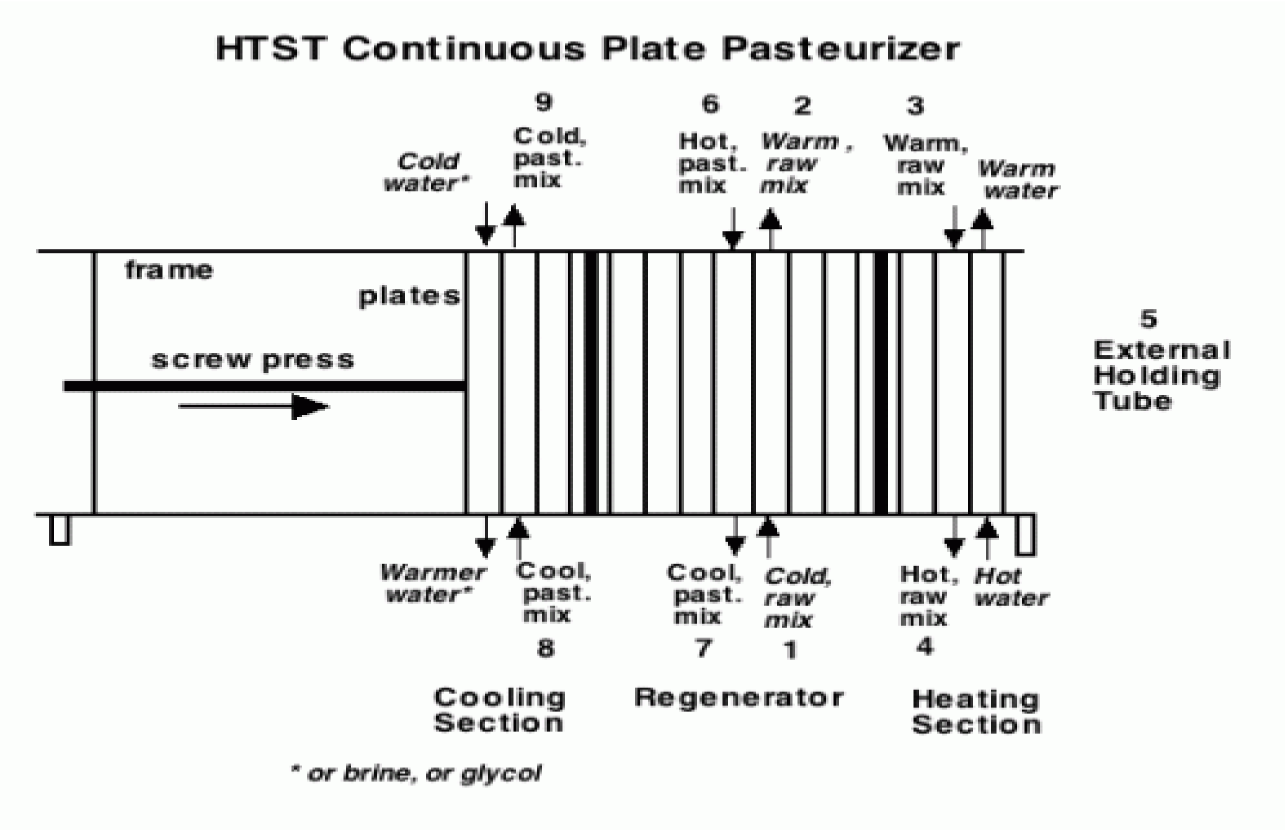
2. Pasteurization of mix

The mix is then pasteurized. Pasteurization is a biological control point in the system, designed for the destruction of pathogenic bacteria. In addition to this very important function pasteurization also reduces the number of spoilage organisms Such as *psychrotrophs* and helps to hydrate some of the components (Proteins, Stabilizers). Batch pasteurizers lead to more whey protein denaturation, which some people feel gives a better body to the ice cream. In a batch pasteurization system, blending of the proper ingredient amount is done in large jacketed vats equipped with some means of heating, usually steam or hot water. The product is then heated in the vat at least 69 C (155F) and held for 30 min to safely legal requirements for pasteurization, necessary for the destruction of pathogenic bacteria. Various time temperature combinations can be used. The heat treatment must be severe enough to ensure destruction of pathogens and to reduce the bacterial count to a maximum of 100,000 per gram. Following pasteurization, the mix is homogenized by means of high pressures and then is passed across some type of heat exchanger (plate or double or triple tube) for the purpose of cooling the mix to refrigerated temperatures (4 C).

High shear blender for incorporating dry ingredients into ice cream mix.



Batch tanks are usually operated in tandom so that one is holding while the other is being prepared. Automatic timers and values ensure the proper holding time has been met. Continuous pasteurization is usually performed in a high temperature short time (HTST) heat exchanger following blending of ingredients in a large, insulated feed tank. Some preheating to 30 to 40 C, is necessary for solubilization of the components. The HTST system is equipped with a heating section, a cooling section and a regeneration section. Cooling section of ice cream mix HTST presses are usually largely than milk HTST presses. Due to the preheating of the mix, regeneration is lost and mix entering the cooling section is still quite warm.



3.

Homogenization of Mix

The mix is also homogenized which forms the fat emulsion by breaking down or reducing the size of the fat globules found in milk or cream to a less than 1 µm. Double stage homogenization is usually preferred for ice cream mix. Clumping or clustering of the fat is reduced thereby producing a thinner, more rapidly whipped mix. Melt- down is also improved.

Homogenization provides the following functions in ice cream manufacture:

- Reduces size of fat globules
- Increases surface area
- Forms membrane
- Makes possible the use of butter, frozen cream etc

By helping to form the fat structure it also has the following indirect effect:

- Makes a smoother ice cream
- Gives a greater apparent richness
- Better air stability
- Increases resistance to melting.

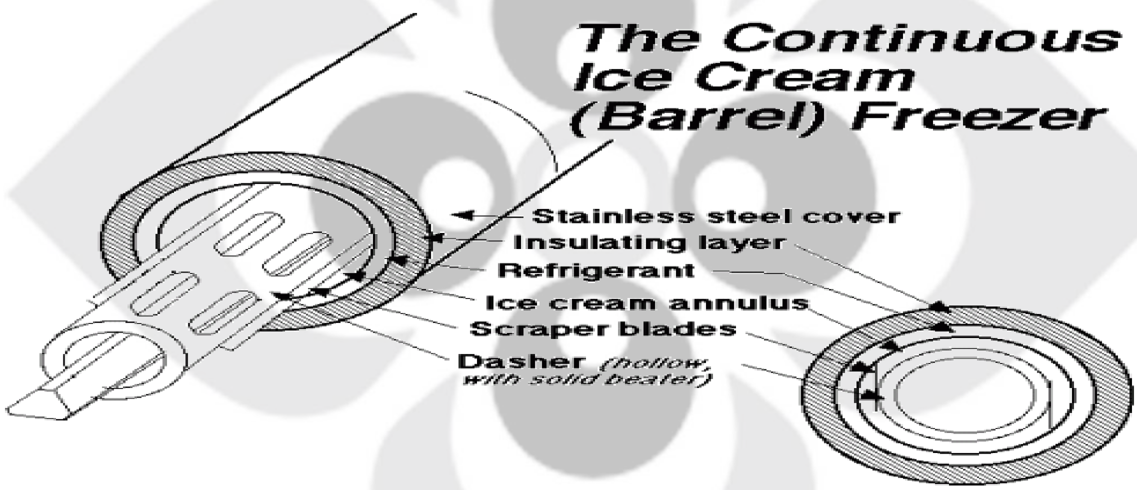
Homogenization of the mix should take place at the pasteurizing temperature. The high temperature produces more efficient breaking up of the fat globules at any given pressure and also reduces fat climping and the tendency to think, heavy bodies mixes. The higher the fat and SNF in mix, lower the pressure should be. If the double stage homogenizer is used a pressure of 2000- 2500 psi on the first stage and 500-1000 psi on the second stage should be satisfactory under most conditions. Double stage homogenization is usually preferred for ice cream. Clumping or clustering of the fat is reduced thereby producing more rapidly whipped mix. Melt-down is also improved.

4. Ageing of Mix

The mix is then aged. This allows time for the fat to cool down and crystallize, and for the proteins and polysaccharides to fully hydrate. The functions of ageing are to Improves whipping qualities of mix and body and texture of ice cream. The mechanism of action is by providing time for fat crystallization such that fat can partially coalesce, allowing time for full protein and stabilizer hydration and a resulting slight viscosity increases and allows time for membrance rearrangements and protein/ emulsifier interaction as emulsifiers displace proteins from the fat globule surface, which allows for a reduction in stabilization of the fat globules and enhanced partial co-alescence. Aging is performed in insulated or refrigerated storage tanks, silos, etc. Mix temperature should be maintained as low as possible without freezing, at or below 5 C. An ageing time of overnight is likely to give best results under average plant conditions. A green or unaged mix is usually quickly detected at the freezer.

5. **Freezing/Whipping of ice cream**

Following mix processing, the mix is drawn into a flavor tank where any liquid flavours, fruit purees or color are added. The mix then enters the dynamic freezing process which both freezes a portion of the water and whips air into the frozen mix. The barrel freezer is a scraped surface, tubular heat exchanger which is jacketed with a boiling refrigerant such as ammonia or Freon. Mix is pumped through this freezer and is drawn off the other end in a matter of 30 seconds with about 50% of its water frozen. There are rotating blades inside the barrel the barrel that keeps the ice scraped off the surface of the freezer and also dashers inside the machine which help to whip to mix and incorporate air.

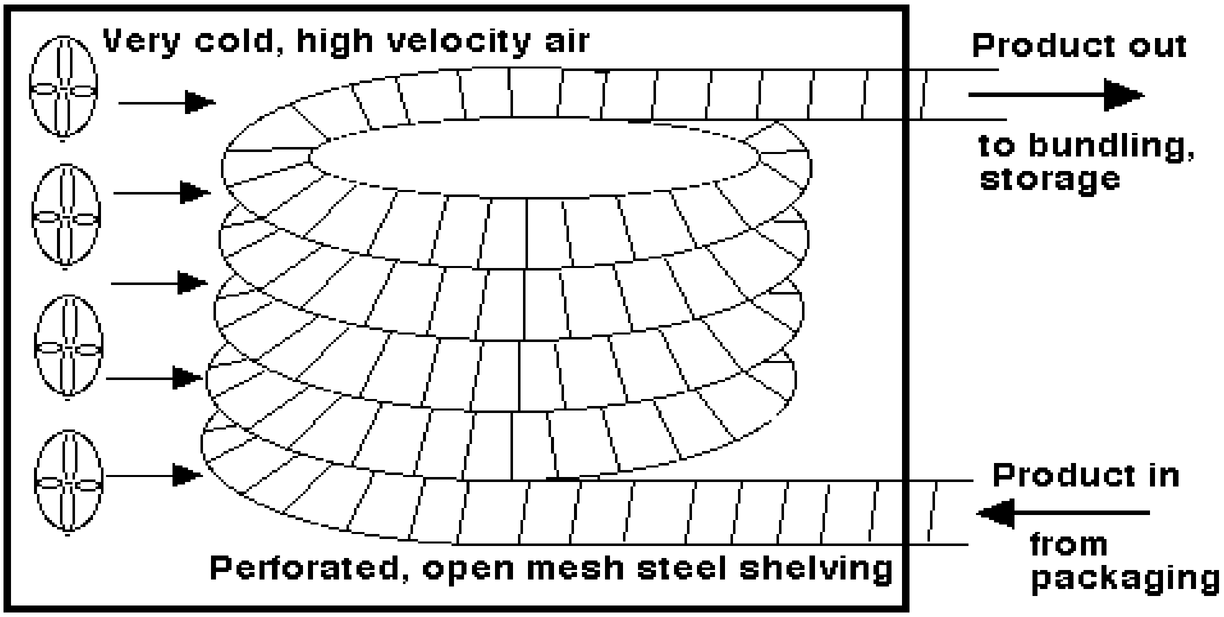


Ice cream contains a considerable quantity of air, up to half of its volume This gives the product its characteristic lightness Without air, ice cream would be similar to a frozen ice cube.

6. Hardening

After the particulates have been added, the ice cream is packaged and is placed into a blast freezer at -30 to -40^{o} C where most of the remainder of the water is frozen. Below above -25^{o} C ice cream is stable for indefinite periods without danger of ice crystal growth.

Above this temperature, ice crystal growth is possible and the rate of crystal growth is dependent upon the temperature of storage. This limits the shelf life of ice cream. Hardening invloves static (still, quiescent) freezing of the packaged products in blast freezer Freezing rate must still be rapid, so freezing techniques involve low temperature (-40oC) with either enhanced convection (freezing tunnels with forced air fans) or enhanced conduction (plate freezers).



Spiral, wind tunnel freezer

The rate of heat transfer in a freezing process is affected by the temperature difference, the surface area exposed and heat transfer coeffient. Thus the factors affecting hardening are those affecting rate of heat transfer.

Defects of Ice Cream

Ice cream defects are generally traceable to some identifiable cause which should be included in the surveillance and control measures assigned to quality assurance. However, gross abuse of the product may occur beyond the sphere of a plant's control (possibly in the hands of the ultimate consumer), in which case little can be done other than to attempt to educate those involved. There are several criteria which may render a product unacceptable

Failure to meet legal composition

• High standard plate count and/or coliform count (above legal maximum)

• Weight below the legal minimum

• Serious flavor defect(s)

• Serious body and texture defect(s)

• Serious defect(s) in appearance (both product and container)

• Contamination with any harmful substance (e.g., bacteria, chemicals)

• Inadequate pasteurization

• Presence of "foreign" substance(s)

• Product mislabeled

• Failure to meet company's own specifications

• Food solids content below legal minimum (e.g., federal standards require that 1 gal of ice cream contains not less than 1.6 lbs of food solids)

• Damaged or unsealed container

Defects Identified by Sight

Some of these defects are the first to be observed by the consumer and, if serious, may lead to rejection of the product. Eye appeal is an important attribute of the product as well as its container.

Defective Container

Numerous problems may be identified, including soiled containers, with either dirt or ice cream on the exterior of the package; dented, torn, or otherwise damaged containers; unsealed or improperly sealed container; improperly or illegibly coded, inferior packaging material; misshapen container; etc.

Product Appearance

Packages may be over- or under filled, which are defects traceable to the filling operation in the plant. However, the product may also be bulging due to changes in atmospheric pressure (when product is transported from a low to a high elevation), or it may be pulling away from the sides and top of the container and appear to be "shrunken." High overrun and heat shock accentuates both problems, although shrinkage may occur for no apparent reason and, just as mysteriously, go away. It seems to be related to some subtle condition in the milk proteins because changing the source of MSNF sometimes stops an outbreak of shrinkage. The color and appearance are largely defined by the ice cream manufacturers who make the product. They decide whether to use artificial colors, and their type and intensity. They also select the fruit, nuts, candy, and variegating syrups and control the concentration of each to be used. The appearance should conform to the manufacturer's design from one run to the next. If an illustration of the product appears on the container, the ice cream should look reasonably the same. Generally, the color should be appealing, compatible with the flavor, and not artificial-looking. Most common color defects are too light, too intense, uneven, and unnatural. The last implies that the color is not compatible with the flavor (e.g., a lemon color in a peach flavored ice cream). Added ingredients (fruit and nut particles, syrups, etc.) should be of desired size, uniformly distributed at the desired density, not icy, and their color should not be bleeding into the surrounding ice cream.

Meltdown Characteristics of Ice Cream

These are observed by the consumer when a serving is not completely consumed. Products may vary in the rate of meltdown and the appearance of the melted portion. Ideally, ice cream should melt to a liquid of the consistency of the mix from which it was made. An old ice cream or one that has been highly stabilized tends to melt slower. Stabilizers and emulsifiers also affect the appearance of the meltdown, which may be curdy, foamy, or actually separated into clear whey. A "buttery" meltdown may result when the ice cream has churned in the freezer. Whey separation may also be observed in the undisturbed mix due to the same causes and when air has been incorporated during processing. The addition of approved food grade protein stabilizing salts (various citrates and phosphates) may affect the meltdown.

Defects of Texture

The aim is to produce an ice cream with a smooth, "creamy" texture consistent with an internal structure made up of small ice crystals and small air cells. There should be no discontinuity of the internal structure perceptible to the consumer as excessive coldness, ice crystals, sugar crystals, or relatively large masses of churned butter. Sugar crystals (lactose) large enough to be perceptible do not melt as rapidly as ice in the mouth and thus impart a "sandy" texture. Smaller undissolved particles may be perceived as chalkiness or astringency. Many steps in the manufacture of ice cream are aimed directly at promoting a smooth textured product (e.g., use of stabilizers and emulsifiers, high solids content, fast freezing, fast hardening, etc.). However, the ice crystals begin to grow in size as soon as the ice cream is made and it is the rate of growth that must be controlled by the choice of proper ingredients and the avoidance of heat shock. Defects in texture due to ice crystals are described as cold, coarse, and icy. The presence of other undissolved particles produces a chalky or sandy texture. The use of excessive emulsifier or ineffective homogenization gives rise to a buttery texture.

Defects in Body

The type of body desired in the ice cream is an option that the manufacturer can exercise. The principal contributors to the body are the solids content (both type and level), stabilizer and emulsifier, and overrun. An ice cream body may be too heavy (excessively "chewy" or resistant to bite), too weak (quick disappearance in the mouth due to low solids, high overrun, or inadequate stabilization), crumbly (lacking cohesiveness due to high overrun, low solids, or ineffective stabilization), short (similar to crumbly and usually caused by high overrun, when scraped, the ice cream lifts up in relatively thin layers, and thus lacks cohesiveness), too dry both in appearance and mouth feel (solids content and certain stabilizers and emulsifiers), or gummy (due to over stabilization).

Flavor Defects

Flavor defects may be impacted by any of the ingredients, but some may also develop in the mix or the ice cream. A logical division of the various defects is based on their source, because it is along these lines that corrective measures must be sought. Some defects will appear under more than one source.

Defects Contributed by the Dairy Ingredients

Any off-flavor present in the milk products may be reasonably expected to appear in the ice cream, although mild defects such as slight feed, slight cooked, or slight flat would be of little consequence or undetectable. More serious off-flavors to be guarded against are:

High acid (sour).

This is one of the defects caused by bacteria when due to favorable temperature and length of storage they are given an opportunity to multiply. Depending on the specific bacteria present, the acid development may be accompanied by other off-flavors of an unpleasant and generally unclean character. Some acid producing bacteria also produce a malty flavor.

Old ingredient.

There are several types of old ingredient flavor. Dehydrated products may become stale due to chemical changes. Fluid dairy products may become subject to bacterial action as in the high acid flavor or when psychrotrophic bacteria (those growing at refrigeration temperature) are active. These bacteria produce off flavors described as fruity, unclean, bitter, putrid, rancid, etc.

Unclean.

When the flavor suggests unsanitary conditions or has a barny character, its generic description is unclean. The term is aptly chosen because of the unpleasant aftertaste which persists after the sample has been tasted.

Oxidized.

Cardboardy, tallowy, and stale-metallic are other terms used to describe this off-flavor. Fat oxidation that leads to the development of oxidized flavor proceeds more rapidly in the presence of copper or iron contamination. Products intended to have a long storage life (dehydrated products, butter, sweetened condensed milk) are also susceptible. Once the off-flavor develops, it continues to get worse, which makes it even more serious. Some milk supplies are particularly susceptible to oxidation. Dry-lot feeding of cows has been shown to be one responsible factor. Another form of oxidation occurs when milk is exposed to sunlight and fluorescent light of low wavelength. It is caused by the oxidation of a protein component and is identified as a cabbage or burnt feathers like flavor.

Rancid.

The enzyme lipase is normally found in milk and under conditions of excessive agitation, foam formation, and alternate warming and cooling, catalyzes the breakdown of the fat. The free fatty acids that are liberated (butyric, caproic, caprylic, capric, and lauric acids) produce the off-flavor which has been variously described as soapy, goaty, bitter, stale coconutlike, and perspiration like. Pasteurization inactivates the enzyme. Mixing of raw milk with homogenized products can initiate the off-flavor production. Homogenization of a product containing active lipase may produce rancidity in a very short time.

Cooked.

There are several variants of the cooked flavor. The milder form is simply described as cooked or custard like. The more unpleasant variants are caramelized, scorched, burnt, or scalded. High-heat NDM, sweetened condensed milk, evaporated milk, ingredients that have turned brown (due to caramelization or Maillard reaction), or ingredients processed at high temperatures when considerable “burn-on” occurred on the heating surfaces are the possible causes of the defect.

Whey.

When whey is used as an ingredient, its flavor quality should be carefully checked. Any off-flavors present will very likely appear in the ice cream.

Foreign.

This represents a serious category of defects caused by contamination of the ingredient by a substance completely foreign to food material. The substances may be sanitizers, detergents, pesticides, paints, lubricants, etc. Quality surveillance of ingredients must discover such problems and reject the ingredient from use.

Defects Due to Mix Processing and Storage

During processing, the mix is susceptible to the development of a cooked flavor. Foreign flavors may also gain access to the mix from the equipment, carelessness on the part of the plant workers, or from the plant environment. If the mix is stored any length of time, it may deteriorate in much the same manner as milk, cream, and other perishable products. Off-flavors may be caused by bacterial action, oxidation, or absorption of odors from the surroundings, including foreign odors.

Defects Due to Flavoring Materials

The quality of flavoring materials must be constantly monitored to ensure that it conforms to the products' design. Difficulties may be encountered with comingling of different flavors when one flavored ice cream follows another in freezing and packaging. The flavoring material may have the desired characteristics, but the imparted flavor may lack perfection due to an excessive or inadequate intensity. The flavor may be slightly lacking in "blend" or be a little harsh, in which case one may criticize it as "lacking fine flavor." If the flavor is uncharacteristic or artificial like,

it can be labeled as unnatural. Other specific shortcomings may be identified by descriptive terminology. For instance, fruits may lack tartness, chocolate may be too bitter, nuts may be rancid, and citrus may have a peel flavor.

Defects Due to Sweetening Agents

In addition to being excessive or deficient, sweetness can also be uncharacteristic. A syrupy flavor suggests caramelization. It may detract from the fine flavor of the flavoring ingredients, particularly vanilla. Defective syrups may also impart a fermented flavor to the ice cream

Defects Due to Storage of Ice Cream

On storage, the flavor of ice cream may undergo chemical changes and the product may absorb odors from the surrounding atmosphere. The flavor may lack the luster of the fresh product, in evident and the criticism becomes storage flavor. Oxidation may also take place giving rise to an oxidized flavor. When the frozen storage facility experiences an ammonia leak, the consequences generally lead to the product being pulled from distribution and discarded.