PAPER NO.: 7

PAPER TITLE: TECHNOLOGY OF MILK AND MILK PRODUCTS

Module – 22: Technology of Ice Cream and Frozen Desserts – III: Hardening, Storage, Distribution and Defects

Introduction

Ice cream is a frozen dairy delicacy. However, freezing of ice cream takes place in two phases (i) Rapid freezing of ice cream mix in the ice cream freezer along with whipping, and (ii) quiescent slow freezing during hardening of ice cream.

The objectives of hardening ice cream are as follows:

(i) To freeze more water in ice cream, which has been drawn from the freezer and filled in the container to obtain better consistency
(ii) To make the ice cream stiff enough to hold its shape during storage and distribution.

Hardening process

After ice cream is drawn from the freezer, it is filled into containers to be placed for hardening; freezing process is continued without agitation until the temperature of ice cream reaches 0^oF or lower, preferably -15^oF (-26.1^oC). Quick hardening is desirable since slow hardening favours formation of large ice crystals and corresponding coarseness of texture in ice cream.

Hardening time

The time necessary for the temperature of the center of the package to drop down to 0^oF is known as 'Hardening time'. When hardening tunnels are used, the rate of hardening is several times faster.

Table 1. Hardening time as affected by type of hardening method and the pack size

Type of hardener	Package size	Hardening time
Still air hardening room	¼ pint	30 min.
Still air hardening room	5 gallon	24 h
Contact Plate hardeners	5 lit.	2-3 h
Cryogenic hardening	5 lit.	1 h

Factors affecting hardening time

Some of the important factors that influences hardening time are:

i) Size, shape, colour and type of package
ii) Air circulation in the hardening room
iii) Temperature of the air
iv) Location of ice cream pack in the section of the hardening room
v) Temperature of ice cream drawn from the freezer

vi) Composition of the ice cream mix
vii) Percent overrun in ice cream
viii) Temperature of the surroundings

Types of hardening units

Traditional method employed Hardening rooms. Hardening cabinet resembles the retail ice cream cabinet and is refrigerated by mechanical refrigeration. These are usually operated at a temperature between -10^{o} and -15^{o}F and are most economical for a limited volume of business. The hardening rooms are classified into (a) Still air hardening rooms, (b) Gravity air type hardening rooms, and (c) Forced-air type of hardening rooms. Quicker hardening methods are being adopted. These include:

(i) Blast tunnel hardeners
(ii) Plate or Contact hardeners
(iii) Cryogenic hardening using liquid nitrogen

Some manufacturers of larger volumes use hardening tunnels that produce an air blast at -30 to -50oF for rapid hardening. These may or may not contain a conveyor belts. The conveying systems have been expanded to include the wide flat belt, fixed tray, suspended free tray, and multishelf carrier types of conveyors. The zone hardening tunnel and the ceiling conveyor systems are other types of hardeners.

Blast tunnel hardeners: Ice cream is hardened in a hardening tunnel, an enclosed chamber into which the ice cream passes on a conveyor belt from the factory freezer. Inside, cold air (typically – 30^{o}C to – 45^{o}C) is blown over the ice cream. The lower the air temperature and the faster the air flow, the faster heat is removed from the ice cream. Air turbulence also increases the rate of heat transfer.

Contact Plate hardener: It is a device used to accomplish rapid hardening of ice cream. It involves an arrangement in which two opposing sides of ice cream packages are placed for a controlled time of contact with two parallel hollow plates, through which cold brine or expanding refrigerant passes. This leads to quite rapid hardening of ice cream in packages.

Cryogenic hardening: This involves hardening of ice cream using liquid nitrogen (i.e. passing ice cream through Cryo's LIN Tunnel freezer at Gulf) which leads to quick hardening of ice cream in bulk in less than 1 h compared to more than 24 h in conventional hardening. The nitrogen remains liquid at temperatures ranging from -346 to -320^{o}F.

Storage of ice cream

After ice cream is hardened, it may be immediately marketed, or it may be stored for a week or two at the most. The manufacturers plan on a maximum of 5 days between freezing and marketing. At least 12 h of this is required for hardening ice cream which frequently remains in the hardening room until marketed.

Since hardened ice cream can be stored satisfactorily at a slightly higher temperature than are required for hardening, it is sometimes more economical to use special storage rooms. The temperature should be maintained uniformly at a point between -10 and 0^{o}F. The packages should be piled very closely to delay any changes in the temperature of the ice cream.

Shipping of ice cream

During marketing, the manufacturer ships it to the retailer under refrigeration at the same temperature as is maintained in the Retailer's cabinet. Dry ice (solid CO_2) may be used for package deliveries. The dry ice is sawed into pieces of appropriate size, which is wrapped in paper to delay rapid evaporation. Then it is placed around the package of ice cream inside an insulated packer, or in single-service type packer. The latter are usually cardboard boxes insulated with corrugated cardboard and are used especially for carryout packages.

Defects in ice cream

Ice cream to be marketed has to possess all of the ideal characteristics associated with the variety of ice cream produced. However, defects may arise in ice cream as a result of use of subgrade raw materials, improper balancing of the ice cream mix, faulty processing, freezing and whipping, hardening and 'heat shock cycle' (temperature fluctuation in the Retailer's cabinet) during storage of ice cream.

Any deviation from the 'ideal characteristics' of ice cream (Table 2) indicates that the product may be 'defective'. The ideal characteristics of ice cream are as follows:

Table 2. Ideal characteristics of ice cream

Attributes	Ideal characteristics of ice cream
Colour and appearance	Delicate, appropriate colours, uniformity of colour should be there. The ideal colour is characteristic of the flavouring used, true in shade, neither too pale nor too intense. Not only uniformity of layers, but also clearness of object outlines should be evident in molded ice creams.
Flavour	The flavor should be typical, pleasing and desirable. The flavor of flavouring added to ice cream mix should be perceptible and should not give harsh note.
Body and texture	Ice cream should be smooth, the solid particles (ice crystals, lactose crystals, etc.) being too small to be detected in the mouth.
Melting quality	Ice cream should slowly melt down to produce a liquid of similar appearance to the mix from which it was prepared. Ice cream should melt down to a non-foamy liquid to present most attractive appearance.
Package	The package should be clean and attractive in appearance; the product inside the package should be completely covered. If cans are used, they should not have rusted.

Defects may result from faults in flavor, body and texture, melting characteristics, colour and package, bacterial content or even composition.

I. Defects in flavor

The ideal flavor should be typical, pleasing and desirable. The type of flavor defects that can probably occur in ice cream are listed in Table 3.

The sources of flavor defects maybe:

- Dairy products of poor quality

- Sweetness – excess or deficient
- Flavouring – excess, deficient or atypical
- Blend – may not be pleasing
- Serving conditions – too hard or too soft product

Table 3. Flavour defects in ice cream

Type of flavor defect	Characteristics	Causative factor
Harsh or low flavour	Excess, unappealing flavor or flavor not perceived aptly	Flavouring ingredient is harsh or not having desired strength of flavour
Unnatural flavour		
Imparted by dairy products		
Cooked flavour	Higher intensity of cooked (heated) flavour	Use of heat treated dairy products viz, evaporated milk, khoa, etc.
Feed flavour	Flavour of feed and weed consumed by milch animals	Milked from milch animal fed on weed and pungent feed
Imparted by tainted dairy products		
High acid	Sour taste	Sour milk ingredients used
Old ingredient	Yeasty, cheesy, musty flavor or bitter taste	Ingredients used were not fresh and had undergone storage changes
Rancid/oxidized	Bitter taste	Ingredients used were oxidized
Salty		
Flavour defect by chemical changes		
Stale and unclean	Flavour of flavouring not quite perceptible	Surrounding of ice cream package not clean
Lacks fine flavour	Lacks desired flavor quality	Flavouring used is unnatural or interfered by other reactions
Acid flavour	Sour taste	Milk ingredients used were acidic
Bitter flavour	Bitter taste	Rancidity of fat source
Flat flavour	Flat flavour	Storage induced flat flavour
Metallic/oxidized flavour	Rancid or metal like taste	Exposing fat to sunlight or diffused light

II. Defects in body and texture

The causative factors for body and texture defects that may be encountered in ice cream are:

- Improper composition of mix
- Improper processing methods
- Improper storage conditions

The probable list of body-texture, melting quality, and color and package defects that have been encountered in ice cream are shown in Table 4.

Table 4. Body and texture defects in ice cream

Defects	Characteristics	Causative factor
Body defects		
Weak	Ice cream lacks firmness or chewiness. When tasted, ice cream is watery and body is fairly light.	Low TS content coupled with insufficient stabilization Withdrawing ice cream from freezer before it has properly frozen Protein destabilized in ingredients
Crumbly	Lacks cohesion and pulls or breaks apart very easily when served	Use of too little stabilizer Low homogenization pressure Too low sugar or TS content Too high overrun, with large air cells
Heavy and soggy	Soggy body is dense, may be somewhat 'wet' in appearance, tastes much colder than normal and is unattractive in appearance	Low overrun, especially when TS is high Excess concentration of stabilizer
Gummy/chewy	Ice cream dishes as a doughy or pasty mass. Ice cream needs to be chewed in mouth	Excessive stabilization, especially with gelatin or gum Excess homogenization pressure Too high TS content
Pasty, sticky or gluey	The ice cream tends to stick to the spoon and trails off when spoon is withdrawn from package	Use of syrups or certain types of gum (pectin, oatgum, etc.) Use of too much egg yolk solids Use of superheated condensed milk and not reducing stabilizer content
Foamy		
Dry	Ice cream tastes very dry and is not very appetizing	Excess amount of emulsifier used Excess homogenization pressure Excess use of certain types of vegetable stabilizers Addition of dry milk solids at the freezer
Texture defects		
Coarse/Icy	Ice crystals are large or not uniform in size; even air cells are too large.	Low TS content of mix Slow freezing (dull freezer blades), slow freezing during hardening, fluctuating storage temperature
Snowy/Flaky/Fluffy	Amount of air incorporated in mix is too great and present as large air cells which makes texture of ice cream light and snowy; it may appear flaky too.	Low TS and high overrun Freezing ice cream too soft in the freezer Use of low stabilizer content
Buttery	Lumps of butterfat, easily	Incomplete homogenization

	detected in mouth while consuming ice cream. As a result of churning of fat, especially during freezing process	Using too high (> 16%) fat content as in Superpremium ice cream Use of too much white butter in the mix Freezing mix too stiff in the freezer
Sandy	Roughness like sand in melted ice cream that is noted not only when rubbed against roof of mouth but also when chewed. It is due to fairly large (> 25 µm) lactose crystals which are slow to dissolve.	High lactose content (i.e. > 8.5%) in relation to amount of water present in mix High and fluctuating temperature in retail cabinet Low viscosity of unfrozen liquid phase Substances present in ice cream (nut piece, cocoa powder) that initiates crystal formation
Melting quality defects		
Foamy meltdown	Melted appearance of ice cream is distinctly foamy	Incorporation of too much air in ice cream, especially due to large air cells Large amount of egg solids High overrun through use of Na-caseinate or some stabilizers
Curdy meltdown/Scummy appearance on melting	Appearance of slightly greenish serum that separated out from the more solid ice cream during melting	Use of stabilizers that destabilize milk protein (i.e. locust bean gum, guar gum, CMC) Excess homogenization pressure Melting and refreezing in the deep freezer
Whey leakage	Whey separates out from ice cream upon melting	Mix is of poor quality Mix is improperly balanced or stabilized
Slow meltdown	When ice cream melts slowly, retains its form after melting, or breaks apart in chunks	Improper processing of mix Homogenizing at too low temperature of mix Use of excess quantity of stabilizers
Very high melting resistance	Ice cream does not melt within 1 h of serving or more	High fat content in ice cream Use of calcium neutralizers Use of certain type of stabilizers Drawing ice cream at too low a temperature from freezer
Colour and Package defects		
Unnatural colour	Insufficient (pale) color, excessive (intense) colour or colour that are not characteristic (true in shade corresponding to the flavor used)	Carelessness in adding colour Improper use of colour Use of foreign materials.
Uneven colour	Colour not uniformly distributed	Colour not properly added

	throughout the matrix of ice cream	Not exercised care when changing flavours in ice cream
Miscellaneous defects		
Shrinkage	The volume of ice cream shrinks (may lose its shape too), leaving a space either at the top or side of the package, which appears as 'not full'. It may develop within 3 or 4 days or even require 3-4 months to manifest itself.	Use of untreated paper containers; loss in moisture from ice cream during storage Temperature fluctuation during storage Excessive overrun in ice cream

Hence, it is imperative to take utmost care starting from ingredient selection for ice cream mix preparation up to storage and distribution, so that consumers can enjoy the frozen delicacy in its ideal condition as manufactured by the ice cream industry.