ICE-CREAM

Module 4. Technological aspects of ice cream manufacture

Lesson 13
FREEZING OF ICE CREAM MIX AND CONTROL OF OVERRUN

13.1 Introduction

Ice cream is a very complex food.The mix has usually more than 60% water. The water dissolves the sugars, both natural lactose and the added sugars, and also dissolves a portion of the salts from the milk solids. Hence there is a colloidal system with proteins suspended in water and an emulsion system with fat – in – water. Freezing the mix is one of the most important steps in making ice cream, since it decides the quality, palatability, and yield of the finished product.

13.2 The Freezing Process

The freezing process may be divided into two parts

1) The mix, with the proper amount of colour and flavouring agents generally added to the freezer, is quickly frozen while being agitated to incorporate air in such a way as to produce and control formation of the small ice crystals that are necessary to give smoothness in body and texture, palatability and satisfactory overrun in the finished ice cream.

2) When ice cream is partially frozen to the proper consistency, it is drawn from the freezer into packages and quickly transferred to cold storage rooms, where the freezing and hardening process is completed without agitation.

The various factors that influence freezing time are

1. Mechanical

2. Character of mix

13.2.1 Mechanical

a) Type and make of freezer

b) Condition of freezer wall and blades

c) Speed of dasher

d) Temperature of refrigerant

e) Velocity of refrigerant passing around freezing chamber

f) Overrun desired

g) Temperature at which ice cream is drawn

h) Rateat which freezer is unloaded.

13.2.2 Character of mix

a)Composition of mix

b) Freezing point of mix

c) Acidity content of ingredients

d) Kind of ingredients, particularly those carrying fat

e) Methods by which the mix is processed

f) Kind and amount of flavoring materials added

13.2.3 Actual freezing process –

Changes during freezing process

The function of the freezing process is to freeze a portion of the water in the mix and to incorporate air into the mix. This involves:-

a) Lowering the temperature of the mix from ageing temperature to the freezing point

b) Freezing a portion of water in the mix

c) Incorporating air into the mix

d) Cooling ice cream from the temperature at which it is drawn from the freezer to hardening room temperature.

The first phase of freezing process accounts for the freezing of 33 to 67 per cent of the water and the second phase (hardening process) accounts for freezing another 23-57 per cent depending on the drawing temperature.

The temperature of the mix which is put into the freezer drops very rapidly while the sensible heat is being removed and before any ice crystals are formed. This process takes less than a minute or two. Meanwhile, the rapid agitation reduces the viscosity by partially destroying the gel structure and by breaking up the fat-globule clusters and also hastens incorporation of air into the mix.

When the freezing point is reached, the liquid water changes to ice crystals which appear in the mix. These ice crystals are practically pure water in a solid form, and thus the sugar as well as the other solutes becomes more concentrated in the remaining liquid water. Increasing the concentration of the solutes slightly depresses the freezing point and when the freezing point is continuously lowered, more ice crystals are formed increasing the concentration of sugar and other solutes in the remaining liquid water until the concentration is so great that further freezing will not occur. Thus all the water does not freeze even after long periods in the hardening room.

13.3 Overrun

Overrun is usually defined as the volume of ice cream obtained in excess of the volume of the mix. It is usually expressed as percentage of overrun.

This increased volume is composed mainly of air incorporated during the freezing process. The amount of air that should be incorporated depends upon the composition of the mix and the way it is processed, and is regulated so as to give the percentage of over run or yield that will give proper body, texture and palatability necessary to good quality ice cream.

13.4 Calculating Overrun

Overrun can be calculated by weighing a container and making a note of it so it can be subtracted later. Note how much the container weighs filled with liquid mix and subtract the container weight. Fill the same container level with frozen product and note its weight.

$$\text{Overrun } \% = \frac{\text{(Wt. of ice crem-Wt. of same vol. of ice cream)}}{\text{(Wt. of same vol. of ice cream)}} \times 100$$

Too much air will produce a snowy, fluffy, unpalatable ice cream; too little air, a soggy, heavy product. Five factors that are usually considered when determining the amount of overrun are

1. Legal regulations enforced in the market area

2. TS content of the ice cream. High TS permit use of a higher overrun.

3. Bulky flavour ice creams require a lower overrun than plain ice cream in order to obtain an equally desirable body and texture.

4. Selling price of ice cream

5. Type of package – bulk packages which are solid for 'dipping' usually contain 90-100per cent overrun, while packages of the carry home type usually are more satisfactory if they contain 70-80 per cent.

The ability to obtain overrun at the freezer depends partly on the concentration and type of ingredients in the mix and on the freezing process itself. Sharpness of scrapper blades, speed of dasher, volume of refrigerant passing over freezing chamber and temperature of refrigerant are important in determining the overrun.

The factors that depress overrun includes

- Fat content
- MSNF content
- Corn syrup solids content
- Increased amount of stabilizer
- Fruits,cocoa and chocolate
- Excessive calcium salts
- Poor homogenization
- Amount of mix in batch freezer
- Insufficient refrigeration
- Mix too warm
- Dull freezer blades
- Freezing the mix to high stiffness.

The Factors specific for continuous freezer includes

- Slow freezer speed
- Slow pump speed
- Pumps worn or need adjusting
- Pump spring bent
- Fruit feeder operation

The factor listed as enhancing overrun includes

- Sodium caseinate
- Whey solids
- Egg yolks
- Emulsifiers
- Certain stabilizers
- Certain salts
- Pasteurization of mix at higher temperature

Those factors specific for continuous freezers includes

- Airleaks in mix intake line
- Erratic springs in air intake value
- Height of flavor tank
- Volume of mix in the flavor tank
- Distance of flavor tank from freezers
- Worn second stage air pump.

To secure uniform overrun and yield, the following points should receive attention:

1. Uniformity in refrigerant temperature and rate of flow of refrigerant.
2. The use of overrun testers, Drawrite or Willman controls.
3. Uniform make, etc., of freezers.
4. Not too many freezers per worker.
5. Hopper systems for filling containers if both freezers are used.
6. The use of a system of checking the weight of packages or containers as they enter the hardening room.

13.5 Changes in Overrun During Discharge From Batch Freezer

The usual sequence of changes is an increase in overrun during the discharge of about first half of the batch, followed by a decrease in overrun during discharge of the last portion of the batch. The initial increase in overrun is due to the greater opportunity afforded for whipping and expansion as part of the batch is removed. The later decrease in overrun is due to the dasher no longer effectively whipping the mix (the quantity of the mix is reduced) and gradual warming up of the mix (since refrigerant is shut off at the start of whipping).

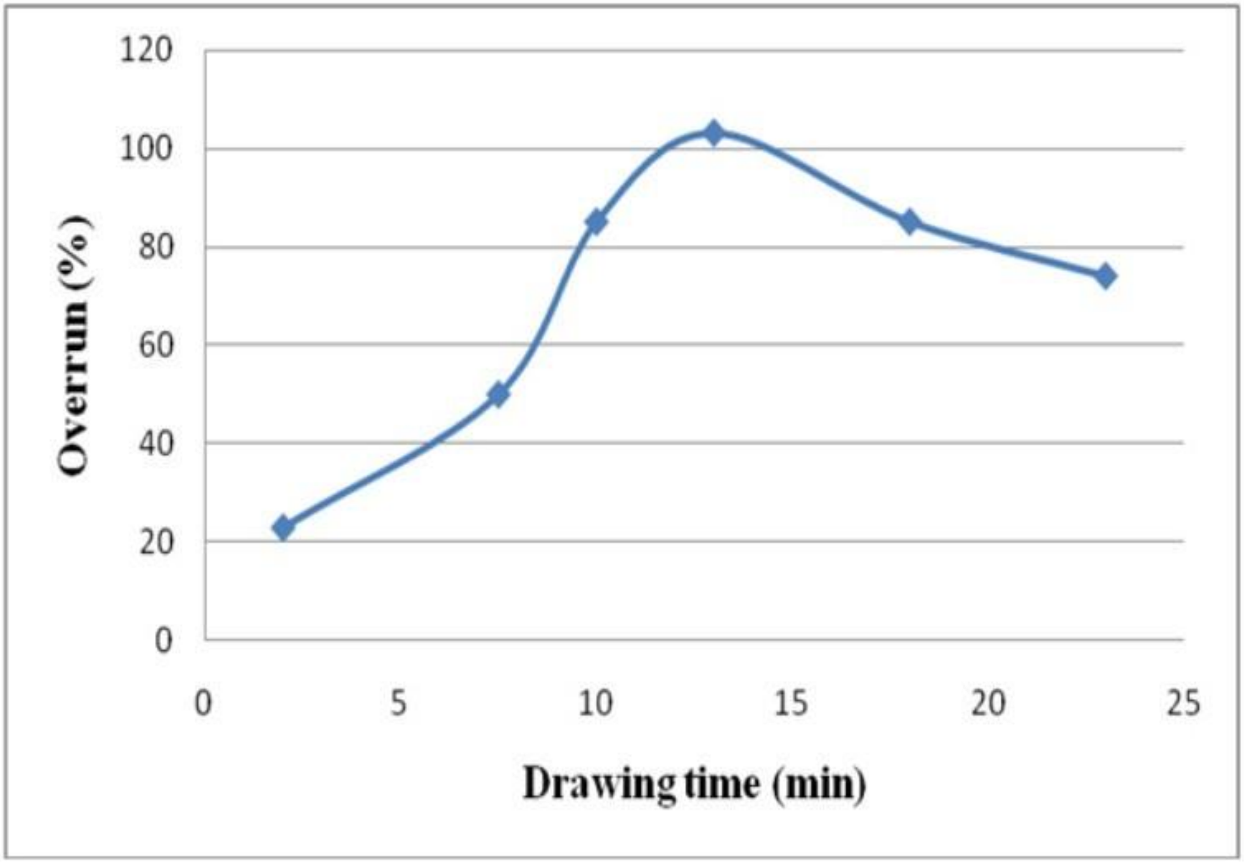

Fig. 13.1 Changes in overrun of ice cream during drawing from batch freezer

13.6 Control of Overrun

The control of overrun is very important and should be maintained as nearly constant as possible from batch to batch and from day to day. A variation of 10% overrun represents sizable differences in profit to the manufacturer. The correct overrun percentage depends upon the kind and composition of product and freezing equipment. The overrun of different products may normally be as shown in table 13.1.

Table 13.1 Percentage of desired overrun for different products

Products	Overrun (%)
Ice cream, packed	70-80
Ice cream, bulk	90-100
Sherbet	30-40
Ice	25-30
Soft Ice cream	30-50
Ice milk	50-80
Milk shake	10-15
Super premium Ice cream	0-20

13.7 Pumps and Overrun System

Pumps on ice cream freezers are usually of the rotary type with the capability to pump against pressure of 7-14kg/cm^2 with reasonable volumetric efficiency. There are two general pumping arrangements, both designed as a part of the overrun systems. The first employs a pump (or pair of pumps) to pump or meter the mix into freezing cylinder, plus a hold back valve at the ice cream discharge port. The hold back value permits imposing a pressure on the cylinder during freezing which compress the air admitted with the mix for overrun. Cylinder pressure of 3.5-4.0 atmospheres keeps the volume of air in the freezing cylinder sufficiently small so that it does not significantly slow the internal heat transfer out from and through the mix, and dispersion into small air cells.

Continuous freezers using the pump and hold back value arrangement have two pumps in close proximity. As mix is pumped, a partial vacuum is produced between the pumps. Air for overrun is allowed to flow into the partial vacuum so that the difference in pumping volume between the pumps is made up with air. An adjustable snifter valve on the air intake allows controlling the amount of air to give the desired overrun.

One of the current freezer shaving this pumping system has a combination pump using into metal, gear type rotors and separate air and mix inlets, air entering the rotors cavities on one side of the pump, mix on the other. This combines the mix and air at the discharge of the pump in the line to the freezer cylinder.

One current model using this two pump system has a hydraulic pump drive which, along with a cylinder pressure sensor and speed controller, permits a continuously variable ratio of pumping volumes between the mix and Ice cream pump to maintain any preset cylinder pressure from 1 atm for products without overrun to in excess of 13 atm for very high overrun products drawn at cold temperatures.

Ice cream freezer pumps are driven by various means, but all of these provides for varying the pump speed. Usually the set of pumps for each cylinder is powered by one drive. Drives are of three types:

1. Electric motor powering a mechanical variable speed drive.

2. Frequency inverters with electronic speed control for standard electric motors. A gear reducer is nearly always used between motor and pump.

3. Hydraulic pumping systems connected to hydraulic motors on the pumps. The hydraulic pumping units may be located within the freezer housing or remotely outside the production room.

13.8 Automated Overrun Control

Automated overrun control system which measure the density of the extruded ice cream and, by feedback, adjust the air supply to attain and maintain the desired overrun are not yet available. The main problem is choosing the point at which to measure the density. Ice cream and related products containing air for overrun are compressible and full overrun is not attained until the product has expanded to atmospheric pressure.This requires some time and, in a continuous flow, is not realized until the products are in its package.

The second major problem is the time lag between density or weight measurement and the change in air input.Current ice cream freezers offer automated overrun systems which use microprocessors to regulate air input in relation to mix input. These provides for presetting the desired overrun. Once overrun has been adjusted, the microprocessor will maintain the flow rates, pressure and other conditions to maintain accurate overrun control.

If the mix has an excess of air incorporated in it from the blending operations, from a leaky seal on the suction side of a pump, or from un melted overrun in the mix, no amount of automation will control the overrun until these undesired air sources are eliminated. Automation is not a replacement for good management practices.

With good management practices and proper operator skills, manual overrun control can be within the standard deviations expected for automated systems. Good practices include proper maintenance of all equipment and pipelines in the system, proper blending of mixes with sufficient Hydration and aging time, minimizing air incorporation, air removal, complete reprocessing of refreeze, keeping mix temperature low and constant throughout the day, supply of mix under uniform pressure to the freezer mix pump, and keeping frozen product lines between freezer and packaging point as short as practical. Good production management will also provide for long operating runs of one productany one day to avoid un necessary changes in products where freezing must be interrupted and restarted.

Last modified: Wednesday, 19 December 2012, 03:33 PM

DT-3