2016

Ice Cream & Frozen Desserts

A. Jana

Suneeta Pinto

P.R.S. Moorthy

ICE-CREAM & FROZEN DESSERTS

A.Jana & Suneeta Pinto
Department of Dairy Technology
AAU, Anand

P.R.S. Moorthy
Department of Dairy Technology
SVVU, Tirupati

Silence Between 2 Unknown People Creates A Relation.
But,
Silence Between 2 Known People Breaks The Relation.
So Be Connected.

EDITOR

AGRIMOON.COM
All About Agriculture...

Course Outline

No.	Lesson No.	Topic
I.	*History, Development and status of ice cream industry*	
	1	Origin and Progress in development of ice cream and frozen desserts industry.
	2	Status of ice cream industry in India and abroad
II.	*Definition, classification and composition of Ice cream and other frozen desserts*	
	3	Definition of ice cream as per PFA. Classification of ice cream-I viz., Plain, Fruit and Nut, Chocolate, Ice lollies, Candies, Kulfi & Malai-ka-baraf,.
	4	Classification of ice cream – II viz., Sherbets and Ices, Mousse, Gelato, Bisque, Custards, Cassatta, Variegated ice cream, Novelties, etc.
	5	Composition of ice cream (low-fat, good average, Premium) and frozen desserts (Sherbets, Ices, Soft serve).
III.	*Ingredients in Ice cream and frozen desserts*	
	6	Dairy Ingredients in ice cream.
	7	Stabilizers and Emulsifiers – classification, types, properties and role in ice cream
	8	Stabilizers and Emulsifiers – selection, mechanism of action, influence on mix and ice cream, proprietary stabilizer blends.
	9	Non-Dairy Ingredients in Ice Cream.
IV.	*Technological aspects of ice cream manufacture.*	
	10	Preparation of ice cream mix – standardization, blending, homogenization.
	11	Preparation of ice cream mix - pasteurization, cooling, ageing and flavour addition.
	12	Types of ice cream freezers – Batch, Continuous, Soft-serve freezers, home-made freezers.
	13	Freezing of ice cream mix and control of overrun.
V.	*Thermodynamics of freezing and refrigeration load*	
	14	Typical freezing curve. Calculating freezing point of ice cream mix.
	15	Calculating refrigeration load. Refrigeration control and related instrumentation.
VI.	*Physico-chemical properties of ice cream mixes and ice cream.*	
	16	Physico-chemical properties of ice cream mixes-I
	17	Physico-chemical properties of ice cream.
	18	Effect of processing on physico-chemical properties. Control of whipping ability of mixes.
VII.	*Packaging, hardening, storage and shipping of ice cream.*	
	19	Packaging of ice cream and Hardening.
	20	Hardening of ice cream – hardening methods, Storage and Shipment of ice cream
VIII.	*Defects in ice cream*	
	21	Sensory Attributes of Ice cream and frozen desserts.
	22	Defects in Ice cream - Flavour, Body & Texture
	23	Defects in ice cream – Colour and appearance, package and melting quality.
	24	Method of Sensory Evaluation of Ice Cream.
IX.	*Technology of dried ice cream mix and Nutritive value of ice cream.*	
	25	Dried ice cream mix – composition, technology, uses.
	26	Nutritive value of Ice cream- calculating and labeling.
X.	*Hygiene, cleaning and sanitation of ice cream plant.*	

	27	Personnel, equipment and plant hygiene, Cleaning and sanitization of ice cream freezers and related equipments.
XI.	***Legal standards, microbiological aspects of ice cream and safety aspects.***	
	28	Microenvironment in ice cream, microbiological quality of ingredients.
	29	Critical process factors – its impact on entry of pathogens, their survival during storage.
	30	Food poisoning outbreaks, food safety and legal standards.
XII.	***Recent advances in ice cream industry and plant management***	
	31	Low-calorie, reduced fat, diabetic and dietetic ice cream and frozen desserts.
	32	Developments in ice cream Industry.

Module 1 - History, Development And Status Of Ice Cream Industry

Lesson-1

Origin and Progress in Development of Ice Cream and Frozen Desserts Industry

1.1.INTRODUCTION

Ice cream evolved from the iced beverages and water ices that were popular in the early medieval period. Alexander - the Great enjoyed snow and ice flavored with honey and nectar. Biblical references also show that King Solomon was fond of iced drinks during harvesting. During the Roman Empire, Nero Claudius Caesar (A.D. 54-86) frequently sent runners into the mountains for snow, which was then flavored with fruits and juices. Centuries later, the Italian Marco Polo returned from his famous journey to the Far East with a recipe for making water ices resembling modern day sherbets. Over a thousand years later, Marco Polo returned to Italy from the Far East with a recipe that closely resembled what is now called 'sherbet'. Historians estimate that this recipe evolved into ice cream sometime in the 16th century. England seems to have discovered ice cream at the same time, or perhaps even earlier than the Italians. 'Cream Ice' as it was called, appeared regularly at the table of Charles I during the 17th century.

France was introduced to similar frozen desserts in 1553 by the Italian Catherine de Medici when she became the wife of Henry II – Duc d'Orleans of France. It wasn't until 1660 that ice cream was made available to the general public. The Sicilian Procopio introduced a recipe blending milk, cream, butter and eggs at *Café Procope*, the first café in Paris.

The earliest reports of people enjoying flavored ice desserts come from the Romans and the Chinese. Marco Polo returned from his famous expedition with fruit-flavored ices, reporting that Asians had been making them for thousands of years. These delicacies became popular in France in the 1500s, but only among royalty. Over the next few centuries, the process of making them evolved from hauling mountain ice to salt/ice freezing methods. Cream was introduced as an ingredient, and by the 1700s, people were enjoying a dessert that was very similar to today's ice cream.

The history of ice cream is closely associated with the development of refrigeration techniques and can thus be traced in several stages:

1. Cooling food and drink it after mixing it with snow or ice
2. The discovery that dissolving salts in water produces cooling
3. The discovery that mixing salts and snow or ice cools even further -in mid to late 17th century; the inclusion of cream in the water ices also evolved around this time
4. The invention of the ice cream maker in the mid 19th century
5. The development of mechanical refrigeration in the later 19th and early 20th centuries, led to the development of the modern ice cream industry.

According to popular accounts, Marco Polo (1254-1324) saw ice creams being made during his trip to China, and on his return, introduced them to Italy.

Iced sweetmeats and other frozen dainties had their origin in Egypt or Babylon.

Ice cream making was revolutionized in 1851, when Jacob Fussel started the first wholesale ice cream manufacturing operation in Baltimore, Maryland. Fussel's dairy business had excess cream and was in dilemma as to what to do with it. He tried using it to make ice cream, and before long his ice cream business outsold the rest of the dairy.

Mix processing in 1941 was carried out by batch pasteurization (Sommer, 1944). While that is still common today in many dairy operations, most large installations have moved to continuous (HTST) pasteurization.

The hand-cranked ice cream freezer was first developed by Nancy Johnson in 1846. The earliest electrical freezers were batch style and either salt and ice or brine cooled, but the design was based on the principles of a scraped surface freezer.

Manufacturing methods and ingredients improved, while refrigeration technology became cheaper and more efficient. By the 1920s, home refrigerators and freezers became more common, which gave the ice cream industry another boost. The rise of the giant supermarket created demand for cheaper, mass-produced ice cream, but quality suffered.The 1960s saw a resurgence in ‘premium ice cream’, while the following decades saw the market fragment into low-fat varieties for the health-conscious, including frozen yogurt, fruit bars, ice milk, fat-free ice cream, etc.However, ice cream still makes up ~ 60 % of the market share among frozen desserts.

The development of industrial refrigeration by German engineer Carl von Linde during the 1870seliminated the need to cut and store natural ice and when the continuous-process freezer was perfected in 1926, it allowed commercial mass production of ice cream and the birth of the modern ice cream industry.

Table 1.1: Developments in ice cream and frozen desserts

1800	Insulated ice houses were developed
1843	Handcranked ice cream freezer patented by Nancy Johnson of Philadelphia
1874	Invention of Ice cream soda by Robert Green
1890s & Late 19th century	In response to religious criticism for eating "sinfully" rich ice cream sodas on Sundays, ice cream merchants left out the carbonated water and invented the ice cream 'Sunday'. The name was eventually changed to 'sundae' to remove any connection with the Sabbath. Ice cream sundae originated
1900	Development of condensed and dried milks took place. Pasteurizer and homogenizer was introduced, improved freezers and other processing equipments were developed.
1904	Several food vendors claimed to have invented ice cream cone at World's Fair in St. Louis, Missouri
1921	The value of ice cream as an essential food was recognized.
1970s	Prepackaged ice cream sold through supermarkets, specialty ice cream stores
Early 20th century	Ice cream cone and Banana split became popular Ice cream soda was popular treat at soda shop, the soda fountain and the ice cream parlor.
20th century	Introduction of soft ice cream, stabilizing agent gluten to which some people have intolerance; 'Gluten free ice cream'.
1980s	Return of older, thicker ice creams sold as 'premium' and 'super-premium' varieties under brands Ben & Jerry's and Haagen-Dazs.

1.2. DEVELOPMENT OF CONTINUOUS ICE CREAM FREEZERS

1.2.1. Vogt Freezer

The principle of operation of Vogt freezer is same as that of the disk type freezer, but direct cooling system is used here and a tube shaped freezing cylinder which causes extremely fast freezing mixture. Metered amount of air and mix is forced into the freezing tube and emulsified there.

1.2.2. Creamery Package Continuous Freezer

Compressed air is passed through a filter, a pressure gauge and check valve which are provided in the line. Ice cream mix is pumped with the help of mix pump and enters the freezing cylinder along with air. Ice cream after freezing is pumped out with the help of discharge pump.

Currently the manufacturers have come up with low temperature continuous freezers which can draw ice cream at -15°C, yielding extremely small sized ice crystals making the ice cream very smooth and preventing coarseness since more percentage of water in ice cream mix is frozen.

1.3. ICE CREAM CONE

The first ice cream cone was produced in 1896 by Italo Marchiony. Marchiony, who emigrated from Italy in the late 1800s, invented his ice cream cone in New York City. He was granted a patent in December 1903.

A similar creation was independently introduced at the 1904 St. Louis World's Fair by Ernest A. Hamwi, a Syrian concessionaire. Hamwi was selling a crisp,waffle-like pastry - zalabis - in a booth right next to an ice cream vendor. The vendor ran out of dishes and to solve the situation he quickly rolled one of his wafer-like waffles in the shape of a cone, or cornucopia, and gave it to the ice cream vendor. The cone cooled in a few seconds, the vendor put some ice cream in it, the customers were happy.

As the modern ice cream cone developed, two distinct types of cones emerged. The rolled cone was a waffle, baked in a round shape and rolled as soon as it came off the griddle. In a few seconds, it hardened in the form of a crisp cone. The second type of cone was molded either by pouring batter into a shell, inserting a core on which the cone was baked, and then removing the core; or pouring the batter into a mold, baking it and then splitting the mold so the cone could be removed. Now, millions of rolled cones are turned out on machines that are capable of producing about 150,000 cones every 24 hours.

Modern era – Ice cream cakes, pies, stick items, novelties and many other items have been introduced from time to time.

The ice cream cone made its mark at the Louisiana Purchase Exposition in St. Louis, Missouri (St. Louis Fair) in 1904. There are conflicting legends about various waffle makers who started selling waffles folded into cones to ice cream vendors who ran out of plates.

Howard Johnson's restaurants advertised "a world of 28 flavours." Baskin-Robbins made its 31 flavours (one for each day of the month). The company now boasts that it has developed over 1000 varieties. Based on ice cream consumption figures, the top five individual flavors in terms of share of segment in the US are: vanilla (30%), chocolate (10%), butter pecan (4%), strawberry (3.7%) and chocolate chip mint (3.2%) (NPD Group's National Eating Trends Services).

Ice cream flavors are only limited by the imagination. Manufacturers, scoop shops and chefs constantly come up with new and exciting flavors for their customers.To keep consumers looking to see what's next in the freezer case, individual processors often release limited time 'seasonal' flavors, such as gingerbread, peppermint or caramel ice cream for the November/December holidays.

In the United States, Dairy Queen , Carvel , and Tastee-Freez pioneered in establishing chains of soft-serve ice cream outlets.

Lesson-2

Status of Ice Cream Industry in India and Abroad

2.0.INTRODUCTION

Continuous freezers did not win wide acceptance until the 'Vogt Instant' freezer was introduced in 1929. This was followed by the Creamery Package continuous freezer in 1934. Continuous freezers remained quite similar for many years until air injection methods for the introduction of sterile air brought about major changes in design. Modern continuous freezers can process volumes of 3000–4000 l/h, equipped with filtered air, exact control of overrun and dosing of particulate ingredients. Production rates of freezers can be synchronized with those of filling machines. Next emerged developments in low temperature extrusion freezers capable of taking ice cream at -5ºC from conventional scraped surface freezers and reducing its temperature through a single- or twin-screw extruder to -15ºC. Now there are sophisticated machinery for the production of novelty or impulse products.

2.1. NOVELTIES

The idea of merchandising ice cream and other frozen confections in novel forms holds considerable appeal to ice cream manufacturers with an aggressive sales policy. Such items, in addition to their direct contribution to sales volume, are thought to have publicity value, serving to attract consumer interest and creating the impression of alertness and progressiveness. Few examples of novelties are: chocolate-coated ice cream bars, popsicles or frozen suckers, ice cream sandwiches and ice cream cake rolls.

For many years, novelties were limited to molded products, cups, cones and sandwiches. Now, sophisticated and novel processing technology for manufacture of hand-held impulse products is readily available, giving rise to a myriad of new introductions around the world. Equipment for extruded novelty production was introduced in the 1980s. Today, extrusion processing has enabled production of avast array of shapes and sizes. Fluting, layering and other fancy molding is widely seen in both single serving products and in ice cream cakes. High quality production of 3D molded products with high definition details is possible with new molding processes. Extruded and molded products can be shaped in post-extrusion or molding processes with deep cooled, non-stick tools with high definition.

2.1.1. Mellorine type products

It is similar to ice cream in which milk fat is replaced by a suitable vegetable or animal fat. The minimum fat standards rage from 6.0 to 10.0%, weight per gallon, minimum milk solids and food solids similar to those for ice cream but maximum stabilizer allowed ranges up to 1.0%.

2.1.2. Diabetic ice cream

It is made with lower sweetening agent content. The sugars are replaced by an artificial sweetener such as aspartame, sucralose, stevioside, etc.

2.1.3. Dietetic frozen dessert

It is formulated to reduce the calorie content. It differs from diabetic ice cream in that, besides the use of low calorie sweetener, the fat content is also reduced.

2.1.4. Probiotic ice cream

Ice cream mix formulated as per PFA but containing added probiotic microorganisms such as *L.acidophilus*, *L. rhamnosus*, *B. bifidum*, etc and frozen in a manner such that viable probiotic count to the tune of 10^6 to 10^8 per gram of product is made available. Such product improves the gut health, may reduce triglyceride and cholesterol levels in human subjects.

2.2. PRODUCTION STATISTICS OF ICE CREAM AND RELATED PRODUCTS IN INDIA AND ABROAD

2.2.1. Ice cream market in India

The liberalization process gave way to organized ice cream sector. The total domestic market is estimated at Rs. 1000 crore out of which organized sector accounts for ~ 65%. The major national brands for ice cream are Amul, Quality Walls and Vadilal. The regional players are Mother Dairy, Arun, Joy, Nandini, Naturals, Dinshaw, etc. The per cent market share of various ice cream brands in India is furnished in Table 2.1. The branded market is worth 100 million litre per annum, valued at Rs. 600 crores.

Table-2.1. Percent market share of few brands of ice cream in India

Company	Per cent market share
Amul	32.0
Kwality Walls (HLL)	8.0
Vadilal	7.0
Mother Dairy, Delhi	7.0
Dinshaw	4.0
Arun	4.0
Metro	3.0
Others	35.0

Source: HLL (2004)

The branded ice cream market is expected to grow at the rate of 10.0% annually. The consumption of ice cream in India is one of the lowest in the world, at 0.1 litre per person per annum compared to 22.0 litre in US, 5.0 litre in UK, 1.0 litre in Thailand and 0.41litre in Pakistan. The global average is 2.0 litre per annum.

Since the consumers are becoming health conscious, the demand for dietetic/health foods is increasing.

2.2.2. Global trends

The global ice cream key players are Unilever, Nestle, Mc Donalds, Dreyer's and Lotte Group.

In the United States in 2004, 6056 million lit of regular, light and low-fat ice cream were manufactured. The US frozen dairy desserts industry utilized 10% of total milk production and 16% of manufactured milk production. Exports of ice cream from the US accounted for 41 million lit in 2004, worth $50 million (USDA). In Canada, frozen dairy dessert production in 2004 was 330.2 million litre Canada imported 0.55 million litres and exported 5.8 million litre of ice cream in2004 (Statistics Canada). In 2006,total US sales of ice cream and frozen desserts reached nearly $23 billion. Of that,$8.9 billion was spent on products for 'at home' consumption, while $13.9billion was spent on 'away from home' frozen dessert purchases (scoop shops, food service and other retail sales outlets. (2007 Dairy Facts/International Ice Cream Association).

Consolidation has allowed for modern improvements in mechanization and automation as well as plant sanitation and hygiene.

The total per capita consumption of all ice cream in the US in 2004 was 18.7 litre This has not changed in the last 25 years. Total US production of ice cream and related frozen desserts in 2006amounted to about 5.86 billion liters, an increase of 0.7% over 2005 (USDA,2006).

In Canada, per capita consumption in 2004 was 9.3 lit of hard and soft ice cream.

Within the ice cream category, there has not been the same trend toward consumption of low-fat products as has been seen in the consumption of fluid milk. On the contrary, the last 20 years has seen the development of a range of premium (range of 12–4% fat) and super-premium (~ 16% fat) products.

In US, regular ice cream accounted for the largest share (63.8%) of the frozen dessert market. Reduced-fat, light, low-fat and non-fat ice cream accounted for 23.5% of the market, followed by frozen yogurt (4.3%), water ice (4.3%), sherbet (3.6%) and others (0.5%) (USDA,2006). Of today's consumption of ice cream in the US, 70% is standard product (10% fat), 28% is low fat and 2% is non-fat.

In US, vanilla topped the flavor for novelties, with more than 27% of the volume share. Fudge was the next highest stand-alone flavor share, with nearly 8% (IRI, 2001). In 2001 supermarket sales, ice cream bars (25%) were the largest dollar market share of the frozen novelty market, followed by yogurt novelties (20%) frozen ice (14.1%) ice cream sandwiches (13.5%), and ice cream cones (10%).

In US, ~ 86% of packaged ice cream retail sales happened in supermarkets in 2003. Next in sale stood at 11.4% at Convenience store sales, drug stores were third at nearly 2%, with 0.6% occurring at other locations.

Table 2.2.Production of Hard and Soft frozen desserts in US (millions of gallons) in 1979

Ice cream	Ice milk*	Sherbet	Water Ices	Mellorine type	Others
811	297	45	32	15	120

* Includes freezer made milkshake.

Source: International Association of Ice Cream Manufacturers, USA.

Americans ate an average of 21.5 liters of ice cream per person in 2004.

2.3. QUALITY SEGMENTS

While the majority of ice cream sales have long been regular-fat products, processors continue to diversify their lines of frozen desserts in order to fit into various lifestyles – 'better for you' products. Consumers can find an array of frozen desserts to fit specific dietary needs or wants, such as reduced-fat, fat-free, low-carb, 'no sugar added', added calcium or other nutrients, or lactose-free ice cream. Novelty/single-serving products are also an important part of this trend, as some consumers prefer the pre-packaged portion when counting calories, carbs or fat grams. Ice cream is generally considered to be costly and luxurious item in India. Amul has recently launched low-fat dietetic ice cream, diabetic ice cream and even probiotic ice cream. Health conscious consumers are always on the lookout for ways to improve nutritional traits, without sacrificing psychological satisfaction.

However, most consumers are looking for an indulgence when eating ice cream. Therefore, ice cream manufacturers make sure to offer a full selection of premium and super-premium products in innovative flavors and with such mix-ins as cookies, brownies, candies and cake.

Module 2 - Definitions, Classification And Composition Of Ice Cream And Other Frozen Desserts (As Per FSSAI)

Lesson-3

Definition of Ice Cream as Per FSSA (2006). Classification of Ice Cream-I, Plain, Fruit and Nut, Chocolate, Ice Lollies, Candies, Kulfi & Malai-Ka-Baraf.

3.1. INTRODUCTION

Ice cream is a frozen dairy product made by suitable blending and processing of cream and other milk products, together with sugar and flavour, with or without stabilizer or colour, and with the incorporation of air during the freezing process.

3.2. DEFINITION

According to the FSSA (2006), Ice Cream, Kulfi, Chocolate Ice Cream or Softy Ice Cream (hereafter referred to as the said product) means the product obtained by freezing a pasteurized mix prepared from milk and /or other products derived from milk with or without the addition of nutritive sweetening agents, fruit and fruit products, eggs and egg products, coffee, cocoa, chocolate, condiments, spices, ginger and nuts and it may also contain bakery products such as cake or cookies as a separate layer and/or coating. The said product may be frozen hard or frozen to a soft consistency; the said product shall have pleasant taste and smell free from off flavour and rancidity; the said product may contain food additives permitted in these regulation including Appendix A; the said product shall conform to the microbiological requirements specified in Appendix B; the said product shall conform to the following requirements, namely:—

Requirement	Ice Cream	Medium Fat Ice Cream	Low Fat Ice Cream
(1)	(2)	(3)	(4)
Total Solid	Not less than 36.0 percent	Not less than 30.0 percent	Not less than 26.0 percent
Wt/Vol (gms/l)	Not less than 525	Not less than 475	Not less than 475
Milk Fat	Not less than 10.0 percent	More than 2.5 percent but less than 10.0 percent	Not more than 2.5 percent
Milk Protein (Nx6.38)	Not less than 3.5 percent	Not less than 3.5 percent	Not less than 3.0 percent

Note: In case where Chocolate, Cake or similar food coating, base or layer forms a separate part of the product only the Ice Cream portion shall conform to the requirements given above. The type of ice-cream shall be clearly indicated on the label otherwise standard for ice-cream shall apply.

3.2.1. Classification of Ice Cream: Depending upon the commercial practices followed, the following classifications are used for different groups of ice cream and frozen products.

3.2.2.Plain Ice Cream: An ice cream in which the total amount of the colour and flavouring ingredients is less than 5%of the volume of the unfrozen ice cream. Examples are vanilla, coffee, maple and caramel ice cream.

3.2.3. Chocolate: Ice cream flavoured with cocoa or chocolate. It usually contains higher sugar content *viz.,*16 to 17%, about 2.5 to 3.5% of cocoa and stabilizer and emulsifier. Other variants of chocolate frozen product includes chocobar (where chocolate acts as a couverture), chocolate frosties (chocolate layer containing crispies), chocochips.

3.2.4. Fruit: Fruit Ice cream is made by adding various fruits at the time of freezing with or without additional fruit flavouring or colour. The fruits may be fresh, frozen, canned or preserved.

3.2.5. Nut: Ice cream containing nut meats, such as almonds, pistachio or walnut,with or without additional flavouring or colour.

3.2.6. Ice Milk / Milk Ice: A product similar to ice cream containing 2 -7% fat and 12-15% MSNF, sweetened, flavoured and frozen like ice cream.

3.2.7. Ices: Made of fruit juices, sugar and stabilizer with or without additional fruits, color, flavouring or water and frozen to the consistency of ice cream. Usually contains 28 – 30% sugar, 15-20% overrun, and no dairy products.

3.2.8.Sherbets: Sherbet is a productmade of fruit juices, sugar, stabilizer, and milk products. It is similar to anice, except milk, either whole, skim, condensed, or powdered, or ice cream mix,is used in place of all or part of the water used in ices, sherbet contains 1-2% milk fat.

3.2.9.Sorbets: The composition of sorbets is similar to that of ices. Sorbets have a high sugar and fruit and fruit juice content (30,30 and 50% respectively). Stabilizer and egg white are also added, and the product has an overrun of 20% or less. Exotic flavours are often included in sorbets.

3.2.10. Mousse: Ice cream containing whipped cream, sugar, colour and flavouring, and frozen without further agitation. Sometimes condensed milk is added to give better consistency

3.2.11 . Bisque: It is made by the addition of grape, nuts, macaroons,sponge cake or other bakery products with appropriate flavourings.

3.2.12.Custards: custard is ice cream cooked to custard before freezing. Frozen custards are also known as French ice cream or French custard ice cream. It contains whole egg or egg yolk in such a proportion that the total egg yolk solids should not be less than 1.4% of the weight of the finished frozen custard or less than 1.12% for bulky flavored products. Parfait is frozen custard with high fat content.

3.2.13. Cassata: This is made in a round mold, hinged so that it may be filled with ice cream and other frozen products.The confection is built up in layers of rich, variously flavoured ice cream,some with fruits, some with liqueurs, and sometimes with chocolate or nuts. Fingers or slices of sponge cake, sometimes soaked in liqueur, may be added. The cassata is frozen for several hours, and then turned out of the mold for serving.

3.2.14. Variegatedor Rippled Ice Cream: Variegated ice cream is produced by injecting approximately 10% of a prepared base into the ice cream. Most popular flavours of variegated ice cream are chocolate, butter scotch, straw berry, pineapple and caramel.

3.2.15. Novelties: Anice cream novelty is defined as a unique single-serve portion – controlled product. Novelties include special combinations of ice cream with flavour and confections, cup items, and fancy molded items. They are usually produced by either extrusion or molding, and examples include coated ice cream bars (e.g.Mars) , Coated ice cream bars on a stick (e.g. Magnum), ice cream cake,and ice cream logs (e.g. Vienetta), ice cream sandwiches, popsicles and fudgesicles.

3.2.16. Puddings: Ice cream containing a generous amount of mixed fruits,nut meats, and raisins, with or without liquor, spices or eggs.

3.2.17. Fanciful-NameIce Cream: These products usually do not contain a single characterizing flavour, but theflavour is due to the mixture of several flavouring ingredients. Two or more distinct flavours in the same package.

3.2.18. New York or Philadelphia: This is generally a plain vanilla icecream with extra colour for Philadelphia and extra fat and eggs for New York Ice Cream.

3.2.19. Rainbow Ice Cream: It is prepared by carefully mixing six or more different coloured Ice Creams as they are drawn from the freezers to give a rainbow coloured effect when the product is hardened.

3.2.20. Fancy Moulded Ice Cream: It is moulded in fancy shapes and composed either of one colour and flavour ofIce Cream or a combination of colours and flavours or especially decorated.

3.2.21. Mellorine Type Products: Mellorine is a product similar to icecream in which the butter fat has been replaced by a suitable vegetable oranimal fat.

3.2.22. Soft Serve Ice Cream: Soft serve ice cream is a type of frozen dessert that is similar to, but softer than the ice cream. These products are sold as drawn from the freezer without hardening. It is generally lower in milk fat (3.6%) than ice cream (10-18%) and produced at a temperature of about -4°C compared to ice cream, which is stored at-15°C. A warmer temperature of soft serve ice cream allows the taste buds to detect more flavour. The air introduced into soft serve ice cream may vary from 0-60% of the volume of the finished product. The ideal acceptable air content is between 33 and 45% of volume.

The premix for soft serve can be obtained in several forms

1. Fresh liquid that requires constant refrigeration until needed. It can be stored for5 to 7 days before spoiling by bacterial contamination

2. **A powdered mix:** This is a driedversion of liquid mix. It has several advantages of easy distribution and canbe stored for longer periods of time without spoiling. Water must be added prior to being churned and frozen.

3. **UHT-Mix:** It is a liquid that has been sterilized and packed in sealed, sterile bags. It can last for a very long time without refrigeration and can be poured into the soft serve freezer immediately upon opening.

All these should be refrigerated to 3˚C prior to use to avoid bacterial contamination and spoilage.

3.2.23. Kulfi: Kulfiis an indigenous frozen milk product. The method of manufacture of kulfi varies widely. The conventional method of kulfi making consists of boiling of milk,addition of sugar, concentration of milk to 2:1 level and addition of khoa,malai, flavour etc. to the concentrated cooled milk. Kulfi mix is then filled into metallic cones and the top of the cone is covered with a lid. The mixture in the moulds is frozen in large earthen vessels containing ice – salt mixturein the ratio of 1:1.

3.2.24. Malai–Ka–Baraf: This term is applied to a variety of frozen product in which sweetened milk or malai may form the chief ingredient.

****** ☺ ******

Lesson-4

Classification of Ice Cream –II, Sherbets and Ices, Mousses, Gelato, Bisque, Custards, Cassatta,Variegated Ice Cream, Novelties, etc.

4.1. INTRODUCTION

The word 'novelty' conveys the qualities of freshness, uniqueness and cleverness in creation and marketing. Novelties have included quiescently frozen bars, special combination of ice cream with flavors and confections, cup items, and fancy molded items. They can be made of many types of frozen desserts, including ice cream with various fat contents, frozen yogurt, sherbet, puddings, tofu, sorbet, gelatin and fruit ices. To these are added chocolate, candies, baked items such as wafers and cakes and numerous kinds of fruits.

4.1.1. Federal (US) Specification for Different Types of Ice Cream

EE-I-116 Most types are subdivided by grade or by class. Although the types are listed below

a. Type I--Ice cream, regular, vanilla.

Grade1--General, 10.0 percent fat (minimum).

Grade2--Premium, 14.0 percent fat (min).

Grade3--Intermediate, 12.0 percent fat (min).

b. Type II--Ice cream, regular, chocolate, fruit, nuts or other bulky flavours.

Grade1--General, 8.0 percent fat (min).

Grade2--Premium, 12.0 percent fat (min).

Grade3--Intermediate, 10.0 percent fat (min).

c. Type III--Ice milk, regular.

d. Type IV--Sherbet, regular.

e. Type V--Water ice.

f. Type VI--Novelties.

Class 1--Coated ice cream bar.

Class 2--Ice bar confection.

Class3--Sherbet/ice cream bar confection.

Class 4--Frozen fudge bar confection.

Class 5--Ice cream sandwich.

Class 6--Ice cream cone (preformed).

g. Type VII--Mellorine and mellorine types, vanilla.

Class1--General, 10.0 percent fat (min).

Class2--Premium, 14.0 percent fat (min).

Class3--Intermediate, 12.0 percent fat (min).

h. Type VIII--Mellorine and mellorine types, chocolate, fruit, nuts, or other bulky flavours.

Class1--General, 8.0 percent fat (min).

Class2--Premium, 12.0 percent fat (min).

Class3--Intermediate, 10.0 percent fat (min).

i. Type IX--Ice milk, mellorine, and mellorine types.

j. Type X--Sherbet, mellorine, and mellorine types.

Table-4.1: Classification of Frozen Dairy Foods Based Upon the Concentration of Certain Constituents

Sr. No.	Group	Distinguishing characteristics	Suggested regulatory limitations
I.	Frozen custard	High in egg yolk solids, which are cooked to a custard before freezing Medium to high in milk fat and MSNF with or without fruit, nuts, bakery products, candy, liquor, or spices with or without agitation while freezing	Not more than : 0.5% edible stabilizer, max. 50,000 bacteria/g Negative ***E. coli*** test Not less than: 1.4% minimum egg solids content for plain and 1.12% for bulky flavours of custard. 10.0% milk fat 20.0% total milk solids 192 g food solids per liter of finished product.
II.	Plain ice cream	Medium to high in milk fat and MSNF with or without egg products with or without agitation while freezing. Without visible particles of flavouring material with the total volume of color and flavor less than 5% of the volume of the unfrozen ice cream.	Not more than : 0.5% edible stabilizer 50,000 bacteria/g Negative E. coli test Not less than: 10.0% milk fat 20.0% total milk solids 192 g food solids per liter of finished product.
III.	Composite ice cream or bulky flavours	Medium to high in milk fat and MSNF with or without egg products with or without agitation while freezing With the total volume color and flavor material more than 5% of the volume of the unfrozen ice cream or with visible particles of such products as cocoa, fruit, nut meats, candy, bakery products, liquor, or spices	Not more than :0.5% edible stabilizer 50,000 bacteria/g Negative ***E. coli*** test Not less than: 8.0% milk fat 16.0% total milk solids minimum 192 g food solids per liter of finished product.

IV.	Ice milk	Low in milk fat With or without egg products chocolate, fruit, nut meats, candy, liquor, or spices with or without agitation while freezing	Not more than :0.5% edible stabilizer 50,000 bacteria/g Negative ***E. coli*** test Not less than: 3.3% milk fat – 2.0% minimum, 7% maximum 14.0% total milk solids 11% minimum 156 g food solids per liter of finished product.
V.	Sherbet	Low in MSNF tart flavor Sweetener, water, harmless fruit, or fruit juice flavouring, colouring.	Not more than 50,000 bacteria/g Negative ***E. coli*** test Not less than: 0.35% acidity as determined by titrating with standard alkali, and expressed as lactic acid , minimum 2.0% and maximum 5.0% total milk solids minimum 719 g weight per liter 216 g food solids per liter of finished product. Citrus fruit flavours 2%, berries 6% and other fruits 10%.
VI.	Ices	No milk solids Tart flavor Sweetener, water, harmless fruit or fruit juice flavouring, colouring	Sanitary requirements same as for sherbet.

VII.	Ice cream soda or float/ Soda fountain	Beverage consisting of one or more scoops of ice cream in either a soft drink or in a mixture of flavoured syrup and carbonated water	Ice cream as per ice cream standards
VIII.	Bisque ice cream	Made from mixes as for plain ice cream with addition of particles of either grape nuts, macaroons, ginger snaps, sponge cake, marshmallow or other bakery products and usually with addition of other flavouring materials.	-
IX.	Filled ice cream (Mellorine)	Milk fat is replaced completely by vegetable oils/fat	Cholesterol free, low saturated fat image of the frozen dessert for health conscious consumers
X.	Imitation ice cream (Parevine type products)	Proper labeling Minimum 10% food fat; few countries have not specified minimum requirements Minimum 20% food solids; few countries have not specified minimum requirements	Sanitary requirements same as for ice milk.

****** ☺ ******

Lesson-5

Composition of Ice Cream (Low Fat, Good Average, Premium) and Frozen Desserts (Sherbets, Ices,Soft Serve)

5.1.INTRODUCTION

For ice cream manufactures, composition is the first pre-requisite for obtaining a good quality with minimum cost. As quality and price are the two most important factors determining not only the current business but also the future of entire ice cream industry, due consideration must be given for deciding the composition of the product.

5.2. COMPOSITION

Composition of ice cream is decided after giving considerations to legal requirements, mix handling properties, quality of product desired, raw material available, plant procedures, trade demand, composition and cost. Ice cream as made in different parts of the country varies rather widely in composition making it difficult to provide a formula that will produce best ice cream. However, an approximate composition for economy, good average and deluxe ice cream is given in table. The recent advances with respect to composition of ice cream are given below.

More dairy ingredients than ever can now be harvested from milk and milk products such as whey to make superior quality ice cream. Innovations such as ultra filtration/ reverse osmosis, gel filtration and electrodylisis can be used to produce a broad base of raw material for formulating dairy dessert. Replacement of a part of MSNF with whey protein concentrate or milk solids concentrate with the use of ultra filtration can be utilized for the manufacturing of better quality product.

- Replacement of a part of MSNF (10-14%) with plant proteins/isolates such as chick pea protein isolate (CPI), peanut protein isolate (PPI) and sesame protein isolate (SPI) in the ice cream
- Replacement of a part of sugar and cocoa in chocolate ice cream with sweet potato.
- Micro encapsulation of flavors
- Manufacturing of dietetic ice cream with low fat and high protein, or with fat replacement or fat mimetics.
- Replacement of milk fat with palm oil or palm kernel oil for obtaining lower cost and improved quality.
- Replacement of a part of sucrose with corn product of varying Dextrose Equivalent (DE) and other sugar substitutes.

Table-5.1: Approximate Composition of Commercial Ice Cream

Sr. No	Milk Fat (%)	MSNF (%)	Sugar (%)	Stabilizers & Emulsifiers (%)	Total solids (%)
1.	**Economy Ice Cream**				
	10	10-11	13-15	0.30-0.50	35-37
2.	**Good average Ice Cream**				
	12	11	15	0.30	37-39
	14	8-9	13-16	0.20-0.40	
3.	**Deluxe Ice Cream**				
	16	7-8	13-16	0.20-0.40	
	18	6-7	13-16	0.25	40-41
	20	5-6	14-17	0.25	

5.3. Raw materials

5.3.1. Fat

The fat content and type used in ice cream and frozen desserts are used to classify individual products according to the national regulations or standards of identity of most countries. The word ice cream can now be used for four categories of ice cream - non fat – ice cream(less than 0.5% fat), low-fat ice cream (2.0% fat), reduced fat ice cream (2.0-10.0%)and regular, premium, and super premium ice cream (more than 10% fat) as per US regulations.

The existing national ice cream legislations in the individual member states of the EU vary considerably with regard to the fat content of ice cream. For example, minimum fat varies from 5% in the UK to maximum of 12% in the final product and no such requirements existed in Italy.

5.3.2. Milk solids not fat (MSNF)

MSNF consists of proteins, lactose and minerals, the components of which vary considerably. The most commonly used MSNF sources and their composition are shown in the Table 5.2.

Table-5.2: Typical Composition of MSNF Sources

Ingredient	Constituents (%)					
	Fat	Casein	Whey Protein	Lactose	Ash	Water
Skimmed milk	0.1	2.5	0.8	4.8	0.8	91.0
SMP	1.0	27.7	9.3	52.0	7.0	3.0
Whey powder	1.0	-	13.0	73.0	9.0	4.0
Whey protein concentrate	2.0	-	35.0	51.0	7.0	5.0

The key components of MSNF are proteins which a part from their contribution to nutritional requirements also have an effect on the whipping characteristics and other physical and sensory properties of ice cream. In addition they have good functional properties such as

- Interaction with some stabilizers.
- Stabilization of the fat emulsion after homogenization
- Contribution to structure of ice cream
- Water binding ability

5.3.3. Sweeteners

Sweeteners which include the lactose added via MSNF, make up the major part of the solids contained in the ice cream. The degree of sweetness is determined by the addition of Sweeteners. Due to their depressing effect on the freezing point, sweeteners also control the amount of frozen water in ice cream and thus thesoftness of the final product. Table-5.3 depicts the most commonly used ice cream sweeteners and compares their influence on the degree of sweetness and freezing point of the ice cream with that of sugar (sucrose).

Table-5.3: Freezing Point Depression and Sweetness in Ice Cream

Carbohydrate	Average molecular weight	FPDF	Relative Sweetness
Sucrose	342	1.0	1.0
Glucose syrup 42 DE	445	0.8	0.3
HFCS (42% Fructose)	190	1.8	1.0
Fructose	180	1.9	1.7
Invert sugar	180	1.9	1.3
Lactose	342	1.0	0.2
Sorbitol	182	1.9	0.5
Glycerol	92	3.7	0.8
Ethanol	46	7.4	-
Saccharin			300-400
Aspartame			160-200
Acesulfame-K			200
Sucralose			600-800

FPDF– Freezing Point Depression Factor

DE– Dextrose Equivalent

HFCS– High Fructose Corn Syrup

5.3.4. Emulsifiers

Emulsifiers are by definition substances which make the formation of an emulsion possible due to their ability to reduce surface tension. In ice cream oil in water in water emulsion and an air – in – partly frozen mix emulsions are involved. Glycerol esters of fatty acids, commercially known as mono and diglycerides, are the emulsifiers most commonly used in ice cream. The benefits of emulsifiers in ice cream manufacture include:

- The dryness of ice cream on extrusion from continuous freezer
- Improved whipping properties
- Improved body and texture
- Richer mouth feel and creamy sensation
- Improved air cell distribution
- Improved heat shock resistance

5.3.5. Stabilizers

Stabilizers influence the movement of water, partly due to their ability to form H-bonds and partly due to their ability to form a three dimensional network throughout the liquid which leadsto the immobilization of water. The water binding / immobilizing effect improves the storage stability of ice cream. Furthermore, stabilizers have positive influence on body and texture of ice cream. Finally, stabilizers contribute to the melting resistance of ice cream and prevent wheying off during melting. The most commonly used stabilizers are as follows

1. Locustbean gum(LBG)

2. Guargum

3. Sodiumalginate

4. Carrageenan

5. Sodiumcarboxy methyl cellulose(Na – CMC)

In order to obtain desired properties, combinations of stabilizers are used. The dosage of stabilizer combination in ice cream is normally between 0.1 and 0.3%.

5.3.6. Composition of Sherbets and Water Ices

Sherbets, or milk lollies and waterices, or ice lollies, are defined as the frozen products containing none orvery little milk solids in comparison with ice cream. These are usually fruit flavoured and acidulated. Thus, these products notonly contain less food solids and more water, but also have higher concentrations of the sweetener. Their fruit and acid content imparts a characteristic flavour and tartness, and the 'ice rich' structure gives the product a typical chewy texture.

A typical sherbet formulation may contain 20-23%sucrose and 7-11% corn syrup solids (CSS), where as the corresponding figures for water ice would be 23-25% and 7-11%. Unlike dextrose, CSS can be used at higher level of sucrose replacement to obtain a smoother texture and a firmer, though stickier body.

Since sherbets and ices contain less total solids, and therefore, less overrun than ice cream, whipping agents (i.e.emulsifiers or surfactants) are generally not required. As most sherbets and practically all ice lollies, besides being fruit flavoured, contain added acid [pH3-4]. The stabilizer used should be stable under such conditions. Alginates, particularly ester alginate, xanthan gum, sodium Carboxy Methyl cellulose(CMC), and certain other hydrocolloids such as gum Arabic, gum karaya, gum tragacanthsetc. have been considered suitable for use in these products.

Fruit-flavoured, especially citrus- flavoured sherbets and ices are acidified to0.30-0.50% acid for a sugar content of 25-30% to 35-40%. Although many acids *viz*, citric, tartaric, lactic, maleic,ascorbic and phosphoric acids can be used, the first one is most frequently employed. Some typical sherbet and ice formulations have been given in the table below.

5.4. Sherbets and Related Products

Fruit Sherbet:

It is a pasteurized product made of fruit juices, sweetener or stabilizer, and 2-5% total milk solids, (1-2%) milk fat and 1-4% (NMS). The minimal acidity of 0.35% is normally adjusted with citric acid, but is calculated as lactic acid. A mixture of 4 parts water ice mix with 1 part ice cream mix can constitute a sherbet mix. Agitation during freezing creates air cells reducing the weight per liter, equivalent to 50% overrun.

Table-5.4: Examples of Sherbet and Ice Lolly Formulations

Ingredient(kg)	Smooth, chewy heavy body sherbet	Medium body sherbet	Coarse sherbet	Non fruit sherbet	Ice lolly	
					High sugar	Low sugar
Cane sugar, kg	9.0	11.0	17.0	9.0	23.0	14.0
Corn syrup solids, kg	22.0	10.0	-	-	-	-
Dextrose DE 42, kg	-	-	7.0	3.0	7.0	4.25
Ice Cream mix(12% fat, 11%MSNF,15% sugar), kg	17.5	17.5	17.5	18.0	-	-
Stabilizer, kg	0.4	0.4	0.4	0.125 (P) 0.125(G)	0.3	0.125 (P) 0.125(G)
Fruit, kg	15.0	15.0	15.0	-	-	-
Water + Acid, kg	36.1	46.1	43.1	30.0(water)	69.7	41.75
Total, kg	100.00	100.00	100.00	60.25	100.00	60.25

P = Pectin; G = Gelatin

Souffle: Sherbet containing egg yolk or whole eggs smoothie, a blend of fresh frozen fruit, fruit juice and frozen yogurt or sherbet Ices and related products.

Water Ice: Also known as ice,the product is made of fruit juice, nutritive sweetener and stabilizer, with or without additional fruit acid, flavoring, color or water and frozen with or without agitation. No dairy products or egg ingredients other than egg white are contained. The mix need not be pasteurized.

Novelties: The novels are from frozen desserts includebars (with or without sticks), sandwiches, cones, molded items, rolls, and cakes.

****** ☺ ******

Lesson-6

Dairy Ingredients In Ice Cream

6.1.INTRODUCTION

Ice cream is made utilizing both dairy as well as non-dairy food ingredients. Each type of ingredient has its own significance in ice cream. There are several fat and SNF sources that can be utilized in preparing the ice cream mix. However, the properties of ice cream mix may change depending on the composition and heat treatment that the milk solids had undergone in preparing such dairy ingredient. The role played by milk fat and milk SNF is detailed hereunder.

6.2. MILK FAT

Imparts a characteristics richness and mellows the flavour of ice cream. It tends to retard the rate of whipping. Lecithin contained in milk fat has important contribution to the flavour and tactual qualities of ice cream. It contributes to smoothness of texture and contributes to body and melting resistance of the product. It does not lower the Freezing point (FP) of mix.

High fat content may limit consumption by increasing the calorific value and cost; and satisfies appetite more readily.

6.3. MILK SNF

It is high in food value, inexpensive and has a role in enhancing its palatability.

MSNF increases viscosity and resistance to melting, but also lowers the F.P. Lactose adds slightly to the sweet taste and minerals tend to have a slightly salty taste. Proteins help to make ice cream more compact and smooth.

The amount of MSNF generally varies inversely with the fat content of the mix and ranges from 7.5-8.0% in an 18% fat ice cream to 14.0% in a 4% fat ice milk mix. Indian PFA regulation does not permit less than 10.7% SNF by specifying a minimum of 3.5% protein content. The limiting factor for MSNF is occurrence of 'sandiness' defect in ice cream. As a thumb rule, the MSNF should not be more than 15.6-18.5% of the TS in the mix; based on the turnover (slow or rapid).

6.4.SOURCES OF MILK FAT

Table-6.1: Sources of milk fat in ice cream

Fat Sources	Characteristics	Specifications
Sweet cream	Most desirable concentrated source of butterfat. Contributes to ease of emulsion due to presence of milk fat globule membrane vs. products like white butter, Anhydrous Milk Fat, etc.	40% fat, Not more than 0.15% LA, free from off flavours and odors
Frozen cream	Use of 10% by weight of cane sugar before freezing the cream is beneficial – improved keeping quality, retains its flavor better, melts more quickly and with less fat separation. Produces mix with higher whipping ability. Disadvantage: Additional capital tied up.	Storage at < - 23.3°C desirable, do not hold more than 6 months. Presence of Cu, Fe, Bronze may lead to tallowy, metallic flavour during storage.
Plastic cream	Similar in consistency to butter at ordinary temperatures. Product is stored and handled commercially like butter. Mixes made using this may show some oiling off and possess slightly lower whipping properties.	Has about 80% milk fat.
Unsalted butter	Next to sweet cream in importance Higher shelf life than cream, transported at lower cost. Any off-flavour in butter may carry over into the mix.	Has minimum 80% milk fat. Compared to cream, use of white butter produces less desirable freezing properties due to low content of lecithin in butter.
Anhydrous Milk Fat	Pre-emulsifying before homogenization of mix is advisable.	Has less than 0.1% moisture; good shelf life if nitrogen gas packed.
Other fat sources	Concentrated sweetened cream, Special heat treated milk fat, Butter sucrose, Butter-sucrose-powder mix products	

6.5. SOURCES OF SOLIDS-NOT-FAT

Table-6.2: Sources of milk solids not fat in ice cream

SNF Sources	Characteristics	Specifications
Fresh skim milk	Cheap source of MSNF. Should have normal acidity and clean flavour	-
Condensed skim milk	Plain condensed skim milk is used more frequently than other condensed milk products.	Milk fat- Max. 0.5% Total milk solids- Min. 20%
Spray dried skim milk powder	It should have fine flavour, light in color, free from darkened particles, fluffy and easily soluble. Types that can have impact include (a) low-heat, (b) medium-heat and (c) high-heat powders. High heat powder is desirable from body-texture, whipping, resistance to heat shock storage and melting properties.	Moisture- Max. 4% Milk fat- Max. 1.5%, Acidity- Max. 1.5% LA.
Spray dried whole milk powder	Not widely used since it can undergo off-flavour development during storage, especially if not packaged in an atmosphere of nitrogen.	Moisture- Max. 4% Milk fat- Min. 26.0% Acidity- Max. 1.2% LA.
Sweet cream buttermilk	Contributes to richness of flavour. It has beneficial effect on whipping ability of mix. Lecithin content of buttermilk ranges between 0.1-0.2 %.	Especially suited to low fat ice cream or ice cream made using white butter as fat source.
Sweetened condensed whole(SCM)/skim milk	High shelf life vs. plain condensed milks, but may pose difficulty in handling since it is thick and viscous. Exercise caution in using SCM with 'sugar down' defect.	Milk fat- Min. 9.0% TMS- Min. 31.0%, Sugar- Min. 40.0% (SCWM) Milk fat- Max. 0.5%, TMS- Min. 26.0%, Sugar- Min. 40.0%
Evaporated milk	Used to limited extent. Imparts a cooked flavour and caramelized color. It is costly milk solid.	Improves whipping ability due to high heat treatment and homogenization meted
Superheated condensed skim milk	Made by heating already condensed product to a high temperature, which increases its viscosity. They result in mixes with higher viscosity, whipping properties, more resistant body and smooth texture.	Can be judiciously used by manufacturers who omit stabilizers.
Sweet cream buttermilk powder	Keeping quality problem similar to WMP due to high fat (~ 10%). Improved whipping properties owing to presence of natural emulsifying substances. Noticeable improvement in flavour also observed.	Should normally replace up to 25-33% of the SMP in the ice cream mix.

6.6. SPECIAL COMMERCIAL PRODUCTS

- Sodium caseinates: Dehydrated product may be used at 0.5-1.0% by weight of mix. It is advantageous in improving the whipping properties of mix and improves the texture of ice cream. However, it may produce slight undesirable flavour in ice cream.
- Low-lactose milk powder: It may be used in high solids ice cream either to replace a portion of the regular milk solids or to supplement the MSNF without the occurrence of sandiness during storage. Dehydrated low-lactose product may be used at the rate of 10-12% of MSNF in ice cream.
- Whey powder: In most mixes, whey powder maybe used at 25.0% of the MSNF or 3.0% of the total mix weight. It can lead to improved body and whipping quality at a reduced cost.

Table-6.3: Composition (%) of few milk based products

Milk product	Moisture	Fat	Protein	Lactose	Ash
Condensed buttermilk	72.0	1.95	10.61	13.01	2.43
Dried buttermilk	3.90	4.68	35.88	47.84	7.70
Condensed whey	48.1	2.4	7.0	38.5	4.00
Dried whey	6.1	0.9	12.5	72.25	10.50
Na-caseinate	4.00	1.50	94.00	0	0.50

****** ☺ ******

Lesson-7

Stabilizers and Emulsifiers-Classification, Types, Properties and Role in Ice Cream

7.1. INTRODUCTION

Ice cream is a complex food colloid that consists of air bubbles, fat globules, ice crystals and an unfrozen serum phase. Ice crystals and air bubbles are generally in the range of 20–50 µm. The air bubbles are usually to some extent coated with fat globules and the fat globules are coated with a protein/emulsifier layer. The serum phase consists of the sugars and high molecular weight polysaccharides in a freeze-concentrated solution. Various steps in the manufacturing process, including pasteurization, homogenization, ageing, freezing, and hardening, contribute to the development of this structure. Proteins and emulsifiers compete for inter facial space during the homogenization of the fat and the creation of the mix emulsion. Following homogenization, the emulsion is further affected by changes occurring during the ageing step, viz., crystallization of the fat and rearrangement of the fat globule membrane to the lowest free energy state. This emulsion then undergoes both whipping and ice crystal formation during the dynamic freezing process, which contributes to the development of the four main structural components of the frozen product: discontinuous foam, a network of partially coalesced fat surrounding the air bubbles, ice crystals, and a continuous, freeze-concentrated, unfrozen aqueous solution

Stabilizers and emulsifiers have been conventionally used in ice cream as additives. Recently, there has been a tendency towards 'all natural' or 'natural' products which have given rise to the so called premium ice cream which is supposed to contain no additives. Yet because of the quality enhancing ability of stabilizers and emulsifiers, they remain as important ingredients for most ice creams and frozen desserts.

Stabilizers are substances which make it possible to maintain the physico-chemical state of a foodstuff; stabilizers include substances which enable the maintenance of a homogenous dispersion of two or more immiscible substances in a foodstuff and include also substances which stabilize, retain or intensify an existing colour of a foodstuff. Emulsifiers are surface active agents which improve the sensory quality of ice cream by aiding the whipping process, improve air cell distribution and enhance the products heat shock resistance. Despite their name, emulsifiers are actually used in ice cream to de-emulsify some of the fat.

7.2. STABILIZERS

Stabilizers are a group of water-soluble or water-dispersible biopolymers used in small amounts (typically 0.2%) in ice cream, sorbets, water ices and other foods. Most stabilizers are polysaccharides of plant origin, *e.g.* alginates and carrageenans (from seaweeds), locust bean gum and guar gum(from tree seeds), pectin (from fruit) and sodium carboxymethyl cellulose (from cotton). Xanthan, a bacterial polysaccharide, and gelatin, a polypeptide of animal origin, are also sometimes used. These biopolymers are polydisperse and polymolecular, because their structures vary with the source and the environmental conditions. Nutritionally, stabilizers are a source of solublefibre. Although they come from natural sources, under European law they are considered food additives and therefore they have associated 'E numbers'.Stabilizers are straight or branched polymers containing hydroxyl groups that can form hydrogen bonds to water molecules. Typically they contain numerous monomer units and have molecular weights of 10^5-10^6. Because they are large, stabilizers do not dissolve in water as readily as smaller molecules: some require high temperatures or shear for complete hydration. When dissolved, they produce high viscosity solutions at low concentrations. Some stabilizers in solution can form gels when heated and/or cooled or on the addition of cations.

7.3. Role of Stabilizers in ice cream

In ice cream, stabilizers, usually used in combination of 2-3 types are primarily used for the following purposes:

§ To increase the viscosity of the mix

§ To stabilize the mix i.e. to prevent wheying off

§ To help in suspension of flavouring particles

§ To produce a stable foam with desired stiffness at the time of packaging

§ To reduce or slow down the growth of lactose crystals during storage mainly during temperature fluctuations

§ To reduce moisture migration from the product to the package or the air

§ To help prevent shrinkage of the product volume during storage

§ To provide uniformity to the product and resistance to melting

§ To produce smoothness in texture during consumption

§ Reduce the rate of meltdown (*i.e.* the rate at which ice cream melts)

§ Prevent shrinkage and slow down moisture migration out of ice

§ Mask the detection of ice crystals in the mouth during eating.

§ Allow easier pumping and more accurate filling during processing.

§ Facilitate the controlled incorporation of air in the freezer

7.3.1. Classification of stabilizers

Stabilizers which are used in ice cream and frozen desserts mainly fall into the following categories

1. Proteins- Gelatin

2. Plantexudates – Arabic, ghatti, karaya and tragacanth gums

3. Seed gums – Locust (carob) bean, guar, psyllium, starch and modified starches

4. Microbialgums – Xanthan

5. Seaweed extracts – agar, alginates, carageenan

6. Pectins– low and high methoxyl

7. Cellulose– sodium carboxymethyl cellulose, microcrystalline cellulose, methyl and methylethyl cellulose, hydroxypropyl and hydroxypropylmethyl cellulose.

7.3.2. Properties of individual stabilizer ingredients

a) **Sodium Alginate**

Sodium alginate (E401) is a polysaccharide of guluronic acid and mannuronic acid. It is extracted from brown seaweeds such as*Macrocystispyrifera* and *Laminaria digitata*. It consists of a negatively charged polymer chain with ionic bonds to positively charged sodium ions (Na+). In aqueous solution, the sodium ions dissociate from the polymer so it becomes charged. Calcium ions (Ca^{+2}) or other doubly charged cations can bind to negative charges on two different polymer molecules. These intermolecular interactions lead to the formation of a gel. In ice cream, alginates are blended with phosphate, citrate or tartrate ions to prevent premature gelation due to the calcium from the milk solids. The major advantage of alginate is its resistance to acid conditions, particularly when heated, whereas other stabilizers would lose their functionality. Usually, it is used at a level of 0.18-0.25%.

Alginic acid extracted from kelp is insoluble in cold water; hence salts of organic acid are prepared or the propylene glycol ester which is readily soluble in hot or cold water is prepared. This product is known as propylene glycol alginate.

b) Carrageenan

Carrageenans (E407) are complex polysaccharides of esters of galactose and m-3,6-anhydrogalactose,found in red seaweeds *(Rhodophycae)*, such **as** *Chondrus crispus* (IrishMoss), *Kappaphycus alverezii* and *Eucheuma denticulaturn.* Carrageenancan have several structures, usually classified as one of three types that have different properties: *kappa* (k), *iota* **(i)** and *lambda (1)*. Carrageenans can also form gels with both milk proteins and locust bean gum. In ice cream applications, k -carrageenan fractions are frequently used not as a primary stabilizer but as a secondary hydrocolloid to prevent wheying off of mix, a condition promoted by the other stabilizers due to their incompatibility in solution with milk proteins. Hence, it is included in most blended stabilizer formulations at a usage rate of 0.01-0.05%. At higher concentrations the carrageenan would begin to gel and fail to function well. k -carrageenan reduces phase separation of milk proteins and polysaccharides which could result in wheying off.

c) Locust Bean Gum

Locust bean gum (E410), also known as LBG, carob gum or St Johns Bread, is extracted from the seeds of the Mediterranean *Ceratoniasiliqua* tree. These large, evenly sized seeds were the original carats used as a measure of weight. LBG is a polysaccharide consisting of a mannose backbone with galactose side branches on about a quarter of the mannose units.The side branches occur in blocks, giving LBG 'smooth' regions of free mannose backbone and 'hairy' regions of galactose side groups. In solution, strong hydrogen bonds can form between the large smooth backbone regions. This leads to gel formation under certain conditions. LBG is the best stabilizer for many ice cream applications and its ability to gel is crucial to some aspects of its use. However, it is also expensive stabilizer.

d) Guar Gum

Guar gum (E412) is extracted from the seeds of *Cyamposistetragonolobus,* an annual crop grown in the Indian subcontinent. Guar has a similar structure to LBG: it has a backbone of mannose units, about half of which have galactose side branches. Guar has a higher molecular weight than LBG and the side groups are more evenly spaced. The larger proportion of galactose units makes guar cold water soluble. The regions of backbone that are free of side chains are smaller than in LBG. Hydrogen bonding between them is therefore not strong enough to form permanent cross-links, but does result in'hyper-entanglements'. These are stronger than purely topological entanglements and account for the high viscosity of guar gum solutions at low concentrations.Guar gum is significantly cheaper than LBG. Both these gums at 0.1-0.15% impart a chewy body to the product. While locust bean gum may cause a comparatively short body, guar gum may impart stickiness to the product.

e) Pectin

Pectin (E440) is extracted from citrus peel and apple pomace. It is a polysaccharide consisting of linear chains of galacturonic acid and galacturonic acid methyl ester units. Pectin is classified according to its degree of esterification. High methoxy *(*>50% esterified)and low methoxy (< 50%) pectins possess different properties. For example,low methoxy pectin requires calcium to gel whereas high methoxy pectin gels at low pH and in the presence of high concentrations of sugar. Pectin is the setting agent used in jam making. It is used as an ingredient in syrups and fruits used in making rippled effects in ice cream and is also effectively used in sherbets and ices. All fruits contain some pectin. Some fruits,such as apples and gooseberries, usually contain enough natural pectin to form a gel, whereas pectin must usually be added to set the jam for other fruits,such as strawberries and cherries. It is not a very satisfactory stabilizer for ice cream.

f) Xanthan gum

Xanthan gum (E415) is produced by the bacterium *Xanthomonascampestris.* It is a polysaccharide consisting of a chain of glucoseresidues with charged trisaccharide side groups. Xanthan has excellent solubility and is suitable for use under acid conditions,*e.g.* in water ice. Xanthan is a rod-like polymer. In solution, the rods are oriented indifferent directions and interact to form a weak network. When a small amount of shear is applied, the rods all line up and the network is broken. When the shear is removed, the network reforms. As a result, the viscosity of xanthan solutions decreases dramatically with shear, but quickly recovers once the shear is removed. This property is useful in sauces for ice cream. During dispensing, the viscosity is low, but as soon as shear forces cease, the viscosity rises substantially. These results in a sauce that remains fixed after dosing onto the product. Xanthan gum provides viscosity which is stable over wide range of pH and temperature. It is effective at low levels when used along with locust bean gum and guar gum, these vegetable gums act synergistically with it. However, xanthan is not widely used in ice cream because it is expensive.

g) Sodium Carboxymethyl Cellulose

Sodium carboxymethyl cellulose (E466) is derived from purified cellulose from cotton and wood pulp. It is a sodium salt polymer of anhydroglucose residues. For use in ice cream, an average of 0.7 of the 3 hydroxyl groups in each glucose unit is substituted with a sodium carboxymethyl group. The long, negatively charged molecules produce a stable thickener that can also reduce casein precipitation. CMC hydrates at low temperatures. It has excellent water holding property but may cause wheying off. Usually used together with other gums, CMC at 0.1-0.2% performs excellently as an ice cream stabilizer. However, its perception as a 'chemical' has resulted in fairly low usage.

h) Gelatin

Gelatin is a mixture of high-molecular-weight polypeptides derived from collagen from animal connective tissues, and was commonly used as a gelling and thickening agent. Gelatin disperses in cold water and forms a gel upon heating the dispersion. It is used at the rate of 0.2-0.3% and requires ageing for at least 4 hours; often a practice of overnight ageing is followed. It is a good ice cream stabilizer since forms a weak gel that melts readily in the mouth giving no impression of gumminess. However, the so called 'instant gelatin' may not require such long ageing periods. The effectiveness of gelatin may be altered by interactions with other mix constituents at high temperatures. It is not suitable for vegetarians, and has now generally been replaced by other stabilizers.

The most important property of gelatin is its ability to form thermo-reversible gels. At a few percent in water, gelatin's gel-melting temperature (<35 C) is below body temperature, which can provide gelatin products with a unique 'melt-in-mouth' quality. Gelatin's most important attribute is its gel strength and, when determined by the standard method, is called the 'Bloom strength' or 'Bloom value.' Commercial products normally have a Bloom value that falls between 50 to 280.

i) Other hydrocolloids

Other hydrocolloids viz. agar agar, an extract from red algae and gums such as tragacanth, Arabic, karaya, etc have found use in sherbets and milk ices.

7.3.3. Milk proteins

With the exception of milk proteins and gelatin, all the other stabilizers are carbohydrates. Casein being a hydrocolloid in nature also causes a appreciable stabilizing effect in ice cream. Therefore, the levels of milk solids, and so milk protein, will determine the amount of stabilizer to beadded. Also, interactions of certain stabilizers such as alginate and k -carrageenan with casein are likely to have considerable impact on the overall stability of ice cream. Skim milk and its concentrated and dried forms are most common sources of milk proteins in ice cream mix, but protein products such as whey protein concentrates (WPC) and total milk protein (TMP) have also been used. High heat skim milk concentrate or powder have been known to give generally a superior texture ice cream.

7.4. Emulsifiers

Emulsifiers have been used in ice cream mix manufacture for many years. They are usually integrated with stabilizers in proprietary blends but their function and action differ remarkably from those of stabilizers. They can be classified as :

7.4.1. Hydrophobic :Examples include sorbitan esters,mono- and diglycerides of fatty acids, polyglycerol polyricinoleate, highly substituted sugars, polyglycerol esters, and propylene glycol esters.

7.4.2. Hydrophilic : Examples include ethoxylatedsorbitan esters, monoglyceride derivatives such as lactates, tartarates,citrates, low-substituted polyglycerol esters, and monosubstituted sugaresters.

7.4.3. Role of emulsifiers in ice cream

Emulsifiers are used to:

§ Promote nucleation of fat during aging thus reducing aging time

§ Improve the whipping ability of the mix due to their function at the air interface resulting in reduced air cell sizes and homogenous distribution of air in the ice cream

§ Produce a dry and stiff ice cream as they enhance fat destabilization, facilitating molding, fancy extrusion and sandwich manufacture

§ Increase resistance to shrinkage and rapid melt down due to a combination of the above two factors

§ Increase resistance to the development of coarse/icy texture, due to the effect of fat agglomerates, more numerous air bubbles, and thinner lamellae between adjacent air bubbles on the size and growth of ice crystals

§ Provide smooth texture in the finished product, due to fat structuring and interaction of fat agglomerates within the mouth during consumption.

6.3.1. HLB concept

Griffin (1949) forwarded hydrophilic-lipophilic balance concept. A specific emulsifier HLB is required to produce a particular type of emulsion. The HLB number indicates the percentage weight of the hydrophilic portion of an emulsifier molecule divided by 5. The HLB scale ranges from 0 to20.

Glycerol Mono Stearate (GMS) has got a HLB number of 3 whereas polysorbate 65 has got a HLB number of 13.

7.6.4. Properties of individual emulsifiers

a) Mono-/diglycerides

The most commonly used emulsifiers in ice cream manufacture are mono-/diglycerides (E471). Mono-/diglycerides are mixtures of monoglycerides and diglycerides. Mono- and diglycerides are surface active because the glycerol end of the molecule is hydrophilic and the fatty acid end is hydrophobic. Mono-/diglycerides are made by partially hydrolysing vegetable fats, such as soybean oil and palm oil. They normally contain 40-60% monoglyceride, together with diglyceride, and a small amount of triglyceride. Fully saturated mono-/diglycerides that contain predominantly stearic and palmitic acids, such as glycerol monostearate, are often used for ice cream production and typically make up about 0.3% of the ice cream mix.

Materials with high monoglyceride content (> 90%) are available. These are difficult to disperse because they can become extremely viscous and form a gel in aqueous systems. However, this may be helpful in some applications. For example, the gelling properties have been exploited in the manufacture of very low fat ice cream.

b) Sorbitanesters

The sorbitan esters are similar to monoglycerides in that the sorbitan esers have a fatty acid molecule such as stearate or oleate attached to a sorbitol (glucose alcohol) molecule, whereas the mono glycerides have a fatty acid molecule attached to a glycerol molecule.To make the sorbitan esers water soluble polyoxyethylene groups are attached to the sorbitol molecule. Polysorbate 80, polyoxyethylene sorbitan monooleate is the most common of these sorbitan esters. Polysorbate 80 is a very active drying agent in the ice cream and is used in many commercial stabilizer/emulsifier blends. Although it is normally a component of stabilizer/ emulsifier blend, it can be added in pure form directly to mix flavour tank post homogenization and will become effective at enhancing dryness within a few minutes. Sorbitan esters of fatty acids, such as polyoxyethylene sorbitan monooleate (also known as polysorbate 80) are structurally similar to monoglycerides. These consist of a fatty acid attached to a sorbitol molecule instead of glycerol. Polyoxyethylene groups are also attached to the sorbitol molecule to make it water soluble. Polysorbate 80 can be used as an ice cream emulsifier, typically at concentrations of 0.1-0.2%.

c) Egg Yolk

Egg yolk, which contains several components with emulsifying properties, notably lecithin, is often used in 'all-natural', premium or homemade ice creams. Egg yolk has the approximate composition (by weight) of 50% water, 16% protein, 9% lecithin, 23% other fat, 0.3% carbohydrate and 1.7% minerals. Lecithin consists of phosphatides and phospholipids. Egg yolk is usually used in ice cream manufacture either as pasteurized fresh egg yolk, frozen sugared pasteurized egg yolk (which has about 10% sucrose added to protect it from damage during freezing) or as dehydrated egg yolk. Egg yolk solids are normally used at about 0.5-3%. High concentrations are only used for super- premium products, and cangive the ice cream an eggy flavour.

Stabilizers and emulsifiers are important ingredients in ice cream and they contribute to a great extent to the desired body and texture characteristics of ice cream and other frozen desserts. Generally a mixture of two or more emulsifiers/stabilizers is preferred to overcome drawbacks of individual compounds. Most of the commercial preparations are blends of emulsifiers and stabilizers which not only provide the convenience of use, but also make it possible to integrate stabilizers in a continuous emulsifier phase thereby facilitating dispersion of the stabilizer. The ice cream industry in India is growing at a commendable rate so the demand of good quality stabilizers and emulsifiers is bound to go up. Intensive research is required to produce stabilizer emulsifier formulations to suit varying needs of the ice cream manufacturer.

****** ☺ ******

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. EMULSIFIERS

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.

Editor:

Lesson-9

Non-Dairy Ingredients in Ice Cream

9.1.INTRODUCTION

Ice cream is made utilizing both dairy as well as non-dairy food ingredients. In this section, the role played by Non-dairy ingredients namely sweeteners, flavourings and colourings will be discussed.

9.2. SWEETENERS

While a sweet ice cream is generally desired by the public, sweeteners should be used in moderation, not only for optimum palatability, but also for handling properties.

9.2.1. Role of sweeteners in Ice cream

- To increase the acceptance of the product, not only by making it sweeter but also by enhancing the pleasing creamy flavour and the delicate fruit flavour.
- It increases the viscosity and TS content of mix; this improves the body and texture.
- It depresses the Freezing point of mix, resulting in slower freezing and thus requiring a lower temperature for proper hardening.
- It is usually the cheapest source of TS in the mix.

Lack of sweetness produces a flat taste, while too much tends to overshadow desirable flavours. Sugar may slow up the whipping of the mix.

For plain ice cream, level of sugar of 14-16% is found desirable. In case of fruit and chocolate ice cream, a higher sugar content of 17-18% is desirable.

9.2.2. Types of Sweetening ingredients used in Ice cream and Frozen desserts

- Sugar (Sucrose) or sugar syrup
- Dextrose
- Invert sugar (in paste or syrup form)
- Corn syrup, Dried corn sugar, Glucose syrup, Dried glucose syrup
- Maple syrup, Maple sugar
- Honey
- Brown sugar

Intense sweeteners (viz., Saccharin, Aspartame,Acesulfame-K, Sucralose, Stevioside, etc.)

Table-9.1: Relative sweetness of sweeteners

Sweeteners	Dextrose Equivalent*	Relative sweetness
Sucrose		1.00
Fructose		1.75
Invert sugar		1.05
Glucose (Dextrose)		0.74
Corn syrup		
High conversion	62 DE	0.68
Medium conversion	52 DE	0.58
Low conversion	42 DE	0.50
Low conversion	32 DE	0.42
90 HFCS		1.60
Lactose		0.16
Polyols:		
Sorbitol		0.50-0.70
Xylitol		1.00
Saccharin		200-700
Aspartame		160-200
Acesulfame-K		200
Cyclamate		30-60
Sucralose		600-800
Stevioside		300

* DE – Dextrose Equivalent

<u>Dextrose equivalent (DE)</u>

It is the percentage weight of dextrose present in the hydrolysed starch referred to as dextrose equivalent: higher the DE, higher will be the sweetness of the corn sugar.

9.2.4. Sucrose

It is a disaccharide composed of glucose and fructose. It is obtained from cane sugar and sugar beets. It may be used in dry or liquid form (67% sucrose). It provides a sweet taste without secondary or after flavours. However, sucrose is a contributor to dental caries. Invert sugar can be prepared by hydrolysis of sucrose with attendant increase in sweetness over that of sucrose.

9.2.5. Fructose

It is a white crystalline powder. It contains as many calories as sucrose. It is available under trade name 'Xyrofin' by Xyrofin Ltd. It seems to have potential as a sweetener in dietetic ice cream because of the high relative sweetness value. It produces a softer, more easily scoopable product when held at -18°C.In fruit ice cream it brings out the flavour of fruit and berries. However,products containing fructose are susceptible to browning reactions.

9.2.6. Corn sweeteners

These are available in three major types viz., (i)Refined corn sugar (Dextrose), (ii) Dried corn syrup (referred to as corn syrup solids), and (iii) liquid corn syrup.

The advantages of incorporating corn syrup solids or corn syrup as part replacement of sucrose is as follows:

It provides firmer and heavier body to finished ice cream.

It serves as an economical source of solids.

It improves the shelf life of the finished product.

High fructose corn syrups (i.e. 42, 55 and 90%) also play an important role as sweetener in ice cream.

9.2.7. Dried corn syrup solids

It is produced by dehydration of corn syrup. It contains sugars like dextrose and maltose, together with dextrin, but usually contains no starch. It is economical than use of cane sugar but due to its lower sweetening effect, it is required to be used in greater amount. The effect on F.P. (raised) and smoothness (stabilizing effect due to higher TS contribution) gives Corn Syrup Solids (CSS) an advantage over that of dextrose. Recommended usage is 25-35% of the total sweetener that is to be supplied by CSS.

9.2.8. Dextrose

It is a white crystalline or granular sugar obtained by hydrolysis of corn starch. It is economical than sucrose. It is recommended for use in high-fat mixes for more desirable body, texture and melting properties. It is necessary in Sherbets and Ices to inhibit the crystallization of sucrose on the surface. Its effect of lowering the Freezing point limits the amount of dextrose that can be used to less than 25.0% of the total desired sugar.

9.2.9. Polyols

a) Sorbitol

It is a hexahydric alcohol, obtained by catalytic hydrogenation of D-glucose or invert sugar at high temperature and pressure, followed by ion-exchange treatment. It is easily water soluble and possess a ‘sweet cool’ and pleasant taste. This sweetener is useful in formulation of ‘soft ice creams’ and ‘diabetic mix’.

b) Xylitol

It is a pentahydric alcohol naturally occurring in fruits and vegetables. Commercially it is obtained by acid hydrolysis of xylan. However it has an excellent taste and has a cooling effect greater than sorbitol. It can be used as an excellent sugar substitute for diabetics.

c) Intense sweeteners

1. Saccharin

It is the first non-nutritive sweetener used commercially– a product derived from coal tar. It has sweetening effect up to 550 times that of sucrose. However, its use is drastically reduced due to its implication to occurrence of cancer in laboratory animals.

2. Aspartame

It is a dipeptide consisting of phenylalanine and L-aspartic acid. It is available under trade names 'Nutra Sweet' or 'Saneeta'. Absence of bitter character and sucrose-like flavour makes it a source of sweetener superior to other high-intensity sweeteners like saccharin. It is non-cariogenic.

3. Sucralose

It is produced from sucrose by chlorination of 3-hydroxyl groups. It has been developed jointly by Mc Neil Specialty Products and Tate and Lyle Specialty Sweeteners. It is a non-caloric sweetener and offers unique combination of a sweet, sugar-like taste, free of any unpleasant aftertaste.

4. Stevia

Stevia rebaudiana known as sweet leaf is widely grown is widely grown for its sweet leaves. As a sweetener and sugar substitute, stevia's taste has a slower onset and longer duration than that of sugar, although some of its extracts may have a bitter or licorice-like aftertaste at high concentrations.

With its steviolglyco side extracts having up to 300 times the sweetness of sugar, stevia has garnered attention with the rise in demand for low-carbohydrate, low-sugar food alternatives. Because stevia has a negligible effect on blood glucose, it is attractive as a natural sweetener to people on carbohydrate-controlled diets.It is available commercially as stevioside

9.3. FLAVOURINGS

Frozen desserts are valued mainly for their pleasing flavor and their cooling and refreshing effects. Among the flavouring substances, the important ones are vanilla, chocolate and cocoa, fruit and fruit extracts, nuts, spices, etc.

Vanilla and Chocolate are the dominant flavours, but there has been some shift in the ranking of other flavourings.

The type of flavourings utilized in ice cream and frozen desserts include:

(a) Natural flvourings: Non-citrus fruit, citrus fruit,tropical fruit, natural flavours from botanicals, spices, cocoa and chocolate,coffee, natural flavourings from vanilla beans and nuts.

(b) Synthetic flavourings: These include aromatic chemicals and imitation flavours.

(c) Liqueur flavourings: Alcohol, whiskey and other distilled beverages, fruit brandy distillate and brandy flavour essence and fruit liqueurs.

The last category (c) is prevalent in countries abroad.

9.3.1. Vanilla

It is obtained from beans of an orchid *Vanilla fragrans*. The natural compound which produces vanilla flavour is vanillin. It is available in liquid or powder forms as pure vanilla, reinforced vanilla with vanillin and imitation vanilla. Cured vanilla beans contain 1.5-2.0% vanillin on dry basis.

9.3.2. Fruit flavourings

Fruit may be crushed and used as such, but often it is necessary to add further flavours,either natural concentrated extracts or even synthetic to bring out the full flavour. The popular fruit flavourings used in ice cream include mango, strawberry,pineapple, orange, apple, papaya, jamun, etc.

9.3.3. Chocolate and cocoa

These are derived from beans of tree Theobroma cacao.When used as an ingredient in ice cream, about 2-3% cocoa is used. To overcome the bitter flavour of cocoa, additional sugar is necessary (17-18% sugar). The chocolate is also used as couverture(coating of other flavoured ice cream) to enrobe a small individual portion of ice cream.

9.3.4. Nutmeats

Several kinds of nutmeats are popular including almonds,raisins, hazelnuts, pistachio, walnuts, pecans, etc. It must be ensured that the nutmeats are clean, free from shells or other extraneous matter and free from rancidity. The nutmeats may preferably be roasted or even fried in oil prior to its use.

9.4. COLOURINGS IN ICE CREAM

Ice cream should have a delicate, attractive color that suggests or is readily associated with its flavour. Fruit ice cream needs to be colored because about 15% fruit commonly added, produces only slight effect on color. Chocolate ice cream is one of the exceptions, wherein the required amount of cocoa furnishes the desired color.

Most of the colors are synthetic origin. A weak alkaline solution of Annatto color is about the only vegetable color used in ice cream.

The list of permitted colorings for use in ice cream is furnished in Table 9.2.

Table 9.2: Colourants permitted by FSSA (2006) in ice cream

Colourant	Color hue imparted
Erythrosine	Red
Allura Red	Red
Caramel	Brown
Brown HT	Brown
Fast Green FCF	Torquoise green
Green S	Green
Sunset Yellow	Orange
Ponceau 4 R	Red
Tartrazine	Yellow
Brilliant Blue	Blue
Indigo Carmine	Indigo
Black PN	Black

Several natural colourings have emerged due to negative health impact of the permitted synthetic colorants in ice cream. However, these have not got wide acceptance due to problems in stability of the colourants.

Some examples of natural colourants that has been tried in ice cream and frozen desserts is depicted in Table-9.3.

Table-9.3: Natural colorants for use in ice cream

Colourant	Natural source	Color hue imparted
Annatto	*Bixa orellana*	Yellow
Betanin	Beet root	Red
Curcumin	Turmeric	Yellow
Caramel	Sugar	Brown
Paprika	Paprika leaves	Pale yellow
Anthocyanin	Grapes	Red
Carotenoid	Saffron	Saffron

****** ☺ ******

Lesson-10

Preparation of Ice Cream Mix –Standardization, Blending and Homogenization

10.1. INTRODUCTION

Ice cream is a complex product containing milk components like emulsified fat, protein in colloidal form and a solution of lactose and salts along with or without cane sugar, eggs, fruit juices, fruits, flavours, colours, stabilizers and emulsifiers.

10.2. PREPARATION OF ICE CREAM MIX

Preparation of ice cream mix involves various essential steps viz.

- Selection of ingredients
- Formulation of ice cream mix
- Blending of mix
- Pasteurization of mix
- Homogenization of mix
- Cooling of mix
- Ageing of mix

10.3. SELECTION OF INGREDIENTS

Good quality materials are essential if the resultant product need to be satisfactory in all aspects. The raw ingredients necessary to provide the components of ice cream must contain sufficient fat and milk solids in proportions that can be combined to make a mix of the desired composition.

Selection of ingredients depends on their

- Availability
- Perishability
- Convenience in handling
- Effect on flavour, body and texture of ice cream
- Cost
- Equipments available etc

Ice cream ingredients may be grouped into dairy and non-dairy products.

10.4. DAIRY INGREDIENTS

Dairy products that supply fat and MSNF – Sweet cream, Sweet milk, fresh butter, unsweetened, condensed and evaporated milks , full-cream milk powder, separated milk powder.

Dairy products that supply MSNF alone – Skim milk, skim milk powder, condensed skim milk, sweet-cream buttermilk.

10.5. NON-DAIRY INGREDIENTS

- Sweetening agents – Cane sugar, beet sugar, corn sugar, corn syrup, invert sugar,saccharin

- Stabilizers– Gelatin, sodium alginate, guar gum, etc.
- Emulsifiers– Mono or di-glycerides of fat forming fatty acids
- Flavours– Vanilla, chocolate, strawberry, pineapple, lemon, banana, mango, orange, etc.
- Colours– Yellow, green, pink, etc.
- Egg solids – Yolk solids
- Fruits & nuts – Apple, banana, mango, pine apple, grape, almond, pistachio, cashew nut, walnut and groundnut.

10.6. FORMULATION OF MIX

Consideration of various factors is highly essential to obtain a proper mix. The fundamental requirement of mix formulation is to obtain a well balanced mix which also satisfies the legal standards. A well balanced mix should always ensure:-

- A correct fat to sugar ratio – to prevent fatty mouth feel in case of high fat ice cream the sugar content has to be raised accordingly. For instances 16% fat ice cream should ideally have 17% sugar as against 15% sugar for economy (10% fat) ice cream.
- A correct total solids to water ratio – if too high, sandiness and rough texture and if too low, glassy or icy texture with weak body. Usually total solids of 36.0 to 40.0% will result in organoleptically acceptable ice cream.
- There is inverse relation between fat and SNF in ice cream mix for e.g. super premium ice cream (high fat) will have lower SNF than good average (moderate fat) ice cream

As a thumb rule, the MSNF should be about 15.6% (slow turn over) to 18.5% (rapid turn over) of the TS of the mix, depending on the turnover of the ice cream.The maximum MSNF that can be kept to prevent sandiness in ice cream is as follows.

For slow turn over the formula is

$$\text{Max. MSNF\%} = \frac{100 - (\text{Sum of \% of all other solids in mix other than serum solids})}{6.4}$$

For rapid turn over the formula is

$$\text{Max. MSNF\%} = \frac{100 - (\text{Sum of \% of all other solids in mix other than serum solids})}{5.4}$$

For proper formulation of the mix, prior calculation of the mix with regard to the proportion of ingredients to be added is mandatory. The following methods can be used to calculate the mixes:

- Pearson square method
- Serum point method
- Formula tables / graphics method
- Algebraic method
- Computer developed formulations

10.7.STANDARDIZATION OF ICE CREAM MIX

In order to attain the desired composition of ice cream mix, the calculated quantities of ingredients (dairy and non dairy) is arrived at through standardization. This is accomplished using either (a) Algaebraic method, (b) Serum Point method.

In algaebraic method the following three equations are used

Quantity equation

$$W + C + P = 100 - NDP ----(1)$$

Fat equation

$$W \times F_1 + C \times F_2 + P \times F_3 = \text{Desired fat \%} \times 100 ----(2)$$

SNF equation

$$W \times SNF_1 + C \times SNF_2 + P \times SNF_3 = \text{Desired SNF \%} \times 100 ----(3)$$

Where

W= whole milk, C= Cream, P= Skim milk powder, NDP= Non Dairy Product (Sugar+stabilizer+emulsifier), F_1, F_2 and F_3 = fat percentage of W, C and P respectively.

SNF_1, SNF $_2$and SNF $_3$ = SNF percentage of W, C and P respectively.

Desired fat and SNF may be 10.0and 12.0 per cent respectively.

Equating the above three equations we can arrive at the individual quantities of each ingredient of ice cream mix.

10.8. BLENDING OF MIX

The ingredients to be blended are taken in a vat, where it can be heated to facilitate dissolving, blending and pasteurizing. Mixing process varies from a small batch operation type to a large scale automatic continuous type depending upon the amount of mix to be processed.

The order in which ingredients are to be added is as follows:-

- Liquid ingredients are mixed together and heated to 49°C prior to the addition of all dry ingredients.
- Sodium alginate is mixed with a portion of sugar and slowly added to the liquid maintained at 71.1°C at a moving agitator point.
- When gelatin is used, it should be dissolved in nine times water by weight with equal volumes of sugar before the liquid temperature reaches 49°C.
- If butter, plastic cream, frozen cream or other frozen products are used, they should be cut into small pieces and allowed for complete melting before pasteurization.

10.9. HOMOGENIZING MIX

Homogenization of ice cream mix is a most essential step to make a permanent and uniform suspension of the fat by reducing the size of the fat droplets to a very small diameter, preferably not more than 2 µm.

Advantages of homogenization

Proper homogenization of the mix will never allow the fat to form the cream layer

- More uniform ice cream
- Smoother texture
- Improved whipping ability
- Shorter ageing period

- Less opportunity for churning to occur in freezer
- Less stabilizer is required

Homogenization of mix is usually done at temperature ranging from 63 to77°C. A pressure of 2000 to 2500 psi (135 to 170 kg/cm^2) with one valve or 2500 to 3000 psi (170 to 200 kg/cm^2) on the first and 500 psi(35 kg/cm^2) on the second stage will usually give good results for an average mix.

****** ☺ ******

Lesson-11

Preparation of Ice Cream Mix –Pasteurization, Cooling, Ageing and Flavour addition,

11.1 INTRODUCTION

Once the formulation of ice cream mix is decided and all the necessary ingredients weighed, the subsequent operations involves blending the ingredients, pasteurizing the ice cream mix followed by cooling and ageing. Thereafter just prior to taking it to the freezer appropriate flavor and colour is incorporated.

11.2. PASTEURIZATION OF MIX

Pasteurization is done to destroy all the pathogenic bacteria in the mix so as to render the final product safe for human consumption

Advantages of pasteurization are:-

- it renders the mix completely free of pathogenic bacteria
- it dissolves and helps to blend the ingredients of the mix
- it improves flavour
- it improves keeping quality
- it produces a more uniform product

Rapid heating and holding of the mix at definite temperature and rapid cooling below 5°C ensures proper pasteurization.

The temperature time combination for pasteurization of the mix as per BIS is as follows

- For Batch method – 68.5°C for not less than 30 min
- HTST method - 80°C for not less than 25seconds
- Vacreation - 90°C for not less than 1-3 seconds
- UHT pasteurization – 98.8 to 128.3°C for not less than 0-40 seconds

High temperature pasteurization is preferred as there is a greater bacterial kill resulting in low bacterial count in ice cream

- Better body and texture
- Better flavour
- Protection against oxidation
- Saving of stabilizer
- Saving of time, labour and space
- Increased capacity

11.3.COOLING OF MIX

After pasteurization, the mix should be rapidly cooled to a temperature below 4°C using a plate heat exchanger. Unless the mix is cooled to a temperature of 4°C or lower, it will become very viscous and the ice cream will not melt down smoothly. Also, temperatures below 5°C retard the growth of bacteria.

11.4.AGEING OF MIX

The cooled mix is left to age preferably for a period of 24 h at 4°C.

The changes that occurs during ageing are

- Hydration of milk proteins
- Crystallization of fats
- Absorption of water by any added hydrocolloids
- Viscosity is increased largely due to the previously mentioned changes.
- Ageing is substantially completed within 24 h and longer period should be avoided to control spoilage by psychrotrophs.

11.5. FLAVOUR ADDITION

Frozen desserts are valued mainly for pleasing flavour and refreshing effects. Among the flavouring substances that play an important part in frozen desserts are vanilla, chocolate, strawberry, pineapple, lemon, banana, mango, orange etc. Type and intensity of flavours are important characteristics in ice cream where delicate flavours are preferred to harsh flavours.

Some points to be remembered

Flavours are added by experience to obtain pleasing flavour and colours should correspond to the flavour.

Fresh or canned fruits should be used as pulp or cut into pieces and added to partially frozen ice cream or as top dressing

Nuts after cut into pieces, roasted / unroasted, should be added to partially frozen ice cream while it is in the freezer.

Examples:-

- Vanilla
- Chocolate and Cocoa
- Fruits – fruit concentrates and essences
- Candied and glazed fruits
- Dried fruits
- Freeze dried fruits & Nuts
- Spices & salt

****** ☺ ******

Lesson-12

Types of Ice Cream Freezers – Batch, Continuous, Soft-Serve Freezers, Home-Made Freezers.

12.1.INTRODUCTION

Freezers used in freezing of ice cream mix can be classified as follows

a) Batch freezer: Horizontal, direct expansion type

b) Continuous freezer: Horizontal, direct expansion type

c) Soft– serve freezer: Batch and automatic continuous freezers of the direct expansion type

Ice-cream mix is frozen in single-batch machines or in continuous freezers. In general, both machines utilize a cylindrical chamber with double wall which acts as a jacket to contain the refrigerant. On the axis of the cylinder, a rotating dasher and scraper keep the mix thoroughly agitated and remove the ice from the refrigerated wall.

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. The air content is termed its overrun, which can be calculated mathematically.

12.2. FREEZING ICE CREAM

Ice cream is an almost complete food. The mix is usually contains more than 60 per cent water. As ice is frozen, the ice crystals are suspended in the water, and very small air cells are incorporated into the mixture. When the drawing temperature is -5.6°C about 50 per cent of the water in mixes is frozen. This means that in a mix having 38 percent total solids, the semi frozen ice cream extruded will have 69 per cent of its contents as solids suspended or dissolved in the remaining water, which amounts to only 31 percent of the whole. If freezing continued to a drawing temperature of -9.4°C where 67 per cent of water is frozen out. As ice crystals are formed, they add to the solids already in the mix, and this increases viscosity and motor load requirements. To prevent coarse, icy ice cream, the product temperature should not be permitted to rise, but should not be lowered continuously until well hardened. When hardened to -15°C, about 80 per cent of the water is frozen. If the temperature goes up to -14°C, about 78.5 percent of the water is still frozen; this one degree difference results in about1.9 per cent of the ice being melted. The freezing point curve shows that temperatures should be lowered continuously, that fluctuations cause iciness,and that at lower temperatures, there is a diminished effect. This information is more important in the proper management of packaging, hardening and cold storage of the product.

12.3. ICE CREAM FREEZERS

In 1843, New England housewife Nancy Johnson invented the hand-cranked ice cream churn. She patented her invention. The photograph of hand cranked ice cream freezer is shown in Figure-12.1

Fig-12.1: Hand cranked ice cream freezer

There are two types of ice cream freezers: the batch type and the continuous flow type. Batch freezers are used in very small ice cream factories. Fast freezing is essential for a smooth product, because ice crystals that are formed quickly are smaller than those formed slowly. Therefore, it is desirable to freeze and draw from the freezer in as short time as possible. The freezing time and temperature are affected by the type of freezer used.

12.3.1 Batch Freezers: In batch freezers, each batch must be measured, colored and flavored separately. They consist of the brine type; the salt and ice type; direct – expansion type(using ammonia or Freon as refrigerant), including vertical, horizontal, and single-, triple -, and quadruple – type freezers. Batch freezers made today are generally of the horizontal cylinder type with the freezing cylinder refrigerated with one of the halo carbon refrigerants, most often being R-22 or R-502. There is a mix supply tank located above the freezing cylinder, so that mix will flow by gravity into the cylinder when a valve is opened. The usual procedure is to charge the freezer, turn on the dasher and start the refrigeration. A slide or pivot on the bottom portion of the front door allows the ice cream to be drawn in to containers or bulk cans. The dasher is designed to propel the product toward the discharge port. Subsequent batches are put into the mix supply tank as soon as the previous charge is dropped into the freezing cylinder. Ice cream can be made by every 6-7 min by experienced operators.

The sizes of batch freezers vary according to the manufactures' designs, but 18-– 20 liters and 36-40 liters of 100 per cent over run ice cream are the two sizes found most often. If greater than 100 percent overrun is desired, then the mix charge must be reduced enough to prevent over flow of ice cream during whipping. Generally, ice cream made with batch freezers has both larger ice crystals and bigger air cells than ice cream made with the same mix on continuous freezers. Modern batch freezers are not much different from the earlier models except in better refrigeration systems.

In another one batch type, a charge of mix about half fills the machine. The brine(refrigerant) is then turned on, and the dasher and scraper started. In about 5to 10 minutes the operation is completed, and the batch is discharged by opening a gate in the front of the freezer. The mix has been frozen to a temperature of about -5° C and has increased greatly in volume by virtue of the whipping motion of the dasher blades, giving it the consistency of whipped cream. It is drawn off quickly into the containers, and rushed into the hardening room. Flavors, fruits, and nuts are added to the batch in the freezer just before it is drawn

12.3.2. Continuous Ice Cream Freezers

The process consists of continually feeding a metered amount of ice cream mix and air into one end of the freezing chamber. As the mixture passes through the freezing chamber it is agitated and partially frozen and then discharged in a continuous stream of about the same consistency usually obtained from a batch freezer. This partially frozen stream is delivered into packages, which are then placed in the hardening room to complete the freezing process. The modern machines for this purpose are known as "Continuous" or "Instant freezers". One major difference in continuous processing is that freezing is done under pressure.

In the continuous freezer, following mix processing, the mix is drawn into a flavor tank where any liquid flavors , fruit purees, or colors are added. A mixture of the ice-cream mix and a controlled volume of air is pumped under pressure into one or more horizontal jacketed tubes, each provided with a rotating dasher and scraper. The mix is chilled to a temperature of about -6.1° C and is slowly and continuously forced out of a vertical discharge tube directly into the final containers. The mix then enters the **dynamic freezing process** which both freezes a portion of the water and whips air into the frozen mix. The internal parts of a continuous ice cream freezer are shown in Fig. 12.1. 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, (or 10 to 15 minutes in the case of batch freezers) with about 50% of its water frozen. There are rotating blades inside the barrel that keep the ice scraped off the surface of the freezer and also dashers inside the machine which help to whip the mix and incorporate air.

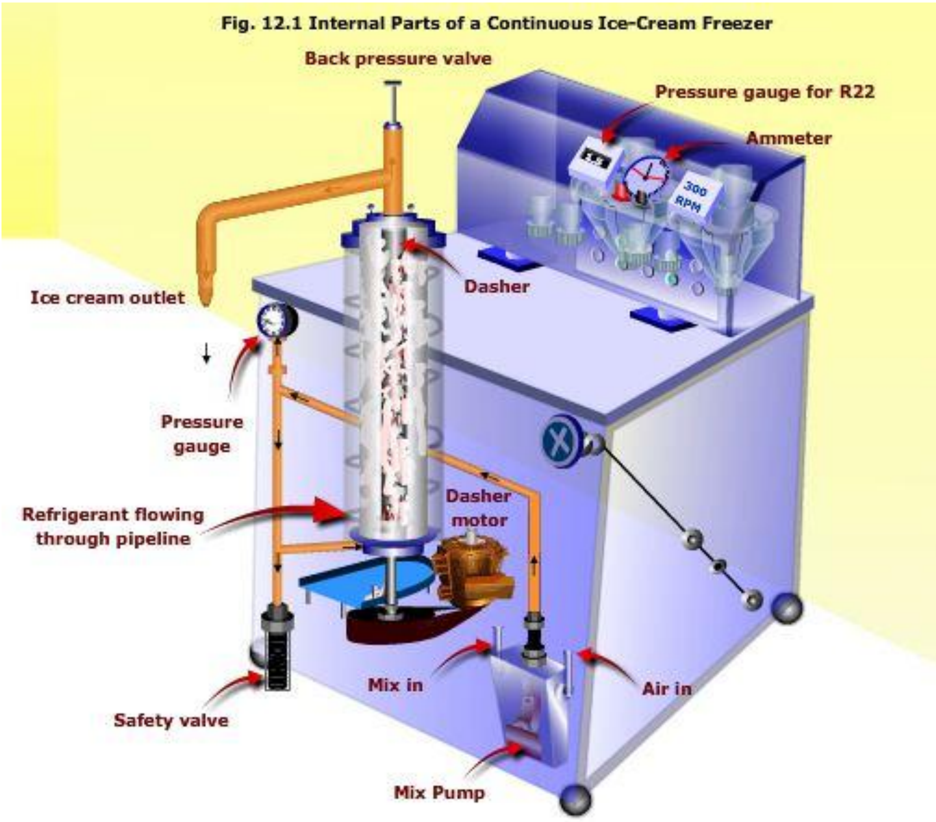


Fig. 12.2: Internal parts of a continuous ice cream freezer

The continuous ice cream freezers may be classified based on the number of pumps used with or without hold back valve system.Figure 12.2 shows internal parts of a continuous ice cream freezer, Figure 12.3 shows the freezer with pump and hold back valve system, Figure 12.4 shows the freezer with three pump system. A microprocessor based continuous ice cream freezer is depicted in Figure 12.5.

Fig. 12.2 Continuous Ice cream Freezer with Pump and Hold Back Valve System

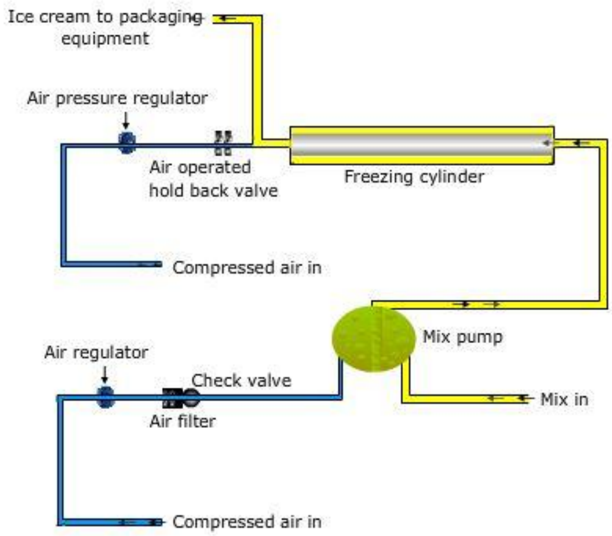


Fig. 12.3 Continuous Ice Cream Freezer with three Pump System

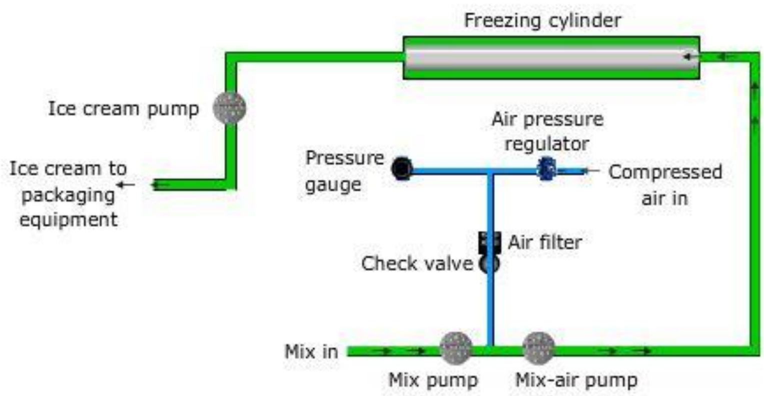
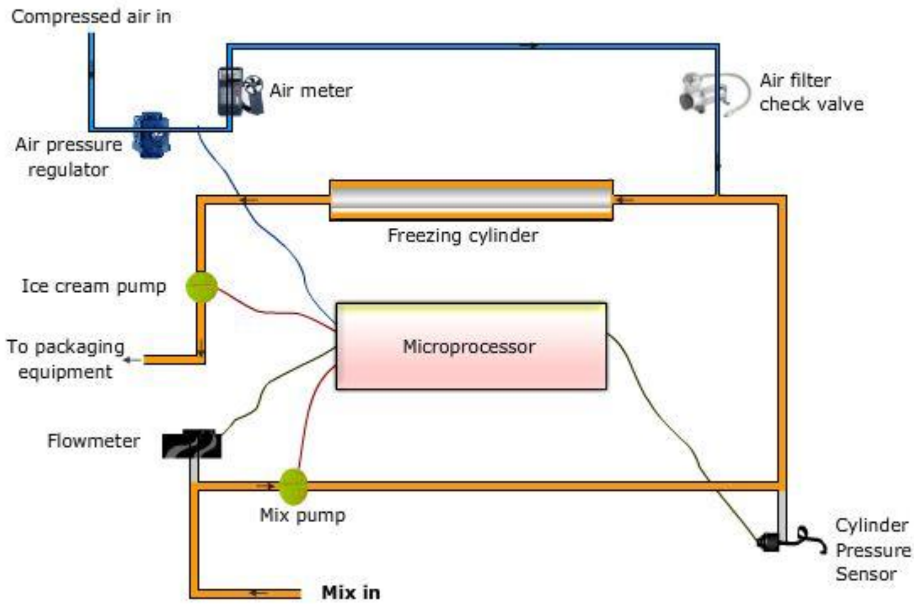


Fig. 12.4 Microprocessor based Continuous Ice Cream Freezer



12.3.3. Disk type of Continuous Ice Cream Freezer

The disk type continuous ice cream freezer in which mix is passed through a tank in which hollow disks containing cold brine are rotated. The disks cooled and aerated the ice cream mix which is discharged on the other end.

12.3.4. Vogt Freezer

The principle of operation of Vogt freezer is same as that of the disk type freezer, but direct cooling system is used here and a tube shaped freezing cylinder which causes extremely fast freezing mixture. Metered amount of air and mix is forced into the freezing tube and emulsified there. The frozen mixture is forced out on the other end of the tube by pressure of a second pump. Ammonia is circulated by means of jet action so that it floods the freezing tube during operation of the machine.

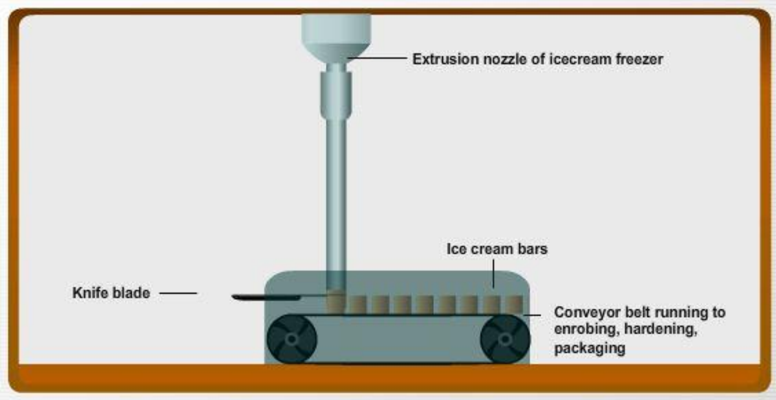
12.3.5. Creamery Package Continuous Freezer

Compressed air is passed through a filter, a pressure gauge and check valve which are provided in the line. Ice cream mix is pumped with the help of mix pump and enters the freezing cylinder along with air. Ice cream after freezing is pumped out with the help of discharge pump. A filling valve is provided between the freezing cylinder and discharge pump. The actual control of overrun of predetermined point is accomplished by controlling the output ice cream as compared to the input of mix. This could be done by actually changing the speed of the ice cream pump only. However, in practice, it has been found that a much simple method is to vary the output of ice cream by changing the pressure on the freezing cylinder,by means of air pressure regulator. The pipeline for ice cream should be kept as short as possible. Since flowing through lines, particularly around a bend,damages the ice cream texture.

Currently the manufacturers have come up with low temperature continuous freezers which can draw ice cream at-10°C, yielding extremely small sized ice crystals making the ice cream very smooth and preventing coarseness since more percentage of water in ice cream mix is frozen.

The schematic diagram of a vertical extrusion and continuous belt type freezing equipment is represented by Fig.12.5.

Fig. 12.5 Schematic Vertical Extrusion and Continuous Belt type Freezing Equipment



12.3.6. Operating the Continuous Freezer

The operator's principal work is to regulate the amount of air being introduced into the mix to give the desired overrun and to regulate the temperature of the refrigerant on the freezing chamber. Once the machine is started, the refrigerant is shut off from the freezing chamber only when the machine is to be stopped. Usually there frigerant is shut off a few minutes before the last mix enters the machine, so that the rinse water (37.8 °C), which follows the mix, will pass through the freezing chamber without being frozen. The temperature of the refrigerant on the freezing chamber is adjusted to give the desired consistency when the product leaves the machine.

The operation of the continuous freezer demands care and management on the part of the operator. The following are the chief requisites for keeping the freezer operating properly:

1. Keep the ammonia jacket clean and free from oil, water and nonvolatile ammonia fractions.
2. Keep the scarper blades sharp and straight.
3. Keep the mix pumps in proper working condition
4. Make certain that there is always a plentiful supply of ammonia at the freezer.
5. Provide a steady suction pressure at all times, at which the freezer must operate to give ice cream of the proper temperature.

Precautions to be exercised

1. Have all mix line connections tight to prevent mix leaking out and air leaking in.
2. Check controls frequently to ensure proper operation.
3. Drain oil trap frequently to ensure that all oil, water, etc., has been removed from the system.
4. Never bend scarper blades. Never drop the freezer dasher. Be careful when removing it from the freezing cylinder.
5. Allow freezing chamber to warm up prior to rinsing with hot or warm water.
6. Check the pump motor to ensure proper lubrication and proper tightness of pulley belts.
7. Use extreme care in handling dasher in assembling or in dismantling the freezer use in order to prevent personal injury.

Cleaning of the Continuous Freezer

1. When the freezer is not going to be used for 2 h or more it should be taken apart, cleaned, and Sanitized. This is efficiently done after the last ice cream is drawn. The rinse water should not be over 37.7ºC to rinse out the ice cream, and the dasher during this process should be turned only a few revolutions.
2. The dasher and other removable parts should be removed to a sink and thoroughly scrubbed with a hot (48.8ºC) washing solution, rinsed, sanitized, and stored where they dry.
3. The freezing chamber and other parts must be scrubbed with a hotter (54.4ºC) washing solution using special care to remove greasy film left on the surface and in the corners. The freezer should not be assembled until it is to be used.
4. Freezers are cleaned by the same CIP procedures used for pasteurizing equipment, the steps that should be taken in the CIP cleaning of freezers are

   a) Rinse with water (37.78^0 C or less) until rinse water runs clear.

   b) Flush for 20 to 30 minutes with 65.5ºC to 71.1ºC water containing 1 – 1.5 lb of alkali detergent for each 10 gallon of water.

   c) Rinse until equipment is cooled. When acid cleaner is used, circulate cleaning solution containing sufficient acid (Phosphoric and hydroxy-acetic) to give0.15-0.6 % acidity, at 65.5° - 71.1° C and 1.5-2.3 m/sec velocity for 20-30min.

   d) Drain and rinse with water at 62.8°C for 5-7 min.

5. During the cleaning cycle all dead ends, air valve connections and the like should be blocked and the freezer run for 10 sec per min.

6.While the circuits are assembled the sanitationcrews can run 82.2-93.3°C water through entire system each time after cleaning, and then, before starting the operation again, 100-200ppm chlorine solution can be run through the entire system.

****** ☺ ******

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.

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

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

- Sodiumcaseinate
- 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).

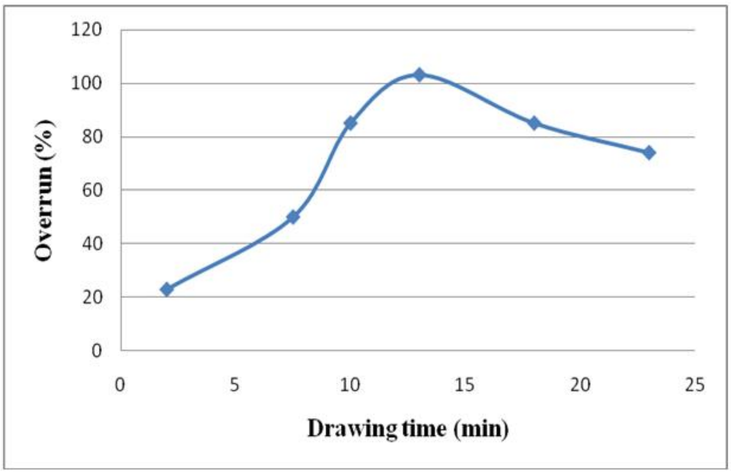


Fig-13.1: Changes in overrun of ice cream during drawing from batch freezer

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.

****** ☺ ******

Lesson-14

Typical freezing curve. Calculating freezing point of ice cream mix.

14.1.INTRODUCTION

The freezing behavior of pure water and a solution made up of various solutes (similar to ice cream mix) are different. The same is depicted in Fig.14.1.

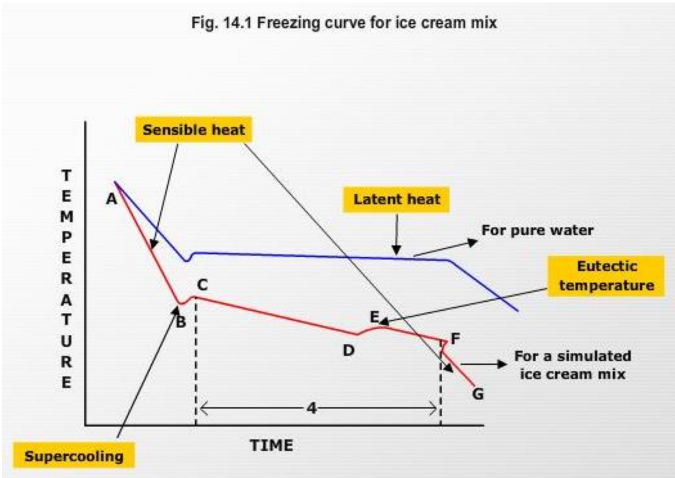


Fig.14.1: Freezing curve of simulated ice cream mix and water

Where

A= Temperature of aged ice cream mix

B= Super cooling of ice cream mix in the freezer

C= Actual freezing point of ice cream mix

D= Lowering of freezing point of ice cream mix

E= Eutectic point at which salts starts to crystallize out along with conversion of water in to ice crystals

F= Eutectic point of another salt in the ice cream mix

G= Further freezing of water in ice cream mix

14.2. BASIC CONCEPTS RELATED TO FREEZING POINT OF ICE CREAM MIX

Freezing point (FP) of ice cream mix varies appreciably with composition.

The mix constituents that affect FP directly are:

- Sugar
- Lactose
- Milk salts
- Any other substances that may have been added and that are in true solution.

Other mix constituents affect FP indirectly by replacing water. For instance, if fat or milk protein or any other constituent, not in true solution, is increased,there is less water in the mix and the resulting higher in-water concentration of truly soluble substances causes a lowering in FP.

Osmometer is used to determine FP of mix. It reads in milli-osmols/kg H_2O.

Where FP(°C) = mOsm/kg of water x –0.001858

14.2.1. Calculating/**Determining the FP of ice cream mix**

Where A =parts of sucrose + lactose/100 parts of water

B = Lowering in FP due to milk salts

$$A = \frac{(\%\ \text{Serum Solids} \times 0.545 + \%\ \text{Sucrose})}{\%\ \text{of Water in the mix}} \times 100$$

From the graph of FP lowering (°C) vs. parts of sugar/100 parts of water, find the FP lowering based on the concentration of sugar.

$$B = \frac{\%\ \text{Serum Solids} \times 2.37}{\%\ \text{of Water in the mix}}$$

FP of mix (° C)= - (A + B)

An average mix containing 12.0% fat, 11.0% MSNF, 15% sugar, 0.3% stabilizer has a FP of about -2.5°C. The FP of mixes with high sugar and MSNF content may be about -3.06°C, while for mixes with high fat, low SNF or low sugar content may be about -1.39° C.

14.2.2. Means to save energy in freezing and cold storage

About 15-30% of the energy can be saved by optimizing the plant performance, better maintenance or replacing the key components. The control of the systems can be used to identify the optimum time to load shed,defrost, and to run compressor to maintain correct temperature whilst minimizing energy usage. Any reduction in the refrigeration system condensing temperature or rise in the evaporating temperature will enable saving energy.Switching off the refrigeration system during peak demand energy periods is advisable.

Unloading the ice cream from the freezer at a faster pace and immediately transferring the packaged products into the hardening room helps in saving energy. In the cold stores, control of evaporator fans, refrigeration system or temperature inside the cold room can help in saving energy used for refrigeration.

****** ☺ ******

Lesson-15

Calculating Refrigeration Load,Refrigeration Control and Related Instrumentation

15.1.INTRODUCTION

Refrigeration systems are widely used for cooling, freezing, and refrigerated storage of food and other products. Refrigeration units used for these applications must be sized to overcome heat gain through the walls of the system and also perform the desired functional operation. For example, freezing a food product may be considered as a three-step operation: (1) the product is cooled to its freezing point, (2) it is frozen at constant temperature, and (3) the frozen product is further cooled to the desired final temperature. The energy required to do this can be computed as:

$$Q = mc_P(t_1 - t_f) + mh_{sf} + mc'_P(t_f - t_2)$$

where: c_p, c'_p = specific heat values above and below freezing,respectively, kJ/(kg°K)

h_{sf} =the latent heat of fusion, kJ/kg

m =the mass of product being frozen, kg

Q =the total energy removed in the cooling operation, (kJ) and

t_1, t_2, t_f =the initial, final and freezing point temperatures, respectively, °C or °K.

where K = degree kelvin

Freezing foods involves the removal of energy from the food. The energy removed to freeze foods is partially the sensible cooling required lowering the temperature to the freezing point, but the primary energy removed is the latent energy for phase change. The latent heat of freezing for water, 335 kJ/kg, is many times larger than the sensible energy removed to lower the temperature by one degree. Latent heat values are used to compute the amount of energy removed for freezing. The thermal conductivity of water and food materials increases greatly at below freezing temperatures; the increase is 4-fold for water. Other thermal properties change, but to a lesser degree, during freezing.

15.2.REFRIGERATION CONTROL AND RELATED INSTRUMENTS

Previously, the refrigeration system was manually controlled, resulting in inefficient operation. Refrigeration systems require operating controls so they can cycle on and off to maintain a certain temperature. They also require safety controls to stop operation if unsafe conditions occur. There are many varieties of controls. Different types respond to temperature, pressure, humidity, liquid levels, other controls, manual intervention and other things.

15.3. THERMOSTATIC CONTROLS

Some thermostatic controls are designed with a capillary line temperature sensor which is intended to be inserted between the evaporator fins on units that have a tendency to ice up. A commercial cooler in a hot environment which is constantly being accessed would tend to ice up. A *Constant Cut In Control,* also known as a beverage cooler control forces an off cycle defrost at the end of each run cycle. The control will remain open until the evaporator has reached a temperature which indicates that any frost accumulated during the previous run cycle has been melted. Adjusting the knob on this type of control changes only the Cut Out setting, the Cut In setting remains fixed.

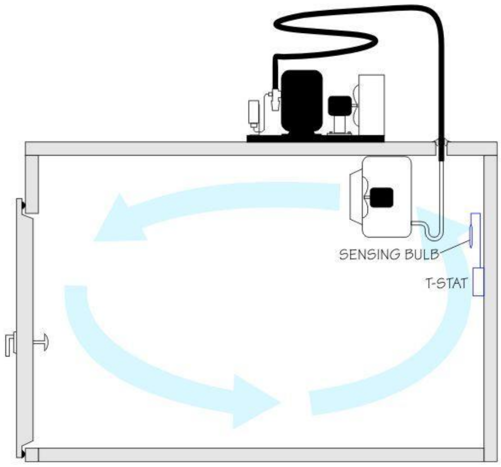


Fig.15.1:Thermostatic control

The sensing bulb of the control should be mounted so that it senses the evaporator inlet air. During the off cycle the constant fan recirculates the air in the box. The temperature of the air becomes an average of the product temperature, the wall temperature,any infiltrated air and any other loads such as caused by a person entering the box. When the air temperature reaches the cut in point of the control it brings on refrigeration.

15.4. PRESSURE CONTROL SYSTEM

A Pressure control can also be used as an operating control. The Refrigeration control system improved refrigeration system efficiency via the following mechanisms: 1) Compressors are turned off as the refrigeration load decreases to maximize the loading and efficiency on the remaining operating-units; 2) Higher efficiency units are preferentially operated to meet the required cooling load; 3) Compressor suction pressure is allowed to increase (if the evaporating temperature can be raised) to reduce compressor head and power consumption; 4) Compressor discharge pressure is allowed to decrease (if lower outside temperatures facilitate heat rejection at the condensers) to reduce compressor head and power consumption;5) Evaporator fans are turned off as allowable (if adequate cooling can be maintained) to directly reduce fan power and fan motor waste heat that must be removed by evaporators; 6) The evaporator defrost cycle is terminated as soon as ice is removed from the coils to minimize waste heat that must be removed by evaporators; 7) Liquid ammonia flow to the evaporators is controlled to minimize frost build-up; 8) The condenser spray pumps and fans are turned off if adequate heat rejection is possible without these auxiliary units running; 9) System equipment is monitored to identify problems quickly and reduce time operating at non-optimum conditions.

****** ☺ ******

Module 6 - Physico-Chemical Properties Of Ice Cream Mixes And Ice Cream

Lesson-16

Physico-Chemical Properties of Ice Cream Mixes-I

16.1.INTRODUCTION

The ice cream mix is a complex colloidal system. It is both an emulsion and a foam. The milk fat exists in tiny globules that have been formed by the homogenizer. The fat globules are in coarse dispersion. Some constituents occur in true solution (sugar, lactose and salts) others are colloidally suspended (casein micelles, stabilizers,insoluble sweetener solids and some calcium and magnesium phosphates).

16.2. MIX STABILITY

Mix stability refers to the resistance to separation of milk proteins (in colloidal suspension) and milk fat (in emulsion). Instability results in separation of fat globules due to creaming, protein particles as coagulated or precipitated material or a clear serum of whey from mix or melted ice cream.

Generally, ice cream mix is homogenized to reduce the relatively large fat globules to fine particles (mean size 0.5 – 1.0 μ and a maximum size of about 2 μ) with a high degree of dispersion. These fat globules are kept from creaming due to their small size after homogenization, the increased density (due to the addition of protein and stabilizers), and the high viscosity in the mix due to the addition of proteins and stabilizers. The optimum stability is that which allows the mix to pass through the processing stages (especially the plate-type pasteurizer in which plates may be pushed apart by high viscosity mixes) while permitting whipping and freezing process to destabilize an adequate amount of fat. The displacement of proteins by emulsifiers helps create this optimum in stability by weakening the emulsion (Figure)

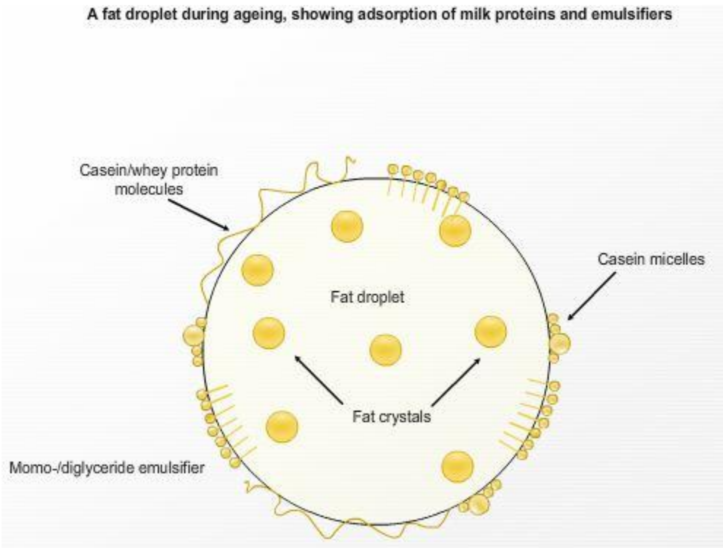


Fig 16.1: Adsorption of protein and emulsifiers on a fat globule during aging

Protein stability results from the state of the proteins and the appropriate balance in the solution of pH and salts. Excessive heat in pasteurization, e.g. may denature the whey proteins, leading to their adsorption to casein micelle and eventual precipitation. Likewise, any change in solvent conditions may lead to enhanced protein precipitation.

Whey separation from mix generally arises from phase separation between milk proteins and polysaccharide stabilizers. Stabilizers tend to move apart from each other (even though they are hydrophilic) leading to formation of clear serum layer in the mix after standing or to leakage in serum from ice cream during melting. To prevent this from happening carrageenan is normally added as a secondary stabilizer.

16.3. Density of mixes

The density or specific gravity(density relative to water) of ice cream mix varies with its composition. Measurements of specific gravity can be made with a hydrometer and of density by weighing a known volume of mix at a known temperature on a gravimetric balance. Density can also be calculated based on composition. Investigations indicate that the density of mix may vary from 1.0554 to 1.1232 g/ml, with an average for a 10% fat mix of approximately 1.1 g/ml.

The density (D) of the mix can be calculated as follows

$$\text{Density of mix} = \frac{100}{\frac{\%\ \text{Fat}}{0.93} + \frac{\%\ \text{MSNF}}{1.58} + \frac{\%\ \text{Water}}{1}}$$

16.4. ACIDITY OF MIXES

The normal titratable acidity of mixes varies with the percentage of MSNF and may be calculated by multiplying the percentage of MSNF by the factor 0.017. Thus, a mix containing 11% MSNF would have a normal titratable acidity of 0.187% lactic acid. The normal pH of ice cream mix is about 6.3. The acidity and pH are related to the composition of the mix – an increase in MSNF raises acidity and lowers pH.

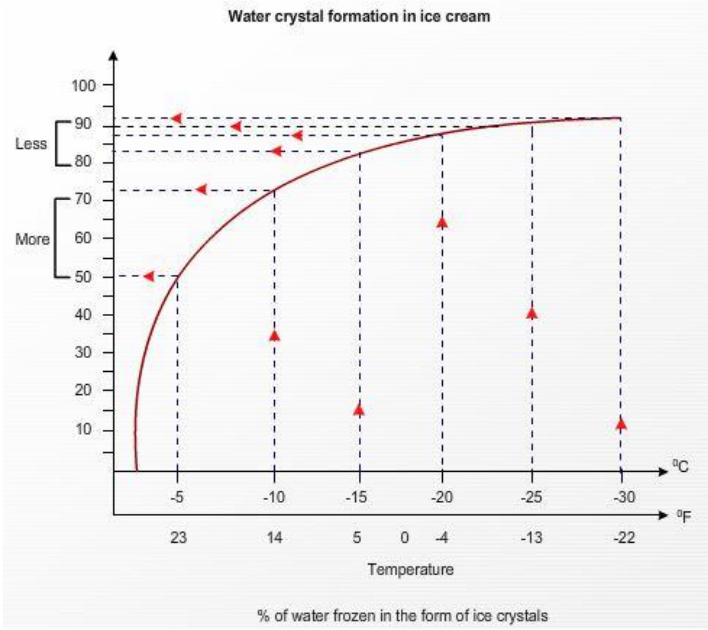
If fresh milk components of excellent quality are used, the mix can be expected to have a normal acidity. The apparent or natural acidity of ice cream mix is caused by milk proteins, mineral salts (mostly citrates and phosphates) and dissolved carbon dioxide. Developed acidity is caused by the production of lactic acid by bacterial fermentation of the lactose in dairy products. When the acidity of the mix or ice cream is above normal, developed acidity is probably present in the dairy products used in the mix. A high acidity is undesirable as it contributes to excess mix viscosity, decreased whipping rate, inferior flavour and a less stable mix. The latter may contribute to 'cook on' during processing and pasteurization, because heat and acidity accelerates the denaturation of proteins.

16.5. Freezing point

The freezing point of ice cream is dependent on the concentration of soluble constituents and varies with composition. The freezing temperature can be calculated with considerable accuracy and can also be determined in the laboratory with a cryoscope or avapour pressure osmometer.

An average mix containing 12% milk fat, 11% MSNF, 15% sugar, 0.3% stabilizer and 61.7% water has a freezing point of approximately –2.5°C. The freezing point of mixes with higher sugar and MSNF contents may range downward to –3°C while for mixes with high fat, low MSNF or low sugar content it may range upward to –1.4°C. Generally, the differences in type and amount of sweetener solids and lactose concentration used in the mixes are primarily responsible for the differences in freezing points of mixes.

The initial freezing point of ice cream mix is highly dependent on the sweetener content of the mix. When latent heat is removed from water and ice crystals are formed, a new freezing point is established for the remaining solution since it has become more concentrated in respect to the soluble constituents. A typical freezing curve for ice cream shows the percentage of water frozen at various temperatures.



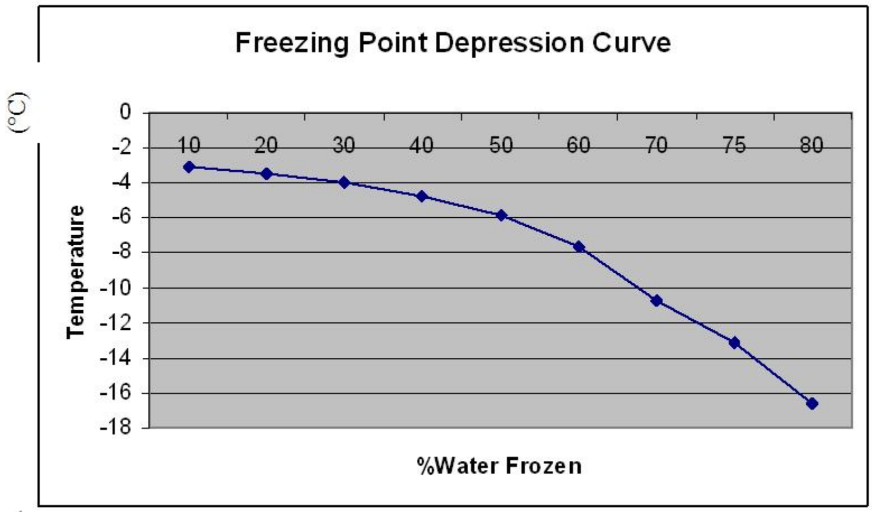


Fig.16.3: A typical freezing point curve for ice cream mix

16.5.1. Freezing point depression

When a solute is added to water the physical properties of freezing point and boiling point change. Water normally freezes at 0°C and boils at 100°C. As more solute is added, the freezing point drops ("freezing point depression"). The freezing point depression ΔT_f is a colligative property of the solution, and for dilute solutions is found to be proportional to the molal concentration c_m of the solution:

$$\Delta T_f = K_f c_m$$

Where K_f is called the freezing-point-depression constant.

16.6. MIX VISCOSITY

The viscosity of the liquid is important. If the liquid is too viscous, it is difficult to beat and therefore to incorporate the air; if it is not viscous enough, the film between the air bubbles rapidly drains, and the bubbles coalesce.

Viscosity, the resistance of a liquid to flow is the internal friction that tends to resist the sliding of one part of the fluid over another. If viscosity is constant, regardless of the applied stress, the liquid is said to be Newtonian and the viscosity can be reported. An example of Newtonian liquid is water. Ice cream mix however, is pseudoplastic. As the shear rate increases, the viscosity decreases. Thus, to characterize the viscous behavior of an ice cream mix, both the underlying viscosity and the shear rate dependence are necessary. The term 'apparent viscosity' is often used to describe the viscosity of a pseudoplastic material at one shear rate e.g. 25 mPa.s. Also, ice cream mix exhibits thixotropy, which means that its apparent viscosity also decreases with time of applied shearstress. A defined pre-shearing time is thus required before the underlying viscosity can be measured.

The mix viscosity can be measured in three ways

1. By the time required to flow under a fixed pressure through a pipette or specially constructed tube
2. By measuring the force required to move one or two parallel plates or coaxial cylinders between which a layer of liquid sample is placed or
3. By measuring the fall of a ball through a column of mix

Some instruments used to measure viscosity of ice cream mix are Falling Ball Viscosimeter, Haake Viscosimeter, Brookefield Viscometer and Ostwald viscometeretc.

A certain level of viscosity isessential for proper whipping and retention of air. The viscosity of the mix isaffected by

1. Composition: viscosity increases with increasing concentration of stabilizer, protein, corn syrup solids, fat and total solids, with the contribution of each decreasing in that order (i.e. stabilizer has more influence on mix viscosity than does fat). Also heat and salts (such as calcium, sodium, citrates, phosphates)can affect viscosity due to their effect on casein and whey proteins
2. Processing and handling of the mix: elevated pasteurization temperatures, increasing homogenization pressures and ageing for up to 4 hours will each increase viscosity of the mix.
3. Temperature: as with all fluids, viscosity is temperature dependent, so decreasing storage temperature will result in increased mix viscosity.

Although much has been written about the causes and effects of differences in viscosity, there is no final answer to the question of how much is desirable in ice cream mixes. A high viscosity was believed to be essential at one time, but for fast freezing (rapid whipping) in modern equipment, a lower viscosity seems desirable. In general, as the viscosity increases, the resistance to melting and the smoothness of texture increases, but the rate of whipping decreases. The mix should be properly balanced (in regard to composition, concentration, and quality of ingredients)and then properly processed to produce the desired whipping ability and body and texture. Under these conditions a desirable viscosity is assured.

Viscosities of ice cream mixes are affected by temperature; the concentration, type and degree of hydration of the stabilizer, carbohydrates, colloidal salts and proteins of the mix; type of heat treatment; whether the mix is homogenized prior to holding; and the rate of shear in the holding tube. When shear rates varies from 50 to 180 s^{-1} , the viscosities at 80°C ranges from 8.7centipoise (cP) in an unstabilized mix to 103 cP in mix containing 0.25% Carboxy Methyl Cellulose; the mixes had 14% fat and 41% total solids.

Lesson-17

Physico-Chemical Properties of Ice Cream-II

17.1.INTRODUCTION

Ice cream structure is often described as a four phase system. These phases include fat, air and ice which are all discrete phases, and the serum phase which surrounds them. The fat phase begins as homogenized globules in the mix that are stabilized by a membrane of adsorbed protein and emulsifier.

17.2. PROCESS OF FAT CRYSTALLIZATION

The fat globules crystallize during cooling and ageing, so after ageing, they contain numerous fat crystals and some non- crystallized liquid oil. Some of the protein is displaced from the fat globule membrane by the emulsifiers during ageing, the result of which is that the globules have a very thin membrane (due to the relatively small molecular weight of the emulsifiers, compared to proteins). During freezing some of the fat globules partially coalesce due to the whipping and shearing action of the dasher scraper unit. As the globules collide with each other they stick and form aggregates. The liquid oil cements the globules together while the fat crystals maintain the integrity of the globular shape, so that the aggregates become chains and clusters, rather than large droplets (hence the need for crystalline fat during freezing). The extent of partial coalescence (fat destabilization) is a measure of the extent to which the globules are converted to fat globule clusters. These clusters exist both adsorbed to air bubbles and in bulk phase surrounding the ice and air. The air in ice cream is in the form of finely dispersed bubbles that are formed by the whipping action of the dasher. The air bubbles are stabilized by the globules and clusters, which adsorb to the air surface, and by a membrane of milk protein and emulsifier. The ice crystals are also formed during freezing. (Figure 17.1)

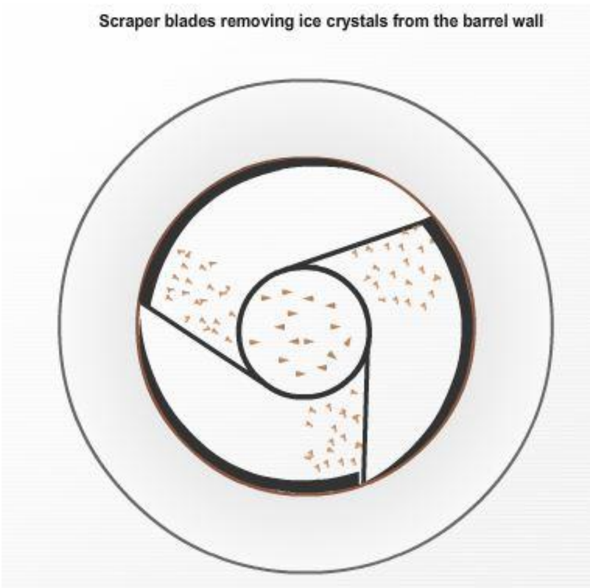


Fig 17.1: Scrapper blades removing ice crystals

The objective during freezing is to create as many small crystals as possible and then to stabilize them from recrystallization during frozen storage, to maintain their small size and smooth texture that arises from them. The formation of pure ice crystals results in the freeze concentration of the sugars, proteins and stabilizers which results in the formation of the unfrozen phase that surrounds the discrete elements. The ratio of ice to unfrozen water is dictated by the concentration of solutes, hence more sugar in the formulation means less ice at any given temperature.

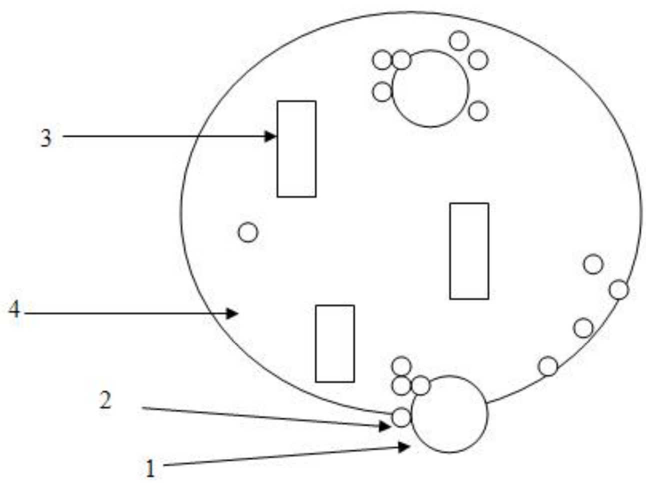


Fig-17.2: The structure of ice cream

1- Air cells

2 - Fat globules and partially coalesced fat surrounding air cells

3 - Ice crystals

4 - Unfrozen freeze concentrated solution of dissolved and suspended solids

17.3. PROCESS OF ICE CRYSTALLIZATION AND RE-CRYSTALLIZATION

Ice crystals are relatively unstable, and during frozen storage, they undergo changes in number, size, and shape, known collectively as re-crystallization. This occurs due to temperature fluctuations. If the temperature during the frozen storage of ice cream increases, some of the ice crystals, particularly the smaller ones, melt and consequently the amount of unfrozen water in the serum phase increases.

Conversely, as temperatures decrease, water will refreeze but does not renucleate. Rather, it is deposited on the surface of larger crystals, so the net result is that the total number of crystals diminishes and the mean crystal size increases. Each time the temperature changes, the smaller ice crystals disappear while the larger ones grow even larger. Re-crystallization can be minimized by maintaining low and constant storage temperatures

17.4. MELTING PROPERTIES

The meltdown of ice cream is important property because it is both a consumer attribute of high interest and it provides considerable information about the structure of the ice cream. Consumers generally want an ice cream that will melt at a reasonably slow rate. However, they do expect it to eventually collapse and flow into a smooth liquid with no curdiness or watery separation. When an ice cream melts two events occur. The ice crystals melt, and the rate of which they do is a function of the temperature of ice cream (and the ice content of that temperature, which is primarily a function of the sugar content) and the temperature of the environment. As the ice is melting, the structure of ice cream must also collapse and flow, but usually at a slower rate thereby providing shape retention. This process is governed primarily by the fat structure of ice cream.

As the ice crystals melt, the water dilutes the unfrozen phase. With no other structure in the system, the melted ice cream will collapse and flow at a rate that is dictated solely by the melting of the ice. The air bubbles would soon collapse as the protein surrounding them would be insufficiently strong to support the weight. The melt would resemble the mix from which it was made and would include all the discrete fat globules. However, if fat destabilization occurred, the presence of fat globules adsorbed to the air bubbles and the presence of chains and clusters of aggregated fat would support the weight of the structure as the ice crystals melted, hence resulting in a slower meltdown, dictated not only by the rate of melting of the ice but also by the collapse and flow of the fat network structure. With more extensive destabilization of fat, there may be very high shape retention and little collapse after several hours.

17.5. Overrun

Ice cream is frozen foam and incorporation of air is an important quality feature and also a significant economic consideration because ice cream is usually sold by volume and not by weight. It is also of much interest because of its influence on the texture as well as the cost of production of ice cream. The measure of air incorporation is given by the volume of mix used and is termed overrun.

Overrun is usually defined as the volume of ice cream obtained in excess of the volume of mix, and is expressed as percent overrun

$$\text{Overrun \%} = \frac{\text{Wt. of a given volume of mix} - \text{Wt. of same volume of ice cream}}{\text{Wt. of same volume of ice cream}} \times 100$$

The overrun to be calculated using volume, is shown below:

$$\text{Overrun \%} = \frac{\text{Vol. of ice cream} - \text{Vol. of mix used}}{\text{Vol. of mix used}} \times 100$$

The amount of overrun desired in ice cream depends on the composition of the mix and the processing conditions employed. Too much overrun is likely to result in a product with a snowy, fluffy defect. On the other hand, too little overrun would result in a soggy, heavy product.

Percent overrun is dependent upon the type of frozen dessert and the freezing equipment. Packaged ice cream may contain 70-75% overrun, while bulk ice cream may contain 90-100% overrun. Super-premium ice cream is generally in the 30-50% overrun range. Sherbet normally has 30-40%; milk shakes have only 10-50%. When packages are being filled on a processing line, package weights should be closely monitored. Deviations can be attributed to variations in the fill level of the package (packaging machine adjustment),variations in the ratio of ice cream to particulate addition (ingredient feeder or ripple pump adjustment), or variations in the overrun of the ice cream (freezer barrel adjustment). The overrun achieved typically increases with whipping speed, until a plateau is reached when equilibrium is established between the rate of bubble formation and the rate of break up.

The length of time that the ice cream needs to spend inside the hardening tunnel depends on several factors, namely the overrun, the formulation, the outlet temperature, the size of the product and the amount of packaging. The greater the overrun, the lower the heat capacity and the thermal conductivity of the ice cream.

17.6. INTERFACIAL TENSION, SURFACE TENSION, ADSORPTION AND WHIPPING

Inter facial tension in ice cream mix refers to the force acting at the interface between the fat and water, which is largely determined by the type and quantity of material adsorbed at the fat interface. Surface tension refers to the force acting at the interface between water and air which is also determined by the type and quantity of material adsorbed at the air interface.

Adsorption involves substances migrating to the interface, forming a layer or film, and hence reducing the inter facial or surface tension. Good 'surfactants' (surface active agents) are those with both hydrophilic and hydrophobic portions and sufficient molecular flexibility to rearrange at interfaces. The hydrophilic portion resides in the aqueous phase while the hydrophobic portion resides in the fat or air phase. Examples are proteins and emulsifiers. Substances accumulate at a surface in order of their abilities to lower down the interfacial tension.Thus, emulsifiers displace proteins adsorbed to the fat globules. Therefore,interfacial tension with regard to emulsifier action is a predictor of protein adsorption/displacement, which in turn is primarily responsible for controlling the extent of fat destabilization. Surface tension provides an indication of ease of air incorporation in the mix and the stability of the resulting air bubbles.

Tobe more enjoyable on eating, most frozen deserts must contain air that has been whipped in as minute bubbles. The rate of incorporation of these bubbles and their individual stabilities determine the overall whipping rate. Mixes with lower surface tension values tend to produce higher overrun and smaller air bubbles. Increasing surface tension above that of freshly processed mix made from fresh ingredients is difficult; however, the surface tension may be readily decreased by the addition of emulsifiers. Mixes with too low surface tension values caused by the addition of emulsifier have shown excessive rates of whipping, fluffy and short body characteristics, and high susceptibility to shrinkage.

The major factors at work during the freezing process that affect whipping rate are (1) effective agitation, (2) the presence of a controlled volume of air, and (3) concomitant freezing of the mix. It is vital that the mix contains surface-active components that will quickly migrate to the surfaces of the formed air cells to stabilize them. Proteins, phospholipids and added emulsifiers, perform this function. It is also important that the fat globules and ice crystals do not mechanically interrupt and weaken the lamellae of the air cells. Therefore, as the freezing progresses, it is required that the fat globules be small and well dispersed. However, to prevent collapse of the foam,especially during storage, and to produce dryness and stiffness, it is vital that fat globules be partially destabilized.

The size, number and physical condition of the fat globules in an ice cream mix determine the rate of whipping and stability of the whipped product. Small fat globules and limited clumping enhance whipping. Non-fat mixes whip more rapidly than those containing fat, but when frozen, they possess a foam structure that is susceptible to shrinkage. Partial coalescence of the fat of ice cream during freezing produces a bridging structure that provides resistance to shrinkage. Protein from MSNF is important for whipping. Factors that lead to less protein functionality such as excessive heat and denaturation or poor solvent quality from ethanol addition, for example may adversely affect the whipping properties of protein.

Added sodium caseinate improves whipping properties and affect air cell and ice crystal distribution to an extent hardly expected of any other commonly used ice cream constituent. However, high levels of caseinate may lead to insufficient fat destabilization, due to its excessive adsorption at the fat interface. Egg yolk solids and buttermilk solids from sweet cream improve whipping ability presumably due to lecithin existing as a lecithin-protein complex. Emulsifiers also improve whipping ability. Finally, the design and operation of the freezer determine whether maximum whipping ability of a given mix is obtained.

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 protein in emulsions is well documented, as is the competitive displacement of proteins by small molecule surfactants. In ice cream, the emulsion must be stable to with stand mechanical action in the mix state but must undergo sufficient partial coalescence to establish desirable structural attributes when frozen. These include dryness at extrusion for fancy molding, slowness of melting, and some degree of shape retention during melting, and smoothness during consumption. This implies the use of small molecule surfactants (emulsifiers) to reduce protein adsorption and produce a weak fat membrane that is sensitive to shear action.

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 (Sodiumcitrate, 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 (Figure 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.

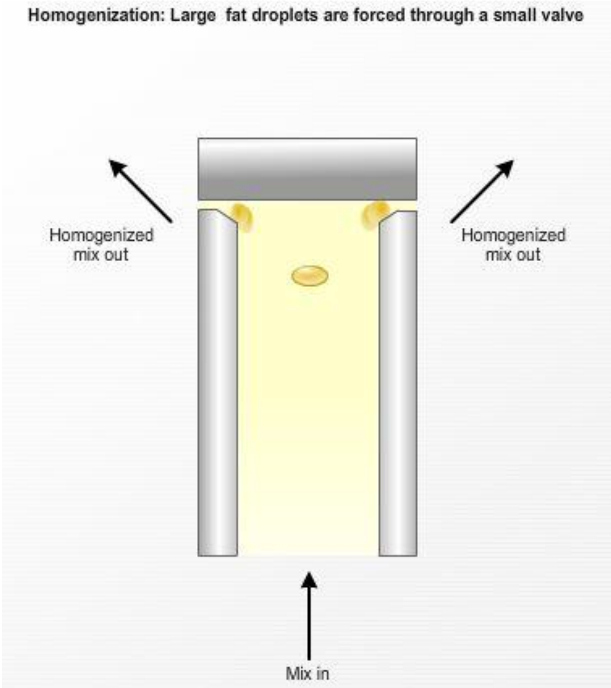


Fig. 18.1: Homogenization of ice cream mix

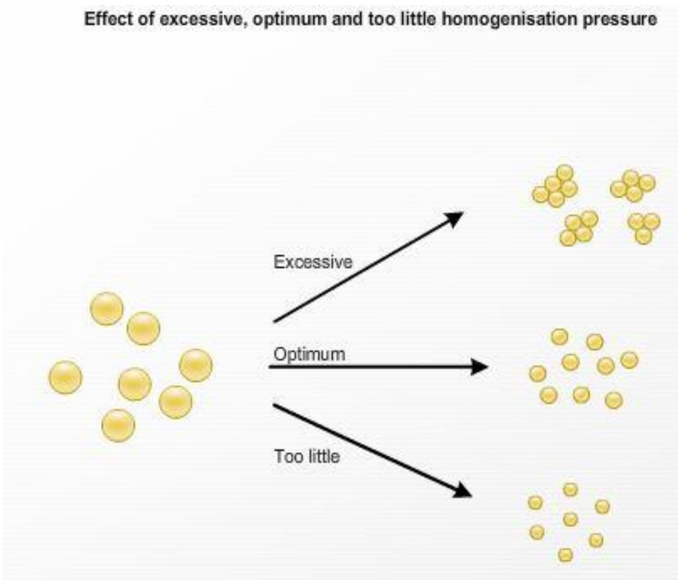


Fig. 18.2: Effect of homogenization pressure on fatglobules

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 during the aging period),crystallization of the fat globules, and a membrane rearrangement, to produce a smoother texture and better quality product. Non aged mix is very wet at extrusion and exhibits variable whipping abilities and faster meltdown. The appropriate ratio of solid: liquid fat must be attained at this stage, which depends on the temperature and the triglyceride composition of the fat used, as a partially crystalline emulsion is needed for partial coalescence in the whipping and freezing step. Emulsifiers generally displace milk proteins from the fat surface during the aging period.

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 (≤ 5°C) without freezing.

18.3.7. Fruits and flavours

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

18.3.8. Freezer

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.

Whipping of air into ice cream mix without freezing will result in low overrun and large sized air bubbles.

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.

At the same time that freezing is taking place within the barrel, changes are also occurring to the lipid phase and air component. In commercial scraped-surface freezers, filtered compressed air is injected under pressure through a diffuser at the end of the barrel where the mix is input. The fine air bubbles formed in the diffuser are incorporated within the mix as the dasher rotates within the barrel. The air cells are broken down into smaller and smaller bubbles based on the shear forces within the freezer as the ice cream is formed. Dispersion of air into fine bubbles (about 20-40 µm in size after drawing) requires that freezing occur at the same time to increase the shear forces within the freezer. Whipping air into ice cream mix without freezing results in lower amounts of overrun incorporated and larger air bubble sizes

In batch freezers, the mix is allowed to whip at atmospheric pressure. Hence whipping properties of the mix are very important, and overrun is more variable,being controlled simply by the head space remaining after the mix charge is put into the barrel. In the continuous freezer, air is injected through controlled valves, so whipping properties of the mix are perhaps less important, and overrun control is exact. Air distribution occurs under pressure in the continuous freezer, and it is the rapid expansion of the air bubbles at draw that establishes the air bubble interface.

****** ☺ ******

Module 7 - Packaging, Hardening, Storage And Shipping Of Ice Cream

Lesson-19

Packaging of Ice Cream and Hardening

19.1.INTRODUCTION

When ice cream is drawn from the freezer, it is put into containers that give it the desired form and size for convenient handling during the hardening, shipping and marketing processes.

19.2. THE FACTORS THAT NEED TO BE CONSIDERED IN SELECTION OF ICE CREAM CONTAINER

Ø Cost

Ø Protection against moisture loss, temperature loss and contamination.

Ø Ease of handling and disposal (i.e. ease of opening and reclosure, if required)

Ø Effect upon the quality of ice cream

Ø Neatness of appearance

Ø Advertising that package may carry.

Ø Storage problem.

Ø Point of consumption in relation to the location of the factory.

Ø Size of unit desired.

19.2.1 Bulk Containers

The three types of packaging materials used for Bulk containers for ice cream include:

i) Fiber board containers

ii) Metals containers

iii) Plastic (Polyethylene) containers

The type of package can be cups, tubs, cones, wrappers, etc.

19.2.2. Wrappers: These may be composed of vegetable parchment or foil laminate.

Containers can be made up of fiberboard, either paper or card board which has been treated to make it impervious to moisture.

19.2.3. Plastic(polystyrene) or wax-coated paperboard cartons may also be used.

19.2.4. Steel cans: These can be tin cans with lead solder(reusable containers). It can be cylindrical or square section cans with radiused corners and with 'slip-on-lids'.

Semi-rigid plastic containers may be used that can be closed with plastic 'wrap-on-lids'. Pre-cut Aluminium lids are also now available.

The ice cream bars may be wrapped with wrapper made of BOPP laminates. Ice cream cone sleeves are made specifically for packaging of cone ice cream. The ice lolly packs maybe packaged in double-sided Polyethylene card board squeezers.

19.3. ICE CREAM HARDENING

In hardening process, the aim is to reduce the temperature of the product to at least 0°F in the center of the package as quickly as possible. After the ice cream reaches this point, it is only necessary to store it at a uniformly low temperature to prevent ice melting and recrystallization.

19.3.1. Objectives of hardening ice cream

1. The physical nature of ice cream when drawn from the freezer is such that it is seldom practicable to market it in this form.
2. To freeze more water in the ice cream that has been drawn from the freezer and filled in the container to obtain better consistency.
3. To make ice cream stiff enough to hold its shape.

19.3.2. Hardening time: The time necessary for the temperature at the center of the package to drop to -18°C is known as 'hardening time'. A hardening time of 6-8 h for 19 liters (5 gal). package is considered as 'excellent' operation when performed in hardening rooms. When hardening tunnels are used, the rate of hardening is several times faster.

Table 19.1: Factors affecting hardening time in same hardening unit

Type of hardening	Package size	Hardening time
Still-air hardening room	118 ml (¼ pint)	30 min
- do -	19 liters (5 US gallon)	24 h

* I US Pint= 473.18 ml; 1US gallon= 3.78 l

19.3.3. Hardening process

After ice cream is drawn from the freezer, it is put into containers to be placed in hardening room. Here the freezing process is continued without agitation until the temperature of ice cream reaches -18°C or lower, preferably -26.1°C (-15°F).

Quick hardening is desirable, since slow hardening favours formation of large ice crystals and a corresponding coarseness of texture.

19.3.4. Factors that affect the rate of hardening

1. Temperature of ice cream when drawn from the freezer
2. Composition of the mix
3. Percent overrun taken in ice cream
4. Size of the containers
5. Whether several containers are bundled together
6. Nature of the wrapping material (paper or plastic)
7. The manner of stacking of the containers
8. The temperature and velocity of the circulating air
9. Obstructed versus unobstructed exposure of the containers to the cooling medium

Very small containers harden quickly, but they warm up quickly when removed from the freezing temperatures. Hence, they are more prone to body and texture damage as a result of heat shock. This also applies to novelties (stick bars, small cups,etc.). Large containers (i.e. 11.34 liters) harden much slower in the interior(cooling is largely by conduction) and must be given ample time to reach -18ºCin the interior.

If containers are stacked before they are adequately hardened, deformation may occur and some overrun may be squeezed out causing surface discoloration.

****** ☺ ******

Lesson-20

Hardening of Ice cream-hardening Methods, Storage and Shipment of Ice Cream

20.1. INTRODUCTION

Hardening of ice cream facilitates stacking of ice cream packages during storage and transportation. There are several hardening methods are available. However, the rapid ones are desirable from the stand point of quality of ice cream. To avoid temperature fluctuations during hardening and storage, frequent opening and closing of the door should be avoided. Use of air lock systems / ante-room before the main hardening room is required.

20.2. TYPE OF HARDENING METHODS

20.2.1. Hardening rooms

1. **Still air type hardening room:** This is obsolete these days.

Advantages

a. It makes the stacking of ice cream easy and systematic.

b. There is less loss of refrigeration when the door is open.

Disadvantages

a. The defrosting of the coils is not very convenient.

b. It is not so adaptive where conveyor systems exist for conveying frozen ice cream

in the hardening room.

1. **Gravity air type hardening room:** The expansion coils are arranged in tiers near the ceiling with sloping baffles below them. A definite circulation of heavy cold air and lighter warm air is set up.

Advantages

a. The main part of hardening room is free from all obstructions and this is convenient where ice cream is conveyed into hardening room on a conveyor.

b. Defrosting of coils is convenient

Disadvantages

Ice cream cannot be stacked as conveniently and systematically as in Still air type

a. Ice cream containers if not properly placed, interferes with the air circulation.

b. Due to freedom from obstructions, the loss of refrigeration with the opening of the door is greater.

1. **Forced air type hardening room:** The expansion coils are in the form of a compact unit utilizing fins to assist in the conductance of heat from the air to the coils. A fan placed directly behind the expansion coil unit, draws the air from the hardening room and blows it over the expansion coils and back into the room.

Advantages

Defrosting requires only a matter of minutes and is so simple that it can be done daily

20.2.2. Unit hardening systems

a. Plate / Contact hardeners

b. Blast tunnel hardeners

c. Hardening cabinet

20.2.3. Hardening rooms

Bundled units of 4 containers requires about 7 h to reach-18°C at core as opposed to about 3 h for unbundled 2 liters containers (convection hardening; air temperature – 34.4°C).

20.2.4.Hardening Tunnels

Some manufacturers of larger volumes use hardening tunnels that produce an air blast at -34.4 to –45.5°C for fast hardening. This may or may not contain a conveyor belt and the advantage comes when hardening smaller packages, which can be hardened in about 1 h.

Blast tunnel hardeners have been used for several years. The conveying systems have been expanded more recently to include the wide flat belt, fixed tray,suspended free tray, and multi-shelf carrier types of conveyors. The zone hardening tunnel and the ceiling conveyor systems are other types of hardeners.

Fig- 20.1: Ice cream packages in the hardening room

Fig-20.2: Hardening tunnel for ice cream

20.2.5. Hardening Cabinet

They resemble the retail ice cream cabinet and are refrigerated by mechanical refrigerant. The ice cream package is placed in the dry, water tight compartments, each of which will hold one or two 19 liters containers. These are usually operated at temperatures of – 23.3 and -26.1°Cand are most economical for limited volume of business.

20.3. CONTACT PLATE HARDENERS

Direct refrigerated contact plate hardening provides very effective heat transfer, but requires that all containers are of same size and geometry. Hardening of 2 liters containers to a temperature of -17.8°Cat the core may be accomplished within a period of 1-2 h.

20.4. CRYOGENIC HARDENING

When individual 500ml packages of vanilla ice cream were immersed in liquid nitrogen at -195.6°Cfor1 min, bagged together in groups of 8 packages and placed in hardening cabinet at -12.8°C, the product had good body and texture. A center temperature of – 22.7°C in 500 ml package could be reached in less than 5 min. with outer temperature of the product at -157.9°C or lower. One minute immersion per 500 ml of ice cream was considered the maximum treatment to which ice cream could be subjected without adversely affecting its body and texture. Liquid nitrogen requirement was 0.56 kg per kg of ice cream to be hardened. The ice cream hardened in such manner was decidedly whiter in appearance compared to the one that was hardened slowly. However, after 2 weeks storage pronounced shrinkage was evident.

In few countries (viz., Sweden) ice cream cones are hardened at the rate of 11,000-16,000 per h with the help of sprayed liquid nitrogen. The cones are pre-cooled by exhaust nitrogen in the first section and final freezing takes place in the second section.

20.5. NITROGEN REFRIGERATED HARDENING TUNNELS

In Sweden, there is an ice cream factory where ice cream cones at the rate of 14,000 – 16,000/h is sprayed with liquid nitrogen for hardening. The cones are pre-cooled by exhaust nitrogen in the first section and finally frozen in the second section.

20.6. STORAGE AND DISTRIBUTION OF ICE CREAM

After the ice cream has been hardened, subsequent steps are dictated by local requirements. The fully hardened ice cream may be loaded directly onto trucks for transfer to distribution points. Whether during warehousing or the transportation and transfer phase, a constant and low temperature (-26.1 to -31.7°C) should be maintained to minimize heat shock. Maintaining a frost-free environment is also important.

After ice cream is hardened, it may be immediately marketed, or it may be stored for a week or two at the most. Manufacturers plan on a maximum of 5 days between freezing and marketing.

Since hardened ice cream can be stored satisfactorily at slightly higher temperature than is required for hardening, it is sometimes more economical to use special storage room.

The retailers use one cabinet for storage in addition to the dispensing cabinets.

The operation is same as in Hardening room, except the following:

i) The temperature should be maintained uniformly at a point between -23.3 and -18°C

ii) The packages should be piled up very closely to delay changes in the temperature of the ice cream.

20.7. SHIPPING OF ICE CREAM

During marketing, the manufacturer ships it to the retailer under refrigeration at the same temperature as it was maintained in the retailer's cabinet.

20.8. INSULATED TRUCKS

Timbers are used for frame; inside glass wool or cork insulation may be used. The outside material is aluminium metal, which reflects light and shines. Ice cream is loaded directly from hardening room into refrigerated trucks for shipment to distribution stations near the point of consumption.

Sometimes dry ice, sawed in to pieces are wrapped in paper and then placed around the package of ice cream inside an insulated pack or in single service type packer. The freezing point of dry ice is about -78.3°C.

Lesson-21

Sensory Attributes of Ice Cream and Frozen Desserts

21.1. INTRODUCTION

Ice cream is a frozen food made of a mixture of dairy products, such as milk, cream, and nonfat milk, combined with sugars, flavoring, fruits and nuts, stabilizers and emulsifiers etc. Different types of ice cream are available in the market including economy, premium, super-premium reduced fat, light, low fat ice cream, mellorine, depending on their composition, soft serve ice cream, sherbets, ice candy and kulfi. All the above products may differ in the type of flavoring, the composition in terms of dairy ingredients and other food solids, and the extent of product overrun. Ice cream is normally judged on the basis of its flavour, body and texture, colour and package and melting.The ideal characteristics of ice cream and requirements for high quality ice cream and frozen desserts are described in this lecture.

21.2. Flavor

High-quality vanilla ice cream should be pleasantly sweet, suggest a creamy background sensation, exhibit a delicate "bouquet" of vanilla flavor, and leave a most pleasant, but brief, rich aftertaste.

The flavor intensity of the vanilla, the sweetener, and the various dairy ingredients should not be so pronounced that, when first tasted, one component of the overall flavor seems to predominate over the others. All of the ingredients should blend to yield a pleasant, balanced flavor.

21.3. Body and Texture

Body and texture are important properties of ice cream and good quality indicators. The associated body and texture defects are evaluated by biting and chewing the product.

As it relates to ice cream, body is best defined as the property or quality of the ice cream as a whole. Texture refers to the parts or structure of ice cream that make up the whole. Both the body and texture of ice cream may be partially determined by applying the senses of touch and sight when the evaluator observes the product's appearance on dipping. The desired body in ice cream is that which is firm, has substance (has some resistance), responds rapidly to dipping, and is not unduly cold when placed into the mouth. The melted ice cream should resemble the consistency of 40% fat cream.

21.4. MELTING QUALITY

High-quality ice cream should show little resistance toward melting when a dish is exposed to room temperature for at least 10–15 min.

During the melting phase, the mix should flow from the center (high) portion of the scooped ice cream. The melted product should be expected to form a smooth, uniform, and homogeneous liquid in the dish. Generally, ice creams with low overrun melt more rapidly than those with high overrun.

21.5. COLOR AND PACKAGE

21.5.1. Color

The color of vanilla ice cream or reduced fat ice cream should be attractive, uniform, pleasing, and typical of the specific flavor stated on the label. Colorants may or may not be added to dairy frozen desserts. As long as the shade of color reasonably resembles the natural color (β-carotene pigment) of cream and is neither too pale nor too vivid, color criticisms are generally resisted for vanilla-flavored products

21.5.2. Package

The ideal frozen dessert package or container should be clean, undamaged, full, neat, attractive (pleasant eye appeal), and protective of the product. Multi use containers (if used)should be free of dents, rust, paint, battered edges, or rough, irregular surfaces. In general, ice cream packages should reflect neatness and cleanliness throughout, giving the consumer the impression that by use of a clean, well-formed container, the manufacturer is definitely interested in supplying a high-quality product.

21.6. Other Frozen Dairy Desserts

21.6.1. Low fat ice cream

The sensory properties of low fat ice cream can be evaluated using the ice cream scorecard and scoring guide.Due to the lower milk fat content, low fat ice cream would be expected to lack the typical richness, mouth feel characteristics, and the overall flavor blend that most ice cream possesses. Also, the body and texture, as expected, can differ considerably from ice cream, due to the lower total solids content of low fat ice cream.

21.6.2. Mellorine

Except for the source and type of fat, this product generally resembles either low fat ice cream (usually) or ice cream in composition. Certain additional defects that may be derived from vegetable or animal fats may be encountered and recorded as appropriate on the scorecard. Flavor defects of main concern in mellorine are the possibilities of oxidation, rancidity, the presence of a distinctive off-flavor derived from the specific fat source, and a lack of flavor or "blandness" (which can be attributed to varied fat sources other than dairy based). The relative hardness and melting properties of the fatty acids that constitute the fat can influence the body and mouth feel of frozen mellorine (typically vegetable fat and/or other animal fats other than dairy,or in a blend with milk fat).

21.6.3.Fruit Frozen Desserts

The flavor of berries and fruits (strawberries, peaches, etc.) may be imparted to frozen dairy desserts by fresh, frozen, or processed fruits, natural extracts(that sometimes contain other natural flavors), imitation flavors, or various combinations of these. The flavor character, body and texture, and the appearance of the finished product, are influenced by the type of flavoring used. Generally, the flavor of the given ice cream should be reminiscent of sweetened fresh fruit and cream (e.g., strawberries and cream, or peaches and cream). To overcome the problem of seasonality, availability, and perishability of fresh fruit, frozen fruit preparations are commonly used.

21.6.4.Nut Frozen Desserts

Walnuts, almonds, peanuts, and pistachio nuts are among the most popular nuts added to ice cream. Generally, ice cream is flavored with either an appropriate background flavor for the nuts (butter pecan, chocolate almond, etc.) or a concentrate of the same basic nut flavor (e.g., pistachio, black walnut). The degree and the method of roasting the nuts (light or heavy roast; dry or butter roasted) provide interesting variables that manifest themselves in the sensory properties of the ice cream. The initial quality and freshness of the nuts must be good; no deterioration should occur as a result of storage. Since some types of nuts contain a high proportion of unsaturated oil, they can be highly susceptible to auto-oxidation. Some nuts (walnuts and hazelnuts) are also prone to the development of hydrolytic rancidity due to the presence of lipolytic enzymes.The nuts should retain their firmness, crispness, and freshness in the frozen product.

21.6.5.Variegated Frozen Desserts

A variegated ice cream should basically emulate an ice cream sundae, although the flavored syrup, sauce, or puree is dispersed throughout the product. The flavoring (or slurry) syrup is usually pumped directly into the ice cream as it emerges from the ice cream freezer; the variegating substance is intended to form a definite pattern within the product. Although some indication of the regularity or uniformity of the variegation pattern is obtained in the course of normal sampling of the ice cream, a more objective visual impression can usually be realized by examining both exposed surfaces, after cutting through the center of the container. Sometimes, several cross-sectional cuts may have to be made to properly assess the distribution or the "pattern" of the variegating material with the frozen product. Typically, the ribbon of syrup should be of medium thickness, and the pattern should essentially reach into all segments of the container. Other quality criteria include the flavor and consistency of the variegating syrups used in the ice cream. The syrup should not "settle out" or mix with the ice cream, but simultaneously, it should not be overly hard, gummy, crusty, or icy.

21.6.6. Soft-Serve Frozen Desserts

These products (usually low fat ice cream or frozen yogurt) are commonly dispensed from a softy freezer for immediate consumption by the consumer. Since the serving temperature is about–7.2C, the hardening step is omitted, which eliminates the "damaging effects"of slow freezing and subsequent temperature fluctuations. As a result, soft serve should generally exhibit creamy, smooth mouth feel properties, as well as provide excellent "flavor release." Generally, the same requirements apply to the flavor of soft-serve as to the corresponding hard-frozen product (low-fat ice cream or frozen yogurt). Most of the body and texture criteria also apply,except that the desired or optimum characteristics should be partially redefined. The body should be fairly resistant and firm (to retain shape on a cone), but obviously not as firm as that of hardened products, which are stored and consumed at much lower temperatures (-13 °C).

The desirable characteristics of soft serve can be summarized as follows:

- A desirable flavor blend and absence of off-flavors.
- Smooth texture: small ice crystals; no lactose crystals; no butter granules; and no excessive coldness.
- Dry appearance; a pleasing color.
- Some modest resistance to melting.
- A reasonably firm, resistant body.
- A neatly shaped serving portion that maintains its shape for a reasonable time before consumption.

21.6.7.Sherbet

Though poor quality dairy ingredients may cause an off-flavor in sherbets, low concentration of total milk solids (less than 5%) somewhat reduces this likelihood. In fruit sherbet, the quality is usually determined by the overall flavor blend of sweetness, tartness, fruit flavor intensity, and by how closely the given fruit flavoring emulates the true fruit flavor at its peak of quality. In non-fruit sherbet,quality differs with each specific flavoring; therefore, only a vague, general statement pertaining to the desired flavor can be made. In non-fruit sherbets,the flavoring and the sherbet base (mix) should be free of perceptible defects,and the frozen product should have a pleasing flavor blend.

21.6.8.Frozen Novelties

A number of frozen novelties may be made of ice cream, low fat ice cream, mellorine, sherbet, sorbet, ice,frozen yogurt, pudding, or combinations of several of these. They may be in many forms, such as bars (with or without a stick), coated or uncoated,"sandwiches," pre-packaged cones, and other numerous forms. The flavor, body and texture of these types of products should be evaluated just as critically as their packaged counterparts, but there are some unique, potential problem are as that should be identified.

A listing of some of the more common quality problems of various types of frozen novelties that require special attention include:

- Incomplete coverage with coatings
- Coating too far down the stick
- Incorrect volume
- Coating too thick/ thin
- Cracked/slipped coating
- Overrun too high/low
- Defective flavor
- Defective texture

- Sticking/damaged wrappers
- Broken sticks
- Sugar "bleeding" from bars
- "Soggy" wafers or cones (lack crispness)
- Brine contamination.
- High coli form count

21.7ICE CREAM SCORECARD

Score cards are helpful in measuring ice cream quality where it is required to judge the quality of products based on established ideal characteristics. The score card had various category criticisms for flavor, body and texture, color appearance and package, melting quality, and bacterial content. The card has two category criticisms, flavor plus body and texture.

The suggested score card for evaluation of ice cream according to Indian standard (IS:15349:2003) is given below:

Table-21.1: Score card for ice cream

Name Date:

Batch no. or code no. Time:

Score the sample using the guidelines given below for deducting for perceived defect

Sr.No.	Characteristic	Max. score	Sample score
1	Flavour	50	
2	Body and texture	40	
3	Colour and appearance	10	
4.	Package	5	

Guidelines for deducing points

Sl. No.	Characteristic	Defects	Degree of defects		
			Slight	Definite	Pronounced
1.	Flavour	Bitter, fermented, flat, foreign, highly acidic, metallic, mouldy, lacks sweetness, oily, old ingredient, oxidized, rancid, salty, sour, yeasty	8	12	18
2.	Body and texture	Buttery, coarse, crumbly, curdy, fluffy, grainy, greasy, icy, low melting resistance, sandy, soggy, spongy	7	11	17
3.	Colour and appearance	Dull, mouldy, foreign particles	1	2	5
4.	Package	Improperly sealed spoiled, soiled	1	2	3

The scoring guides that accompany the scorecard will be given in practical exercises. Scoring guides are useful in training new evaluators and in promoting standardization of judgments among different evaluators.

The score card suggested by American Dairy Science Association(ADSA) is shown in Table-21.2.

Table-21.2:The ADSA score card for ice cream

Criticism		1	2	3	4	5
Flavour -10	**Score**					
No criticism = 10 **Unsalable = 0** **Normal range = 1-10**	**Flavouring system** - lacks fine flavour - lacks flavouring - too high flavour - unnatural flavour					
	Sweeteners - lacks sweetness - too sweet - syrup flavour -					
	Processing - cooked					
	Dairy ingredients - acid - salty - lacks freshness - old ingredient - oxidized - metallic - rancid - whey -					
	Others - storage (absorbed) - stabilizer/ emulsifier - neutralizer - foreign -					
Body and texture- 5	**Score**					
No criticism = 5 **Unsalable = 0** **Normal range = 1-5**	- coarse/icy - crumbly - fluffy - gummy - soggy - weak -					
Colour, appearance and package -5	**Score**					
No criticism = 5 **Unsalable = 0** **Normal range = 1-5**	- dull colour - non-uniform colour - too high colour - too pale colour - unnatural colour					
Melting quality- 3	**Score**					
No criticism = 3 **Unsalable = 0** **Normal range = 1-3**	- curdy - does not melt - flaky - foamy - watery - wheyed off -					
Bacterial content- 2	**Score**					
	- standard plate count - coliform count -					
Total 25	Total score of each sample					

Lesson-22

Defects in Ice Cream – Flavour, Body & Texture

22.1. INTRODUCTION

High quality ingredients are required in the production of high quality ice cream. Adherence to formulation, industry processing standards and proper storage requirements are also critical. Incorporation of inferior dairy ingredients, sweeteners, or other ingredients always will result in a substandard product. Some of the defects likely to be found in ice cream are discussed below.

22.2. FLAVOR DEFECTS

Flavour is the most important sensory attribute in judging and grading of ice cream and frozen desserts. Even a minor flavour defect in ice cream will affect its acceptability by the consumer. Some of the prominent flavour defects are discussed in this chapter along with their causes and prevention.

Table-22.1: Classification of ice cream flavor defects according to their cause

I. Off-flavors due to the ingredients	
A. The flavoring system	
1. Lacks (deficient)	2. Lacks fine flavor (harsh, lacks balance)
3. High flavor (excessive)	4. Unnatural (atypical)
B. **Sweeteners**	
1. Lacks sweetness	2. Too sweet
3. Syrup flavor (malty)	
C. **Dairy products**	
1. Acid (sour)	2. Cooked (rich, nutty, egg-like)
3. Lacks freshness (stale)	4. Old ingredient
5. Rancid (lipolytic)	6. Salty
7. Whey	8. Oxidized (cardboard, metallic)
D. **Other ingredients**	
1. Eggs (egg-like)	2. Stabilizer/emulsifier
3. Non-milk food solids	
II. **Off-flavors due to chemical changes** (in the mix or product)	
1. Lacks freshness (stale, old)	2. Rancid (lipolytic)
3.Oxidized (cardboard, metallic)	4. Storage
III. **Off-flavors due to mix processing**	
1. Cooked (rich, nutty, egg-like)	2. Caramelized/scorched
IV. **Off-flavors due to microbial growth in the mix**	
1. Acid (sour)	2. Psychrotrophic (fruity/fermented, cheesy, musty, unclean)
V. **Off-flavors**	
1. Foreign	2. Neutralizer

22.2.1. High flavor

This flavor condition, when it occurs, is best recognized when the sample is first placed into the mouth. The intensity of the flavoring seems so striking or sharp that the desired, pleasant flavor blend is not achieved due to the harsh tones imparted by the flavoring level observed in the product. Ice cream that is too highly or excessively flavored is not severely criticized as a rule, especially if the quality of the flavoring used is high. An associative "ethanol-like" note may be present.

22.2.2. Too sweet

An ice cream that is observed to be excessively sweet tends to exhibit a candy-like taste sensation; this defect is readily noted upon the first stages of tasting. Too much sugar (or other form of sweetener) tends to interfere with the overall desirable blend of flavor(s). Another unfortunate characteristic of a given ice cream that is perceived as being too sweet is a general lack of refreshing property.

22.2.3. Lacks sweetness

An ice cream that lacks sweetness is readily noted upon tasting; the product simply manifests a distinct flat or bland taste. The desired or anticipated blend of flavor is missing. An adequate amount of sweetener is required to bring out the full flavor "bloom" in a given flavor, whether it is vanilla, fruit, or chocolate ice cream. Since preferences for the desired level of sweetness vary among individuals, the product is not severely criticized for lacking sweetness, within reasonable limits, if this is the only flavor defect encountered. However, a severe deficiency in sweetener solids may give rise to readily evident defects in body and texture or mouth feel.

22.2.4. Syrupy /Malty flavour

This sweetener off-flavor is still commonly encountered in certain forms of corn syrups and corn syrup solids; hence "syrup flavor" is the common descriptor for this characteristic defect. Frequently encountered descriptions for syrup flavor might be malty,caramel-like, molasses-like or similar to low levels of burnt sugar. Some evaluators distinguish syrup flavor from high sweetness by the "catch"experienced in the throat, similar to the feeling after a dose of cough syrup.Certain forms or sources of corn syrup solids, corn syrup, and some liquid sugar blends (with excessive levels of corn syrup), when used in ice cream in high proportion to sucrose, may convey a slight to distinct malty or caramel-like off-flavor.

22.2.5. Lacks fine flavour

This criticism is generally used to describe an ice cream that is basically "good" or "very good," but for some less than clear reason, it seems to just barely fall short of being "perfect" or "ideal." experienced ice cream judges are able to recognize the desirable, delicate, balanced flavor notes of a high quality flavor. The novice judge should remember that "lacks fine flavor" is not readily described in more definitive or specific terms.

22.2.6. Lacks flavouring

An ice cream with this defect is often criticized as flat, bland, or deficient in the amount of added flavoring. Even though the ice cream may be pleasantly sweet and free from any dairy ingredient off-flavor, it seems to lack the characteristic delicate "bouquet" of excellent vanilla; the desired intensity is missing. The obvious cause of this defect is failure to use sufficient quantities of flavoring. However, there are instances when certain ingredients mask (or hide) the vanilla flavor, thus invoking the "lacks flavor" criticism, even though the added quantity of flavoring seemed adequate to the manufacture.

22.2.7. Acid (Sour)

An acid or sour off-flavor in frozen dairy desserts may be distinguished from other off-flavors by a sudden, tingly, taste sensation (on the tip or top of the tongue), plus an associated "clean and refreshing" mouth feel. This flavor defect may be caused by the use of acid whey in the ice cream mix. The off-flavor may also result from uncontrolled bacterial activity at elevated temperature; other bacterial off-flavors may also be present. In such cases, the flavor defect(s) may be more appropriately described as a combination acid (sour) and psychrotrophic bacteria-caused off-flavor (unclean, fruity, or putrid).

22.2.8. Cooked flavour

The "cooked" flavor of ice cream is commonly experienced.It is also referred to as "rich," "egg-like," "sulfide," "custard,"scalded milk, condensed milk, or caramel-like. Cooked (or rich) flavor is not considered a serious defect in ice cream, unless it is so intense as to be perceived as caramel, scorched, or burnt. Quite commonly, the dairy ingredients incorporated into ice cream which has been pasteurized already; regulations require that the blended or final ice cream mix must also be re-pasteurized. Additional heat treatment is likely to produce some degree of cooked flavor in the mix. As indicated earlier, this is not typically objectionable in ice cream; in fact,it may be quite desirable or preferred in many instances. An excessive cooked off-flavor usually results from using ingredients that have received such severe heat treatment that a scorched or burnt effect is attained. Mix pasteurization, under some adverse conditions, may also develop a cooked off-flavor.

22.2.9. Lacks freshness (Stale)

The descriptor, "lacks freshness," or "stale," refers to a moderate off-flavor of ice cream and related frozen desserts. This flavor defect is generally assumed to result from either a general flavor deterioration of the mix during storage, or from the use of one or more marginal quality dairy ingredients in mix formulation. For instance, some old milk or old cream, or stale milk powder (nonfat milk solids), may have been incorporated as an ingredient. If the off-flavor imparted by the "marginal" ingredients were quite intense, then "old ingredient" would probably be the most appropriate criticism. However, if the other milk components and/or mix ingredients dilute the adverse sensory aspects of the dairy ingredient(s) in question, a lacks freshness (or stale) descriptor is more applicable.

22.2.10 Oxidized (Cardboard, Metallic) flavour

In dairy products, the oxidized off-flavor may vary so widely in character and intensity that several terms or descriptors are used to distinguish between the various stages. In ice cream or low fat ice cream, this off-flavor may be encountered to such a slight intensity that the product flavor seems flat or "missing." a further development of this off-flavor may be described more accurately as astringent, metallic, or puckery (with an associated mouth feel of shrinking of the mucous membranes). Other, more moderate intensities of the off-flavor might be described progressively as oxidized, papery, or cardboard. In the most intense stages of the oxidation of milk products, oily, tallowy, paint, or fishy are common descriptors. The oxidized off-flavor is usually noted soon after the sample is placed into the mouth; if intense, it may persist long after the sample has been expectorated. Depending on the intensity, such an ice cream may not been tirely repulsive to the evaluator (or consumer). However, an oxidized defect definitely conveys the idea that the product is not made from high-quality ingredients, is not refreshing, or may be stale or old.

22.2.11. Rancid flavour

Fortunately, a rancid off-flavor is infrequently observed in ice cream. A specific, delayed, reaction time of perception is characteristic of rancidity, and it has an attendant persistent repulsiveness. However, the sweeteners and flavoring may tend to mask any potential rancidity to the extent that unless the defect is quite pronounced, this off-flavor may not be recognized for what it actually is. If rancidity were to occur in ice cream,the peculiar blend of flavors and off-flavors would typically terminate as anun clean or unpleasant aftertaste, which is characteristic of the rancid defect. Rancidity is severely criticized, since it indicates either utilization of mishandled dairy ingredients or serious processing errors that led to mixing raw milk or cream with homogenized milk ingredients.

22.2.12. Salty

Occasionally, a salty off-taste may be encountered in frozen dairy desserts. This taste may be readily detected, since the reaction time is relatively short; hence, it is a quickly perceived taste. A salty taste could be due to added salt, the use of salted butter as a milk fat source, or it may be associated with use of a high percentage of concentrated whey, whey solids, or milk-solids-not-fat (MSNF) in the formulation. High replacement of MSNF with whey solids (i.e., in excess of25%) seems to occasionally lead to a slight salty off-taste in ice cream or ice milk. Other sensory defects may accompany the higher usage rates of some sources of dry whey (see the following discussion on the whey off-flavor). To most evaluators, a salty taste in frozen dairy desserts seems distinctly "out-of-place" for this form of product; hence, it is usually criticized in line with the level of intensity and the specific flavor involved.

22.2.13. Storage flavour

The "storage" off-flavor generally refers to flavor that may develop either in the mix or in the frozen ice cream (or low-fat ice cream) during the storage period. When ice cream is stored for an extended period of time, the flavor loses its initial luster, even though no specific defects seem to stand out. In one instance, the product may simply lack the sensation of freshness. Smoke, ammonia, and various chemical odors are but a few examples of absorbed substances that may be responsible. Serious storage flavor defects have been known to develop when odor, absorption, and chemical change or deterioration in storage occurred simultaneously. The storage off-flavor is commonly considered more serious or objectionable than the "lacks freshness"(stale) defect in ice cream.

22.2.14. Foreign (Atypical)

As a rule, a foreign off-flavor may be easily detected, but the exact substance or specific contaminant is often difficult to positively identify. This flavor defect is definitely atypical (foreign) for dairy products or the ingredients ordinarily associated with good quality ice cream. Detergents, sanitizers,paint, gasoline, pesticides, and other chemicals of chance contact are some of the possible serious offenders. Unfortunately, chemical substances may not only impart off-flavors but also be nauseating or toxic. Obviously, any products found to contain this defect must be severely downgraded and not marketed for human consumption.

22.3. BODY DEFECTS

The various body and texture defects that may be encountered in ice cream are termed or classified as follows

- Crumbly: brittle, falls apart when dipped.
- Fluffy: large air cells, disappears quickly in mouth, very weak.
- Greasy: a distinct greasy coating of the mouth surface after expectoration, a tallowy or Chapstick sensation on the lips after evaluation.
- Gummy: opposite of crumbly, pasty, putty-like; feels some what sticky like gum between tongue and roof of mouth.
- Icy/coarse: most common texture defect, not smooth, ice crystals or particles.
- Sandy: one of the most objectionable defects in ice cream; fine hard particles sand-like, lactose crystals.
- Soggy: heavy, doughy, pudding-like.
- Weak: lacks body and resistance, low solids, watery, more like ice milk

22.3.1. Crumbly, brittle, friable

Abrittle, crumbly, and friable body is evident by a tendency of the ice cream to fall apart when dipped. The product appears to be dry, open, and sometimes as friable as freshly fallen snow. The particles seem to lack the needed property to stick together or be retained as a common mass. The defect may be aggravated by the use of certain gums, inadequate stabilization, too high overrun, and/or low total solids in the mix. Generally lower fat ice creams (7% and less) tend to develop crumbly defect more readily than an ice cream mix with higher fat content (10% and more).

22. 3 .2. Flaky, snowy

Flaky, snowy is a similar defect like crumbly. A flaky, snowy textured ice cream manifests itself by a tendency to fall apart when dipped. In this respect, it has the same characteristics as that noted in a crumbly body. The condition seems to be associated with low solids, low stabilizer, and/or high overrun in the product.

22.3.3. Gummy, pasty, sticky, elastic

A gummy or sticky body is the exact opposite of a crumbly body. Such ice cream seems pasty and the ice cream hangs together, so much so that it has a marked tendency to curl just behind the scoop as it is pulled across the surface, which leaves coarse, deep, irregular waves. Frequently, there is a correlation between a gummy body and a high resistance to melting; gummy ice cream often resists melting. If melting does occur, the mass often tends to retain its original shape. Ice cream should only be severely criticized when the stickiness is so severe that it is obviously pasty and would probably be difficult to dip or scoop.

22.3.4. Shrinkage, Shrunken

A shrunken ice cream manifests itself by the product mass being with drawn from the sides of the container. This defect is noticed when the package is first opened for examination. This defect may be associated with high overrun, low mix solids, fluctuations in air pressure, or substantial changes in altitude during product distribution. However,under certain storage and/or transport conditions, any ice cream may shrink. Product shrinkage may suddenly be encountered where none existed before, even when no changes were made in the product's composition or manufacturing procedures. Certain environmental conditions, such as season of the year, stage of lactation, feed,etc., may unfavorably affect the normal formation of strong air cell walls(which contain proteins) in the frozen mix.

22.3.5. Soggy, heavy, doughy, pudding-like

A heavy, resistant body is best described by the terms heavy, doughy, or pudding-like. This defect can readily be noted when the product is dipped. Portions of an ice cream with this criticism, when placed in the mouth, seem colder than those free of the defect. Apparently, this is due to a greater heat conductivity of heavy bodied products. The body of such products is generally quite resistant, firm, or heavy. This defect is associated with high solids content of the mix,especially increased fat and sugar, too much stabilizer, and/or a low overrun.

22.3.6. Weak,watery

A weak, watery body is usually associated with a low melting resistance and a thin, milky, low viscosity meltdown. A weak-bodied ice cream conveys the impression of having a low proportion of food solids, when a sample is placed into the mouth. The mouth feel of the sample may more likely resemble reduced or non fat ice creams (or the former ice milks) more than ice cream. Such an ice cream may be easily compressed by slight pressure of a spoon or scoop. This defect may also be associated with coarse texture; low solids and high overrun also contribute to causing a weak-bodied ice cream.

22.4. Texture defects

22.4.1. Fluffy, Foamy, Spongy

A fluffy texture may be noted in high overrun ice cream. Such an ice cream tends to compress substantially upon dipping or applied pressure with a flat object. This defect is closely associated with a high overrun. A fluffy ice cream usually melts slowly in the dish, yielding a relatively small proportion of liquid, which is often foamy and spongy.

22.4.2. Greasy, Buttery, Churned

This defect may be noted by the presence of actual butter particles in the mouth after the ice cream has melted, or by a distinct greasy coating of the mouth surface after expectoration. Common causes of a greasy mouth feel are inadequate homogenization, a relatively high milk fat content and over-emulsification of the product. In soft-serve frozen dairy desserts, churning may be due to de-emulsification of milk fat during prolonged agitation in the soft-serve freezer. If fat globule aggregation exceeds a size of 30–50 µm, visible fat particles form in the samples with the associated buttery defect. High fat mixes are more susceptible to this defect.

22.4.3. Icy, Coarse, Grainy, Ice Pellets, Spiny

This defect is the most commonly encountered texture defect in frozen dairy desserts. Such a product may be characterized by comparatively large ice crystal particles, a feeling of unusual coldness within the mouth, a simultaneous lack of a smooth, velvety character, and a rough visual effect. A coarse texture is due to comparatively large particles of frozen water; each ice crystal is sufficiently large that the coarseness is obvious. When extremely coarse, grainy textures are noted, the product is criticized as being icy or spiny. Among the many possible causes of coarse-textured ice cream are the following:

- Faulty formulation
- Inadequate protection against heat shock
- Ineffective or improper stabilization and/or emulsification
- Inadequate hydration of dry mix constituents
- Incomplete protein hydration
- Inadequate homogenization
- Insufficient aging of the mix
- Too high product temperature coming out of the freezer
- Extended interval between freezing, packaging, and/or transfer to the hardening system
- Slow hardening
- Too high a hardening temperature
- Fluctuating storage temperatures
- Extended storage and distribution times.

Ice crystals are unstable because during frozen storage, they undergo changes in number, size, and shape, known collectively as re-crystallization. This occurs due to temperature fluctuations. If the temperature during the frozen storage of ice cream increases, some of the ice crystals, particularly the smaller ones, melt and consequently the amount of unfrozen water in the serum phase increases.

Conversely, as temperatures decrease, water will refreeze but does not re-nucleate. Rather, it is deposited on the surface of larger crystals, so the net result is that the total number of crystals diminishes and the mean crystal size increases. Each time the temperature changes, the smaller ice crystals disappear while the larger ones grow even larger. Re-crystallization can be minimized by maintaining low and constant storage temperatures.

22.4.4. Sandy, Gritty

A sandy texture is one of the most objectionable texture defects encountered in frozen dairy desserts, but it is also one of the easiest to detect. Such a texture conveys to the tongue and palate a definite lack of smoothness and an associated distinct form of grittiness. When the sample melts, there remains in the mouth fine, hard,uniform particles that suggest fine sand, and are crystals of lactose. Sandy texture should not be confused with the course, icy texture, which results from the presence of comparatively large ice crystals. The lactose crystals dissolve markedly more slowly than ice crystals; therefore, they may be noted even after the ice cream has fully melted. A high percentage of serum solids, high total food solids, product age, and "heat shock" are all related to the development of this defect.

****** ☺ ******

Lesson-23

Defects in Ice Cream- Colour and Appearance, Package and Melting Quality

23.1. COLOUR AND APPEARANCE DEFECTS

23.1.1. Gray, Dull

Though infrequently encountered any more, a gray, dull colour is easily recognized by its “dead,” so ice cream suggests lack of cleanliness in manufacture and, therefore, it is one of the more serious and objectionable colour defects.

If the gray colour is caused by the use of flavoring with ground vanilla beans, which may be apparent by the presence of small pepper-like particles of the ground bean, the colour should not be criticized. Ice cream that displays ground particles of vanilla bean (often labeled “Vanilla Bean”) is in demand by some consumers and may be preferred in some locales.

23.1.2. Not uniform

Lack of colour uniformity in vanilla ice cream is comparatively uncommon but may be easily recognized when it occurs. Although the most appealing colour for vanilla ice cream may be a moderate creamy shade of white, certain portions may be darker or lighter than others. Particularly, this may be true of the top or bottom surface or portions next to the side of the container where some desiccation may have occurred.

This defect is often associated with age (extended product storage). If the colour uniformity defect is restricted to the surface layer (which is usually discarded when taking samples), it is not considered serious. At times, streaks or waves of different colour may be encountered throughout the mass of a vanilla ice cream. This can be caused by varying overruns attained from multi-barrel freezers or may derive from different freezers that have a common discharge. Sometimes, a non-uniform colour may originate from successive changes in the flavor source (and associated colour) throughout the freezing and packaging process.

23.1.3. Too high / Vivid

A high colour level is often objectionable because it appears unattractive and often connotes an“artificial” impression. Although individual preferences for colour vary,evaluators have a general tendency to downgrade products that have an obvious,excessive intensity of colour. Such a product conveys the idea of cheapness,imitation, poor workmanship, or a general lack of understanding and care on the part of the manufacturer.

23.1.4. Too Pale / Chalky / Lacking colour

A pale, chalky, or snow-like colour is the opposite of too high colour. This defect is not particularly serious, although a lighter coloured product may not have as much eye appeal as a creamy shade of white colour. However, uncoloured ice cream, especially vanilla,should not necessarily be criticized for lack of colour. For special markets,ice cream without any form of added colour is a must; many products meet that marketing objective and it does not seem logical to penalize the colour in those circumstances.

23.1.5. Unnatural colour

Unnatural colour of ice cream should be recognized at a glance; the product appearance is not “in keeping” with the impression conveyed by cream (or milk fat). An unnatural colour may be any shade of yellow, orange, or tan– colours that do not correspond to the true colour characteristics of milk fat. Some more common off shades of colour in vanilla ice cream include lemon yellows, light green yellows, orange yellows, and occasionally red yellows or tan browns. Unnatural colour may also arise from the use of extensive amounts of annat to-coloured Cheddar cheese whey solids, of product rerun, re-melted ice cream, or commingling of successive freezer runs of product (that have contrasting colours). The criticism for unnatural colour is a broad designation.

"Unnatural"colour might also describe an ice cream whose colour is gray, dull, high,vivid, pale, chalky, or non uniform. Generally, the several colour defects of vanilla ice cream do not occur at the "serious" level. Since different types of lighting will significantly affect colour characteristics as viewed by human subjects, the type of light employed during examinations should certainly be standardized.

23.2. PACKAGE DEFECTS

The ideal frozen dessert package or container should be clean, undamaged, full, neat, attractive (pleasant eye appeal), and protective of the product.

Multi use containers (if used) should be free of dents, rust, paint, battered edges, or rough, irregular surfaces. In general, ice cream packages should reflect neatness and cleanliness throughout, giving the consumer the impression that by use of a clean, well-formed container, the manufacturer is definitely interested in supplying a high-quality product. Some more common package defects that may be encountered are a slack-filled container, bulging container, improperly sealed container, ill-shaped retail packages or product adhering to the outside of the container, ink smears, lack of a parchment liner on the top of bulk containers, and a container that is soiled, rusty, or damaged (the last two defects pertain to refillable containers).

These packaging defects, when they occur, are generally so obvious that additional descriptors or discussion hardly seems necessary. Encountering a high proportion of defectively packaged products from a production run is most unlikely, but such a problem might occur in the absence of adequate supervision. Just a few defective packages or containers present a problem of some magnitude because consumers will simply not select and purchase damaged units of products from the retail ice cream cabinet. Thus, evaluators must keep in mind that defective containers generally render a product unsalable.

23.3. MELTING QUALITY

High-quality ice cream should show little resistance toward melting when a dish is exposed to room temperature for at least 10–15 min. During the melting phase, the mix should flow from the center (high) portion of the scooped ice cream. The melted product should be expected to form a smooth, uniform, and homogeneous liquid in the dish. Generally, ice creams with low overrun melt more rapidly than those with high overrun. The defects of melting quality frequently observed in ice cream judging will be elaborated.

The melting quality may be observed by placing a scoop full of the sample on a dish and noting its meltdown response from time to time, as the other sensory qualities are being examined. Although fiber dishes may be used, petri dishes seem to permit more accurate observation of the melted ice cream; the contrast between the product and the dish background is greater.

While evaluating the melting quality of ice cream some precautions are necessary:

1. Select a uniformly heated,well-lit area for placing and observing the samples (~23℃)

2. Set the sample out for meltdown at the beginning of the judging (if feasible).

3. Absolutely, avoid dipping some of the samples with a warm dipper and others with a cold dipper.

4. Be sure that the sizes of the reasonably small samples used for the meltdown test are uniform in volume (use the same scoop or spoon for each sample).

5. Always use a flat-bottom dish (not a cup), so the melted ice cream is free to spread out.

6. Once melting has started, do not disturb the samples by tilting or swirling the containers.

7. Observe the melting quality at various stages of melting and score on the basis of the scheme suggested in the scorecard.

23.3.1. Does not melt/ Delayed melting

This defect is easily recognized since the ice cream retains (or tends to retain) its original shape after it has been exposed to ambient temperature for a period in excess of 10–15 min.

This defect is related to the use of an excess of certain stabilizers and emulsifiers, high overrun, the age of the ice cream, and several processing and product composition interactions that promote formation of a highly stable gel(even when the temperature is above the freezing point). This attribute is considered objectionable to some, as it conveys the impression that excessive amounts of product thickeners were used. However, in other cases, this attribute is an objective.

23.3.2. Flaky/Lacks Uniformity

This defect may be noted when the sample is about half-melted, but it is more noticeable when the sample has completely melted. Flakiness is shown by a feathery, light-coloured scum formation on the surface. Sometimes it resembles a fragment of crust. Usually,no indication of wheying off (water separation) accompanies the defect.Furthermore, it is not particularly objectionable. However, it does not give an impression of ideal white, and attractive appearance; the product is also not uniform or homogeneous in appearance.

23.3.3. Foamy/Frothy

A foamy meltdown is usually only noted when the sample is completely melted. Ice cream that exhibits many small, fine bubbles upon melting is not commonly criticized, but a sample that demonstrates a mass of large bubbles, 0.3–0.5 cm (1/8–3/16 inches) in diameter, is criticized.

The meltdown should be uniform and attractive; this is not the case when large air bubbles or excessive foam occur. The consumer may associate the presence of foam with excessive overrun,even though this defect may not be associated with high overrun, but more often(or rather) with some of the particular constituents used in the mix.

23.3 .4. Curdy

A meltdown with a curd-like appearance lacks product uniformity and is, for the most part, unattractive. The melted ice cream appears flaky; it separates from the mass in small distinct pieces rather than leaving the impression of a creamy fluid. The surface layer may exhibit formation of dry, irregular curd particles. To the layman, this defect suggests souring of the milk or cream, although the cause is usually another matter. Any conditions that lead to the destabilization of proteins are potential causes of this defect in frozen dairy desserts.

A combination of factors may be responsible, including (1) high acidity; (2) the salt balance (related to calcium and magnesium salts); (3) age of the ice cream;(4) certain adverse processing conditions (involving temperature, time, and method of heating, homogenization pressure and temperature, and rate of freezing and hardening); and (5) the type and concentration of stabilizers and emulsifiers.

The meltdown characteristics and the formation of curdy/flaky appearance are influenced by the protein stability, fat agglomeration, and air cell size. In the industrial processing of ice cream, formulations and processing can be modified to increase the availability of surface-active proteins for foam stabilization. Partially coalesced three-dimensional network formed by the fat globules with air and ice is in part responsible for the melt resistance and smoother texture of the frozen dessert. Presence of surface-active proteins will stabilize the weak fat–serum interface first. Increased emulsification results in depletion of protein from the fat molecule that increases fat destabilization, hence decreases melting rate and enhanced shape retention during the melting process. Stabilizers increase the resistance of the frozen product to meltdown by decreasing the mobility of water through increasing the viscosity of the serum phase. This has been previously explained in the separate section on emulsifiers and stabilizers. Except for viscosity, all of the factors listed above, either independently or in combination, affect fat agglomeration. Substantial fat agglomeration is responsible for the “slow melt,” and/or an unattractive dry, “flaky” surface of the melted product. Protein destabilization will result in melting throughout and hence “curdy”ice cream. This defect can be prevented by minimizing the temperature abuse.

23.3.5. Wheying-off

Wheying-off (syneresis) may usually be noted by the appearance of a bluish fluid leaking from the melting ice cream at the initiation of the meltdown test. If the sample is disturbed during melting or the observation is delayed, it may be difficult to see this condition. Whey separation may be noted in some ice cream and reduced fat ice cream mixes even before they are frozen. This is a common complaint of operators of soft-serve freezers who buy their mix from a wholesale manufacturer. These mixes tend to be stored longer and are subjected to more abuse than those mixes that are made and frozen within the same plant.

Factors contributing to the difficulty include (1) the salt balance of milk ingredients, (2) the mix composition (a product with a high protein-in-water concentration can be expected to be less stable than one with a lower concentration), (3) certain adverse processing conditions, (4) and the extent of abuse (excessive agitation, air incorporation, and “heat shock”).

Separation is a natural phenomenon occurring in soft-serve ice cream mixes; increasing the amount of whey proteins, while maintaining the same protein content, and the use of k-carageenan at >0.015% in the mix prevent visible separation,although it still occurs on the microscopic level. Locust bean gum and sodium caseinate are incompatible, and undergo phase separation on a microscopiclevel. k-carrageenan has a much weaker stabilizing effect upon soft-serve ice cream emulsions formulated with sodium caseinate and locust bean gum, compared to skim milk powder emulsions stabilized with locust bean gum.

23.3.6. Watery/Low melting resistance

This defect is not consistent with the characteristics of the highest quality ice cream. As the terms suggest, the sample melts quickly and the resultant meltdown has a thin, watery consistency.

This defect is commonly associated with low solids or low stabilizer levels in the mix and may often be associated with a coarse, weak-bodied ice cream or ice milk. Curdiness and delayed melting are the two of the most common meltdown defects; they may occur simultaneously. Whey separation may be observed frequently, since protein destabilization is a common problem.

****** ☺ ******

Lesson-24
Method of Sensory Evaluation of Ice Cream

24.1.INTRODUCTION

Ice cream is a frozen food made of a mixture of dairy products, such as milk, cream, and nonfat milk, combined with sugars, flavoring, fruits and nuts, stabilizers and emulsifiers etc. Different types of ice cream are available in the market including economy,premium, super-premium reduced fat, light, low fat ice cream, mellorine, soft serve ice cream, sherbets, ice candy and kulfi. All the above products may differ in the type of flavoring, the composition in terms of dairy ingredients and other food solids, and the extent of product overrun.

24.2.ICE CREAM SCORING TECHNIQUE

Ice cream with no criticisms is considered perfect and is given a score of 10 and 5in each flavour and body and texture respectively. Ice cream products rarely receive a perfect score. When a defect is identified, the smallest deduction a judge can make is one point. The deduction can increase depending on these verity of the defects identified. Defects are described as slight, definite,or pronounced depending on the intensity of the defect. Those product samples (representative of a lot) that receive a "zero" in anyone or more quality categories should or would generally be regarded as unsalable products.

24.2.1. Tempering the samples

Generally, temperatures between-18° and -15°C are satisfactory for tempering ice cream for judging. This can be best accomplished by transferring the ice cream samples from the hardening room to a dispensing cabinet at least several hours prior to judging, or preferably tempered overnight. This ensures that the ice cream tempers uniformly.

24.2.2. Sampling

Generally, a good quality ice cream dipper,scoop, or spade, rather than a spoon, is preferred for obtaining samples. If the product surface has been exposed, then any dried surface layer (to a depth of approximately 0.8 cm) should be removed before securing the sample for evaluation.

For meltdown test, the petridish should be set in a convenient place (but away from heat sources) where melting qualities may be observed from time to time during the overall evaluation process.

The melting quality may be observed by placing a spoonful of the sample on a dish and noting its meltdown response from time to time, as the other sensory qualities are being examined. Although fiber dishes may be used, petri dishes seem to permit more accurate observation of the melted ice cream; the contrast between the product and the dish background is greater.

While evaluating the melting quality of ice cream some precautions are necessary:

1. Select a uniformly heated,well-lit area for placing and observing the samples (~23°C)

2. Set the sample out for meltdown at the beginning of the judging (if feasible).

3. Absolutely, avoid dipping some of the samples with a warm dipper and others with a cold dipper.

4. Be sure that the sizes of the reasonably small samples used for the meltdown test are uniform in volume(use the same scoop or spoon for each sample).

5. Always use a flat-bottom dish (not a cup), so the melted ice cream is free to spread out.

6. Once melting has started, do not disturb the samples by tilting or swirling the containers.

7. Observe various stages of melting and then score accordingly.

24.3. ORDER OF EVALUATION

The state of ice cream changes rapidly when exposed to ordinary temperatures. Therefore it is imperative that the sensory evaluation should be completed in minimum time. An orderly sequence of observations has been found to be most effective in evaluating ice cream for sensory characteristics.

24.3.1. Examine the container. Note the type and condition of the container, the presence or absence of a liner and cover on bulk containers, and any package defects that may be present.

24.3 .2 Note the color of the ice cream. Observe the color of the ice cream, its intensity and uniformity, and whether the hue is natural and typical of the given flavor of ice cream being judged.

24.3.3. Sample the ice cream. During the course of dipping the sample, carefully note the way the product cuts and the feel of the dipper as its cutting edge passes through the frozen mass. Note particularly whether the ice cream tends to curl up or roll in serrated layers behind the dipper, thus indicating excessive gumminess or stickiness. The "feel" of dipping (i.e., the resistance offered), the evenness of cutting, the presence of spiny ice particles, and whether the ice cream is heavy or light and fluffy should be especially noted.

24.3.4. Begin judging. Start examining the body and texture and flavor. When the sample is liquefied and warmed to near body temperature, detection of the flavor characteristics is not particularly difficult. Manipulate the sample between the teeth and palate, and simultaneously noting the taste and/or volatile sensations. To evaluate the body and texture characteristics, Immediately after placing a portion into the mouth, roll the sample between the incisors and bring them together very gently, noting (relatively) how far apart the teeth may be held by the ice crystals and for how long. Note if any grittiness is apparent between the teeth. By pressing a small portion of the frozen ice cream against the roof of the mouth, the relative degrees of smoothness, coarseness, coldness, the presence or absence of sandiness and the relative size of ice crystals may be determined.

Because the sample is too cold at the time of tasting, sense of taste is often impaired. Therefore, use as small or modest a sample as possible to evaluate body and texture.

24.3.5. Sense the flavor . The first perceived sensory reaction will probably be one of the fundamental tastes (if present), and in the order of salty, sweet, sour, and/or bitter. As the sample is warmed in the mouth, the volatile, flavor-contributing substance(s) will soon evoke a perceived aroma (smell). Since sweetness is practically always perceived prior to detection of volatile, odor-contributing substances, the characteristics of the sweetener should be noted at once. Ice cream may be perceived as pleasantly sweet, intensely sweet, lacking in sweetness, or "syrup flavor"; the latter denotes a departure from a simple, basic sweet taste.

Note,whether the flavor is harsh (coarse) or delicate, mild or pronounced; whether the flavor seems creamy, pleasantly rich, or possesses a pronounced, objectionable, unnatural taste; and whether the mouth readily "cleans up"after the sample has been expectorated.

All samples should be expectorated after completing the flavor evaluation task. Note the melting qualities. By the time the flavor attributes have been determined, the samples previously set aside for the observation of melting properties should have softened sufficiently to yield an impression of those characteristics.

Observe whether the ice cream sample has retained its form and approximate size, even though some free liquid may have leaked (oozed) out, and whether the melted liquid appears homogenous and creamy, curdled, foamy, or watery (wheying-off).

24.3.6. Record the results. Once all of the sensory observations have been completed,record the sensory observations on a scorecard and assign the appropriate numerical values.

The quality and sensory attributes of ice cream as perceived by the consumer in terms of the most desirable flavor, body and texture can be evaluated but it is not easy. For a successful and dependable sensory evaluation of ice cream and frozen desserts, judges needs to have experience and knowledge about the effect of ingredients, product formulation, processing and handling on the properties of the products. Additionally, due to the uniqueness of frozen desserts, it is important that samples are prepared properly and the evaluation is conducted in a suitable environment.

****** ☺ ******

Module 9 - Technology Of Dried Ice Cream Mix And Nutritive Value Of Ice Cream

Lesson-25

Dried Ice Cream Mix- Composition, Technology, Uses

25.1. INTRODUCTION

Ice cream is a delicious, wholesome,frozen dairy product and is liked equally by the people of all age groups. Ice cream is obtained with the addition of milk, cream, sugar in certain proportions and freezing. During lean season, there is a acute shortage of milk and milk products. Significant advancements in drying techniques have overcome this difficulty by manufacturing ice cream mix powder during flush season and using it during lean season for the ice cream manufacture. The advantages claimed for dried ice cream mix are reduction in volume with a consequent saving in storage space, ease of packaging and handling, lesser perish ability,refrigerated storage space not necessary and lower transportation costs due to reduction in weight.

25.2. COMPOSITION OF DRIED ICE CREAM MIX

The general composition of dried ice cream mix is shown in the Table25.1

Table.25.1: Composition of dried ice cream mix

Constituents (%)	Full sugar mix	20% sugar mix
Moisture	1.0 – 2.5	1.0 –2.50
Milk fat	25.0 – 29.0	39.7 – 45.20
SNF	25.0 – 30.0	39.7 – 46.80
Sugar	37.0 – 42.0	07.4 –8.40
Stabilizer/Emulsifier	0.5 – 1.2	0.8 –1.56

BIS specifications for dried ice cream mix (IS: 7839– 1975) is shown in Table 25.2.

Table-25.2: BIS specification for dried ice cream mix

Sr. No.	Constituents	Percentage (%)
1.	Moisture % by mass, maximum	4.0
2.	Milk fat % by mass, minimum	27.0
3.	Milk protein % by mass, minimum	9.5
4.	Sucrose % by mass, maximum	40.0
5.	Stabilizers and emulsifiers % by mass,Maximum	1.25

Dried ice cream mix has to be reconstituted in water in certain proportion (1:1.7) and is ready for freezing.

25.3. MANUFACTURE OF DRIED ICE CREAM MIX

There are two approaches to the preparation of base mix for drying

a) Standardization of whole milk and cream to the required fat to SNF ratio, and condensing in vacuum pan.

b) Preparation of standardized ice cream mix in a normal manner with the desired amount of sugar in it and using the usual sources for various ingredients of the mix Standard conditions were used for the manufacture of ice cream mix and only 25% of the total sugar was added before spray drying. The basic principle of spray drying consists in atomizing the milk, to form a spray of very minute droplets which are directed into a large, suitably designed drying chamber, where they mix intimately with a current of hot air (inlet air temperature 190 to 195°C; outlet air temperature 85 to 87°C) owing to their large surface area. The milk particles surrender their moisture practically instantaneously and dry to fine hollow, spherical particles with some occluded air. This method has been successfully employed in the manufacture of ice cream mix powders.

Prompt cooling of the powder is necessary because it decreases the cooked flavour, which is a common defect in powders,and also because it decreases the rate of development of stale flavour.

Since dried ice cream mix is very rich in milk fat, hence it is very susceptible to oxidative rancidity on storage. In order to delay the appearance of this particular defect, it is essential to have low moisture content in dried mix and the product should be gas packed and stored at low temperature conditions.The flavour of dried ice cream mix is adversely affected by high moisture content, metallic contamination, high storage temperatures and long storage periods.

Dried ice cream with less than 3% moisture keeps well even at 30°C if it is double gas packed. Higher fore warming temperature also prolongs the keeping quality and retards the oxidized flavour.

25.4. USES OF DRIED ICE CREAM MIX

The use of dried ice cream mix is gaining momentum and is of great utility to small scale ice cream manufacturers.

- It is convenient to use as a value added product
- Soft serve ice cream manufacturers have a great utility of this product

A good market in the households can be created for those who prepare their own ice cream using small domestic freezers

****** ☺ ******

Lesson-26

Nutritive Value of ice cream-Calculations and labeling

26.1. INTRODUCTION

The energy value and nutrients of ice cream depend upon the food value of the products from which it is made. Ice cream contains three or four times as much fat, carbohydrate and 12-16 % more protein than does milk. In addition, it contains other food products such as fruits, nuts, eggs,candies and sugar, which enhance its nutritive value. Like milk, ice cream is not a good source of iron and some of the trace minerals.

Ice cream is an excellent source of food energy, and fully 50% of its total solids content is sugar, including lactose, sucrose, and corn syrup solids. These constituents are almost completely assimilated and makes ice cream an especially desirable food for growing children.

26.2. CALORIC CONTENT OF ICE CREAM AND RELATED PRODUCTS

The amount of energy normally expected to be derived from milk per gram of Carbohydrates, fats and proteins is as follows: Carbohydrates 3.87 kcal; Fat 8.79 kcal; protein 4.27 kcal. Proteins and carbohydrates are of equal energy value per gram and fats are 2.25 times as rich in energy. Minerals and vitamins do not furnish appreciable amounts of energy. The lactose content of MSNF is about 52.0% and the protein content of MSNF is about 36.0%.

26.3. CALCULATING CALORIFIC VALUE PROVIDED BY ICE CREAM

The total calorific value of ice cream depends on

(1) The percentage of carbohydrates including lactose, added sweeteners, and sugars that may be present in fruit or flavouring

(2) The percentage of protein including milk protein or any other source of protein that may be present in nuts, eggs, or stabilizer and

(3) The percentage of fat from any source including emulsifier, egg, cocoa, or nut fat that may be in the mix.

The caloric value of100g of vanilla ice cream containing 12.5% fat, 11% MSNF, 15% sugar and 0.3% gelatin may be calculated as follows:

Carbohydrates $[15 + (11x\ 0.52)] \times 3.87$	=	80.19
Fat $[12.5 \times 8.79]$	=	109.86
Protein $[(11 \times 0.36) \times 0.30] \times 4.27$	=	14.09
		204.14 kcal/100g

In determining the caloric value of a package or serving of ice cream, it is necessary to determine the exact weight of the product contained therein.

26.4. PROTEIN CONTENT OF ICE CREAM

The milk proteins contained in ice cream are of excellent biological value, because they contain all the essential amino acids. They are important sources of tryptophan and are especially rich in lysine. They are not only known to be complete but the assimilation of ingested milk proteins is 5~ 6 % more complete than for other proteins in general.

Ice cream has a high concentration of MSNF, which is34 ~ 36 % milk protein.

26.5. MILK FAT CONTENT

Milk fat consists mainly of triglycerides of fatty acids. It contains at least 60 fatty acids. It also contains non saponifiable fractions and other matter such as cholesterol,lecithin, and tocopherols.

Table-26.1: Selected fatty acids and cholesterol in ice cream and other related products (per 100g)

Products	Fatty acids			Cholesterol (mg)
	Total unsaturated (g)	Oleic (g)	Linoleic (g)	
Ice cream	7.0	4.0	Trace	45.0
Ice milk	3.0	2.0	Trace	21.6
Edible ice cream cone	1.0	1.0	Trace	0.0

26.6.CARBOHYDRATES IN ICE CREAM

Lactose, milk sugar is a disaccharide, unique, found only in milk. Liberal quantities of lactose in the ice cream produce a favorable medium in the intestinal tract for the establishment of growth of *Lactobacillus acidophilus*,an organism that aids carbohydrate fermentation, which in turn results in an acid condition in the intestinal contents unfavorable to protein putrefaction. Lactose favors calcium assimilation and phosphorus utilization.

26.7.MINERALS IN ICE CREAM

Milk and its products, including ice cream, are the richest sources of calcium, phosphorus and other minerals essential in adequate nutrition. Ice cream, which is rich in lactose, should favor assimilation of calcium, which is needed by growing children and some adults. The calcium and phosphorus content of milk and ice cream are

The calcium and phosphorus content are 0.118 and 0.093; and 0.122 and 0.105 respectively in milk and ice cream.

The daily requirement of calcium as recommended by the National Academy of Sciences (1974) is as follows

Table-26.2: Requirement of calcium

Individual	g/day
Children and adolescents	1.40
Adult	0.80
Pregnant mother	1.50
Nursing mother	2.00

26.8.VITAMINS IN ICE CREAM

Like milk, ice cream is a richsource of many of the essential vitamins. Ice cream is an excellent source of vitamin A, and a good source of vitamin B (B_1, B_2, B_6,B_{12}) and a fairly good source of Niacin, vitamin E etc. A brief description of the better known vitamins may help to emphasize the importance of milk and ice cream in the diet.

26.8.1.Vitamin A

It is the principal butter fat vitamin. It is the most important in building resistance to infection in the respiratory tract, in preventing night blindness and in maintaining general good health.

26.8.2.Vitamin B_1 (Thiamine)

This vitamin is essential for growth and metabolism. A deficiency in thiamine may produce symptoms of loss of appetite and weight, general weakness, degenerative changes in the nervous system and enlargement of the heart. Ice cream contains an average of 0.48 mg/kg with a range of 0.38 – 0.65 mg/kg.

26.8.3.Vitamin B_2 (Riboflavin)

Riboflavin is a dietary essential for humans. The symptoms of riboflavin deficiency are lesions of the skin and of the eye, mouth and tongue; abnormally red lips; lesions in the corners of the mouth. Ice cream contains an average of 2.3 mg/kg with a range of 2.0 – 2.6 mg/kg.

26.8.4.Vitamin B_6

This vitamin has an important role in amino acid metabolism. A deficiency may produce decreased growth rate, dermatitis, anemia and convulsions. Ice cream contains an average of 0.68 mg/kg with a range of 0.27 – 1.15 mg/kg.

26.8.5.Vitamin B_{12} (Cyanocobalamine)

This vitamin has the most complex structure of all vitamins. It is an essential metabolite for a wide variety of organisms. A deficiency may produce pernicious anemia. Ice cream contains an average of 0.0047 mg/kg with a range of 0.0026 – 0.0078 mg/kg.

26.8.6.Vitamin C (Ascorbic acid)

This is the antiscorbutic factor important in the prevention of scurvy. It is not stored in the body. Ice cream contains about 10 -11 mg/kg of Vitamin C. However, fruit ice cream is a good source of this vitamin.

26.8.7.Vitamin D

It is the antirachitic vitamin. Its deficiency is accompanied by a decreased rate of growth and lowered calcium and inorganic phosphorus levels in the blood. These vitamin is present in trace amounts in ice cream unless milk products have been fortified with it.

26.8.8.Vitamin E

This is known as the anti-sterility vitamin since it helps to maintain normal health and the reproductive organs. Ice cream is a fair source. It contains an average of 3 mg/kg.

26.8.9.Vitamin K

This vitamin has been found necessary for coagulation of the blood. The concentration of vitamin K is very low in milk, and it may be destroyed during pasteurization and evaporation.

26.9.Nutritional Labeling

The correct labeling of food product is of paramount importance in order to protect both the consumer and the manufactures.

In United Kingdom the requirements for ice cream are given below and the major points that must be covered by the label include

1. The correct name of the productas described in the food labeling regulations 1996. That is, “Ice cream” or‘dairy ice cream’ and in the case of “ice cream” it is necessary for the words “Contains non-milk fat” or “Contains vegetable fat” as applicable to be included near the name “Ice cream”.

2. The pack must include a list ofthe ingredients given in weight descending order. It is permitted to list the stabilizer, emulsifier and color using their “E” numbers. It is not sufficient to use the term “Milk non fat” because the actual source itself has to be named (eg. Liquid skim milk, skim milk powder, condensed milk or whey solids). For example, dairy ice cream made from milk, cream, skim milk powder, sugar, dextrose, stabilizer and emulsifier, flavor, and color would probably be labeled: Ingredients: Full cream milk, sugar, cream (48% milk fat), skim milk power, dextrose, emulsifier, permitted flavor and color.

3. In ice cream a “Use by Date” indicationis included together with the appropriate storage conditions (eg. Keep attemperature below -18°C)

4. The name and address of the manufacturer or packer, or the name and address of the seller.

5. The size of the pack, either in fluid ounces, pints or gallons or in metric sizes for which there is a set of specified metric volumes.

Theaspects of nutritional declaration include

· a statement of nutrition information per serving

· the serving size

· the number of servings per container

· the number of calories per serving

the amount of protein, carbohydrates and fat per serving.

****** ☺ ******

Lesson-27

Personnel, Equipment And Plant Hygiene; Cleaning And Sanitization of Ice Cream Freezers And Related Equipments

27.1. INTRODUCTION

People have the right to expect the food they eat to be safe and suitable for consumption. Food borne illness and food borne injury are at best unpleasant; at worst, they can be fatal. But there are also other consequences. Outbreaks of food borne illness can damage trade and tourism, and lead to loss of earnings, unemployment and litigation. Food spoilage is wasteful, costly and can adversely affect trade and consumer confidence.

International food trade and foreign travel are increasing, bringing important social and economic benefits. But this also makes the spread of illness around the world easier. Eating habits too, have undergone major change in many countries over the last two decades and new food production; preparation and distribution techniques have developed to reflect this. Effective hygiene control, therefore, it is vital to avoid adverse effect on human health and economic consequences of food borne illness, food borne injury and food spoilage. Everyone, including farmers and growers, manufacturers and processors, food handlers and consumers, has a responsibility to ensure that food is safe and suitable for human consumption.

Ice cream is one of the most popular foods widely consumed by people of all classes and age groups including high-risk people without further processing; for this they rely on the hygienic standards of premises where ice cream is manufactured. Consumers do not have the available knowledge or means of determining the hygienic quality of ice cream they purchase.

The main objective and importance of maintaining hygiene and sanitization is:

To maintain good product quality and shelf life it is essential to have proper cleaning and sanitizing practices, including personnel hygiene and habits. The primary purpose of cleaning dairy equipment after each use is to remove all milk based residues. Residues harbour the bacteria which affect dairy product quality, shelf life and have a potential to cause disease. The cleaning of equipment does not guarantee a sanitary surface at the time of next use. For this purpose an efficient bactericidal treatment is necessary. Sanitization involves bactericidal treatment.

27.2. PLANT HYGIENE AND SANITATION

Plant hygiene and sanitation may be classified into

I. Design and facilities

II. Control of operations

III. Plant maintenance and sanitation

27.2.1. Design and facilities

Establishment should be located away from the environmentally polluted area, which may be threat to contamination. It should be located away from areas prone to flooding, infestations of pests and where wastes (solids or liquid) cannot be removed effectively.

a) Location of equipment

Location of equipment should permit adequate maintenance and cleaning, function in accordance with its intended use and facilitate good hygiene practice including monitoring.

b) Internal structure and fittings

Surfaces of walls, partitions and floors should be impervious materials with no toxic effect. Surface should be smooth up to working height, i.e. operation height. Floors should be constructed to allow drainage and cleaning. Overhead ceiling and fixtures should be properly finished to minimize build up of dirt and condensation and shedding of particles. Windows should be easy to clean, minimize the build up of dirt, with removable and cleanable insect proof screen. Door should be smooth, non-absorbent surfaces, easy to clean and disinfect. Surfaces coming in direct contact with food should be in sound condition, durable and easy to clean, maintain and disinfect, should be made of smooth, non-absorbent materials and inert to the product, detergent and disinfectants.

c) Equipment

Equipment and containers coming in contact with food should be designed and constructed to cause that they can be adequately cleaned,disinfected and maintained to avoid the contamination of materials with no toxic effect in use, durable, movable or capable of being disassembled to facilitate maintenance, cleaning, disinfections and monitoring.

d) Containers for waste and inedible substances

Containers should be specifically identified and suitably constructed for waste, byproducts, and inedible or dangerous substances.

27.2.2. Facilities

a) Air: Air plays a major role in ice cream manufacture. Air is rather an ingredient of ice cream. Proper care should be taken of the area from where the air is drawn. It should have a clean environment without any off smell and controlled humidity to ensure the safety and suitability of ice cream. It is desired that the air that is incorporated in ice cream should pass through sterile filters.

b) Water : Plants must have adequate water supply. Potable water should be used. Potable and non-potable water should be properly and clearly identified.

c) Drainage and waste disposal: There should be adequate and proper drainage and waste disposal system and facilities so that there is no risk of contamination.

d) Storage: Ice cream requires special storage at low temperatures (-18° to -20°C), so appropriate food storage facilities should be designed and constructed to permit adequate maintenance and cleaning and should enable food to be effectively protected from contamination during storage.

27.2.3. Control of operations

Effective control of temperature is critical, the safety and suitability of product should be taken into account and the following steps are to be taken to control the hazards in ice cream processing

- Identify- possible hazards in process lines
- Implement- effective control procedure for these

- Monitor- control procedure for continuous effectiveness
- Review- periodically the operations.

System should be in place to prevent contamination of chemical as well as physical nature during processing.

Packaging materials should provide adequate protection for ice cream to minimize contamination. Packaging material must be non-toxic.

27.2.4. Plant maintenance and sanitation

Plant and equipment should be kept in an appropriate state of repair and condition to facilitate all sanitation procedures to prevent contamination from metal shards, flecking plasters, debris and chemicals.

a) Cleaning: procedure and method

Cleaning should remove milk residues and dirt, which may be a source of contamination. Physical methods and chemical methods may be used for cleaning i.e. combination of heat scrubbing, turbulent flow, vacuum cleaning and using detergents,alkal is or acids. Cleaning procedures should remove gross debris from surface. Apply detergent solution to loosen soil and bacterial film and hold them in solution or suspension. Rinse with water to remove loosened soil and residue detergent. Apply appropriate methods for removing residues and disinfecting plant.

b) Cleaning programme

Cleaning and disinfections programme should ensure that all parts of the plant are appropriately cleaned. Cleaning and disinfections programme should be continuous and effectively monitored for its suitability and effectiveness.

c) Personnel hygiene training

Those engaged in ice cream operations that come directly or indirectly in contact with products should be trained and/or instructed regarding food hygiene to a level appropriate to the operations they are to perform. Training is fundamentally important to any ice cream hygiene system. Inadequate ice cream hygiene training, and/or instruction and supervision of all people involved in ice cream related activities pose a threat to the safety of ice cream and its suitability for consumption.

No worker should be allowed to perform tasks in the plant without having been taught the necessities of personnel hygiene and approved practices within the plant. The personnel hygiene is the key issue; contaminate the ice cream, post processing directly or indirectly. To ensure the product quality it is important to see that those who come directly or indirectly in contact with the product are not likely to contaminate the product by maintaining an appropriate degree of personnel cleanliness and behaving and operating in an appropriate manner. People known or suspected to be suffering from, or to be a carrier of a disease or illness transmitted through product, should not be allowed to enter any product handling area if there is likelihood of their contaminating the ice cream. Any person so affected should immediately report illness or symptoms of illness to the management. Medical examination of a product handler should be carried out if medically or epidemiological indicated. Conditions which should be reported to management so that they need medical examination and possible exclusion from food handling can be considered, including: jaundice, diarrhoea, vomiting, fever, visibly infected skin lesions (boils, cuts, etc.) and discharges from the eye, ear or nose.

d) Personnel cleanliness

Product handlers should maintain a high degree of cleanliness and where appropriate wear suitable protective clothing, head covering and footwear. Suitable waterproof dressing should cover cuts and wounds where personnel are permitted to continue working. Personnel should always wash their hands when personnel cleanliness may affect the product safety, for example at the start of product handling activities; immediately after using the toilet; and after handling any raw material of contaminated material, where this could result in contamination of other product items.

e) Personnel behaviour

People engaged in product handling activities should refrain from behavior, which could result in contamination of product, for example, smoking, spitting, chewing or eating and sneezing or coughing over unprotected product. Personnel effects such as jewellery, watches, pins or other items should not be worn or brought into product handling areas if they pose a threat to the safety of the product.

f) Visitors

Visitors to the ice cream manufacturing, processing or handling areas should wear appropriate protective clothing and cap and adhere to other personnel hygiene provisions given above.

g) Personnel hygiene practices

Good personnel hygiene of ice cream handlers is an essential factor in reducing the risk of food poisoning. Ice cream handlers must be aware of the sources of bacteria to prevent the contamination or cross contamination by the food handler. To comply with the personnel hygiene requirements employees need to follow good hygiene practices and in order to do this, proper facilities need to be provided.

h) Plant Hygiene and practices

- Freedom from infection, which can be transmitted (e.g. tuberculosis, hepatitis A, typhoid fever, dysentery, parasites, etc.)
- Wearing of protective clothing such as gloves, hair and beard nets
- Hygienic procedures in manufacturing
- High standard of personnel hygiene that includes: hygienic toilet habits, clean body and clothing, control of subconscious hand movements and not spitting or chewing of beetle nut.

Issues to consider include education of employees, socio-economic status, cultural and religious beliefs which may impact on personal hygiene practices.

i) Hand habits

Hand habits are of particular significance to the ice cream handler. There are many actions, which may be done sub-consciously which are potentially hazardous when associated with ice cream handling. Examples include

- Picking the nose
- Running fingers through hair
- Rubbing eyes, ears and mouth
- Scratching parts of the body

j) Basic hygiene rules

Clothing must be washed regularly. Clean clothes, apron and headgear must be worn when handling ice cream. Hands must be kept clean. Nails should be kept short without nail polish. Cuts, scratches and other wounds must be covered with a waterproof bandage and changed regularly. Hair must be covered with a net and a cap. Ice cream handlers are not permitted to wear jewellery (jewellery harbors bacteria and there is a risk that part of or whole ear rings and jewellery may fall off).

27.3. CLEANING AND SANITIZATION OF ICE CREAM FREEZERS AND RELATED EQUIPMENTS

All the storage tanks should be cleaned by hand or internal spray systems and should be completely dried after washing. For cleaning the packaging machinery, conveyor belts and ancillary equipment they need to be completely dismantled followed by hand cleaning and chlorine sterilization. Pasteurizers are cleaned by cleaning-in-place (CIP) procedures.Some precautions need to be taken during cleaning by CIP are

1. All enclosed plant should be inspected at weekly intervals
2. Parts located out of circuit e.g. some specialized type of pumps should be cleaned by hand.

27.3.1. Freezers

1. **Batch freezers**: The freezer is rinsed with cold water to remove any traces of ice cream. Then it is dismantled, cleaned and sanitized. Before re-assembly, it should again be sanitized. The freezer should be allowed to drain properly. Before use, it should be rinsed with 200 ppm chlorine solution.

Cleaning and sanitation of batch freezers

1. Turn off refrigerant and turn beaters on to expel remaining product.

2. Rinse freezer with cool tap water.

3. Prepare chlorinated alkaline detergent solution at52-55°C at 0.5-1% concentration.

4. Remove the hopper cover and mix tube assembly. Pour detergent into the hopper and brush thoroughly as the solution flows into the freezer cylinder.

5. Run dasher for 30 s then draw off the detergent solution. Rinse with warm water (Note: Running the beater without any mix in the chamber causes excessive wear and tear of the blades and cylinder).

6. Remove freezer door, dismantle all the parts and clean it manually.

7. Rinse all the parts thoroughly. Inspect all gaskets for cracks or hard deposits and replace if necessary (at least every 90 days).

8. Just prior to use sanitize the freezer with 250 ppm chilled chlorine solution and minimum contact period of 10 min. Drain completely (do not rinse with non -chlorinated solution because this may reintroduce contaminants to the machine).

27.3.2. Cleaning of continuous freezer

The usual steps are

1. Rinse with water at 38°C until the rinse runs clear
2. Circulate alkaline detergent (1-1.5%) solution at 65-70°C through the equipment for 20-30 min.
3. Rinse with water
4. Rinse with low concentration (0.1%) of phosphoric acid

Drain at all low points in the system. The entire assembled system must be sanitized with suitable sanitizer before use.

****** ☺ ******

Lesson-28

Micro Environment in Ice Cream, Microbiological Quality of Ingredients

28.1. INTRODUCTION

Micro environment refers to the immediate conditions that surround the ice cream. Micro environment may include the temperature, storage container, packaging material that surrounds the ice cream etc… During storage the temperature should be maintained at around -20°C without any major fluctuations. If there is variation in the temperature with time it may lead to quality deterioration in the ice cream and microbial spoilage. The surface of the container in which the ice cream is stored also plays a major role in the quality. The contact of ice cream with the container serves as a medium of heat transfer to maintain the storage temperature. High heat conducting, odourless, non-corrosive stainless steel material may be used to contain the ice cream to maintain the ice cream in a fixed frozen temperature. If packed in packaging materials prior to storage, they should not impart any colour, odour etc. There should not be any air pockets in the ice cream storage, as they serve as the sources of spoilage during storage.

The potential enteropathogens encountered in ice cream are mainly originating from either the gradients or as environmental contaminants. Amongst the ingredients,raw milk and cream are the likely source of *Campylobacterjejuni*, *Salmonella dublin*, *E. coli*,*Listeria monocytogenes* and *Yersiniaenterocolotica*. Sweeteners, especially systems have been known to contribute *E. coli* and salmonella.The pathogene of importance from egg and eggs products are proteins areproteus, Salmonella, Enterococcus spp. Similarly, Colouring material can also be a source of *E. coli* and Salmonella from the environmental sources the major pathogens of importance are *Listeria monocytogenes*, *Yersinia enterocolitica* and salmonell aspp. They may be found more in wet than in dry areas of dairy plants.

28.2. MICROBIOLOGICAL QUALITY OF INGREDIENTS

The ultimate quality of the finished ice cream depends not only on the numbers but also the types of bacteria present in the mix ingredients. In considering the mix ingredients we should, therefore, discuss not only numbers but also types of organisms, as far as possible.

The various mix ingredients that may act as the source microorganisms to the ice cream fall under the following heads.

- Dairy products
- Gelatin
- Sugar
- Flavouring materials
- Colouring materials
- Eggs
- Air

28.2.1. Raw Milk

The dairy products that enter the mix vary widely in their bacterial counts. Some of the dairy products such as liquid milk, cream and skim milk concentrate should have been subjected to adequate heat treatment, cooling and storage. The original raw milk may have a count of less than 10,000 per ml. if produced under sanitary conditions and properly cooled, or it may have a count as high as 5 x $10^6$to 1 x 10^8 cfu/ml. if carelessly produced and improperly cooled.

The numbers and types of micro-organisms in milk immediately after productions directly reflect microbial contamination during production, collection and handling. A use full indicator for monitoring the sanitary conditions present during the production, collection, and handiling raw milk is the 'total' bacterial count or standard plate count (SPC). SPC values for raw milk can range from < 1000 cfu/ml, where contamination during productions is minimal, to >1 x 10^{65} cfu/ml for milk intended for heat treatment before consumption. cfu/ml. High initial SPC values (eg. >100,000 cfu/ml)are evidence of serious deficiencies in production hygiene, where as SPC values of < 20,000 cfu/ml reflects good sanitary practices. In many countries, a standard for grade A raw milk is an SPC of <1 x 10

Type of aerobic mesophilic microorganisms in fresh milk which form colonies on SPC agar are shown in Table28.1.

Table-28.1: Type of aerobic mesophilic microorganisms in fresh milk

Micrococci	**Streptococci**	**Asporogenes Gram positive Rods**	**Spore former Group**	**Gram -ve Rods groups**	**Miscellaneous groups**
Micrococcus	Enterococcus	Microbacterium	Bacillus	Pseudomonas	Streptomycetes
Staphylococcus	*Streptococcus agalactiae*	Corynebacterium		Acinetobacter	Yeasts
	Streptococcus uberis	Arthrobacter		Flavobacterium	Moulds
				Enterobacter	
				Klebsiella	
				Aerobacter	
				Escherichia	
				Serratia	
				Alcaligenes	

Table-28.2: Thermoduric and Psychrotrophic Microorganisms in Raw milk

Thermoduric Genera[1]	**Psychrotrophic Genera[2]**
Microbacterium	Acinetobacter-Morexella
Micrococcus	Flavobacterium
Bacillus spores	Enterobacter
Clostridium spores	Alcaligenes, Bacillus
Alcaligenes	Arthrobacter

1-Survive heating at 63°C for 30 min

2-Visible growth at 5-7°C in 7-10 days.

The most commonly occurring psychrotrophs in raw milk are the GNRs (Gram negative Roads). Pseudomonas spp. accounts for at least 50% of the GNRs with *Pseudomonasfluorescens* predominating. Other species include pseudomonas putida, *P.fragi*,*P.aeruginosa*, Flavobacterium, Acinetobacter-Moraxella, Achromobacter, Alcaligenes, Chromobacterium, Aeromonas,Klebsiella, and Coliform group comprise most of the remaining psychrotrophsic GNRs. The majority of these coliforms are the Aerobacter spp. By using the most probable number (MPN) or membrane filter method for quantifying coliform, ananalyzed sample of 100ml of water may not have more than 1.1 MPN or 1 cfu on a membrane filter to be considered an acceptable potable water supply.

28.2.2. Microflora of Pasteurized Milk

- The microflora of pasteurized milk is primarily bacterial in nature, originate from
- Thermoduric organisms present in raw milk supply
- Raw milk contact with contaminated handling and processing equipment
- Entry after the pasteurization process.
- Typical total bacterial numbers in freshly pasteurized milk are less than 1000 cfu/ml.

28.3. CREAM

In fresh cream, the predominating organisms at 50°C are pseudomonas,Alcaligenes, Acinetobacter, Aeromonas, and Achromobacter, and at 30°C, are Corynebacterium, Bacillus, micrococcus, Lactobacillus and Staphylococcus. EU standards (EEC, 1992)for pasteurized cream is shown in Table- 28.3

Table-28.3: EU standards for pasteurized cream

L. monocytogenes	Absent in 1g
Salmonella spp.	Absent in 25 g

28.4. BUTTER

Historically, butter has not been regarded as high risk products. However, the presence of a potentially pathogenic genus given an indication of a post process contamination problem. EU regulations require *L.monocytogenes*to be absent in 1g butter, salmonella spp to be absent in 25 g and coliform in butter made from pasteurized cream to be <10^5. Butter and anhydrous milk fat (butter oil) are products made under careful control from cream that has been heat treated at a relatively high temperature. Therefore, a very high microbiological quality is to be expected, and spoilage is usually the result of chemical changes producing rancid and other off flavours. Tests for yeasts, moulds, mesophilic bacteria, coliforms and the presence of lipophilic organisms should be carried out. However, in particular the presence or absence of *Pseudomonas fragi* should be noted, as these organisms can cause unpleasant taints in butter. Butter should preferably be stored at a temperature below -20°C and as for all the ingredients, careful stock control should be ensured.

Standards for maintaining the quality of the ingredient:

In India, the Bureau of Indian standards (BIS) has prescribed a maximum limits for total count of 2,50,000/ g and coliform count of 10/g. Also the ice cream should be phosphatase negative. However the BIS standards are not mandatory. In UK,a modified methylene blue test has been valuable in helping to raise the hygienic quality of ice cream to high level. The International Commission on Microbiological Specifications for Foods (ICMSF) suggested the limits for ice cream as show in Table28.4.

Table-28.4: ICMSF Standards for plain ice cream

Microbiological test	Acceptable (Max. per g)	Defective (≥ per g)
Standard plate count	10^4	2.5×10^5
Coliform	10	10^3
Staphylococcus aureus	10	10^2
Salmonella spp	Nil	Nil

Table-28.5: Suggested microbiological tests for Raw Materials

Raw material	Microbiological tests
Milk	SPC, coliform count
Milk powder	SPC, spore count
Butter	SPC, yeast and mould, coliforms, lipolytic count
Cream	SPC, coliform count
Sugar	SPC, yeast & mould , coliform
Confectionery item	SPC, coliform, yeast & mould, staphylococci

28.5. PROCESSING STANDARDS

Table-28.6: Minimum heat treatment for pasteurization of ice cream mix

Method	Temperature	Time
LTLT	69°C (155 °F)	30 min
HTST	80 °C (175°F)	25s
	83 °C (180 °F)	15s

28.6. CONCENTRATED MILKS

Skim milk powder may, on occasion,contain numbers of *Bacillus cereus*.In addition *Listeria monocytogenes* may survive the typical spray drying process and thus dried milk may serve as a source of Listeria.

The American Dry Milk Institute has classified skim milk powder intended for human consumption into two grades:-

- Extra grade – The bacterial count must be less than 30,000 cfu/ml when 10g of powder is suspended in 100ml of sterile water.
- Standard grade – The bacterial count must be less than 100,000 cfu/ml of the above said suspension.

28.7. SUGARS

The number of organisms contributed to the ice cream mix by the sugar is usually insignificant. However it was found to be necessary to heat the sugar solution separately in the form of a solution to 112.7° to 115.5°C, in order to meet the rigid standards which classify ice cream with a count of less than 10,000/g as good and with a count of less than 50,000/g as fair. Granulated sugar, as well as other dry sugars such as dextrose, should be almost sterile, and the only organisms that may normally be present are small numbers of yeasts. Sugar syrups, sucrose, corn syrups, or mixtures of these, or lactose and whey syrups, again may contain some yeasts. It is suggested that tests for yeasts should be made on bulk deliveries of sugar and sugar syrups.

Typical manufacturer's maximal standards for microorganisms in syrups are: SPC, 100 cfu/g; yeasts, 20 cfu/g: moulds, 20 cfu/g *Escherichia coli* absent in 30g and Salmonella absent in 100g.

28.8. FLAVORING AND COLORING AGENTS

Other food stuffs added to icecream include flavoring and coloring materials. They include fruits [canned, fresh or frozen (in concentrated sugar syrup)], nuts, chocolate, broken biscuit, colors and flavors. Most of these should be of a satisfactory microbiological standard, particularly canned fruits, but fresh and frozen fruits may contain yeasts; nuts may be infected with moulds (with the risk of a flatoxin); and desiccated coconut may be a hazard because it can be contaminated by Salmonella and should be heat – treated. The examination of these materials should include a visual inspection and the enumeration of mesophilic bacteria, coliform, yeasts and moulds.

Colors may be infected by careless handling and this must be avoided by maintaining good management control. Flavors are normally added to the mix after it has been heat treated, and so they must also be handled with great care to avoid contamination.

Flavouring ingredients, mainly vanilla extract, is mostly an insignificant source of bacteria as the concentration of alcohol in the extract effectively prevents any growth. Fresh strawberries have been reported to be a source of *E. coli*.

28.9 Air

Air that is incorporated into the ice cream may be a source of contamination. Therefore, it is of crucial importance that the air be filtered so as to ensure that no contamination can be attributed due to the introduction of air.

****** ☺ ******

Lesson-29

Critical Process Factors - Its Impact on Entry of Pathogens, Their Survival During Storage

29.1. INTRODUCTION

Critical process factors include those important steps during the processing of ice cream which check the entry, growth and survival of the microorganisms and those factors if not optimum may lead to contamination and spoilage of the ice cream.

Some of the critical process factors in the manufacture of ice cream include pasteurization, homogenization, chilling, ageing, freezing and hardening.

29.2.PASTEURIZATION

Pasteurization is one of the main steps that determine the microbiological quality of the finished product. The extent to which pasteurization will reduce the bacterial count depends upon the heating temperature, holding time and the type of organisms present. Fortunately pathogenic organisms are destroyed at a relatively low heat treatment. Bacteriologists agree that the tubercle bacilli (*Mycobacterium tuberculosis*) show the highest heat resistance of those that come into consideration in milk and dairy products; and it has been destroyed at 60°C for 20 minutes of heat treatment. The usual pasteurization temperature of 62.8°C for 30 minutes applied to ice cream mixes therefore allows a generous margin of safety with suspect to all pathogenic organisms that may be present. Pasteurization in excess of 62.8°C for30 minutes is helpful in eliminating *E. coli* and *Aerobacteraerogenes.*

29.3. HOMOGENIZATION

The opportunities for recontamination are considerably greater in the case of ice cream mixes than in the case of pasteurized market milk. The pasteurized ice cream mix comes into contact with more pieces of equipment, and some of this equipment is admittedly difficult to sterilize. Two factors are involved in producing an increase in the bacterial count of ice cream mixes on homogenization,

a. Contamination from the homogenizer

b. The breaking up of the group's of bacterial cells.

A study revealed that the average plate count before and after homogenization of ice cream mix were 14,500 and 49,236 respectively which has accounted for an increase of 239.5%.

From various studies it was found that homogenization will usually cause an increase in the plate colony count because it breaks up groups of bacterial cells, but in addition the count will be increased due to organisms harboured in the machine. The latter factor can be controlled by efficient washing and sterilization with scalding hot water or chemical sterilizers. The piston packing represents an important source of contamination and the ideal procedure would be to replace the packing daily.

29.4. CHILLING/COOLERS

Coolers may act as an important source of contamination if they are carelessly washed and sterilized. Surface coolers should be sterilized by pumping water at 82.2° to 87.8°C over them in ample amounts so that the entire surface is actually heated. Chemical sterilization with chlorine at 100 ppm level is advocated. Tubular coolers can also be sterilized with hot water. Chemical sterilization is frequently used and it should be done just before the equipment is used.

29.5. AGEING

If ageing conditions are moderately good, there will be little increase in the bacterial count of the mix. It is well known that the growth of bacteria is very slow at the temperatures commonly used in ageing ice cream mixes. The ageing procedure should therefore be undertaken only if accompanied by a program of efficient sterilization of equipment.

29.6. FREEZING AND HARDENING

An increase in the plate colony count which is commonly observed when the mix is frozen into ice cream involves two factors

a. Breaking up of group of cells

b. Actual contamination from the freezer.

The latter factor is therefore difficult to evaluate, but it is obvious that the freezer may be as important source of bacteria if it is carelessly washed and sterilized. During the hardening of ice cream and storage in a hardened condition there is usually a gradual decrease in the bacterial count. While there is no agitation involved in the hardening, the scattering of cell groups may still tend to increase the count due to the disrupting effect of the ice crystal formation.

During the storage of ice cream in a hardened condition at -17.8°C, or lower there is a gradual decrease in the count, but this is slow that it is of no value in the problem of meeting bacterial standards. Temperature fluctuations during storage are likely to have an effect on the count. Slight softening of the ice cream is likely to cause an increase in the count.

****** ☺ ******

Lesson-30

Legal Standards, Microbiological and Safety Aspects of Ice Cream

30.1. INTRODUCTION

Food poisoning is defined as an illness caused by the consumption of food or water contaminated with bacteria and / or their toxins, parasites, virus, or chemicals.

Food poisoning outbreaks may be broadly discussed under two periodical heads:-

I. Historical outbreaks

II. Recent outbreaks.

30.2. HISTORICAL DISEASE OUTBREAKS

In UK there were several outbreaks of food poisoning before the IInd World war, as there was no heat treatment requirement at that time. Consumption of ice cream was a major cause for two historical outbreaks of one in the year 1945 and another in1947.

In 1945, the food poisoning outbreak was due to *Staphylococcus* spp. which were introduced into batches of ice cream mix after the ingredients have been cooked. The mix was allowed to cool slowly overnight and was frozen 26-30hrs later. Around 700 peoples were affected by a staphylococcal toxin, which developed during the period.

In 1947, a major outbreak of typhoid fever occurred during the summer of 1947 in Aberystwyth, soon after ice cream manufacture was allowed again after several years of being prohibited during the war. About 210 cases were reported, including 4 deaths, and ice cream from one particular source appeared to be the common factor. Investigation revealed that the source of pathogen (*Salmonella typhi*) in ice cream was urine.

Other food poisoning cases reported were a paratyphoid incident at a North Devon holiday resort, which had its source from*S.paratyphi* on the hands of the ice cream vendor and his wife. A case of *Shigella* poisoning characterized by dysentery in a child who had consumed ice cream licked by monkey in a pet corner of a store. *Shigella* was isolated from the stool samples of the ill child.

Between 1950 & 1955, there were 11 outbreaks of food borne disease in UK due to consumption of ice cream and ice lollies involving *Salmonellae*, two including *Staphylococci* and mix of unknown cause.

Since 1955, only few outbreaks were reported from ice cream and it is certainly due to the fact that the heat treatment regulations introduced in 1947, became effective from 1950.

30.3. RECENT DISEASE OUTBREAKS

In the last 3 decades most serious outbreaks of food – borne infections from ice cream were due to *Salmonella Enteritidis* in US.

Table- 30.1: Outbreaks of food borne disease caused by the consumption of ice cream

Year	Country	Pathogens involved
1989	Belgium	*Listeria monocytogenes*
1992	South West England	*Salmonella enteritidis*
1993	Wales	*Salmonella enteritidis*
1994	US	*Salmonella enteritidis*

Epidemiologist from the Minnesota Department of Health calculated that 29,100 Minnesotans became ill after eating ice cream and up to approximately 224,000 people in US were infected. Investigations revealed that the cross contamination of a pasteurized ice cream premix occurred during transport in tanker trailor that had previously handled non pasteurized liquid eggs containing *S. enteritidis*.

Two out of 20 outbreaks associated with the consumption of milk & dairy product between 1992 & 1996 in England & Wales were associated with ice cream. *S. enteritidis* was the cause in both the cases.

Asporadic case of listeriosis has been reported in Belgium.

30.4. LEGAL STANDARDS

30.4.1.FSSA STANDARDS

1. DAIRY BASED DESSERTS/ CONFECTIONS

1. **Ice Cream, Kulfi, Chocolate Ice Cream or Softy Ice Cream** (hereafter referred to as the said product) means the product obtained by freezing a pasteurized mix prepared from milk and /or other products derived from milk with or without the addition of nutritive sweetening agents, fruit and fruit products, eggs and egg products, coffee, cocoa, chocolate, condiments, spices, ginger and nuts and it may also contain bakery products such as cake or cookies as a separate layer and/or coating. The said product may be frozen hard or frozen to a soft consistency; the said product shall have pleasant taste and smell free from off flavour and rancidity; the said product may contain food additives permitted in these regulation including Appendix A; the said product shall conform to the microbiological requirements specified in Appendix B; the said product shall conform to the following requirements, namely:—

Table-30.2: Standards for ice cream, kulfi, chocolate ice cream or softy ice cream

Requirement	Ice Cream	Medium Fat Ice Cream	Low Fat Ice Cream
(1)	(2)	(3)	(4)
Total Solid	Not less than 36.0 %	Not less than 30.0 %	Not less than 26.0 %
Wt/Vol (g/l)	Not less than 525	Not less than 475	Not less than 475
Milk Fat	Not less than 10.0 %	More than 2.5 % but less than 10.0 %	Not more than 2.5%
Milk Protein (N x 6.38)	Not less than 3.5 %	Not less than 3.5 %	Not more than 3.0 %

Note:In case where Chocolate, Cake or similar food coating, base or layer forms a separate part of the product only the Ice Cream portion shall conform to the requirements given above. The type of ice-cream shall be clearly indicated on the label otherwise standard for ice-cream shall apply.

1. **Dried Ice Cream Mix/ Dried Frozen Dessert/ Confection** (hereafter referred to as the said product) means the product in a powder form which on addition of prescribed amount of water shall give a product conforming to the requirements of the respective products, namely - ice cream, medium fat ice-cream, low fat ice-cream as prescribed under regulation 2.1.7 (1) and frozen confection, medium fat frozen confection and low fat frozen confection as prescribed under regulation 2.1.7 (3) of these regulations except the requirement of weight/volume for both the products. The moisture content of the product shall not be more than 4.0 percent. It may contain food additives permitted in these regulation including Appendix A. It shall conform to the microbiological requirements prescribed in Appendix B.

Frozen Dessert / Frozen Confection (hereafter referred to as the said product) means the product obtained by freezing a pasteurized mix prepared with milk fat and / or edible vegetable oils and fat having a melting point of not more than 37.0 degree C in combination and milk protein alone or in combination / or vegetable protein products singly or in combination with the addition of nutritive sweetening agents e.g. sugar, dextrose, fructose, liquid glucose, dried liquid glucose,maltodextrin, high maltose corn syrup, honey, fruit and fruit products, eggs and egg products coffee, cocoa, chocolate, condiments, spices, ginger, and nuts. The said product may also contain bakery products such as cake or cookies as a separate layer/or coating, it may be frozen hard or frozen to a soft consistency. It shall have pleasant taste and flavour free from off flavour and rancidity and may contain food additives permitted in Appendix A. It shall conform to the microbiological requirements prescribed in Appendix B. It shall conform to the following requirements:—

Table-30.3: Standards for Frozen Dessert / Frozen Confection

Requirement	Frozen Dessert / Frozen Confection	Medium Fat Frozen Dessert / Frozen Confection	Low Fat Frozen Dessert / Frozen Confection
(1)	(2)	(3)	(4)
Total Solid	Not less than 36.0 %	Not less than 30.0 %	Not less than 26.0 %
Wt/Vol (g/ l)	Not less than 525	Not less than 475	Not less than 475
Total Fat	Not less than 10.0 %	More than 2.5 % but less than 10.0 %	Not more than 2.5 %
Total Protein (N x 6.25)	Not less than 3.5 %	Not less than 3.5 %	Not less than 3.0 %

Note: In case where Chocolate, Cake or similar food coating, base or layer forms a separate part of the product only the frozen dessert/ confection portion shall conform to the requirements given above. The type of frozen confection shall be clearly indicated on the label otherwise, standards of frozen dessert / frozen confection shall apply and every package of Frozen Dessert / Frozen Confection shall bear proper label declaration under regulation 2.4.5 (41) of Food Safety and Standards (Packaging and Labeling) Regulations, 2011.

1. **Milk Ice or Milk Lolly** (here after referred to as the said product) means the product obtained by freezing a pasteurized mix prepared from milk and/or other products derived from milk with or without the addition of nutritive sweetening agents, fruit and fruit products, eggs and egg products, coffee, cocoa, chocolate,condiments, spices, ginger and nuts; the said product may also contain bakery products such as cake or cookies as a separate layer and/or coating; the said product shall have pleasant taste and smell free from off flavour and rancidity. It may contain food additives permitted in Appendix A; the said product shall conform to the microbiological requirements prescribed in Appendix B; the said product shall also conform to the following requirements,namely :

(1) Total solids (m/m) Not less than 20.0 percent

(2) Milk Fat (m/m) Not more than 2.0 percent

(3) Milk Protein (Nx6.38) Not less than 3.5 percent

ICE LOLLIES OR EDIBLE ICES

1. **"ICE LOLLIES OR EDIBLE ICES"** means the frozen ice produce which may contain sugar, syrup, fruit, fruit juices, cocoa, citric acid, permitted flavours and colours. It may also contain permitted stabilizers and/or emulsifiers not exceeding 0.5 per cent by weight. It shall not contain any artificial sweetener.

Ice Candy means the product obtained by freezing a pasteurized mix prepared from a mixture of water, nutritive sweeteners e.g. sugar, dextrose,liquid glucose, dried liquid glucose, honey, fruits and fruit products, coffee, cocoa, ginger, nuts and salt. The product may contain food additives permitted in these Regulations and Appendices. It shall conform to the microbiological requirements prescribed in Appendix B. It shall conform to the following requirement: — Total sugars expressed as Sucrose ... Not less than 10.0 percent

APPENDIX A

Table-30.4: List of food additives for use in ice cream & frozen desserts

Sr. No.	Name of Additive	Ice Cream , Kulfi, Dried Ice Cream Mix, Frozen Dessert, Milk Ice, Milk Lolly, Ice Candy
A	**Stabilizers and emulsifiers singly or in combination expressed as anhydrous substance**	
2	Carrageenan	10g/kg max.
6	Pectins	10g/kg max.
7	Sodium carboxymethyl cellulose	10g/kg max.
8	Agar	10g/kg max.
9	Guar gum	10g/kg max.
10	Xanthan gum	10g/kg max.
13	Furcellaran	10g/kg max.
14	Propylene glycol alginate	10g/kg max.
15 (c)	Polyoxyethylene sorbitan tristearate	10g/kg max.
16	Mono and di glycerides of fatty acids	10g/kg max.
17	Methyl cellulose	10g/kg max.
21	Any other emulsifying and stabilizing agents listed in regulation 3.1.6 suitable for these products	40g/kg max.
B.	**Thickner and modifying agent singly or in combination**	
1	Microcrystalline cellulose	10 g/kg max

C	**Modified Starch Singly or in Combination**	
1	Acid Treated Starch	30 g/kg max subject to declaration
2	Alkali Treated Starch	100 ppm max. (only in flavoured & fruit yoghurt)
3	Bleached Starch	100 ppm max. (only in flavoured & fruit yoghurt)
4	Distarch adipate acetylated	100 ppm max. (only in flavoured & fruit yoghurt)
5	Distarch glycerol	100 ppm max. (only in flavoured & fruit yoghurt)
6	Distarch glycerol, acetylated	100 ppm max. (only in flavoured & fruit yoghurt)
7	Distarch glycerol, hydroxypropyl	100 ppm max. (only in flavoured & fruit yoghurt)
8	Distarch phosphate	100 ppm max. (only in flavoured & fruit yoghurt)
9	Distarch phosphate, acetylated	100 ppm max. (only in flavoured & fruit yoghurt)
10	Distarch phosphate, hydroxypropyl	100 ppm max. (only in flavoured & fruit yoghurt)
11	Monostarch phosphate	100 ppm max. (only in flavoured & fruit yoghurt)
12	Oxidised starch	100 ppm max. (only in flavoured & fruit yoghurt)
13	Starch acetate	100 ppm max. (only in flavoured & fruit yoghurt)
14	Starch hydroxypropyl	100 ppm max. (only in flavoured & fruit yoghurt)
D	**Flavours**	
4	Natural flavours and natural flavouring substances/ Nature Identical flavouring substances/ Artificial flavouring substances	GMP subject to declaration
E	**Colours (Natural: singly or in combination)**	
1	Curcumin	100 ppm max.
2	Riboflavin	50 ppm max.
4	Beta Carotene	100 ppm max.
6	Annatto extract on Bixin/Nor bixin basis (50:50 ratio)	100 ppm max.
7	Beta apo-8 carotenal	100 ppm max.
8	Methyl ester of beta apo-8 Carotenoic acid	100 ppm max.
10	Canthaxanthan	100 ppm max.
11	Caramel colours (Plain)	GMP
12	Caramel colours (Ammonium Sulphite process)	3.0 g/kg max.

E	**Colours (Synthetic: singly or in combination**	
13 (a)	Ponceau 4R	100 ppm max.
13 (b)	Carmoisine	100 ppm max.
13 (c)	Erythrosine	100 ppm max.
13 (d)	Tartrazine	100 ppm max.
13 (e)	Sunset yellow FCF	100 ppm max.
13 (f)	Indigo carmine	100 ppm max.
13 (g)	Brilliant blue FCF	100 ppm max.
13 (h)	Fast green FCF singly or in combination	100 ppm max.
J	**Acidifying Agents singly or in combination**	
6	Malic acid (DL-)	GMP
7	L-(+ Tartaric acis & Sodium/Potassium salts)	1 g/kg max.
8	Sodium hydrogen carbonate	GMP
9 (a)	Sodium/Potassium/Calcium orthophosphate expressed as P_2O_5	2 g/kg max. singly or in combination with as P_2O_5
9 (b)	Sodium/Potassium polyphosphate expressed as P_2O_5	
N	Miscellaneous	
1	Glycerol	50 g/kg max.

APPENDIX B

Table-30.5: Microbiological parameters for ice cream mix, ice cream , frozen dessert, milk lolly, ice candy milk products

Sl. No.	**Requirements**	**Sampling Plan**	**Ice Cream Mix** (Max. cfu/g)	**Ice Cream , Frozen Dessert, Milk Lolly, Ice Candy** (Max. cfu/g)
1	Total Plate Count	m	40,000/g	2,00, 000/g
		M	50,000/g	2,50,000/g
2	Coliform Count	m	10/g	50/g
		M	50/g	100/g
3	*E. coli*	m	Absent/g	Absent/g
4	Salmonella	M	Absent/25g	Absent/25g
5	*S. aureus* (Coagulase positive)	m	-	-
		M	Less than 10/g	Less than 10/g
6	Yeast and mold count	m	-	-
		M	-	Less than 10/g
7	Spore count			
8	(a) Aerobic (*B. cereus*)	m	100/g	-
		M	1000/g	-
9	(b) Anaerobic (*Clostridium perfringens*)	m	10/g	-
		M	100/g	-
10	*Listeria monocytogenes*	M	Absent/g	Absent/g

m = Represents an acceptable level and values above it are marginally acceptable in terms of the sampling plan.

M = A microbiological criterion which separates marginally acceptable quality from unsatisfactory/potentially hazardous quality. Values above M are unacceptable in terms of the sampling plan and detection of one or more samples exceeding this level would be cause for rejection of the lot.

Table-30.6: BIS requirements for Ice-cream (BIS: 2802-1964)

Sl.No	Characteristics	Requirement	
		Ice cream	Fruits, Nuts and Chocolate Ice-cream
1	Weight in g per lit. (Min)	525	540
2	Total solids % by weight (Min)	36.0	36.0
3	Milk fat % (Min)	10.0	8.0
4	Acidity % as lactic acid (max)	0.25	----
5	Sucrose % by Weight (max)	15.0	15.0
6	SPC per gram (max)	2,50,000	2,50,000
7	Coliform count (max)	100/g	10/g
8	Phosphatase test	Negative	Negative
9	Odour and Flavour:	The product shall have a pleasant odour and flavour	
10	Texture and appearance:	The product shall be attractive in appearance, smooth in texture and of a uniform consistency and shall have no apparent ice or lactose crystals and as far as possible free from butter fat granules.	
11	Free from dirt	The product shall be free from dirt and such other foreign material.	
12	No fat other than milk fat shall be present in the product with the exception of that derived from eggs, cocoa, nuts and emulsifiers.		

B. Kulfi(BIS:10501-1983)

Kulfi means the frozen product obtained from cow or buffalo milk or a combination thereof or from any other milk products with or without the addition of cane sugar, dextrose, liquid glucose and dried liquid glucose, eggs, fruits, fruit Juices, preserved fruits, nuts, chocolates, edible flavours and permitted food colours.

· Odour and flavours: The product shall have a pleasant agreeable aroma and taste.

· Texture and appearance: The product shall be attractive In appearance, uniform In consistency free from big sized ice-crystals and coagulated milk particles.

· Free from dirt: The product shall be free from dirt and such other foreign

materials.

No fat other than milk fat shall be present in the product with the exception

of that derived from eggs, cocoa, nuts and emulsifiers.

Table-30.7: BIS requirements for Kulfi (BIS : 10501-1983)

Sl.No	Characteristics	Requirement	
		Ice-cream	Fruits, nuts and Chocolate Ice-cream
1	Total solids % by mass (min)	35.0	30.0
2	Milk fat % by mass (min)	8.0	6.0
3	Protein % by mass (min)	3.5	3.5
4	Acidity % by mass (Max) (as lactic acid)	0.3	0.3
5	Sucrose % by mass (Min)	13.0	13.0
6	SPC (Max) per gram	2,50,000	2,50,000
7	Coliform count per gm. (Max)	100	100
8	Phosphatase test of mix	Negative	Negative
9	Presence of starch	Negative	Negative

****** ☺ ******

Module 12 - Recent Advances in Ice Cream Industry and Plant Management

Lesson-31

Low Calorie, Reduced Fat, Diabetic and Dietetic Ice Cream and Frozen Desserts

31.1. INTRODUCTION

Ice milk as defined by the FDA is the food prepared from the same ingredients and in the same manner as prescribed for ice cream, However its milk fat content is more than 2 per cent but not more than 7 per cent, MSNF content not less than 4 per cent, total milk solids content not less than 11 per cent, and it may contain added caseinates;it shall contain not less than 156 g food solids per liter.

Low fat ice cream (i.e. ice milk) may be frozen hard, or sold in the form of a soft serve product, as practiced in the US. In spite of its reduced fat content, it is expected to taste like normal ice cream. Therefore, the formulation in terms of total solids content, and emulsification and stabilization must be such that the resulting product has body and texture characteristics similar to those of ice cream. To be able to be served directly on drawing from the freezer, the low fat product should have dry appearance, and stiff body which necessitates that the right kind of emulsifier system be used in the mix formulation. The soft serve product usually has a lower sugar content (e.g. 13 per cent with30-34 per cent TS) as compared to the hard frozen product (15 per cent with 35-38 per cent TS). A good quality low fat ice cream contains 6.0 per cent fat, and 12.5 per cent MSNF, can be obtained by using 0.35 per cent stabilizer (a 70:30 blend of Isabgul husk and guar gum) and 0.08 per cent tween 80 as emulsifier and ageing the mix for 16h.A soft serve ice milk composition has reported to include 1 per cent Lecithin,0.15 per cent pectin and 0.1 per cent xantan gum and/or locust bean gum.

While formulating a low fat ice cream, those ingredients which can make up for the reduced fat content with regard to the mouth feel of the product get special considerations. Fat sparing or fat substituting ingredients include microcrystalline cellulose, malto – dextrin's, sodium caseinate, whey protein concentrate, preparations containing egg white, soy proteins etc. Milk protein isolates may be sought to impart the desired sensory attributes, but the quality of ice milk has been found to be more dependent on stabilizer /emulsifier. Often standard ice milk is cultured with suitable starter culture to produce frozen yoghurt.

The ever increasing demand of health conscious consumers to lower the daily fat intake has prompted change in many food products, and a recent trend in ice cream formulation has been to reduce the calorific contribution of fat in the mix. Ice cream made with 25 percent fat or less fat than the reference ice cream is labeled on reduced fat, where as a light version is also available (i.e.) 50 per cent less fat than the reference ice cream.

Two more products with even lower fat contents are also marketed:

a) Low– fat with not more than 3.0 g of fat per serving and

b) Non– fat with less than 0.5 g of fat per serving.

Low fat ice creams are manufactured with fat substitutes like protein mimetics (e.g. Simplesse) carbohydrates (sucrose polyester) etc.

The international ice cream association has proposed new standard of identity for ice cream related products to FDA as follows:

Table-31.1: New standards of identity for ice cream and related products

Product	Fat content
Ice cream	10 %
Reduced fat or light	2 – 7 %
Low – fat	0.5 – 2 %
Non - fat	< 0.05 %

31.2. LOW CALORIE, DIABETIC AND DIETETIC ICE CREAM AND FROZEN DESSERTS

Low calorie, diabetic and dietetic ice cream and frozen desserts contribute to lower calories or energy from fat and sugars that are present in the ice cream. These products were developed for diabetics or other with specific medical conditions, including obesity. The development and approval of a variety low – calorie sweeteners, fat replaces and other low – calorie ingredients play a vital role in the availability and success of low~ calorie food in general.

Replacing the high calorie yielding ingredients such as fat and sugars that are present in the ice cream and other frozen desserts with artificial sweeteners, fat replacers and low –calorie ingredients yields a final product with low or least calories that are required by diabetic and obese persons.

Numerous low – fat dairy desserts have been introduced over the past decade. During 1989 – 1990, 56 different ice cream lines or extensions, over 260 flavours were introduced. More than one third of these were marketed as low – fat ice milk and frozen desserts.

In mid – 1991, the first sugar free, low – fat frozen dessert, 'simple pleasures height', was introduced. Low calorie, diabetic and dietetic ice cream can be manufactured using the following ingredients

a) Intense sweeteners /artificial sweeteners/sugar substitutes

b) Fat substitutes

31.3. PROBIOTIC ICE CREAM AND FROZEN DESSERTS

In line with the probiotic yoghurt, probiotic ice cream and frozen desserts have been introduced and well accepted by the health conscious consumers. In such products the basic ice cream mix remains the same, however about 1.5 to 2.0% of an established probiotic microorganism (*Bifidobacteriumbifidum*, *Lactobacillus acidophilus*, *Lactobacillus rheuteri*, etc) with or without a prebiotic (oligofructose, inulin etc) is inoculated in the ice cream mix (preferably without sugar which can be added at a later stage) incubated for few hours, aged and frozen as for regular ice cream. Such product is implicated to improve gut health, retard the level of triglycerides and cholesterol in human subjects. Such product is already launched by AMUL.

31.4. INTENSE SWEETENERS/ARTIFICIAL SWEETENERS/SUGAR SUBSTITUTES

These are the important components of low-calorie foods. Sugar substitutes may be either caloric or non – caloric, depending on their metabolism in the body. High – intensity nutritive or calorie sugar substitutes do not contribute significant calories to the products they sweeten because very small quantities of the substance are required to impart sweetener. For example, aspartame provides the same number of calories as sucrose gram for gram, but because it is approximately 200 times sweeter than sucrose, it may be used in very small quantities, thereby contributing negligible calories to the products it sweetens. The sugar substitutes and their relative sweeteners is made on a weight basis and compared to sucrose (standard) and are listed below.

Table31.2: Sweetness Intensity of Sugar Substitutes

Substitutes	Relative sweetness
Crystalline fructose	1.2 – 1.8
Mannitol	0.5
Sorbitol	0.54 – 0.7
Xylitol	1
Isomalt	0.45 – 0.65
Lactitol	0.4
L- sugars	< 1.0
Maltitol	0.85 – 0.95
Acesulfame - k	200
Aspartame	180 – 220
Saccharin	300 – 500
Glycyrrhizin	50-100
Thaumatin	2000 – 3000
Alitame	2900
Cyclamate	30
Sucralose	600

31.4.1.Fat substitutes: Fat substitutes or fat replaces can be classified into 3 groups

(1) Protein based substitutes – eg: Simplesse

(2) Oil compounds

(3) Carbohydrate based substitutes

Some of the fat substitutes that can be used in low– calorie foods are

a) Sucrose polyesters

b) Syntheti coil compounds

eg: Trial poxytricaballylate (TATCA)

Esterified propoxylated glycerol (EPG)

Raffinose polyesters (RPE's)

Olestrin and Prolestra

31.5. FORMULAS FOR DIABETIC AND DIETETIC FROZEN FOODS

Diabetic and dietetic frozen dairy foods are special preparations for persons on restricted diets. Diabetic frozen dairy foods are made in resemblance of ice cream or ice milk using no caloric sweeteners. The ideal fat level for diabetic frozen dairy foods is 6per cent. The ideal butterfat content for dietetic frozen dairy foods is 3-4per cent and should be made free from substitute sweeteners. Sugar substitutes for diabetic frozen dairy foods include hexahydric alcohols, sucaryl (sodium and calcium), and saccharine.

The hexahydric alcohols are classified as sugar alcohols and are made commercially principally from corn sugar and are available as Sorbo (70 per cent of sorbitol and 30% Mannitol). Mannitol has 2 kcal/g and Sorbo has 2.8 kcal/g as compared to 4 kcal/g for sugar. The hexahydric alcohols have about half the sweetening value of sucrose and they affect the freezing point and contribute to the TS as do sugars.

Sucaryl products are non caloric sweetening agents and do not affect the freezing point. Sucaryl sodium is most often used within the rate of 0.8 per cent as it can be added at higher concentration than sucaryl calcium within the rate of 0.5 per cent without affecting the flavor. Sucaryl has a relative sweetness value approximately 30-50 times that of sucrose. Saccharine is a non-caloric sweetening agent. It is excessively sweet and cannot be used in amounts to affect the freezing point or TS. It has a relative sweetness of 300-500 times the sweetness of sucrose. It is used at the approximate rate of 31 g per 100 kg of mix.

Diabetic base products are available commercially to build solids when substitute sweeteners are used. The following formulation are examples of diabetic and dietetic products.

Table-31.3: Composition of diabetic and dietetic products

Constituents	Diabetic medium fat product	Diabetic full fat product	Dietetic product	Low-fat high protein
Fat	6.0	10.0	3.00	2.00
MSNF	10.5	9.0	12.00	13.50
Sucrose	-	-	13.00	13.00
Mannitol (95 %TS)	8.0	8.0	-	-
Sorbo(70 %TS)	8.0	8.0	-	-
Sucaryl (Na or Ca salt)	0.016-0.021	-	-	-
High protein base or diabetic base	3.0	3.0	3.0	3.0
Stabilizer	0.3	0.3	0.35	0.35
TS	33.0	25.5	31.35	31.85

****** ☺ ******

Lesson-32

Developments in Ice Cream Industry

32.1. INTRODUCTION

Many of the new technologies in the plant are computer-automated and designed to work together. This increases efficiency, reduces energy usage, maintains a consistent level of ingredients and allows the ice cream factory to consistently achieve a creamy texture in its ice cream products. Perhaps the most sophisticated hardware among these is the continuous freezer, and it's the machine that continues to offer new innovations for the ice cream maker. These innovations include machines that are adaptable to off-the-shelf PLC controls, machines that offer faster start up and other features designed to reduce waste, and even a new feature that automatically adjusts airflow rates to compensate for fluctuations in barometric pressure.

Unlike traditional continuous freezers which chill ice cream mix down to -6°C, the Hoyer Frigus LF 1000-F1 freezes the mix rapidly to –12°C prior to filling. Filled products can, in many cases, be transported direct to the cold store, sidestepping the cooling tunnel and securing maximum production throughput. This efficient freezing capability paves the way for even more cost savings via fat reduction. Due to the formation of smaller crystals when frozen at very low temperatures, low-fat ice cream can maintain a high level of creaminess and a warm, full-bodied mouth feel. New low temperature continuous freezers are allowing processors to manufacture ice cream that tastes creamier at lower fat levels. Such technology is being applied to extruded novelties, and works particularly well for ice cream sandwiches. An added benefit is that the processors have more time between extrusion and hardening to work with the product, meaning more opportunities for packaging.

The CS Freezer from WCB Ice Cream line was engineered to provide features, which make a cleanable and 'open' freezer design, with accessibility to the heart of the machine for quick wash down. Such freezer allows for low initial capital investments while providing consistent product. Automatic WS Freezers feature the visco-control system to maintain constant ice cream viscosity, whether it is stiff and dry for extrusions, or soft and flowable for mold filling. Such freezers are designed for easy cleaning and maintenance. The WS-EU freezer by the WCB Ice cream has a simplified control system, including a color touch-screen and electronic level control for ammonia or Freon. Other features include open design for easy cleaning and maintenance access, modular design: 1, 2, or 3 cylinders and low cost for maintenance. Capacity ranges up to 3,000 lit/h. It is simple to operate, and features all stainless steel wash down construction.

In a recent Gram freezer, the mix is pumped in at 2.2° to 3.3°C, the overrun is automatically adjusted, with the smart mass flow meters and air flow correction. The controls also monitor and allow automatic operation of parts during the CIP mode. The freezers offer faster start up with less waste and a consistently high-quality product. The employee can start the freezers up in the morning and set your recipe and you can basically let the freezers run all day long and monitor the process and be confident of its performance while focusing on the rest of the operations.

The condition under which 'Gelato' is dispensed from the freezer is critical. Some gelato freezers are capable of discharging product at temperatures as low as -12.8°C (typical ice cream draw temperatures are -6.6 to -4.4°C). Some freezers adjust dasher speed in response to changes in temperature. Gelato maybe dispensed semi-soft from the freezer into pans, in which it is presented for viewing at the point of consumption in special "dipping" cabinets designed for enhanced viewing of multiple products. Added eye appeal is created by artistically distributing particulates or syrups appropriate to a particular flavor over the surface. Additional appeal is created by sculpting the surface into fanciful shapes.

32.2.OVERRUN ACCURACY

To control overrun, one method is the barometric pressure feature,another is a mass flow meter that helps compensate for air in mix, which is particularly problematic in rework. Barometric air pressure changes can result in up to 6.0% change in the amount of air that is dissolved into the ice cream. So having a freezer that can automatically compensate is very beneficial. Another concern that is addressed by new features in continuous freezers is of air pockets in the mix. Such phenomena are a fairly common problem when reworked ice cream mix is introduced to the freezer. Most manufacturers think that a standard mass flow meter will solve the problem, but unless it is sensitive to density, it only makes the problem worse. What is actually needed is a sophisticated mass flow meter with accurate density measurements that tells you how big is the flow change so that we can use that information to compensate for the air in the mix.

Some of the features of recently fabricated continuous ice cream freezers involve constant overrun; optional automatic viscosity and overrun control, two dasher choices tailored to customer's product and various options to meet production needs. It is all stainless steel frame with capacity up to 1060 lit./hr. capacity.

32.3. CRYOGENIC HARDENING

Most ice cream products have to undergo a hardening phase after they are formed, and the most common tools for achieving this are tray hardening tunnels or spiral hardeners.

When individual half liter packages of vanilla ice cream were immersed in liquid nitrogen at -320°F (-160°C) for 1 min, bagged together in groups of 8 packages and placed in hardening cabinet at -9°F (-12.8°C),the product had good body and texture. A center temperature of -30°F(-1.1°C) in half liter package could be reached in less than 5 min.with outer temperature of the product at -250°F (-121°C)or lower. One minute immersion per half liter of ice cream was considered the maximum treatment to which ice cream could be subjected without adversely affecting its body and texture. Liquid nitrogen requirement was 0.56 kg per kg of ice cream to be hardened. The ice cream hardened in such manner was decidedly whiter in appearance compared to the one that was hardened slowly. However, after 2 week storage pronounced shrinkage was evident.

The Cryoline CS spiral acts as a heat exchanger, in which the liquid nitrogen is sprayed directly on the product,thus efficiently extracting heat from it. The cold gas generated is circulated around the products and the 28 m^2 belt, the gas is then extracted by the exhaust system. The freezer uses a disposable plastic film which travels through a conventional freezing tunnel in contact with cold plates. The chilling for these plates is generated by the vaporization of liquid nitrogen at -196°C, giving very fast and effective freezing to the contact surface of the product.

32.3.1. Nitrogen refrigerated hardening tunnels

In Sweden, there is an ice cream factory where ice cream cones at the rate of 14,000 – 16,000/h is sprayed with liquid nitrogen for hardening. The cones are pre-cooled by exhaust nitrogen in the first section and finally frozen in the second section.

32.4. QUALITY POLICY

- Delight the customer by analyzing and reviewing customer feedback and provide new varieties and flavours.
- Monitor and measure all the process parameters and reduce the in process rejection level.
- Increase the market share and customer's base.
- Meet delivery schedule as committed.
- Train the employees continually and improve upon retention period.
- Reduce the down time of plant and production equipment and improve productivity.
- Be always in compliance with ISO 9001-2008 and HACCP management system.

The mission of the ice cream plant is development, implementation and maintenance of an Integrated Management System based on the following standards:

- ISO 9001 (Quality Management System),
- ISO 14001 (Environment Management System),
- ISO 22000 (Food Safety Management System),
- OHSAS 18001 (Occupational Health & Safety Audit System),
- HACCP Codex Alimentarius (Hazard Analysis Critical Control Points) principles and other norms and regulation concerning the food industry

The waste water that comes out of the dairy plant is treated in Effluent Treatment Plant to reduce the BOD and COD of the waste. Such treated water is utilized for watering the gardens and farms.

32.4.1. Emphasis on Food Safety

HACCP procedures are refined every year. The company runs quality assurance tests in its lab and sends samples to a third-party lab. Everything gets tested twice.

All the employees of ice cream plant are fully trained and certified for their job responsibilities and participate in an annual safety review. Most companies publishes a monthly newsletter (i.e. 'Scoop on safety')to reinforce safety tips and procedures. Enhanced ergonomic features in the new layout and equipment include conveyors at comfortable heights for less lifting and an overall improved environment.

The people there have been well trained in aspects of personal hygiene, from using cutlery to how to use the washrooms. Anyone going into the production area must have a shower and change into a set of clothes given by the dairy plant. Each time they step out, they need to do this before they go back in.

The company may plan a "robust" HACCP plan and a thorough emergency contingency plan is in place. The company ensures a very stringent vendor qualification program. Through the HACCP program, a robust vendor evaluation is created and high standards of vendors is required. The company performs weekly and monthly self-audits. The managers work with suppliers to ensure full traceability of products, ingredients and packaging, which is in full compliance with the food defense program.

Few companies may have one CIP program for its raw processing operations and another CIP for pasteurization. The mix room and the production room each receive a thorough wash down at the end of each day. CIP tanks on the production floor clean implements and other accessories. The plant may have anon-site lab where all incoming ingredients and finished products undergo general microbiological and organoleptic testing. Basic microbiological testing is done on site, however an extra step may be taken by sending samples to an outside lab for further testing. Multiple samples are taken at various stages throughout each product run. QC technicians look for proper taste, texture,color, consistency of mix-ins as well as a battery of microbiological tests. Testing is performed by their own quality assurance manager with assistance from the plant manager, production manager, lead flavor man and a designated daily taste panel. Standard Operations Procedures are strictly adhered to while manufacturing ice cream.

32.5. PREVENTING CHANCES OF ACCIDENTS IN ICE CREAM PLANT

The ice cream section may also be prone to accidents if proper care and maintenance is not exercised. The following tips can help in avoiding any chance of accident.

Whenever the floor is wet (after cleaning) signboard indicating 'Wet floor' should be displayed.

Inside the hardening room, a provision of alarm should be there in case the door handle gets locked; outside the hardening room a flash bulb and buzzer should operate in such circumstances.

Due care should be taken to monitor leakage of refrigerant in the refrigeration plant.

No blades or sharp devices should be entertained in the ice cream section.

****** ☺ ******