TECHNOLOGY OF ANIMAL FOODS

UNIT – I

MILK

PHYSICAL PROPERTIES

Colour and optical properties

Milk appears turbid and opaque owing to light scattering by fat globules and casein micelles. Optical properties are influenced by the manner of scattering of light by the molecules. Light scattering occurs when the wavelength of light matches the magnitude of the particle. Thus, smaller particles scatter light of shorter wavelengths and vice versa. Skim milk appears slightly blue because casein micelles scatter the shorter wavelengths of visible light (blue) more than the red. Beta-carotene, the carotenoid precursor of vitamin A, is responsible for the creamy colour of cow milk. The greenish tinge in whey is due to the presence of riboflavin. Refractive index of milk is an optical property and ranges from 1.3440 to 1.3485 at 20ºC. The relation between solids content of milk and refractive index is linear.

Flavour of milk

The natural sweet flavour of milk is due to the combined effect of its components. Off-flavours are very quickly developed in milk owing to several factors. The feed consumed by animals may lead to some undesirable flavours. Bacterial growth in milk causes fruity, barny, malty or acid flavours. Enzyme activities also may lead to unnatural flavours, rancidity due to lipase action being a classic example. Oxidative reactions may cause a cardboard flavour in milk. Processing of milk may produce cooked flavours.

Specific gravity and density

Milk is heavier than water. The specific gravity of cow milk varies from 1.018 to 1.036 and of buffalo milk from 1.018 to 1.038. Though specific gravity varies with temperature, (lower at higher temperature and vice versa), the rate of this variation is not uniform.

The density of milk varies within the range of 1.027 to 1.033 kg/cm3 at 20°C. The density of milk is used to estimate the solids content, to convert volume into mass and vice versa and to calculate other physical properties such as dynamic viscosity. It is dependent on temperature at the time of measurement, temperature history of the sample, composition of the sample (particularly fat content) and inclusion of air.

Viscosity

Viscosity of milk depends on the temperature and the amount and state of dispersion of the solid constituents, mainly casein and fat. Viscosity of the whole milk at 25°C is about 2.0 cp. Cooler temperatures increase viscosity due to the increased voluminosity of casein micelles whereas temperatures above 65°C increase viscosity due to the denaturation of whey proteins. An increase or decrease in pH of milk also causes an increase in casein micelle voluminosity. The effect of agitation on viscosity is not uniform. Sometimes, agitation causes partial coalescence of the fat globules, hence increasing the viscosity and at other times, agitation may disperse fat globules that have undergone cold agglutination, leading to a decrease in viscosity.

Surface tension

The surface activity of milk is related to proteins, fat, phospholipids and fresh fatty acids present in it. Homogenization and heat sterilization increase the surface tension of milk. Milk has a surface tension of 50 dyne/cm at 20°C.

Freezing and boiling points of milk

The freezing points of cow and buffalo milk vary from -0.512 to -0.572ºC and from -0.521 to -0.575ºC respectively. Freezing point of milk is mainly used to determine added water. The boiling point of milk is 100.17ºC.

Acidity and pH

Freshly drawn milk has a pH value in the range of 6.5 to 6.7 and contains 0.14 to 0.18% titratable acid calculated as lactic acid. There is no developed acidity in freshly drawn milk, the slightly lower than the neutral pH being attributed to the presence of carbon dioxide, citrate, casein etc.

Heat stability of milk

Heat stability is defined as the length of time required to induce coagulation at a given temperature or the temperature required to induce coagulation in a given time. The stability of milk system at the high processing temperatures to which milk is exposed for the manufacture of certain products is very important. Caseins and salt balance of milk governs its heat stability. Added citrates, phosphates and calcium have a great impact on the heat stability.

PROCESSING OF MILK

Once the milk has been inspected, it is moved from the tanker and mixed with the rest of the milk supply in a clarifier. Since the milk comes from many different dairy farms, it has different amounts of cream. Therefore, the milk must be blended during a process called standardization until it all contains the same amount of butterfat.

Now, processing can begin. In the first step, milk is pasteurized which means that it is heated by a series of plates then cooled quickly back down to its normal storing temperature. Pasteurization kills any disease-causing bacteria that may be present in the supply and helps to make the milk stay fresher for a longer time period.

The milk then travels to a separator that separates the butter fat out of the milk and then give the milk the proper amount of fat content. During the next step, milk undergoes a homogenization process in which the milk is forced through tiny openings under high pressure. This breaks down the fatty globules of cream so that the cream will not float on top of the milk, and every drop of milk will contain equal amounts of cream.

During processing, vitamins A and D can also be added to the milk in a step called fortification. Furthermore, tests are run regularly on milk samples in the dairy plant labs that check for its water content, fat percentage, and for presence of bacteria. The water that is in milk is not added on purpose, but it is water from the machinery that is accidentally mixed into the milk supply. The maximum water content in milk that government allows is 1.8%. This whole procedure from the standardization of milk to its pasteurization is called processing.

STERILIZATION OF MILK

According to Food Safety and Standards Rules-2011, the term 'sterilization' when used in association with milk, means heating milk in sealed container continuously to a temperature of either 115°C for 15 min or at least 130°C for a period of one second or more in a continuous flow and then packed under aseptic condition in hermetically sealed containers to ensure preservation at room temperature for a period not less than 15 days from the date of manufacture.

Ultra–high temperature processing has been designed to give a commercially sterile product which is free from pathogens and provides little chance of spoilage during transportation and storage under recommended conditions. In contrast to pasteurized milk which may or may not be homogenized, it is essential to homogenize UHT milk so as to prevent formation of a cream plug during extended storage. Various systems exist for the production of UHT milks, each using a different method of heat transfer.

Definition

Sterilized milk may be defined as (homogenized) milk which has been heated to a temperature of 100°C or above for such lengths of time that it remains fit for human consumption for at least 7 days at room temperatures.

Commercially sterilized milk is rarely sterile in the strict bacteriological sense. This is because the requirements for complete sterility conflicts with the consumer's preference for normal color and flavor in the product. The spore-forming bacteria in raw milk, which are highly heat-resistant, survive the sterilization temperature-time employed in the dairy and ultimately lead to the deterioration of sterilized milk.

Requirements

Sterilized milk must:

i) Keep without deterioration, i.e., remain stable and be of good commercial value for a sufficient period to satisfy commercial requirements;

ii) UHT processing can be applied to that milk and milk product which can also be processed using HTST process.

iii) Be free of microorganisms harmful to consumer health, i.e., pathogenic, toxicogenic germs and toxins;

iv) Be free of any microorganisms liable to proliferate, i.e. it should not show signs of bacterial growth.

1. Method of In-bottle Sterilization

The raw milk, on receipt, should be strictly examined by the prescribed physicochemical and bacteriological tests and only high-quality milk should be used for the production of sterilized milk. Care should be taken to accept milk supplies which have no developed acidity and which contain the least number of spore-forming bacteria. The intake milk should be promptly cooled to 5°C for bulk storage in order to check for any bacterial growth. Next, it should be pre-heated to 35-40°C for efficient filtration/clarification, so as to remove visible dirt, foreign matters etc., and to increase its aesthetic quality. The milk should again be cooled to 5°C so as to preserve its quality. It should then be standardized to the prescribed percentages of fat and SNF content in order to conform to the legal standards (which may vary from State to State for both cow and buffalo milk). It must be stored at 5°C until processing. The milk should be promptly pre-heated to 60°C for efficient homogenization to prevent any subsequent formation of a cream layer; usually, single-stage homogenization is carried out at 2500 psi pressure. The homogenized milk must be clarified so as to remove the sediment formed during the homogenization process. The hot milk from the homogenizer should be filled into the (hot) cleaned and sanitized bottles coming from the bottle washing machine and then sealed with special caps (of the crown seal type). The filled and capped bottles should then be placed in metal crates for sterilization by the Batch Process, or fed into conveyors for the Continuous Process. Usually, the milk is sterilized at 110 - 118°C for 15-25 minutes. The sterilized milk bottles should be gradually cooled to room temperature. Any sudden cooling may lead to bottle breakage. Finally the milk-in-bottles should be stored in a cool place.

Advantages

i) Remarkable keeping quality; does not need refrigerated storage

ii) no cream layer/plug

iii) forms a soft digestible curd, and hence useful for feeding of infants and invalids

iv) distinctive rich flavor

v) economical to use

vi) less liable to develop oxidized taints

Disadvantages

i) increased cost of production

ii) more loss in nutritive value than pasteurization (50 per cent of the vitamin C and 33 percent of vitamin B originally present, are destroyed, and there is a slight reduction in the biological value of the milk proteins)

iii) Gerber test by normal procedure not so accurate.

Types of Sterilization Process

Batch process (In-bottle sterilization)

Milk is first subjected to platform tests, clarified and then standardized. It is then pre-heated and homogenized at 145 pa pressure. Milk is then filled in glass bottles which are sealed with crown caps and sterilized.

Semi-continuous In-bottle Sterilization

This method is similar to the one described in Batch process except that an arrangement for rotating the crates is provided. The rotation helps in more uniform and efficient heat transfer, thereby minimizing colour and flavor changes. After the heating process is over, the crates containing the bottles are released into a tunnel of cooling air.

Continuous in-bottle sterilization

In this case sealed milk bottles pass continuously on chain conveyors through the pre-heating water and then to the steam chest for the required temperature and time. Thereafter the bottles move through the cooling water and finally to the atmospheric exit. This method is commonly used by large-scale manufacturers of sterilized milk as it helps in efficient energy usage and also for comparatively better colour and flavour of the finished product.

In-can continuous sterilization

This method is the most commonly used throughout the world. It comprises of a pre-heater, a sterilizer and a cooler with a leaking-can detector at the pre-heater and cooler discharge. The sealed milk cans are passed into a pre-heater where the cans are carried through a spiral path inside a drum filled with hot water. The cans then pass through a can detector to observe any leakage and thereafter are subjected to steam under the pressure for sterilization. Finally, the milk cans move through the pressure air cooler and are discharged. Recently a continuous milk sterilizing line with high-temperature short-time operation has been developed. It processes milk for 2 min at 127°C with a resultant improvement in quality mainly in colour and flavour.

2. Ultra high temperature (UHT) method of sterilization

In these processes, the milk is heated to 135-150°C for a few seconds, generally in a plate or tubular heat exchanger. The milk, which is almost sterile, is filled into containers and sealed aseptically in a specially designed aseptic packaging system. The packed milk can be stored at room temperature upto a period of six months.

Tests

• Turbidity test – To ascertain sterilization efficiency

• Bacterial count

Note: Phosphatase test is not applicable to sterilized milk.

Demerit

The most common is browning. Because of this fault, 'Plain' sterilized milk is not so popular. Flavored (and simultaneously colored) sterilized milk is more popular.

PASTEURIZATION OF MILK

Definition (FSSAI, 2006):

The terms ―Pasteurisation, ―Pasteurised and similar terms shall be taken to refer to the process of heating every particle of milk of different classes to at least 63^{0}C and holding at such temperature continuously for at least 30 minutes or heating it to at least 71.5^{0}C and holding at such temperature continuously for at least 15 seconds or an approved temperature-time combination that will serve to give a negative Phosphatase Test. All pasteurised milk of different classes shall be cooled immediately to a temperature of 10^{0}C, or less.

There are two distinct purposes for the process of milk pasteurization:

- **Public Health Aspect -** to make milk and milk products safe for human consumption by destroying all bacteria that may be harmful to health (pathogens)

- **Keeping Quality Aspect -** to improve the keeping quality of milk and milk products. Pasteurization can destroy some undesirable enzymes and many spoilage bacteria. Shelf life can be 7, 10, 14 or up to 16 days. The extent of microorganism inactivation depends on the combination of temperature and holding time. Minimum temperature and time requirements for milk pasteurization are based on thermal death time studies for the most heat-resistant pathogen found in milk, *Coxiella burnetii*.

Methods of Pasteurization

There are two basic methods, batch and continuous.

Batch method

The milk or milk products is heated and cooled in one, two or sometimes more than those tanks. The process involves heating every particle of milk at least to the temperature of 63 ^{o}C for 30 min, and cooled rapidly to below 10 ^{o}C.

The parts of a typical batch pasteurizer are following:

- Insulated outer casing
- Insulated hinged cover
- Stainless steel inner vessel
- Agitator and its motor
- Outlet cock and heating water distribution pipe.

This system is well suited for a small-scale operation, where less than 3000 to 5000 litres of milk are available. The vat may be rectangular, but a vertical, cylindrical design is preferred for practical reasons. The vat normally consists of an inner vessel, surrounded by an insulated outer casting, thus forming a jacket, through which hot water or steam is passed. After the milk has reached the required temperature (63.0°C), it is usually held at that temperature for a certain fixed period (30 minutes). Thereafter, it is cooled as quickly as possible either by circulating refrigerant/chilled water or through a plate/surface chiller. Cooling the milk after pasteurization by circulating a refrigerant – in most cases cold water through the jacket or the vat may take much time. Therefore, a separate small-capacity surface, tubular or plate cooler may be used to rapidly cool the milk to the required temperature. This system also has the advantage that the vat will be available sooner for the pasteurization of another batch of milk.

Batch pasteurizers have a small heating surface area relative to their contents. Heat transfer is greatly improved by agitating the milk. Agitators of different designs are used for this purpose. They may even consist of double-walled paddles or other devices with internal steam or water circulation. Care must be taken to avoid foam formation during the filling of the vat. It is very difficult to heat the milk and foam together uniformly and consequently, microorganisms present in the foam may survive pasteurization. If the inlet valve is at the bottom of the vat, foam formation can easily be prevented. A lid or cover on top of the vat promotes a uniform temperature of the contents and prevents skin formation on the milk

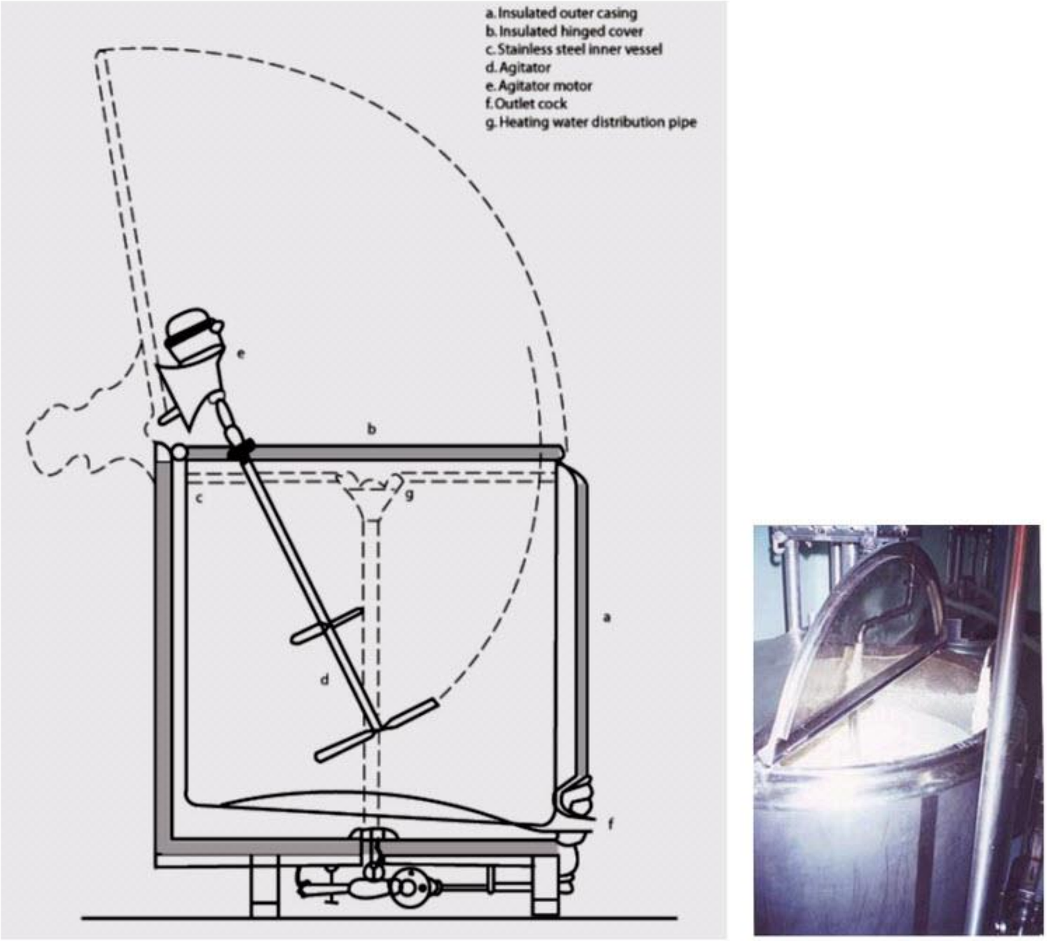


Fig 11.1: Batch Pasteurizer

Continuous Method

The continuous method has several advantages over the batch method, the most important being time and energy saving. For continuous processing, a high temperature-short time (HTST) pasteurizer is used. The heat treatment is accomplished using a plate heat exchanger. This piece of equipment consists of a stack of corrugated stainless steel plates clamped together in a frame. There are several flow patterns that can be used. Gaskets are used to define the boundaries of the channels and to prevent leakage. The heating medium can be vacuum steam or hot water.

Cold raw milk at 4° C in a constant-level tank is drawn into the regenerator section of the pasteurizer. Here it is warmed to approximately 57°C - 68°C by the heat given up by hot pasteurized milk flowing in a counter-current direction on the opposite side of thin, stainless steel plates. The raw milk, still under suction, passes through a positive displacement timing pump which delivers it under positive pressure through the rest of the HTST system.

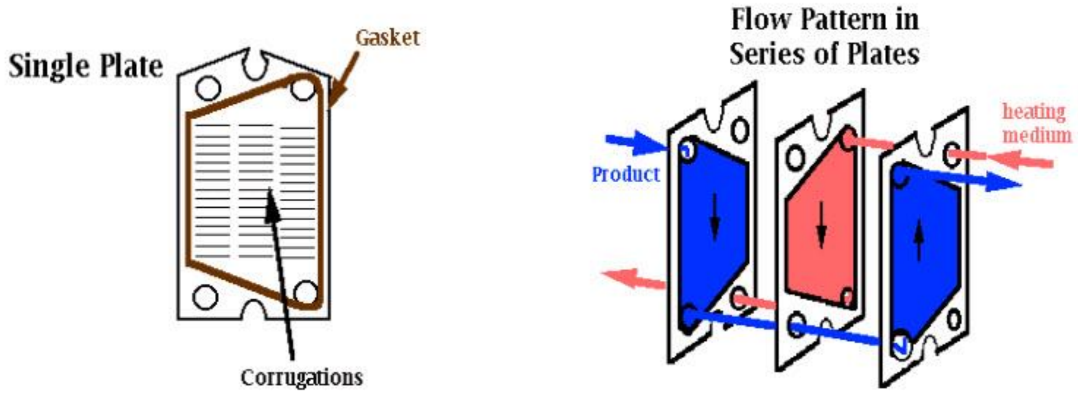


Fig 11.2: HTST Milk Flow Overview

The raw milk is forced through the heater section where hot water on opposite sides of the plates heat milk to a temperature of at least 72° C. The milk, at pasteurization temperature and under pressure, flows through the holding tube where it is held for at least 16 sec. The maximum velocity is governed by the speed of the timing pump, diameter and length of the holding tube and surface friction. After passing temperature sensors of an indicating thermometer and a recorder-controller at the end of the holding tube, milk passes into the flow diversion valve (FDV). The FDV assumes a forward-flow position if the milk passes the recorder-controller at the pre-set cut-in temperature (>72° C). The FDV remains in normal position which is in diverted-flow if milk has not achieved pre-set cut-in temperature. The improperly heated milk flows through the diverted flow line of the FDV back to the raw milk constant level tank.

Properly heated milk flows through the forward flow part of the FDV to the pasteurized milk regenerator section where it gives up heat to the raw product and in turn is cooled to approximately 32° C - 9° C. The warm milk passes through the cooling section where it is cooled to 4° C or below by coolant on the opposite sides of the thin, stainless steel plates. The cold, pasteurized milk passes through a vacuum breaker at least 12 inches above the highest raw milk in the HTST system then on to storage tank filler for packaging.

HOMOGENIZATION OF MILK

Homogenization implies mechanical treatment to break fat globules into smaller sizes of 2µm or less and uniformly disperse them in milk. Homogenization in the dairy industry is used principally to prevent or delay the formation of a cream layer in full cream milk by reducing the diameter of the fat globules. After homogenization, the size of fat globules becomes less than 2µm. The average size of milk fat globule in milk is 2-12µm. The number of fat globules is 3-4 billion in a millilitre of milk.

In the past, pasteurized milk usually was not homogenized, although the flavor of the milk becomes fuller by homogenization. A certain amount of cream was permitted to form to show the consumer clearly the full cream character of milk. Sterilized milk, evaporated or condensed milk and cream are generally homogenized.

History

Homogenization was introduced by Buttenberg (1903) of Germany, and later developed in 1904 in London and the milk produced by this process was known as 'Gaulin milk'.

Definition

Homogenization can be defined as the process in which fat globules in milk are broken down to a size small enough to prevent the formation of a cream layer. Homogenizer is a machine, which disintegrates the fat globules of milk.

According to the United States Public Health Services (USPHS), 'homogenized milk is one that has been treated in such a manner as to ensure the break-up of the globules to such an extent that after 48 hours of quiescent storage, no visible cream separation occurs in milk and the fat percentage of the milk in the upper 10% portion, i.e., in the top 100 ml of milk in a quart bottle or of proportionate volumes in containers of other sizes, does not differ by > 10% of itself from the fat percentage of the remaining milk, as determined after thorough mixing'.

The number of fat globules in homogenized milk is about 10,000 times greater than those in unhomogenized milk. The size of fat globule is reduced to < 1 micron, while normal fat globule size averages 2 – 12µm in milk. The number of fat globules will be increased, but total volume of fat globules will remain almost same. The surface area of newly formed smaller fat globules is increased by 4-6 folds.

Merits of Homogenization

- No formation of cream layer/plug
- Fat will not churn
- Thick body and rich appearance
- Produces soft curd, easily digestible
- Less susceptibility to oxidation

Demerits

- Increased cost of production
- Fat from returned homogenized milk is difficult to salvage.
- Sediment is greater
- May produce rancidity if the temperature is not kept adequately high.

CENTRIFUGATION OF MILK

Cream is a fatty product of milk, and creams of different fat contents can be prepared by the separation of milk fat from non-fat solids portion of milk. Market creams for retail sale are made with different fat contents according to the intended use. Cream is a richly flavored product, which makes it desirable for use in applications such as desserts, cakes and some chocolate confectionery. It is also used in some beverages like coffee and cream liqueurs.

In dairy industry, the process of separating milk into cream and skim milk is known as separation. Cream comprises of fat concentrate in milk. Milk fat can be removed in the form of cream and the remaining portion is serum referred to as skim milk. The skim milk contains predominantly SNF and is having very little fat.

Method of Separation

Separation of milk can be carried out by the following methods

- By gravity
- By centrifugal force

Separation by gravity

Earlier, this technique was used in dairies to separate fat from milk. Milk was left in a vessel where, after some time (hours), the fat globules aggregate and float on the surface forming a layer called '*malai*' on top of the milk. There are two types of gravity separation as discussed below:

(a) Shallow pan method

The milk is poured into the pans, immediately after milking. The pans, which are four inches deep, are placed preferably in a cool place. Skimming is done at the end of 24 h, and by this time, the milk below the cream is coagulated. Skim milk from the shallow pan system contains 0.5-1.5% fat.

(b) *Deep setting method*

In this method, milk is set in 20 inches deep cans which are 8"-15" in diameter, maintained at 8-10°C. Glass strips are inserted in the wall of the can, one near the bottom and the other near the top, to absorb cream. Due to low temperature better quality product results. After 12-14 h of storage, the fat layer from the top is skimmed off leaving skim milk in the container.

Advantages of Centrifugal Separation over Gravity Separation

- Speed of separation is greater (instantaneous) for centrifugal separation.
- Bacteriological quality of cream and skim milk is superior in centrifugal separation than gravity separation.
- Greater fat percentage of cream is possible using centrifugal separation (25-80%) vs. gravity separation (10-25%).
- Fat recovery in cream is 99-99.5% for centrifugal separation. Such value for gravity separation is about 75% or so.

PRESERVATION OF MILK

CONDENSED MILK AND EVAPORATED MILK

Condensed milk are the milk obtained by evaporating part of the water of whole milk, fully or partly skimmed milk, with or without the addition of sugar. The term 'condensed milk' is commonly used when referring to "full cream sweetened condensed milk" while the term evaporated milk is commonly used when referring to 'full cream unsweetened condensed milk'. Skimmed milk products are known as "sweetened condensed skim milk" and “unsweetened condensed skim milk”. The ratio of the concentration of milk solids is about 1: 2.5 for full cream products and 1: 3 for sweetened condensed skim milk.

According to the PFA (1976), the various condensed milk have been specified as follows:

- Unsweetened condensed milk (evaporated milk) is a product obtained from cow or buffalo milk or a combination therefore, or from standardized milk, by the partial removal of water. It may contain added calcium chloride, citric acid and sodium citrate, sodium salts of orthophosphoric acid and polyphosphoric acid not exceeding 0.3 per cent by weight of the finished product. Such addition need not be declared on the label. Unsweetened condensed milk should contain not less than 8.0 percent milkfat, and not less than 26 per cent milk solids.
- Sweetened condensed milk is the product obtained from cow or buffalo milk or a combination thereof, or from standardized milk, by the partial removal of water and after the addition of cane sugar. It may contain added refined lactose, calcium chloride, citric acid and sodium citrate, sodium salts of ortho phosphoric acid and poly phosphoric acid not exceeding 0.3 per cent by weight of the finished product. Such addition need not be declared on the label. Sweetened condensed milk should contain not less than 9.0 percent milk fat, and not less than 31 per cent milk solids and 40.0 per cent cane sugar.

Indian Standard Specifications for condensed milk

Characteristics	Requirement for	
	Condensed milk	**Skim sweetened**
Total milk solids (%wt.) Min	31.0	26.0
Fat (% wt)	Not less than 9.0	Not more than 0.5 %
Sucrose (% wt.) Min	40	40
Acidity (% lactic) Max	0.35	0.35
Bacterial count (per g.)	500	500
Coliform count (per g)	Negative	Negative
Yeast and mould count (per g.) Max	10	10

Food and Nutritive value of condensed and evaporated milk

- Both have high nutritive value, both are rich in fat and fat-soluble vitamins A, D E and K, body building proteins, bone forming minerals and energy-giving sucrose, Evaporated milk is suitable for infant feeding since it makes a soft curd which is easily digested.

Physico-chemical properties

- Specific gravity/density: Evaporation of water in the manufacture of condensed milk raises their specific gravity/density, which is universally employed to control their composition. Baume hydrometers are widely used for this purpose.
- Freeing point: The freezing point of condensed milk is –14.9ºC and that of evaporated milk is - 1.3ºC
- Colour and flavour: Heat treatment during manufacture of condensed milk tend to darken their color and develop cooked flavour, the darkening/browning-discoloration results from the interaction of the amino-compounds with sugar (casein and lactose) and is called as Maillard-type browning. The brown pigment is called as melanoidin.

Method of manufacture, packaging and storage of condensed milk

Receiving milk

↓

Filtration /Clarification (38-40ºC)

↓

Standardization

↓

Fore warming/preheating (115-118 ºC / No Hold)

↓

Condensing (1:2.5)

↓

Addition of sugar

↓

Homogenization

↓

Quickly cooled to 30ºC

↓

Seeded with 0.1 - 0.3% lactose

↓

Vigorous stirring and slow cooling for 1 hour.

↓

Temperature of 15 ºc reached

↓

Stirring continued until packed.

↓

Storage at 10 ºc.

Details of manufacture

- The basic principle in the production of condensed milk and evaporated milk is that high quality milk is filtered /clarified, standardized, fore-warmed and condensed /evaporated to the desired level. The concentrated product is preserved by the addition of sugar for condensed milk and by heat sterilization for evaporated milk.
- When the milk is received at the plant, its temperature should be at 10ºC or below. The milk should be clean, sweet, and free from off-flavours and odours and reasonably free form extraneous material. Contamination by antibiotics, pesticides and other chemical residues and metals is highly undesirable; abnormal milk should not be accepted. Acid development is objectionable for not only does this indicate an excessive bacterial count, but it also reduces the heat stability of milk.
- The various platform tests and laboratory tests usually performed on the intake milk to determine its acceptance /rejection are
    - Alcohol test
    - Clot on boiling tests.
- **Alcohol test:** To make this test, 5 ml of milk is placed in a test tube and an equal amount of solution with 68 % alcohol added, the mixture is shaken and any formation of clot or flake denotes a positive test, i.e., the milk is susceptible to heat coagulation. A disturbed salt balance affects alcohol coagulation in the same manner as heat coagulation. The test detects: abnormal milk including colostrum. Which is high in mineral salts and developed acidity in milk, mastitis milk likely to result in sweet curdling etc., It is more sensitive than the COB test.
- **Alcohol index:** determined by placing absolute alcohol in the burette and 10 ml of milk in a beaker. The number of ml of alcohol required for flake formation is known as the Alcohol Index (AI). An AI of 7 is indicative of

good stable milk for acceptance, while 3 or less shows that the milk is fit for rejection.

- **Alcohol alizarin test:** This test not only determines the heat stability of milk but also the pH.
- **Clot on boiling test:** In this test, 5 ml of milk is placed in a test tube and kept in a boiling water bath for 5 minutes, afterwards it is removed and examined for precipitation, if curd is observed, the milk is said to fail the COB test and should be rejected.

DRIED MILK

Drying is the separation of a liquid from a compound or blend of compounds by evaporation. The product to be dried exists either in a solid or solid–liquid phase. The separation is into a solid and a gas phase. Dried milk products are manufactured to reduce bulk so as to reduce packaging and the transportation costs, to improve the storage life of the product, etc.,

Definition

- "Dried milk or milk powder is the product obtained by the removal of water by heat or the suitable means, to produce a solid containing 5 per cent or less moisture. The dried product obtained from whole milk is called Dried whole milk or whole milk powder (WMP); and that from skim milk is known as Dried Skim Milk or Skim Milk Powder (SMP), or Non-fat Dry Milk (NFDM).

PFA Legal Standards

- Whole Milk Powder
  - "According to the PFA Rules, (1976), whole milk powder is the product obtained from cow or buffalo milk, or a combination thereof, or from standardized milk, by the removal of water. It may contain calcium chloride, citric acid and sodium citrate, sodium salts of ortho phosphoric acid and poly phosphoric acids, not exceeding 0.3 per cent by the weight of the finished product, and 0.01 per cent of butylated hydroxy anisole (by weight) of the finished product. Such additions need not be declared on the label. Milk powder should contain not more than 5.0 per cent of moisture and not less than 26.0 per cent of fat. The total acidity expressed as lactic acid should not be more than 1.2. per cent. The standard plate count may not exceed 50,000/g and the Coliform count may not exceed 90/g. The maximum solubility index should be 15.0 for roller dried and 2.0 for a spray dried product.
- Skim Milk Powder
  - "According to the PFA Rules, (1976), skim milk powder is the product obtained from cow or buffalo milk, or a combination thereof, by the removal of water. It may contain calcium chloride, citric acid and sodium citrate, sodium salts of ortho

phosphoric acid and poly phosphoric acids, not exceeding 0.3 per cent by the weight of the finished product. Such additions need not be declared on the label. Skim milk powder should contain not more than 1.5 per cent of fat and the moisture may not exceed 5.0 percent. The total acidity expressed as lactic acid should not be more than 1.5 per cent. The standard plate count may not exceed50.000/ g. and the Coliform count may not exceed 90/g. The maximum solubility index should be 15.0 for roller dried and 2.0 for a spray dried product.

Composition

The average percentage composition of whole milk and skim milk powder is given in the following table: (Percentage)

Type of dried milk	Average composition				
	Moisture	Fat	Protein	Lactose	Ash
Whole milk powder	2.0	27.5	26.4	38.2	5.9
Skim milk powder	3.0	0.8	35.9	52.3	8.0

Food and nutritive value

- Under modern methods, the nutritive value of milk is preserved to a great extent. While there appears to be only a slight destruction of lysine in spray drying, the severe heat treatment of roller drying destroys more lysine. Dry whole milk is a good source of vitamin A, calcium and phosphorus. It is also a valuable source of riboflavin.

Milk drying systems

- The manufacturing process consists of unit operations of milk selection and pre-treatment, concentrate manufacture, homogenization, drying and filling/packaging. The basic difference is in the type of drying, and can be achieved in several ways and means.

Drying by Cold Treatment

- Drying milk by freezing out the water and centrifuging. This system was proposed and patented as early as 1884 and is now obsolete.
- Drying milk by freezing and sublimation: This freeze-drying method, which seems to have been developed in 1945, consists of freezing the product and supplying heat, so that moisture is removed by sublimation by maintaining a vacuum in the vaporizing chamber.

Drying by application of heat

- Roller/Film/Drum drying
- Spray drying
- Dough or paste drying
- Foam drying
- Fluid bed drying.

Milk selection and pretreatment

- Milk is selected according to the requirements and clarified and standardized in the usual ways.

Heat Treatment

- Milk or milk products must be heat treated by an officially approved pasteurization process in order to inactivate possible pathogenic or other harmful germs and to inactivate most of the enzymes. Another intensive preheating, such as is normal for evaporated milk, is not required here, because the recontamination germs cannot grow at the moisture levels available in the powders, and protein stabilization is not necessary. On the contrary, very gentle pasteurization is required in order to have the least whey protein denaturation.
- Among the other factors, the quality of skim milk powder is measured by the non-denatured whey-protein-nitrogen index (WPN index), which characterizes the heat treatment involved. From this heat classification the application or utilization of the powder can be derived. For certain applications, e.g., baby food, the classification of the gently heated proteins by the WPN is not sufficient, and other criteria such as the protein number (ratio of casein nitrogen and whey protein nitrogen Vs. total protein nitrogen), organoleptic evaluation of the reconstituted milk or the coagulation and acidification capability (e.g., for cheese manufacture) must be taken into account.
    - For the manufacture of "low-heat" skim powder, the short-time heat treatment must be used; for "high-heat" skim powder, the process temperature is 90ºC for 30minutes.
    - For the production of whole milk powder base, milk is heated to 90-95º C and held for 15-30 should, which is considered optimal.
- The milk is concentrated to its flow limits, i.e., dry matter will be 40-50 %.
- The concentration ratio selected is controlled by the finished product and the drying process; the ratios are as follows: -
- Drum-dried milk powder 1: 3.5-4
- Drum-dried skim milk powder 1: 4-6
- Spray-dried whole milk powder 1: 3.5
- Spray-dried skim milk powder 1: 4-5

UNIT – II

PROCESSING OF MILK BYPRODUCTS

PROCESSING OF CHEESE

The word 'cheese' is derived from the Old English 'cese' which in turn was derived from the Latin 'caseus' which means correct or perfect thing. Cheese may be defined 'as the curd of milk separated from the whey and pressed into a solid mass'. This definition of cheese is satisfactory but too limited and vague from a technical standpoint. Therefore, a relatively complete definition is as follows:

Cheese is the curd or substance formed by the coagulation of milk of certain mammals by rennet or similar enzymes in the presence of lactic acid produced by added or adventitious microorganisms, from which part of the moisture has been removed by cutting, warming and pressing, which has been shaped in mould and then ripened (also unripened) by holding for some time at suitable temperatures and humidity.

The expansion of the number of types of cheese makes a simple definition of cheese difficult. Thus the definition, of the curd produced from milk by enzyme activity and subsequent separation of whey from the coagulum does not cover whey cheese, lactic cheese, cream cheese and some of the cheeses produced by newer techniques, viz. ultrafiltration and reverse osmosis. The definition is, therefore, not universally acceptable.

According to the FSSR (2011), cheese means the ripened or unripened soft or semihard, hard and extra hard product, which may be coated with food grade waxes or poly film, and in which the whey protein/casein ratio does not exceed that of milk. Cheese is obtained by coagulating wholly or partly milk and/or products obtained from milk through the action of non-animal rennet or other suitable coagulating agents and by partially draining the whey resulting from such coagulation and/or processing techniques involving coagulation of milk and/or products obtained from milk which give a final product with similar physical, chemical and organoleptic characteristics. The product may contain starter cultures of harmless lactic acid and/or flavor-producing bacteria and cultures of other harmless microorganisms, safe and suitable enzymes and sodium chloride. It may be in the form of blocks, slices, cut, shredded or grated cheese. FSSR (2011) has also defined cheese on the basis of ripening as follows:

(i) Ripened cheese is the cheese that is not ready for consumption shortly after manufacture butwhich must be held for some time at such temperature and under such other conditions as will result in necessary biochemical and physical changes characterizing the cheese in question.

(ii) Mould-ripened cheese is a ripened cheese in which the ripening has been accomplished primarily by the development of characteristic mould growth through the interior and/ or on the surface of the cheese.

(iii) Unripened cheese including fresh cheese which is ready for consumptionshortly after manufacture.

Cheese or varieties of cheeses shall have pleasant taste and flavor free from off fflavorsand rancidity. It may contain permitted food additives and shall conform to the microbiological requirements prescribed in the regulation.

Classification of Cheese

Several schemes to classify cheese have been proposed to assist international trade and to provide compositional and nutritional information. The basis for such classification includes age, type of milk, country of origin, ripening process/agents, important compositional varieties, like moisture and fat, general appearance, texture and rheological qualities. However, none of the above schemes is complete in itself. There are about 2000 names of cheeses. It is very difficult to classify the different cheeses satisfactorily, in groups. There are probably only about 18 types of natural cheeses. These are: Cheddar, Gouda, Edam, Swiss, Brick, Herve, Camembert, Limburger, Parmesan, Provolone, Romano, Roquefort, Sapsago, Cottage, Neufchatel, Trappist, Cream and Whey cheeses.

Such a grouping, though informative, is imperfect and incomplete. These can also be classified on the basis of their rheology, and according to the manner of ripening as shown below:

1) Very hard (grating) - Moisture < 35% on matured cheese and ripened by bacteria, e.g. Parmesan, Romano.

2) Hard - Moisture < 40%

  a) Ripened by bacteria, without eyes: Cheddar

  b) Ripened by bacteria, with eyes: Swiss

3) Semi-hard - Moisture 40-47%

  a) Ripened principally by bacteria: Brick

  b) Ripened by bacteria and surface microorganisms: Limburger

  c) Ripened principally by blue mould

    i) External – Camembert

    ii) Internal – Gorgonzola, Blue, Roquefort.

4) Soft - Moisture > 47%

  a) Unripened – Cottage

  b) Ripened – Neufchatel

Composition and nutritional value of cheese

Cheese is a nutritious and versatile dairy food. It contains a high concentration of essential nutrients relative to its energy level. Its precise nutritional composition is determined by multifactorial parameters, including the type of milk used (species, breed, stage of lactation, and fat content) and the manufacturing and ripening procedures. In general, cheese is rich in the fat and casein constituents of milk, which are retained in the curd during manufacture. It contains relatively small amounts of water-soluble constituents (whey proteins, lactose, and water-soluble vitamins), which are partitioned mainly into the whey.

Protein

Cheese contains a high content of biologically valuable protein. The protein content of cheese ranges from approximately 4-40%, depending upon the variety. It varies inversely with the fat content of cheese. During cheese manufacture, most of the whey proteins are lost in whey and thus only casein remains in cheese. Casein is slightly deficient in sulfur-containing amino acids. Thus, the biological value of cheese protein is slightly less than that of the total milk protein. Cheese protein is almost 100% digestible, as the ripening phase of cheese manufacture involves a progressive breakdown of casein, to water-soluble peptides and free amino acids. Hence, a significant degree of breakdown of cheese protein has occurred before it is consumed and subjected to the effects of gastrointestinal proteolytic activity. A range of bioactive peptides are released during the proteolysis of cheese, which exert specific health benefits to the human body (e.g. the peptides that inhibit the activity of angiotensin-I converting enzyme which give rise to antihypertensive and immunomodulatory effects).

Carbohydrate

The principal carbohydrate in milk is lactose, most of which is lost in whey during cheese manufacture. Only a trace amount of carbohydrate remains in the cheese, this too is hydrolyzed by starter lactic acid bacteria. Cheese is, therefore, a safe food for lactose-intolerant people.

Lipids

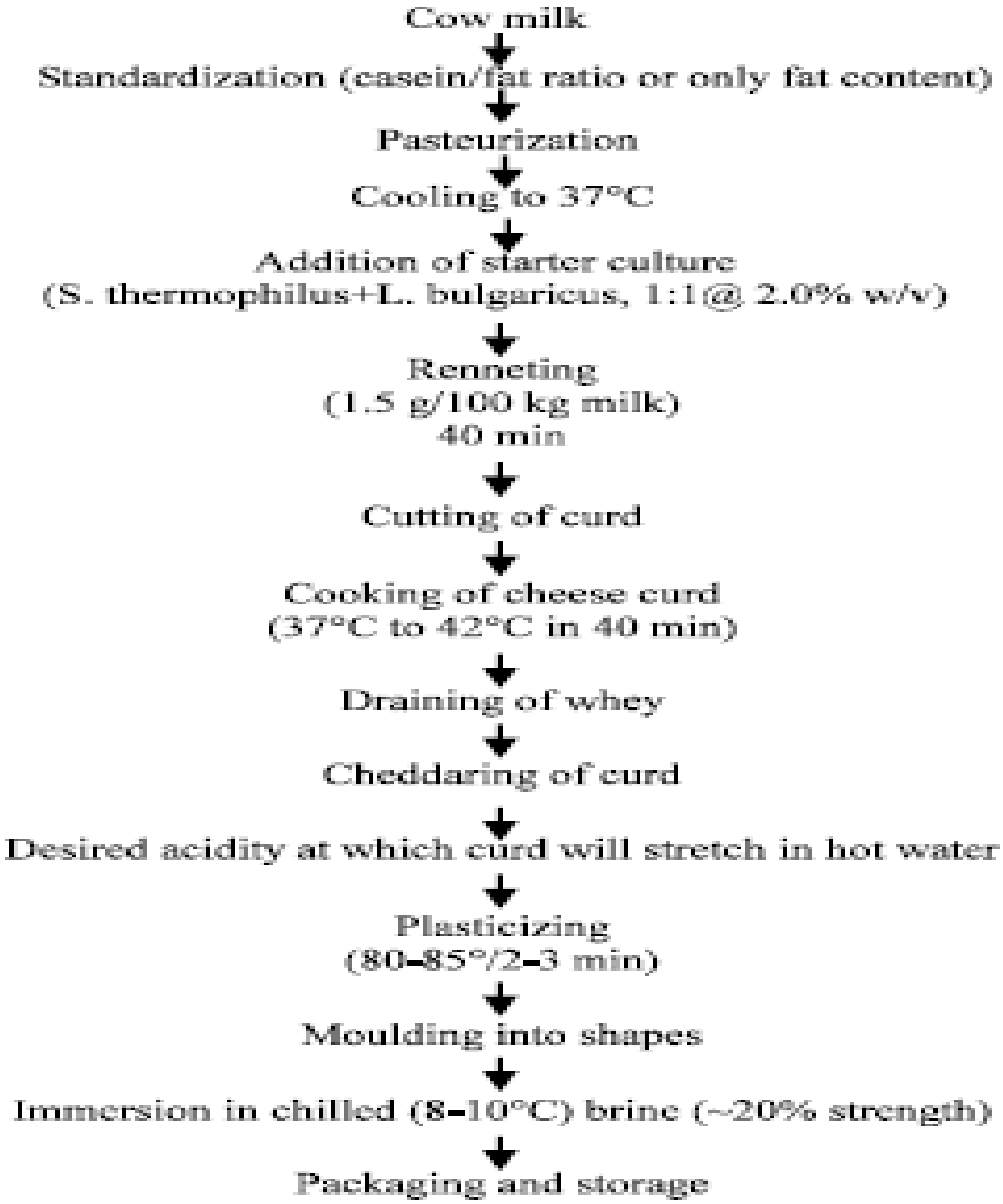
Most of the cheese varieties are rich in fat. Fat affects cheese firmness, adhesiveness, mouthfeel and flavour and also provides nutrition. It contributes a significant amount of both saturated and total fat to the diet. Cheese fat generally contains 66% saturated, 30% monounsaturated and 4% polyunsaturated fatty acids. Thus, cheese represents a significant dietary source of both total fat and saturated fatty acids. The cholesterol content of cheese is a function of its fat content and ranges from approximately 10-100 mg/100 g, depending on the variety. Dietary cholesterol has much less influence on blood cholesterol level than dietary saturated fat. Thus, the cholesterol content of cheese is of lesser importance than its saturated fat content.

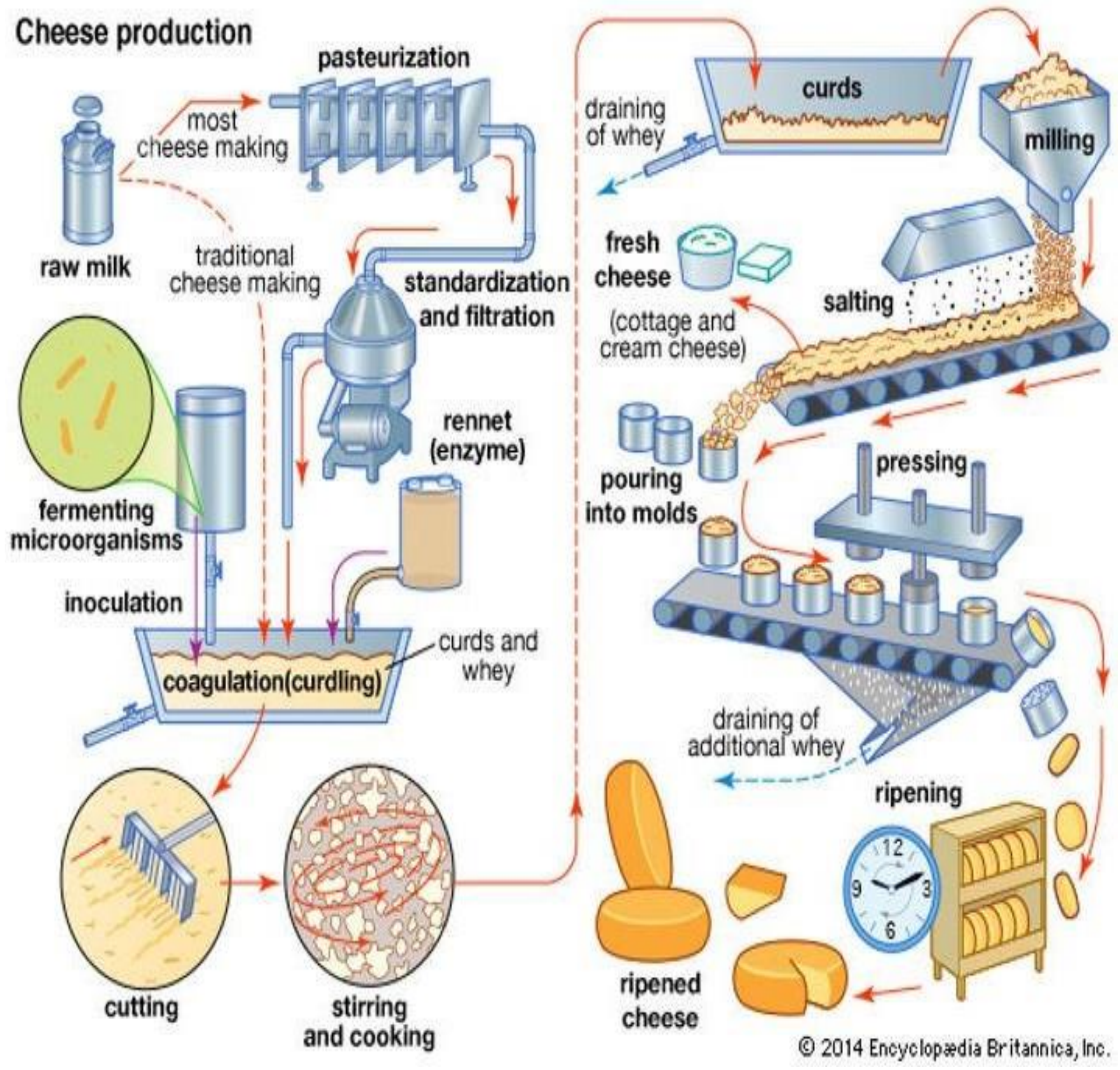
Vitamins and Minerals

As most of the milk fat is retained in cheese curd, the fat-soluble vitamins remain in the curd while most of the water-soluble vitamins are lost in whey. However, some microbial synthesis of B vitamins may occur in cheese during ripening. In general, most cheeses are good sources of vitamin A, riboflavin, vitamin B12, and, to a lesser extent, folate. Cheese contains negligible amounts of vitamin C.

Cheese is also an important source of several nutritionally important elements, including calcium, phosphorus, and magnesium. It is a particularly good source of bioavailable calcium, with most hard cheeses containing approximately 800 mg calcium/100 g cheese. Cheese has a potential role in supplying extra and highly bioavailable calcium. However, acid-coagulated cheeses (e.g., Cottage) contain considerably less calcium than rennet-

coagulated varieties. The bioavailability of the calcium from cheese is equivalent to that from milk. It has been reported that 22.9, 26.7 and 25.4% of total calcium was absorbed from cream cheese, whole milk and yoghurt, respectively. Adequate calcium intake during childhood and teenage years is important
in the development of high bone mass which may prevent osteoporosis in the later years.





Selection of Milk

The quality of milk has a profound effect on the quality of cheese made from it. The composition of cheese is strongly influenced by the composition of the milk, especially the content of fat, protein, calcium and pH. The constituents and composition of milk are influenced by several factors, including species, breed, individual variations, nutritional status, health and stage of lactation of milk-producing animals.

The firmness of the rennet coagulum or cheese curd is enhanced by:

a) acidity
b) high calcium
c) high casein content.

It is reduced by alkalinity, low casein, high albumin plus globulin and high sodium. A major cause of variation in the characteristics of cheese is the species of dairy animals from which milk is obtained. The principal dairying species are cattle, buffalo, sheep and goats, which produce 85%, 11%, 2% and 2% of commercial milk, respectively. Goats and sheep are significant producers of milk in certain regions, e.g. around the Mediterranean, where their milk is used mainly for the production of fermented milk and cheese. Many world-famous cheeses are produced from sheep's milk, e.g. Roquefort, Feta and Romano; traditional Mozzarella is made from buffalo milk. The medium chain (C_6-C_{10}) fatty acids liberated during ripening are markedly more 'peppery' or biting in flavor than the very short (C_2-C_4) or longer (C_{12}-C_{18}) fatty acids. As it is known that cheese flavor is due to fat break down, it might be expected that varieties made from the milk of those mammals containing a higher proportion of C_6-C_{10} fatty acids would develop a characteristic peppery flavor, as seen in Roquefort, which is always made from sheep milk. There are significant differences in milk composition between breeds of cattle, which influence cheese quality.

The milk should be of good microbiological quality, as contaminating bacteria are concentrated in the curd and may cause defects or public health problems. However, cheese milk is usually pasteurized or subjected to alternate treatments to render it free of pathogenic, food poisoning and/or spoilage bacteria.

Inhibitory Substances in Milk

All cheeses depend on the growth of lactococci and all matured cheese depends on the development of lactobacilli. It has been known for a long time that milk behave differently in the way lactic acid bacteria grow in them. Most important in cheese making is the slow growth of *Lactococcus lactis* subsp. *lactis* and *Lactococcus lactis* subsp. *cremoris* in some milk, especially raw milk. One of the factors may be the presence of a group of inhibitory substances naturally occurring in milk. It has been reported that a substance called lactenin found in milk may inhibit the growth of certain streptococci. Lactenin has been shown to have two components, L1 and L2. L1 is present in colostrum and is inactivated by heating to 70°C for 20 min and L2 present in mid-lactation milk and is inactivated by heating to 70°C for 20 min.

The presence of antibiotics in milk has been a major cause of trouble in cheese making. Penicillin and other antibiotics used to control mastitis in cows find their way into milk and inhibit the growth of starter organisms. The best method to control this problem is to exclude such milk for cheese making. Alternatively, starters resistant to antibiotics should be used. Also enzymes such as penicillinase can be used to neutralize the antibiotics.

Preservatives like formalin, hypochlorite, quaternary ammonium compounds and other disinfectants present in milk may inhibit the growth of starter organisms.

In modern commercial practice, particularly in Western countries milk for cheese is normally chilled to 4-5°C immediately after milking and may be held at about this temperature for several days on the farm and at the factory. Apart from the development of an undesirable psychrotrophic microflora, cold storage causes physicochemical changes (e.g. shift in calcium phosphate equilibrium and dissociation of some micellar caseins), which have undesirable effects on cheese making properties of milk.

Standardization of Milk

The composition of cheese is prescribed in 'Standards of Identity' with respect to moisture and fat in dry matter, which in effect defines the protein: fat ratio. Fat and casein together with moisture left in the curd control cheese yield, but fat also has a marked influence on the appearance and feel of the curd and cheese. When the ratio of casein to fat is high, the curd is more leathery and the final cheese does not acquire the mellow, velvetiness of whole milk cheese. Skim milk cheeses are usually consumed ‘green’. In general, the casein: fat ratio (C/F ratio) in milk should be about 0.7 for good-quality cheese. Depending on the ratio required, it can be modified by:

- Removing some fat by natural creaming or centrifugation,
- Adding skim milk,
- Adding cream,
- Adding milk powder, evaporated milk or ultrafiltration retentate.

Such additions also increase the total solids content of the milk and hence increase the yield of cheese curd per unit volume.

Heat Treatment of Milk

Traditionally, cheese was made from raw milk, a practice that was almost universal until the 1940s. Although cheese made from raw milk develops more intense flavor than that produced from pasteurized milk, the former is less consistent and poses a public health risk. Pasteurization of cheese milk became widespread about 1940, primarily from public health reasons, but also to provide a milk supply of more uniform bacteriological quality.

Pasteurization alters the indigenous microflora and facilitates the manufacture of cheese of more uniform quality, but unless due care is exercised, it may damage the rennet coagulability and curd-forming properties of milk. Even when properly pasteurized, Cheddar cheese (and probably other varieties) made from pasteurized milk develops a less intense flavor and ripens more slowly than raw milk cheese. Several heat-induced changes, e.g. inactivation of indigenous milk enzymes, killing of indigenous microorganisms, denaturation of whey proteins and their interaction with micellar κ-casein, perhaps even shifts in salt equilibria and destruction of vitamins, could be responsible for these changes. Until now it has not been possible to establish which of these factors was principally responsible for the differences in quality between raw and pasteurized milk cheese. Therefore, normally sub pasteurization temperature is preferred to heat cheese milk, which is termed ‘thermization’. Thermization (65°C/15 s) of cheese milk on arrival at the factory is common or standard practice in some countries. The objective is to control psychrotrophs and milk is normally pasteurized before cheese making.

Acidification of milk

The increase in acidity in the milk to be used for cheese making is usually brought about by starter culture. Acidity developed inhibits the growth of undesirable organisms and influences the rate of coagulation. When the desired acidity (0.01% increase) is reached, most varieties of cheese require the addition of rennet to the milk in order to obtain a curd of the desired characteristics. It is now almost universal practice to add a culture (starter) of selected lactic acid bacteria to pasteurized cheese milk to achieve a uniform and predictable rate of acid production. For cheese varieties that are cooked to not more than 40°C, a starter consisting of *Lactococcus lactis* subsp. *lactis* and/or *Lc. lactis* subsp. *cremoris* is normally used while a mixed culture *Streptococcus salivarus* var. *thermophilus*, *Lactobacillus* spp. (*L.*

bulgaricus, *L. helveticus*, *L. casei*) or lactobacillus culture alone is used for varieties that are 'cooked' to higher temperature, e.g. Swiss, hard Italian varieties.

Coagulation

The essential step in the manufacture of all cheese varieties involves coagulation of casein of milk to form a gel, which entraps the fat, if present.
Most cheese varieties, and about 75% of total production, are produced by rennet coagulation but some acid coagulated varieties, e.g. Quark and Cottage cheese, are of major importance. Rennin is milk-curdling enzyme, which is usually obtained from the fourth stomach (abomasum) of suckling calves. In other animals, the proteolytic enzyme, pepsin, substitutes rennin. Rennin is prepared commercially for use in cheese making as a salt extract of dried calf stomach. Such an extract containing the enzyme is called rennet or rennet extract.

Rennin is an extremely powerful clotting enzyme; one part of pure rennin can clot more than five million parts of milk. The optimum pH for rennin action on milk is 5.4 and for pepsin it is 2.0. However, it can function very powerfully as a clotting agent at almost neutral pH (6.2-6.4).

The formation of curd depends upon the coagulation of the casein in milk. With rennet this occurs in two steps. The calcium caseinate in milk is first changed to paracasein, which then combines with the calcium ions present in the milk to form an insoluble curd. This curd is elastic and when heated or pressed it will shrink, squeezing out most of the retained whey. Slow development of curd may be due to too little rennet or to the use of overheated milk. In the latter case, the addition of a small amount (0.02%) of calcium chloride to the milk usually will restore the calcium ion balance and permit the normal functioning of rennin. No satisfactory substitute for rennin has been found but at times other milk clotting enzymes, such as pepsin, papain, and microbial and recombinant rennets have been used.

Rennet extract is diluted up to 20-30 times with clean potable water before being added to the cheese milk. After the addition of the rennet, the milk is stirred for about two minutes to distribute the rennet thoroughly, and then currents are stopped in the milk with a paddle or rake. Vibration of the vat must be prevented during setting. Steam leakage into the jacket of the vat during setting should be avoided. The milk is then left undisturbed for the curd to form, and this becomes apparent in about 15 min. After about 30 min the milk is 'set' with a firm curd.

Cutting the Coagulum

The rennet gel is quite stable if maintained under quiescent conditions but if it is cut or broken, syneresis occurs rapidly, expelling whey. Syneresis concentrates the fat and casein of milk by a factor of about 6.012, depending upon the variety. The rate and extent of syneresis are influenced by milk composition, especially Ca++ and casein, pH of the whey, size of cutting of cubes, cooking temperature, rate of stirring of the curd-whey mixture and time.
The coagulum is ready to cut after a period of from 25 min to 2 h, as defined by the recipe.
The determination of the exact time of cutting is very critical for the quality of cheese.
The main method employed by cheesemakers is to plunge the hand, rod or thermometer stem below the surface layer and to lift the coagulum causing it to break in a cleavage line. A clear cleavage with green whey at the base of the cleft indicates that the curd is ready to cut. A soft irregular cleavage with white whey indicates that the curd is too soft. The sides of the cleft show the quality of the curd. Granular curds indicate that the curd is too firm. A rule used by

some cheesemakers is that the curd should be cut earlier rather than later, and once cut; the curd should be left to complete its forming process in the warmer whey which rises over it. If the coagulum becomes too firm, knives or curd breakers crush the curd rather than cut it cleanly. When the curd is ready for cutting, it is first cut horizontally and then vertically. This sequence is essential to follow because if the curd is cut vertically first, the slabs so made will not have sufficient strength to stand and thus, will shatter.

Cooking the coagulum

Then, the fractions of the coagulum are heated up to 38 degrees Celsius for the desired time. The time and temperature of cooking cheese usually differ in different processes of cheesemaking.

The cooking involves stirring the whey-curd mixture to obtain a compact mass of the coagulum. This step is necessary for the following:

- For the control of acid production by the starter culture.
- To suppress the growth of spoilage microorganisms.
- To influence the curd texture.
- It also controls the amount of moisture content.

Releasing the whey

After separating curds and whey, further processing of the curds helps release more of the whey trapped in the network of micelles before it is drained away. The exact processing steps vary depending on the type of cheese. However, generally, the curds are captured, pressed and molded to form blocks of cheese.

Historically, whey was considered a waste product of cheesemaking. However, growing concern over the environmental impact of its disposal encouraged research to better understand the properties and potential uses of whey. Increasing scientific understanding and technological advances have led to a wide range of uses for whey and established it as a valuable coproduct of the cheese industry, find out more about other uses of whey.

Brining

It is a process where salt acts as a stabilizer, which increases the shelf life of the cheese. You could either sprinkle salt over the loose curd or dip the freshly made cheese in the brine solution. Brining is a step necessary for cheese making:

- It suppresses the growth of spoilage microorganisms
- It also reduces the amount of moisture in the finished cheese.
- Salting also adds characteristic flavour and texture to the cheese.

Pressing of curd

After brining, keep the curd fractions in the cheese hoops. Then, apply hydraulic pressure to the coagulum. This step can be skipped in the case of cheese with an open texture.

In cheddar cheese, piling is done before pressing, where the fractions of curd are stacked one over the other and flipped periodically through cheddaring. This step expels more whey, thereby providing more compactness and characteristic shape to the cheese.

Ripening the cheese

Cheese is left to ripen, or age, in a temperature and humidity-controlled environment for varying lengths of time depending on the cheese type. As the cheese ripens, bacteria break down the proteins, altering the flavour and texture of the final cheese. The proteins first break into medium-sized pieces (peptides) and then into smaller pieces (amino acids). In turn, these can be broken down into various, highly flavoured molecules called amines. At each stage, more complex flavours are produced.

During ripening, some cheeses are inoculated with a fungus such as Penicillium. Inoculation can be either on the surface (for example, with Camembert and Brie) or internally (for example, with blue vein cheeses). During ripening, the fungi produce digestive enzymes, which break down large protein molecules in the cheese. This makes the cheese softer, runny and even blue.

Cheese is ripened at uniform temperature and humidity, depending on the variety of cheese. Ripening temperatures of some of the varieties of cheeses are as follows: Emmental, 22-24°C (for part of ripening, i.e., the critical 'hot room' period); mold and smear-ripened cheeses, 12-15°C; Dutch varieties, 12-14°C; and Cheddar, 6-8°C (the ripening temperature for Cheddar is exceptionally low). The above temperatures are the maximum in the profiles and are usually maintained for 4-6 weeks to induce the growth of a desired secondary microflora. Thereafter, the cheese is transferred to a much lower temperature (e.g. 4°C). Cheddar is an exception, since it is normally kept at 6-8°C throughout the ripening process.

Packaging

Finally, cut the cheese and package them into blocks by appropriately labeling the brand's name along with the nutritional facts, market price, manufacturing date, expiry date, and other product details.

PANEER PROCESSING

Paneer is a heat-acid coagulated milk product obtained by coagulating standardized milk with the permitted acids at a specified temperature. The resultant coagulum is filtered and pressed to get the sliceable curd mass. Paneer has a firm, close, cohesive, and spongy body and smooth texture. It is mainly prepared from buffalo milk and used for a large number of culinarydishes. Though originally it was localized in Northern part of India now it is preferred in almost all parts of the country. Paneer is generally sold as blocks or slices, it is also referred as Indian fresh cheese. It is reported that about 5% of the milk produced in India is converted into paneer and paneer production is growing annually at the rate of 13%.

FSSR - 2011 standards of paneer

Paneer means the product obtained from cow or buffalo milk or a combination thereof by precipitation with sour milk, lactic acid, or citric acid. It shall not contain more than 70% moisture and milk fat content shall not be less than 50% of dry matter. Milk solids may also be used in the preparation of paneer. Low-fat paneer shall contain not more than 70% moisture and not more than 15% milk fat on dry matter basis. Buffalo milk is boiled in a bigger iron vessel and a small portion of this is transferred to a smaller vessel. The coagulant (usually sour whey) is added to hot milk and stirred with a ladle till coagulation is completed. The contents of the vessel are emptied over a piece of coarse cloth to drain off the whey. The whole process is repeated till all the milk is coagulated. The curd is collected after draining the whey and pressed to remove more whey. Finally, the product is then dipped in chilled water.

Industrial method for paneer making

Buffalo milk is standardized to 4.5% fat and 8.5% SNF (standardize the buffalo milk to a fat: SNF ratio of 1:1.65). Milk is heated to 90°C without holding (or 82°C with 5 min holding) in a jacketed vat and cooled down to 70°C. Coagulation is done at about 70°C by slowly adding 1% citric acid solution(70°C) with constant stirring till a clean whey is separated at (pH 5.30 to 5.35) and the coagulum is allowed to settle for 5 min and drained off the whey. The curd so obtained is filled into hoops lined with muslin or cheesecloth. Pressure is applied on top of the hoop at a rate of 0.5 to 1kg/cm^2. The pressed blocks of paneer are removed from the hoops and immersed in pasteurized chilled water for 2-3 hr. The chilled paneer is then removed from the water to drain out. Finally, paneer blocks are wrapped in parchment paper/polyethylene bags and placed in cold room at about 5 to 10°C.

Paneer from cow milk

Cow milk yields an inferior product in terms of body and texture. It is criticized to be too soft, weak and fragile and unsuitable for frying and cooking. Buffalo milk contains a considerably higher level of casein and minerals particularly calcium and phosphorous, which tends to produce a hard and rubbery body while cow milk produces soft and mellow characteristics. By replacing one-third of buffalo milk with cow milk, a good quality paneer can be made. Buffalo milk paneer retains higher fat, protein, and ash content and lactose as compared to cow milk paneer. To make paneer exclusively from cow milk, certain modifications in the conventional procedure have to be made. The addition of calcium chloride at the rate of 0.08 to 0.1% to milk helps in getting a compact, sliceable, firm and cohesive body and closely knit texture. A higher temperature of coagulation (85°-90°C) withcoagulation of milk at pH 5.20 to 5.25 helps in producing good quality paneer from cow milk. However, at this pH of coagulation, moisture, yield and solids recovery are less.

BUTTER PROCESSING

A water-in-oil emulsion, comprised of >80% milkfat, also contains water in the form of tiny droplets. The principal constituents of a normal salted butter are fat (80 – 82%), water (15.6 – 17.6%), salt (about 1.2%) as well as protein, calcium and phosphorous (about 1.2%). Butter also contains fat-soluble vitamins A, D and E

Butter, a fat rich dairy product obtained by churning cream and working the granules thus obtained into a compact mass, has been a staple item of diet in many countries of the world. Up to the middle of the nineteenth century, manufacture of this product was mainly confined to the farm on cottage scales. It was only after the development of centrifugal cream separator in 1879, fat testing methods by Babcock (1890) and Gerber (1892) together with introduction of artificial refrigeration and pasteurization around 1980, the industrial production of butter developed rapidly. Prior to 1970 most of the worlds, butter was manufactured by batch-process. However, since World War-II, continuous processes have been introduced to achieve increased manufacturing efficiencies. Regardless of manufacturing method employed, the essential feature of churning evolves destabilization of cream emulsion by means of mechanical agitation.

Preparation of Cream

Commercial butter can be produced from both sweet as well as cultured cream. Very little cultured butter is produced in India and U.S.A., although in Europe and Canada, cultured butter is an important product. However, most creameries prefer to produce butter from sweet cream as it result in sweet butter milk which has better economic value than sour butter-milk that results when sour/cultured cream is churned.

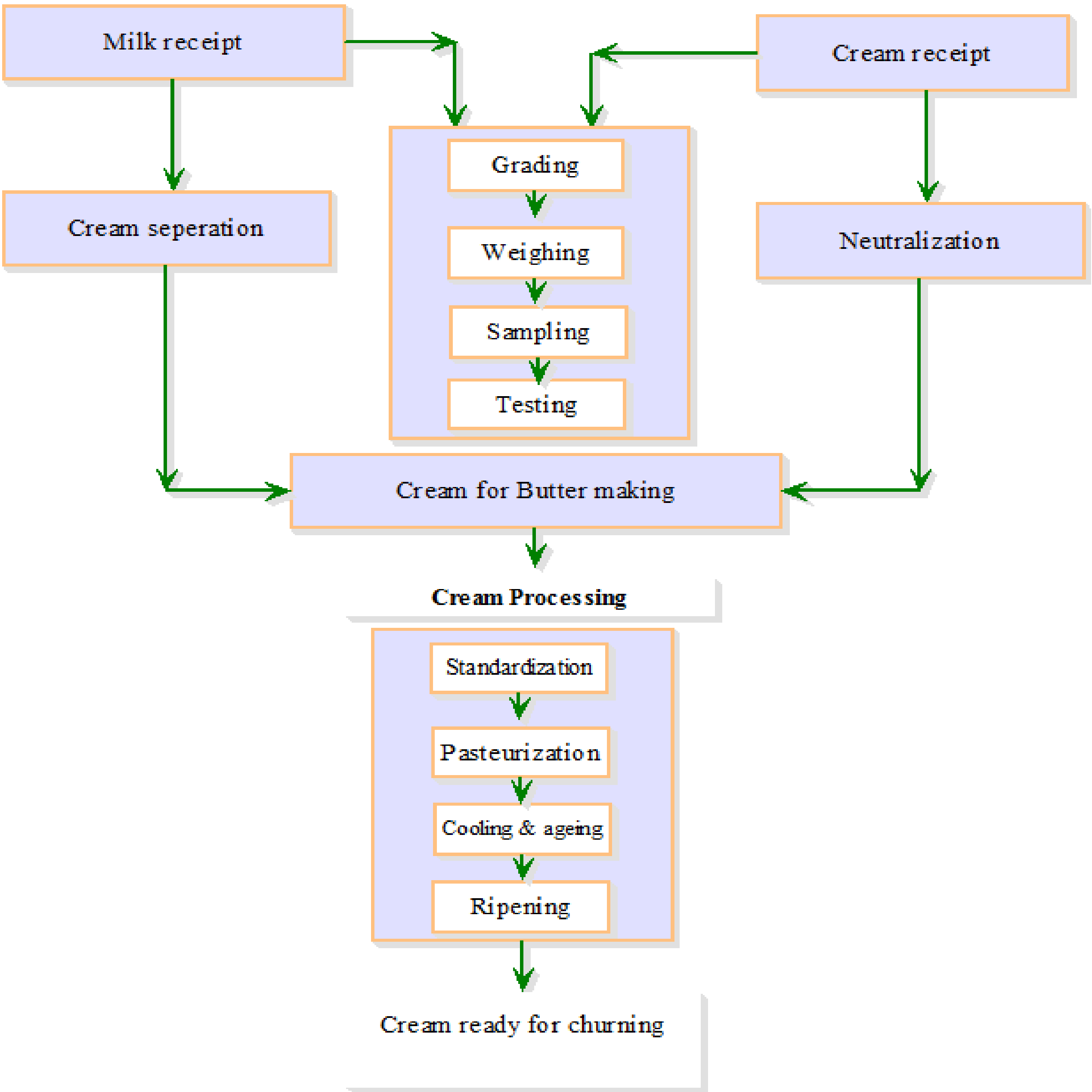
Neutralization of cream

Sour cream must be neutralized to make butter of good keeping quality. It is understood that by neutralization of cream acidity of cream is reduced. Churning of high acid cream may cause high fat loss which can be prevented by neutralization. In pasteurization of sour cream, the casein curdles, by entrapping fat globules, as the bulk of curd goes in butter milk, causing high fat loss.

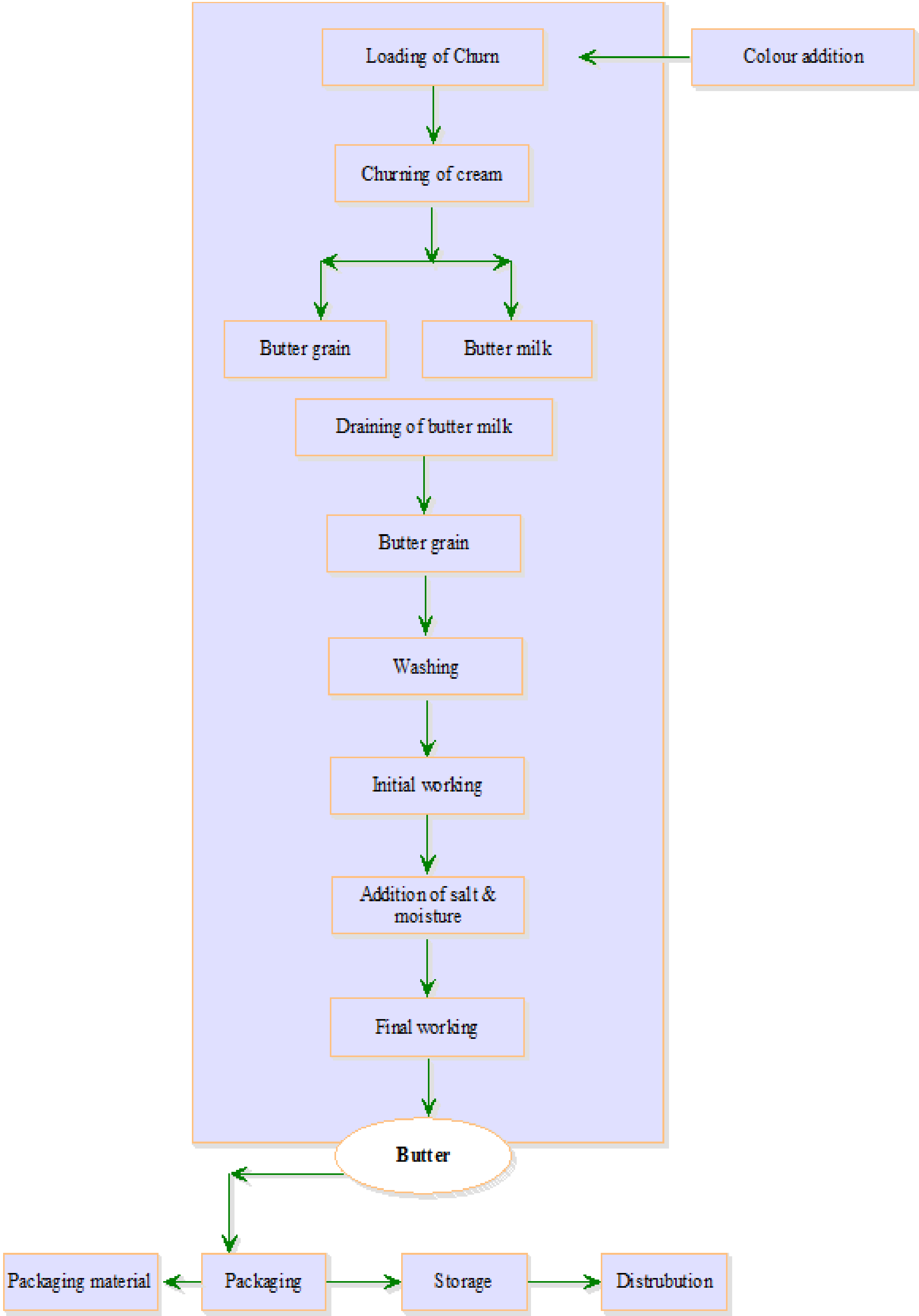
Adding neutralizer in the correct manner

Neutralizer should be dissolved or emulsified in clean water, diluted to approx. 20 times its weight with water; the solution must be distributed quickly & uniformly throughout the entire batch of cream and mixed thoroughly with cream. For efficient mixing, neutralizer is usually sprayed onto the surface of well agitated cream. While the neutralizer is added, the cream should be agitated vigorously and continuously. Agitation of cream is preferable for 5-10 min after neutralization. Temperature at the time of neutralization should be 30°C. (High enough for smooth consistency & low enough to prevent abnormal heat curdling of the sour cream)

The above precautions are essential, if efficiency of neutralization, protection of butter against neutralizer flavour, oily metallic flavour and mealy body, avoidance of pasteurizing difficulties and prevention of excessive fat losses in the buttermilk are to be assured.



Flow diagram of cream preparation for butter manufacturing



Flow Diagram of Butter Manufacturing

Type of Neutralizers

Neutralizers in order to accomplish the purpose, for which they are used in the creamery, must have alkaline properties. They must be alkalis, alkaline earths or their substances. An alkali is a substance that has the property of neutralizing acids, forming salts with them. The neutralizers used for reducing acidity in cream belong to either one or the other of two groups namely.

- Lime Neutralizers
- Soda Neutralizers

Lime neutralizers

The principal constituent of the majority of lime neutralizers is calcium. Many of the lime neutralizers available for cream neutralization also contain some magnesium. The various commercial lime neutralizers differ from one another chiefly with respect to the proportion of calcium and magnesium they contain. They are conveniently placed in three groups, as follows:

a. Low magnesium limes: Containing 5% or less of magnesium. A well-known brand of creamery lime belonging to this group is peerless lime.

b. Medium magnesium limes: Containing about 30-35% magnesium. The brands that belong to this group are Kelly Island lime, Neutra-Lac and Neutra-Lime.

c. High magnesium limes: Containing about 45 to 55% magnesium. All wood lime is an outstanding representative of this group. All magnesium limes in the form of magnesium oxide and magnesium carbonate are also available. They are artificially prepared limes and demand a higher price than the natural limes. Their effect on the flavor of cream and butter however is outstandingly favorable.

Calcium carbonate - low solubility, low alkalinity unsuitable for cream neutralization and action is very slow.

In general the medium and high magnesium limes react somewhat more satisfactorily in the cream than the low magnesium limes. The higher the magnesium oxide content of lime the greater is its alkalinity and its neutralizing strength.

Soda neutralizers

Soda neutralizers commonly used in the creamery are:

1. Bicarbonate of soda or baking soda

2. Sodium carbonate or soda ash

3. Mixtures off baking soda and soda ash, such as Sodium sesquicarbonate, Neutralene and Wyandotte.

Standardization of cream

It refers to adjustment of fat to desired level. It is done by adding calculated quantity of skim milk or butter milk. Desired level of fat in cream for butter making is 33 to 40 per cent.

Standardization to both higher and lower-level leads to higher fat loss in butter milk. Reduction of fat by adding water should be avoided as it interferes ripening of cream and also results in butter with flat or washed off flavour.

Pasteurization of cream

It refers to adjusting every particle of cream to a temperature not less that 71^0C and holding it at that temperature for at least 20 min or any suitable temperature-time combination using properly operated equipments. The main objectives of pasteurization are:

(i) it destroys pathogenic microorganisms in cream so as to make it, and the resultant butter, safe for human consumption.

(ii) It also destroys bacteria, yeast, mould, enzymes and other biochemical agents that may lower keeping quality.

(iii) It also eliminates some of the gaseous and training substances. A number of equipment viz. LTLT, HTST and vacreator, a direct steam injection method, can be employed for this purpose. More severe heat treatment of cream should be avoided as higher, the temperature the greater the migration of copper from the milk serum into milk fat globules. This increases the level of copper associated with the milk fat making it more prone to the development of oxidative rancidity and reduce the shelf-life of butter.

Ripening of cream

Ripening refers to the process of fermentation of cream with the help of suitable starter culture. This step can be eliminated if sweet-cream butter is desired. The main object of cream ripening is to produce butter with higher diacetyl content. Starter culture consisting of a mixture of both acid-producing (*Streptococcus lactis, S.cremories*) and flavour-producing (*S.diacetylactis, Leuconostoc citrovorum* and/or *Leuc. dextranicum*) organisms is added. The amount of starter added depends on several factors and usually ranges between 0.5-2.0 percent of the weight of the cream. After being thoroughly mixed, the cream is incubated at about 21°C till desired acidity is reached. Cream is subsequently cooled to 5-10^0C to arrest further acid development.

Biosynthesis of diacetyl is not sufficient above pH 5.2. Stopping fermentation of cream by cooling at pH 5.1-5.3, results in a milder flavour; whereas continuing fermentation upto pH 4.5-4.7 results in higher levels of both diacetyl and lactic acid, giving more pronounced flavour.

Purpose

The fundamental objects of cream ripening are to produce butter with a pleasing, pronounced flavor and aroma, and to produce this flavor and aroma uniformly from day to day. Ripening also influences somewhat the exhaustiveness of churning and it affects the keeping quality of the butter whether made into salted or unsalted butter.

Churning of Cream

It is during the churning process that cream is converted into butter. Here the fat globules are disrupted under controlled conditions to destabilize oil-water emulsion and bring about agglomeration of milk fat. The sequence of events that occur during churning is as follows:

i) Churning is initiated by agitation of cream causing the incorporation of numerous air bubbles into the cream.

ii) With the incorporation of air there is an increase in the volume of cream and air plasma interface.

iii) Surface active (such as frictional, impact, concussion etc.) causes partial disruption of the fat globule membrane

iv) The fat film, thus formed, serves as a foam depressant causing the air bubble to burst.

v) The liquid fat also serves as cementing material causing fat globules to clump together and eventually butter grains are formed which float in plasma i.e. buttermilk.

Initial working

Working of butter is essentially a kneading process in which butter granules are formed into a compact mass. During this operation, any excess moisture or buttermilk is removed. However, the emulsion water-oil at this stage is not fully stable.

Salting of butter

In conventional process, butter may be salted by adding salt to butter churn after initial working of butter. Salt to be added must be high quality e.g. IS 1845:1961, with low level of lead, iron and copper. The grain should be fine, all passing through IS: sieve-85 (aperture 8424). It should be 99.5 to 99.8% sodium chloride and microbial count should be less than 10/g. Salt sets up osmotic gradient which draws water from the butter grains. This can lead butter to being leaky. Salted butter should, therefore, must be thoroughly worked. Salt may be added either in dry form or as a saturated brine solution.

Adjustment of moisture

After the addition of salt, the moisture content in butter is adjusted by adding calculated amount of additional water. In most countries, maximum limits of 16% is placed on the level of moisture. Amount of water is to be added in a batch of butter is calculated as follows:

$$Amount\ of\ water\ (to\ be\ added) = \frac{(desired\ moisture - initial\ moisture) \times 1.5\ \times x\ kg\ fat\ in\ cream}{100}$$

Starter distillates, if required, may also be added at this stage to enhance the flavour of resultant butter, if cream has not been cultured.

Final working of butter

The objective of working butter is to incorporate moisture and uniformly distribute added moisture and salt in butter. During this process remaining fat globules also break up and form a continuous phase, and moisture is finally distributed to retard bacterial growth in butter. It is safer to slightly over-work butter than to under-work. Under-worked butter may be leaky in body with large visible water droplets and may develop mottles on standing. Moisture droplet size normally ranges from 1 to 15 micron and there are approximately 10 billion droplets per gram of butter. Working affects the colour of butter (making is slightly light). Working also increase air content (this favors growth of microorganisms, oxidative effects and therefore poor keeping quality). Vacuum working of butter may be carried out with advantage to reduce the air content of butter. Vacuum range from 15-40 cm of Hg may be used. Air content of conventional butter range from 3-7% by volume with an average of 4 ml/100 while that of vacuum worked butter it is about 1 ml/100g.

GHEE PROCESSING

Ghee production is the largest segment of milk utilization in India. Most of the dairy plants have ghee production facilities to meet the demand of the market as well as to utilize the excess fat in a profitable manner. Since simple technology is involved in ghee production and relatively less investment for ghee production units as already plant has steam boilers with them. Method of production varies from small scale to large scale. Cost reduction on energy consumption for production of unit quantity of ghee is the recent trend and equipment is designed to meet the requirement. Following are the various processes available in the industry to make ghee including the Desi method which is followed largely at the rural household level.

Methods of Preparation

The principle involved in ghee preparation include;

1. concentration of milk fat in the form of cream or butter.

2. Heat clarification of fat-rich milk portion and thus reducing the amount of water to less than 0.5%.

3. Removal of the curd content in the form of ghee residue.

There are five methods of ghee making:

i. Desi or Indigenous Method

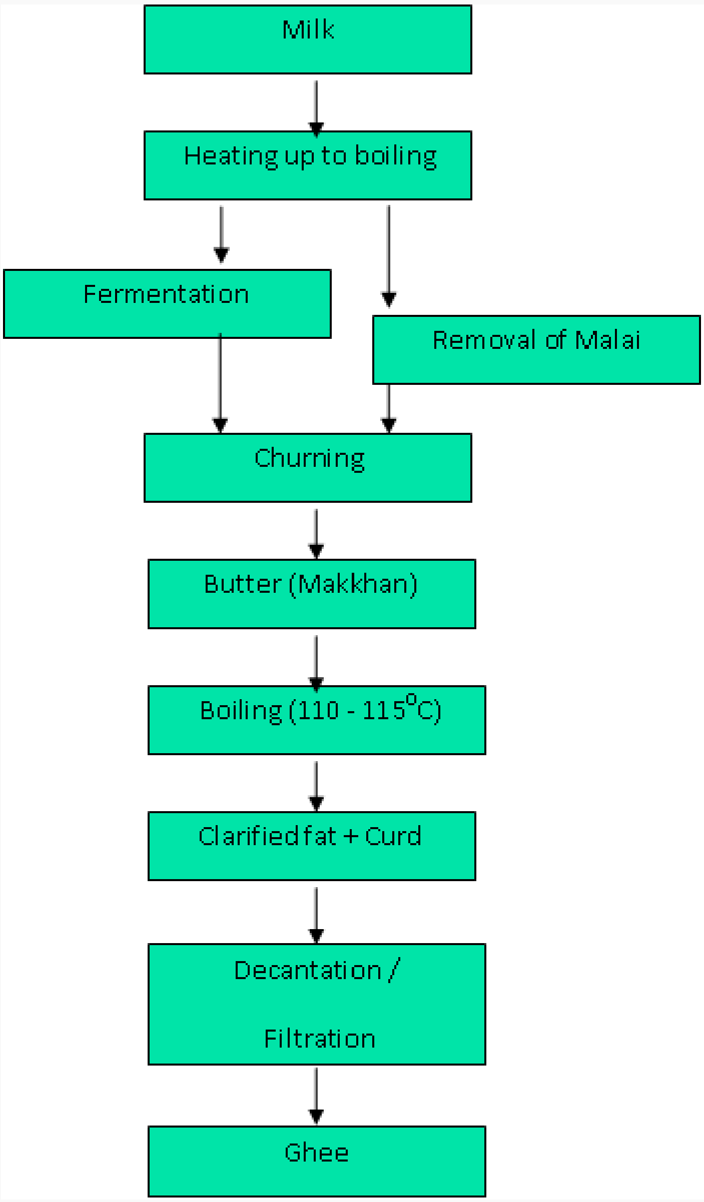
ii. Direct Cream Method

iii. Creamery Butter Method

iv. Preratification Method

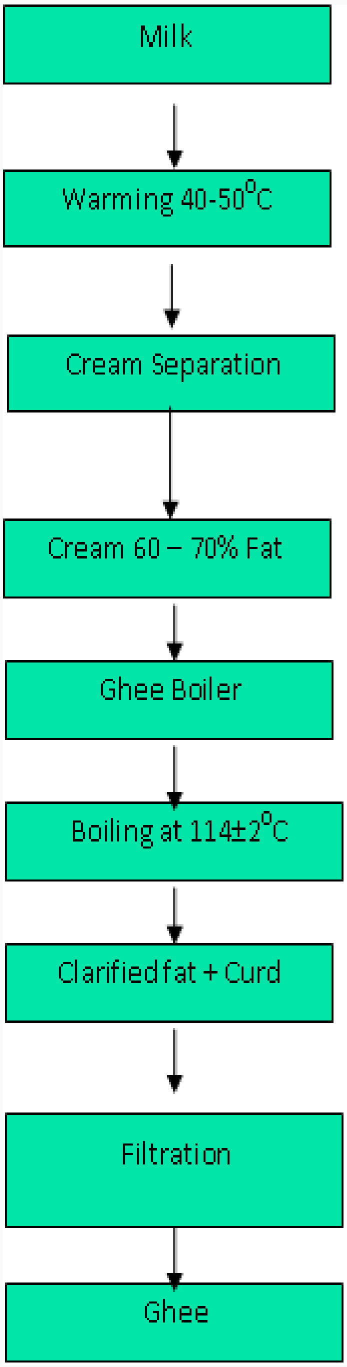
v. Continuous Method

Desi Method



This was the practice from age-old days in rural areas where excessive milk will be cultured and kept for overnight for fermentation. The resultant curd was churned using hand-driven woodenbeaters to separate the milk fat in the form of desi butter. Some follow slightly different method wherein milk is heated continuously to about 80°C, the malai (creamy layer) that forms over the surface was collected manually. This malai is then churned to get the desi butter. After collection of desi butter over a period of time, this butter is melted in a metal pan or earthenware vessel on an open fire. The extent of frothing is an index to judge when to terminate heating. Heating should be stopped when sudden foaming appears and leave the contents undisturbed afterheating. Curd particles start settling down over a period of time and decant the clear fat carefully. In this method, it is possible to achieve only 75 – 85% fat recovery.

Direct Cream Method



This method involves separation of cream of 60 to 70% fat from milk by centrifugation process, fresh cream or cultured cream is heated to 114±2°C in a stainless steel, jacketed ghee kettle. This kettle is fitted with an agitator, steam control valve, pressure and temperature gauges. A movable hollow stainless steel tube centrally bored for emptying out the contents or alternatively provision can be made for tilting device on the ghee kettle to decant the product. Heating is discontinued as soon as the colour of the ghee residue turns to golden yellow or light brown. Usually, first plenty of effervescence accompanied by a crackling sound in the preliminary stages of boiling but both gradually subsides when the moisture content decreases. When almost all the moisture is evaporated, the temperature of the liquid medium suddenly spurts up and care has to be exercised at this stage to control the heating. The end point is indicated by the appearance of second effervescence, which is subtler than the first one accompanied by the browning of curd particles. At this stage the typical ghee flavour emanates and this indicates that the final stage in the preparation of ghee.

Advantages of this method are

1. No need for butter production prior to manufacturing of ghee.

Limitations

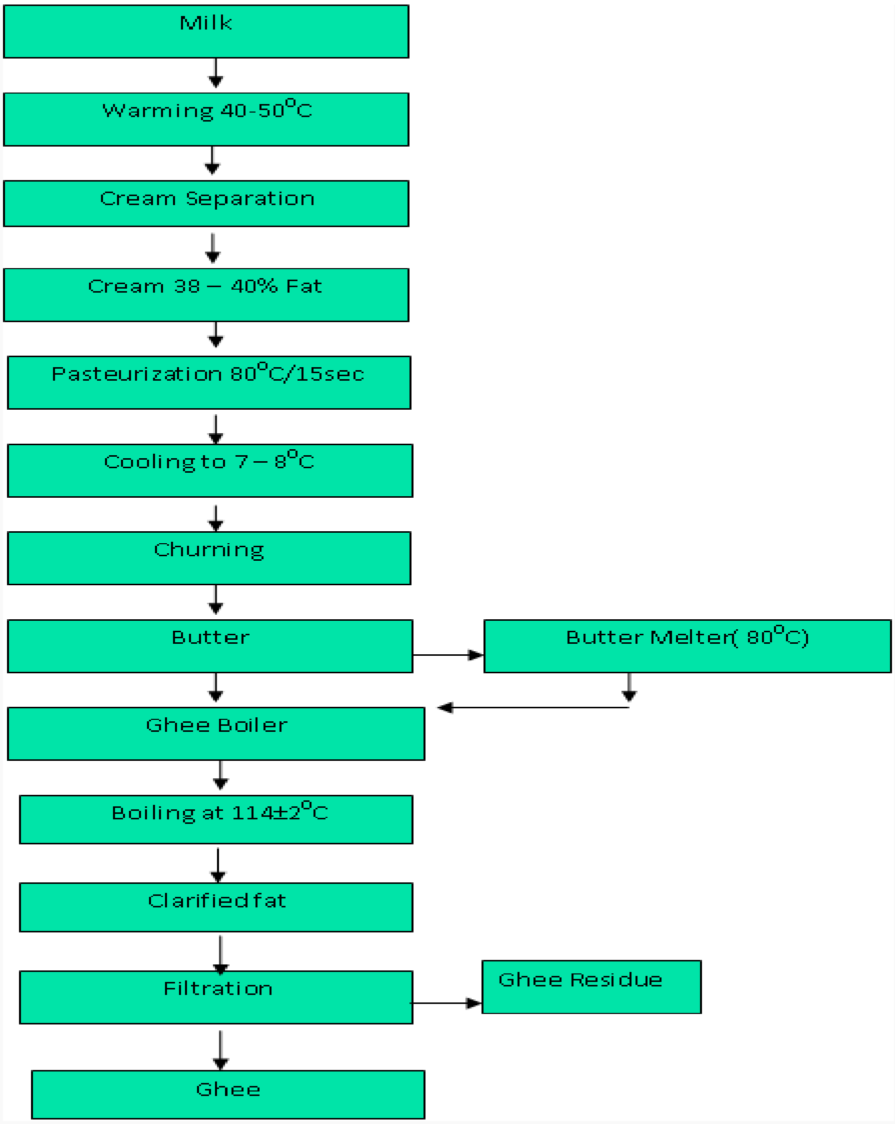
1. Long heating time to remove the moisture.

2. High content of serum solids in the cream may also produce a highly caramelized flavour in the ghee.

3. 4 – 6% loss of butter fat in the ghee residue & during the handling operations.

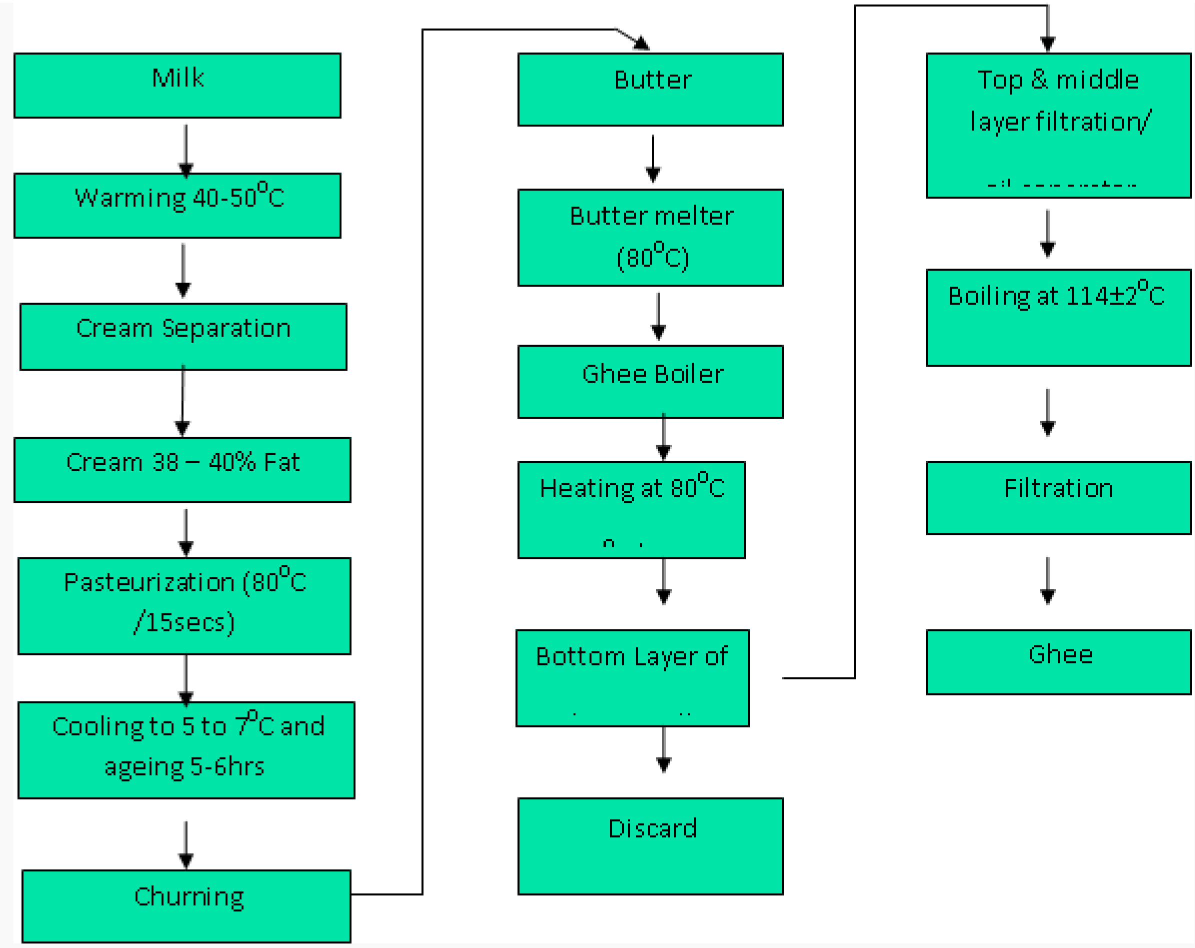
4. So, 70 – 80% fat cream is recommended to minimize both fat loss and steam consumption

Creamery Butter Method



This is the standard method adopted in most of the organized dairies. Unsalted or white butter is used as raw material. Butter mass or butter blocks are melted at 60°C to 80°C in butter melter. Molten butter is pumped into the ghee boiler where final heating will be done using steam as heating medium. Increase the steam pressure to raise the temperature. Scum which is forming on the top of the surface of the product is removed from time to time with the help of perforated ladle. Moment of disappearance of effervescence, appearance of finer air bubbles on the surface of the fat and browning of the curd particles indicates to stop heating. At this stage typical ghee aroma is produced. Final heating temperature is adjusted to about 114±2°C. To get the cooked flavour, heating beyond this temperature is also being in practice. Ghee is filtered via oil filter into the settling tank.

Pre-Stratification Method



Butter is produced from aged cream of 38 to 40% fat using continuous butter making machine or batch churn. Butter is then transferred to butter melter, and melt at 80°C. This molten butter is kept undisturbed in a ghee kettle or boiler at a temperature of 80-85°C for 30 min. Here, in ghee kettle, stratification of mass takes place, product stratifies into 3 distinct layers. Denatured protein particles (curd particles) and impurities are collected on top layer and floats on surface. Middle layer consists of clear fat and bottom layer consists of buttermilk serum carrying 80% of moisture and 70% of solods-not-fat contained in butter.

The bottom layer is then carefully removed without disturbing the both top and middle layers. Middle layer, largely consists of fat is heated to 114±2°C along with top layer of floating curd particles and denatured protein. This step is necessary to develop characteristic ghee aroma. Milder flavour ghee can be produced, since most of the curd content is removed before final clarification temperature of ghee.

Advantages of pre-stratification method

* Removal of buttermilk (bottom layer) eliminates prolonged heating for evaporation of the moisture

* Formation of significantly low quantity ghee residue

* Low quantity of ghee absorbed into ghee residue so less fat loss along with ghee residue

* Production of ghee with lower FFA and acidity

Continuous Method

This method was developed to meet the requirement of high volume production and to overcome the limitation of batch method. Limitations of batch method are as follows:

* Requires high energy, due to low heat transfer co-efficient

* Cleaning and sanitation of equipments, not satisfactory

* Equipments and process unsuitable for large volume of production

* Floor becomes slippery due to ghee spillage

* Handling losses are more

So, continuous method was invented and has following benefits;

* Better control on quality of the product

* Only small hold-up of raw material in the plant at any time and hence no chance for whole batch getting spoiled

* Contamination by handlers can be eliminated

* CIP can be possible

* No foaming of the product during production

Butter is heated in a butter melter to molten state and then transfer into balance tank, and pumped further to scraped surface heat exchanger (SSHE), followed by flashing in vapour separator. And this heating in SSHE and flashing are repeated in next two stages to reduce the moisture level. Ghee is then pass through centrifugal clarifier where residue will be removed. Clarified ghee is stored for filling and packing.

Granulation and Cooling of Ghee

Granulation is important criterion of quality; higher temperature of clarification gives better grain size due to high phospholipids content.

Phenomenon

Completely melted ghee on cooling to prevailing Indian temperatures, can assume the form of large, coarse grains suspended discretely or in clusters in a liquid phase. The process of crystallization is initiated with the formation suitable nuclei. Rate of cooling strongly influences the rate nucleus formation. Stirring or agitation and seeding (at the rate of 1 – 3%)

encourage the nucleus formation. For better granulation, ghee should be slowly cooled to 28°C in 2-3 hours time and agitation is required during granulation to form smaller granules.

Causes of granulation

The partly granular form assumed by ghee is primarily due to certain content of glycerides of higher melting saturated fatty acids, especially palmitic & stearic. Thus, buffalo milk ghee showpredominant granulation than cow milk ghee.

Yield

The yield of ghee from cream or butter is influenced by fat content of raw material. Factors which influence the yield are listed below.

Factors influencing yield

Following factors influence the yield of ghee,

1. Method of production: The fat recovery in indigenous method is lowest in range of 80-85% in creamery butter method it ranges from 88-92% and highest in direct cream method ranging from 90-95%.

2. The fat content of the raw material used: Higher the fat content higher will be the yield and vice versa.

3. Quality of milk or cream: If the acidity of milk or cream intended to use in ghee production is higher then fat losses in ghee residue will be higher, thus it reduces the yield.

4. Fat recovery from ghee residue: Scientific reports suggest to extract as much as fat from ghee residue by dissolving ghee residue in hot water followed by filtration and centrifugation. By this method, it is possible to extract the fat from ghee residue and that fat can be added back to cream or butter melter.

Use of Substandard Milk for Ghee Production

India is a tropical country, where in ambient temperatures touches the mark of 40°C in summer. Collection system for raw milk in rural area is still carried out at ambient temperature. Especially in summer while collecting the milk cans from ton-of places causes acidity of milk to increase and results in souring of milk. This milk cannot be useful for making market milk or for thermal process.

Therefore, there is a need to utilize, this milk for products preparation. Where in it does not affect such the quality of end product. So, in commercial dairy plants such milk is diverted and collected separately based on platform tests (COB, sensory etc…). This sourced milk is collected in balance tank and circulated using high sped pump. This causes the breakdown of far globule membrane and release the fat. After a circulation of 30 min milk is kept undisturbed. This facilitates the separation of cream base or gravity. Then this cream is used for ghee production directly or collected over-a-period of time and neutralized to produce butter from this cream. This butter will be used for ghee making.

WHEY PROTEIN

Whey is derived from the cheesemaking process. Once the milk passes quality tests, enzymes are added to separate the curd from the liquid whey. The liquid whey is then pasteurized and the protein is concentrated and isolated. The two main methods to achieve this are membrane filtration and ion exchange technology.

Membrane Filteration

Membrane Filtration (MF) is a cold temperature separation process that uses porous membranes. Due to their different pore sizes, membranes are capable of eliminating bacteria, defatting the whey, allowing the pass-through of carbohydrates and minerals, and retaining the whey protein.

Ion exchange

Ion exchange is a process that selectively isolates specific protein components. The raw whey is sent through a column that collects the proteins and separates them based on differences in their net charge. The rest (lactose and minerals) is washed away and further processed into a different ingredient.

Ion exchange allows the selection of all functional and nutritional proteins in whey, including bioactive proteins such as immunoglobulins and lactoferrin.

The resulting whey protein therefore has less fat and lactose than other whey protein isolates on the market. It also allows complete solubility with a clean and neutral taste. Whey Protein Concentrate, Whey Protein Isolate and Hydrolyzed Whey Protein are the highest quality sources of whey protein. The consumer finds them as ingredients in a wide variety of food products, as well as powdered supplements.

DAIRY ENZYMES

Enzymes are complex proteins which act as catalysts to accelerate the chemical reactions of living cells and bring specific chemical changes for converting specific set of reactants or substrates into specific products, without being changed themselves. These are not permanently modified by their participation in reactions and have a great specificity. In dairy industry, the use of enzymes, particularly exogenous enzymes are not fully exploited and limited to a few major and some minor applications. Enzymes play important role in the preparation of certain dairy products like cheeses, yoghurt etc., by improving texture, flavor and bringing about desirable changes in the product. Lipolytic and proteolytic enzymes can accelerate the production of flavor compounds. Successful use of preparations containing these enzymes is complicated by the need to attain a satisfactory balance among the various enzymes involved in the cheese ripening process.

IMPORTANT ENZYMES USED IN DAIRY INDUSTRY

The most important enzymes used in dairy industry are rennet, protease, lipases, lactase etc. as the principal constituents of milk are proteins, lipids and lactose.

Rennet

Rennet, an exogenous enzyme, is used as a milk-clotting agent in cheese industry for the manufacture of quality cheeses with good flavor and texture. The action of milk clotting enzyme i.e. rennet in cheese making is splitting of κ-casein which causes destabilization of casein micelles and subsequently leads to the formation of a coagulum.

Proteases

These are enzymes that are added to milk during cheese production for hydrolyzing caseins, specifically κ-casein, which stabilizes micelle formation preventing coagulation. Certain proteinases are used in enhancing the cheese flavor and also in acceleration of ripening process. An extract of *B. subtilis,* which contains a neutral proteinase, active at higher temperature seems to be quite suitable in this regard. Moreover, it has the advantage of being barely active below 8°C, and even sometimes inactivated at lower temperatures. Hence, over-ripening can be prevented. Flavour defects can be kept to a minimum by combining the endopeptidase activity (catalyze the hydrolysis of peptide bonds in the interior of peptide chain or protein molecule) of enzyme preparations with the exopeptidase activity (catalyze the cleavage of the terminal/last or next-to-last peptide bond from a polypeptide or protein, releasing a single amino acid or dipeptide) of extracts of lactic acid bacteria.

Lipases

These are used in the preparation of stronger flavoured cheeses, such as Italian, Romano cheese etc., by breaking down milk fats and giving rise to characteristic flavours to cheeses. Lipase acts on Triglycerides and on hydrolysis yields fatty acids, partial glycerides plus glycerol. This process is very critical in natural cheese making and should be controlled as milk fat contains high levels of short-chain fatty acids, which when in the free form are very volatile and have low flavour threshold.

Beta-galactosidase (lactase)

It helps in the hydrolysis of lactose to glucose and galactose and hence plays a significant role in dairy processing. Lactose intolerance in humans is characterised by typical symptoms like severe tissue dehydration, diarrhoea, and at times, even death and such condition results due to the lack of ability of individuals to synthesize lactase enzyme which hydrolyses milk sugar i.e. lactose. Hence exogenous lactase is used in the preparation of lactase-treated milk and in the manufacture of lactose-free products, particularly milk, for such individuals. Other applications of lactase enzyme include modification of functional properties and preparation of dietetic products, in accelerating the process of cheese ripening.

The other enzymes that have limited applications in dairy industry are catalase, lactoperoxidase, and lysozyme.

PROCESSING OF FERMENTED MILK PRODUCTS

The fermented milks are the product obtained by the souring of milk by use of starter cultures. Historically speaking, the art of fermentation of milk might have been learned by mankind by accident. The nomadic communities acquired the art of preserving their merge supplies of milk by souring them in animal skins or crude earthenware pots. Initially, the intention could well have been simply to keep the milk cool through the evaporation of whey from the porous surface but the chance transformation of the raw milk into a refreshing, slightly viscous foodstuff would soon have been recognized as a desirable innovation. Later on, the art of fermentation has been refined and has come to the present-day knowledge of several types of fermented milks.

The fermented milks are popular because of following reasons:

1. Preservation-Fermented milk has higher shelf-life than normal raw milk. This is because fermentation of milk results in a product that is hostile to undesirable bacteria.

2. Organoleptic Properties - A variety of flavours in fermented milk, refreshing taste, and specific consistency and viscosity favourably influence the consumption of these products.

3. Production of varieties - it is possible to make several modifications in fermented milks to have varieties like sweet or sour, salted or spiced, beverage or gel, etc.

4. A “healthy” image - Fermented milks undoubtedly possess a “healthy” image and smart popularity. Generally, people look at fermented milks as natural food that is good for them.

5. Ideal for probiotics – fermented milk is an ideal medium for carrying probiotic microorganisms and also makes probiotic and symbiotic foods.

Yoghurt

Yoghurt is the most popular and widespread fermented milk product in the world. The word ‘yoghurt’ or ‘yogurt’ is derived from the Turkish word ‘Jugurt’. Yoghurt is a traditional food and beverage in the Balkans and the Middle East. However, its popularity has now spread to Europe and many other parts of the world. The general definition of yoghurt was given by Tamime and Deeth (1980). They defined yoghurt as a product resulting from milk by fermentation with a mixed starter culture consisting only of *Streptococcus thermophilus* and *Lactobacillus bulgaricus.*

FAO/WHO(1977) gave a more legal and scientific definition of yoghurt. Accordingly, "Yoghurt is a coagulated milk product obtained by lactic acid fermentation through the action of *Streptococcus thermophilus* and *Lactobacillus bulgaricus* from milk and milk products (pasteurized or concentrated) with or without the optional additions (SMP, WMP, whey powder, etc) and the final product must contain viable organism in abundance".

FAO/WHO expert committee also permitted the use of other suitable lactic acid bacteria in addition to *S. thermophilus* and *L. bulgaricus* for the manufacture of yoghurt. These organisms, however, should only be used as the supplementing flora when justified.

In India, Yoghurt has been defined by PFA as under: It means a coagulated product obtained from pasteurized or boiled milk or concentrated milk, pasteurized skimmed milk and or pasteurized cream or a mixture of two or more of these products by lactic acid fermentation through the action of Lactobacillus bulgaricus and Streptococcus thermophilus. It may also contain cultures of Bifidobacterium bifidus and Lactobacillus acidophilus and other cultures or suitable lactic acid-producing harmless bacteria and if added, a declaration to this effect shall be made on the label. The microorganisms in the final product must be viable and abundant. It may contain milk powder, skimmed milk powder, unfermented buttermilk, concentrated whey, whey powder, whey protein, whey protein concentrate, water soluble milk proteins, edible casein, and caseinates manufactured from pasteurized products. It may also contain sugar, corn syrup or glucose syrup in sweetened yoghurt and fruits in fruits yoghurt. It shall have smooth surface and thick consistency without separation of whey. It shall be free from vegetable oil/fat. animal body fat, mineral oil, and any other substance foreign to milk.

Dahi

PFA rules (2006), defines dahi or curd as: “It is the product obtained from pasteurized or boiled milk by souring, natural or otherwise, by aharmless lactic acid or other bacterial culture. Dahi may contain added canesugar. Dahi shall have the same minimum per cent of milk fat and milk solids-not-fat as the milk from which it is prepared. Where dahi or curd is sold or offered for sale without any indication of the class of milk, the standards prescribed for dahi prepared from buffalo milk shall apply. Milk solids may also be used in the preparation of this product”.

Koumiss

Koumiss (Turkish: kimiz, Mongolian: airag) is a fermented dairy product traditionally made from mare's milk as a result of lactic-acid and alcoholic fermentation. It is a traditional drink of normands-cattle-breeders and remains important to the people of the Central Asian steppes, including the Turks, Bashkirs, Kazakhs, Kyrgyz, Mongols, Yakuts and Uzbeks. It is also known as "Milk Champagne".

- Starter Cultures

In the early days koumiss from a previous batch was used as starter. Nowadays purified starters are being used for the production of koumiss. It mainly comprised of L. bulgaricus and Saccharomyces lactis. Various strains of lactic acid bacteria and yeasts have been isolated from commercial koumiss viz., Lactobacillus delbruckei subsp. bulgaricus, Lactobacillus paracasei subsp paracasei, Lactobacillus rhamnosus, Lactobacillus paracasei subsp tolerans, Candida kefir and Kluyveromyces marxianus subsp lactis. It is also possible to find lactic streptococci, coliforms and some spore forming bacilli in koumiss.

Kefir

Although no clear definition of kefir exists, it is a viscous, acidic, and mildly alcoholic milk beverage produced by fermentation of milk with a kefir grain as the starter culture (FAO/WHO 2003). The Codex Alimentarius description of kefir state it as Starter culture prepared from kefir grains, Lactobacillus kefir, and species of the genera Leuconostoc, Lactococcus and Acetobacter growing in a strong specific relationship. Kefir grains constitute both lactose-fermenting yeasts (Kluyveromyces marxianus) and non-lactose-fermenting yeasts (Saccharomyces unisporus, Saccharomyces cerevisiae and Saccharomyces exiguus).

Kishk

Kishk is a typical wheat-milk mixture fermented food popular in Egypt and most of the Arab World. It consists of small, round, or irregular pieces, yellowish brown in color, which have a rough surface and hard texture. When moistened with water, it becomes white and breaks up after a short time. Kishk is rich in nutritive constituents and is a possible source of many vitamins and growth factors associated with the microbial fermentative processes. It is of good keeping quality and consumed throughout the year.

1. **Microflora in Kishk**

Kishk is a naturally fermented product and aerobic spore formers like *B. subtilis* and *B.megaterium* are high in numbers in the initial stage but inhibited later on due to high acid.

The most predominant microflora, which is responsible for fermentation is lactic acid bacteria. Among LAB, homo and heterofermentative lactobacilli,
mainly *Lb. plantarum, Lb.casei* and *Lb.* b*revis* are predominate bacteria.

During the later stage of fermentation, yeasts develop, which produce gas and improve porosity and also enrich the product with vitamins.

2. **Manufacture of Kishk**

Kishk preparation involves three main stages.

Preparation of Par-boiled wheat

Wheat grains are placed in the large cooking pan, covered with water, and heated slowly to boiling, and simmered until soft. The cooked wheat or *helila* is then washed with cold *water,* spread on straw mats, and left to dry in the air. The dry material which is hard in texture is coarsely ground in stone mills, then sieved and seed coats are removed.

Preparation of Laban Zeer

Laban-zeer is sour coagulated milk. Traditionally, the milk was churned in a skin bag, and left out fluid is called sour milk. In hot weather, milk coagulates spontaneously and is then often considered unsuitable for cheese making. Such sour milk is stored in earthenware containers known as *zeer*. A suitable quantity of salt judged by taste is added and the contents of the zeer are mixed. The whey oozes through the walls and thus the consistency of sour milk becomes considerably thicker. Accumulated laban zeer is especially used in summer, when wheat is plentiful in the farmer's store for making kishk.
The most dominant microflora of laban zeer compose of *Lb. casei, Lb. plantarum and Lb. brevis*.

Preparation of hamma (kishk mix)

The coarser pow*er of* the par-boiled wheat is placed in large pots and moistened with slightly salted boiling water. Then raw milk or laban zeer diluted with water is added and thoroughly mixed to obtain a homogenous paste, called *hamma*.
After 24h, the *hamma,* wh*ich h*as meanwhile increased in volume as a result of fermentation, is kneaded by hand. Later on Laban zeer, twice the volume added before is diluted with water or milk with a syrupy consistency, is added in portions to the hamma, and left for a further 24h. Subsequently, the fermented mix is thoroughly remixed, cut in small balls, and placed on straw mats to dry in the open. The dried product is kishk. Sometimes spices like cumin or pepper are added for enhancing taste. Complete drying of the product takes 5-7 days and during this period also fermentation goes on gradually at reducing rates.

Yakult

Yakult is a probiotic fermented milk product that originated in Japan almost 70 years before. It is made with the help of a culture of *Lactobacillus casei* strain Shirota, which is named after the inventor Prof. Minoru Shirota. The product is most widely studied for clinical benefits and it is claimed that the product aids digestion, modulates immunity, and prevents infection.
Yakult is originally made from skim milk & sweetener agents like sucrose, glucose, liquid sugar & starch syrup. It may contain fruit juices & flavoring essences.
The average composition of Yakult is given below:

Fat 1.1 %
Protein 1.2 %

Lactose 1.1 %
Other Sugar 14.1 %
Ash 0.34 %

Villi

Villi is a traditional Finnish fermented milk product made from pasteurized unhomogenized milk with capsule or slime-forming starters that have adapted to grow at a lower temperature than the ambient temp., *viz.* 18 - 19^{0}C.

Starters for villi

Lactic streptococci - *Lactococcus lactis* subsp *lactis, L. lactis* subsp *cremoris*
Mold - *Geotrichum candidum*
Because villi are made from unhomogenized milk, the cream rises up to the top in the cup during fermentation and this mold grows on it, so there is a uniform velvet-like layer is seen when the cup is opened for eating.

ICECREAM

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.

Classification of ice cream

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

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.

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 choco bar (where chocolate acts as a couverture), chocolate frosties (chocolate layer containing crispies), and chocochips.

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.

Nut

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

Ice Milk / Milk Ice

A product similar to ice cream containing 2 -7% fat and 12-15% MSNF, sweetened, flavored and frozen like ice cream.

Ices

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

Sherbets

Sherbet is a product made 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.

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 flavors are often included in sorbets.

Mousse

Ice cream containing whipped cream, sugar, color and flavoring, and frozen without further agitation. Sometimes condensed milk is added to give better consistency.

Bisque

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

Custards

Custard is ice cream cooked to the 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.

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.

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.

Novelties

A nice 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.

Puddings

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

Fanciful-name ice cream

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

New york or philadelphia

This is generally a plain vanilla ice cream with extra colour for Philadelphia and extra fat and eggs for New York Ice Cream.

Rainbow ice cream

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

Fancy molded ice cream

It is molded in fancy shapes and composed either of one colour and flavour of Ice Cream or a combination of colours and flavours or especially decorated.

Mellorine type products

Mellorine is a product similar to ice cream in which the butter fat has been replaced by a suitable vegetable or animal fat.

Soft serve ice cream

Soft serve ice cream is a type of frozen dessert that is similar to, but softer than 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 the 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 dried version of liquid mix. It has several advantages of easy distribution and can be 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.

Kulfi

Kulfi is an indigenous frozen milk product. The method of manufacture of kulfi varies widely. The conventional method of kulfi making consists of boiling of milk, the addition of sugar, the concentration of milk to 2:1 level and the addition of khoa, malai, flavor 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 mixture in a ratio of 1:1.

Malai–ka–baraf

This term is applied to a variety of frozen product in which sweetened milk or malai may form the chief ingredient.

Composition of ice cream

The composition of ice cream is decided after giving consideration 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 the best ice cream.

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 ultrafiltration/ reverse osmosis, gel filtration, and electrodialysis can be used to produce a broad base of raw material for formulating dairy desserts. Replacement of a part of MSNF with whey protein concentrate or milk solids concentrate with the use of ultrafiltration can be utilized for the manufacturing of better quality products.

- 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.

Raw Materials

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 - nonfat – 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.

Milk solids not fat (MSNF)

MSNF consists of proteins, lactose and minerals, the components of which vary considerably.

The key components of MSNF are proteins which apart 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 the structure of ice cream
- Water binding ability

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 the softness of the final product.

FPDF– Freezing Point Depression Factor

DE– Dextrose Equivalent

HFCS– High Fructose Corn Syrup

Emulsifiers

Emulsifiers are by definition substances that 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 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 the continuous freezer
- Improved whipping properties
- Improved body and texture
- Richer mouth feel and creamy sensation
- Improved air cell distribution
- Improved heat shock resistance

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 leads to the immobilization of water. The water binding / immobilizing effect improves the storage stability of ice cream. Furthermore, stabilizers have a positive influence on the 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. Locust bean gum (LBG)

2. Guargum

3. Sodium alginate

4. Carrageenan

5. Sodium carboxy 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%.

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

Dairy Ingredients

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

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

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, pineapple, grape, almond, pistachio, cashew nut, walnut and groundnut.

Formulations 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 that also satisfies the legal standards. A well-balanced mix should always ensure

- A correct total solids to water ratio – if too high, sandiness and rough texture and if too low, glassy or icy texture with a weak body. Usually, total solids of 36.0 to 40.0% will result in organoleptically acceptable ice cream.
- There is an 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.

- 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.

As a thumb rule, the MSNF should be about 15.6% (slow turnover) to 18.5% (rapid turnover) 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.

Defects

Flavor Defects

Flavour is the most important sensory attribute in judging and grading of ice cream and frozen desserts. Even a minor flavor 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.

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.

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 properties.

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.

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.

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.

6. Lacks flavoring

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 manufacturer.

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 temperatures; other bacterial off-flavors may also be present. In such cases, the flavor defect(s) may be more appropriately described as a combination of acid (sour) and psychrotrophic bacteria-caused off-flavor (unclean, fruity, or putrid).

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.

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 mixed ingredients dilute the adverse sensory aspects of the dairy ingredient(s) in question, a lack of freshness (or stale) descriptor is more applicable.

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.

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.

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.

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.

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.

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.

1. Crumbly, brittle, friable

A brittle, 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).

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.

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.

4. Shrinkage, shrunken

A shrunken ice cream manifests itself by the product mass being withdrawn 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.

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 ice cream with this criticism, when placed in the mouth, seem colder than those free of the defect. Apparently, this is due to the 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.

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 nonfat 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.

Texture Defects

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 applying pressure with a flat object. This defect is closely associated with a high overrun. Fluffy ice cream usually melts slowly in the dish, yielding a relatively small proportion of liquid, which is often foamy and spongy.

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.

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.

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 remain in the mouth fine, hard, uniform particles that suggest fine sand, and are crystals of lactose. The sandy texture should not be confused with the coarse, 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.

UNIT – III

MEAT

SLAUGHTERING TECHNIQUES AND POST-MORTEM INSPECTIONS

Slaughtering Procedures

After the animals have rested for sufficient time, they are quietly taken to the stunning area. Animals may be facilitated through mechanical means like canvass straps or rolled plastic or prodded to move forward. However, tail twisting or beating is forbidden. Slaughter animals are properly restrained before stunning or bleeding. Different types of restraints are used for different species.

Stunning

It is a process to inactivate animals so that it is not able to move. It is an obligatory process with large animals. Stunning ensures that the animal is unconscious before it is slaughtered in order to eliminate pain, discomfort, and stress from the procedure. Many countries have legislation that requires pre-slaughter stunning. Care should be taken not to affect the heart and it should function normally to ensure complete bleeding which ensures better meat quality. Stunning is done in the special stunning pan (box with movable side wall).

Stunning methods

1. Most common method employed is striking the head with a wooden hammer or captive bolt. However, the blow should not damage the frontal bones as it may cause a brain hemorrhage.
2. Electrical stunning- An electric current of 75-120 volts is passed for 15-70 seconds through the hind part of the animal head in the regions of parietal boxes by puncturing the skin. This causes unconsciousness of the animals which may last for 5 min and it is enough to transfer the animal from a stunning pan to a bleeding runway.
3. Anesthetization- Anaesthetization may be carried out on swine using a mixture of CO_2 and air in equal volume with 0.18% chloroform and the inhalation period may last for one min.

Slaughter

The most common methods of slaughter practiced worldwide are the Halal (Islamic), the Kosher (Jewish), and the Jhakta (Sikh) methods.

Halal: *Halal* is one of the most popular methods of slaughter. This method prescribes the slaughtering of animals with a sharp knife to make a swift, deep incision that cuts the front of the throat, the carotid artery, the windpipe, and jugular veins but leaves the spinal cord intact. The animal is then hung upside-down and left to exsanguinate i.e. drainage of blood. The *Halal* slaughter requires that the name of Allah (or God) should be mentioned at the initiation of the operation. This method of slaughter ensures that the blood flows out completely from the animal.

Jhatka: It is an instant decapitation process limited mostly to sheep and goats and practiced in countries like India by a few religious sects. The animals are killed by a single strike of a sword or axe by severing the head.

Jewish Slaughter (Kosher): Kosher is the term applied to the procedures and techniques of slaughter practiced under the Jewish faith. In the Hebrew language, Kosher means fit to be used as food. Under this method of slaughter, the animals in a fully conscious state are killed and bled thoroughly with one clean stroke of the knife. Animals are however hoisted and shackled first. A 16-inch (40.6 cm) razor-sharp steel knife called the Khalaf is stuck into the throat by a trained slaughterer, the Shohet, in an operation in which the animal is killed and bled at the same time. Skinning is made from the chest down to the level of the belly, and the chest is cut open first for inspection and later evisceration.

Bleeding

Bleeding is a procedure in the slaughter process that is performed by cutting the jugular vein in the neck and carotid artery in order to allow blood to drain from the carcass, resulting in the death of the animal from cerebral anoxia. The bleeding knife should be continuously sharpened as a blunt knife may prolong the incision and damage the cut ends of the blood vessels. This may result in premature clotting and blockage of the vessels thus delaying the bleeding process. A prolonged delay in bleeding could result in the animal regaining consciousness. The delayed bleeding may also result in an increase in blood pressure causing the blood vessels to rupture and hemorrhage muscle. The extra blood in the tissues may lead to the meat getting decomposed quickly. Incisions should be therefore swift and precise. In poultry, sheep, goats, and ostriches, the throat is cut behind the jaw.

S**kinning**

After successful bleeding, first, the head is skinned, separated from the body, marked with the same number as the body, and then hung on the hook for post-mortem examination. Skinning is a term mostly used for small ruminants and the method of skinning is known as case-on. The skinned materials are called skins. Skin is the most valuable byproduct economically. In sheep and goats, skin is first cut around the leg to expose and loosen the tendon of the hock and used for hanging the carcass. This process is called legging. The second step that follows is called skinning which involves removal of the entire skin and preparation of the animal body for evisceration. Skinning can be done either in the horizontal or hanging position depending on the convenience and available facilities. If the animal's body is in a hanging position, the legging is generally started at the back of the free leg by removing the skin around the hock and continuing towards the toes. This exposes the tendon on the back leg and the foot is cut off at the joint above the toe. The body skin is removed by making an opening in the front legs, cutting towards the jaw, and continuing over the brisket to the naval. Once the brisket has skinned, the knife is seldom used to protect the fell (a fine membrane between the skin and the carcass). This helps in improving carcass appearance and reducing surface shrinkage. This is largely accomplished by using a fist/hand. After the skin has been removed, the carcass is washed and placed on a hook. In horizontal skinning, the animal is placed on its back on a flat raised surface and a similar process is repeated.

This operation is absent in pigs, because skin is a part of the carcass. In the case of large ruminants (cattle and buffaloes), cuts are made on the skin along the mid-ventral line and also on the medial side of the limbs connecting to the respective points (sternum and pelvis) in the mid-ventral line. Skinning of large ruminants is known as flaying and the incisions made on the skins are known as ripping lines. The deskinned materials are called hides.

Evisceration

It should be carried out without damaging the internal organs or disturbing the internal surface of the carcass. Damage to the gastrointestinal tract (GIT) may contaminate the carcass with microorganisms. The first step in evisceration is to cut around the tied bung or rectum and free it completely from all attachments. The breastbone is then cut along the midline up to its tip. Another cut is made from the cod or udder down the midline into the breast cut. Then the ureter connections to the kidneys are severed and the intestines loosened. The stomach and intestinal mass are removed. The lever could be detached from its connecting tissues and then pulled out along with the contents of the abdominal cavity. The gallbladder is carefully removed from the liver so that its content does not spill out and contaminate the carcass. The pluck consisting of the heart, lungs, trachea, and esophagus can be pulled out as a unit. The carcass is then washed and carried manually or mechanically to the inspection area.

Carcass splitting and sizing

In the slaughterhouses, carcasses of small ruminants are not split into sides or quarters; carcasses of large ruminants are split into four quarters; and carcasses of pigs are split into two sides. Therefore, at the retail meat stalls selling buffalo meat, pork, and mutton, we find quarters, sides, and whole carcasses of respective animals. Carcasses are sawed by electric or pneumatic saws starting from the hind part to the central vertebrae. This facilitates transport, storage, and efficient refrigeration.

POST MORTEM EXAMINATION

Postmortem examination/inspection refers to the inspection of carcasses and organs by qualified veterinarians to ensure that carcasses and organs are fit for human consumption. During the inspection, care should be taken not to contaminate the carcass and organs of diseased animals. The knives and other instruments used for cutting and examining organs, glands, and tissues should be properly sterilized before and after use. The particular sequence should be followed during postmortem examination so that each carcass and thereof organs are checked thoroughly.

Objectives of postmortem examination

Carcasses should not be sent to the chilling section without inspection after dressing. Some of the diseases that are not apparent during the antemortem examination can be detected easily in postmortem examination. Thus, post-mortem inspection ensures safe meat to the consumers and also controls diseases right at the farm level itself. It also directs to the adoption of a proper disposal procedure for condemned meat and offal. Since postmortem inspection is performed for carcasses as well as their viscera, it ensures a systematic way of evisceration and handling of offals.

Facilities required for postmortem examination

- The area where the examination is being conducted should have sufficient and well-distributed light. Natural light is considered better than artificial light. The intensity of light must be 540 lux
- The person carrying the inspection needs clean, sharp, stainless knives
- There must be provision for hot and cold water
- There should be a sterilizer to sterilize the knives, saws, and cleavers. The postmortem examination should be carried out under hygienic conditions. The knives should be sterilized by dipping them in boiling water for 30 minutes or by autoclaving them for 10-15 minutes. (The sterilization of anthrax-contaminated knives requires special consideration).
- To put a mark on the carcass and its viscera, marking dyes should also be provided, which should be cheap, non-toxic, and non-corrosive in nature. The marking indicates that the carcass has been inspected and guarantees the consumer about its wholesomeness. Marking of meat is done by (i) using a stamp (ii) branding or (iii) labeling. A common method is a Metal stamp dipped in stamping ink.
- There should be a provision for detained room side by the inspection site.

General consideration

The following points should be considered during postmortem examination/ inspection:

- The examination must be done as soon as possible. Carcasses of beef and pork set rapidly and if the inspection is delayed especially in cold weather the examination of lymph nodes becomes difficult.
- Carcass and organs are to be examined methodically following a definite sequence. The healthy carcass should be examined before inspecting the diseased or suspected ones.
- Great care must be taken at the time of inspection, particularly in cases suspected of zoonotic diseases.
- The identity of the carcass and its viscera should be maintained.
- Inspectors should avoid unnecessary cuts considering the value of high-quality food. One should incise the carcass in such a way that the surface of the carcass appears clean and undistorted.

Postmortem principles

Visual perception

First, the carcass and visceral organs should be examined visually for any visible abnormalities. The examination is done for any change of color, atrophy, hypertrophy, neoplastic condition etc.

Palpation

The organs are palpated for any change in consistency, sliminess or gelation, cyst, etc.

Incisions

The organs are incised if needed. This is done to examine any parasite inside an organ, structural deformity etc.

Laboratory tests

These are done for confirmation and support the observation made by macroscopic examination. While examining the organs of the carcass, lymph nodes of the adjoining area must be examined.

Postmortem Examination of Carcasses

Large animals

In the case of large animals like cattle, the sequence of postmortem examination is as follows:

Head

- Verify the number, age, and sex of the animal
- Inspect gums, lips, and tongue for FMD, necrotic and other forms of stomatitis, actinomycosis, and actinobacillosis (Palpate the tongue for the latter).
- Incise the internal and external masticatory muscles and tongue for *Cysticercus bovis.*
- Incise retropharyngeal, submaxillary, and parotid lymph nodes for tuberculosis (TB) lesions.
- For sheep & goats, the lips, gums, and nasal cavities should be examined for contagious ecthyma.

Lungs

- Examine visually and then palpate for the detection of pleurisy, pneumonia, tuberculosis, fascioliasis, and hydatid cysts.
- Incise the bronchial and mediastinal lymph nodes and expose the lung by giving deep incision from the base to the apex (for checking TB lesions).
- Check the tumors, abscesses, etc. by palpation.

Heart

- Examine the pericardium for traumatic or tubercular pericarditis.
- Incise the ventricles of the heart and pay attention to look for petechial hemorrhages on the epicardium and endocardium and cuts in the myocardium. Flavy condition of the myocardium is indicative of septic conditions.

Liver

- A visual examination should be made for fatty changes, abscesses, hydatid cysts, actinobacillosis etc.

- For examination of fascioliasis, incise the thin portion of the left lobe of the liver and examine the contents.
- For sheep and goats, lungs, heart, and liver:
- Palpate lungs, heart, and liver and accompanying lymph glands for abscesses.
- Cut the bile duct for examining possible fluke infestation

Stomach and intestines

- Check the serous surface of the intestine for TB lesions and actinobacillosis.
- Palpate the mesenteric lymph node and if necessary incise and examine the same.

Spleen

- Examine the surface and substance for TB lesion, anthrax, hematoma, and presence of infarcts.

Uterus

- Check for septic conditions by viewing, palpating, and incising if necessary.

Udder

- Check the supra mammary lymph nodes by incising for evidence of TB lesions.
- Check for abscesses if any.

General inspection of the carcass

- Look for injuries and bruises. Bruises are dark in colour after 24 hours and there is watery condition after 24 to 38 hours. After 3 days, the area becomes rusty orange color and soapy to the touch.
- Look for inflammation, abscesses, and TB lesions in the thoracic and abdominal cavities.
- Examine the kidneys.
- Incise and examine renal lymph nodes.

Postmortem judgment

- Similar to antemortem examination, a competent veterinarian has to submit its judgment report
- Fit for human consumption
- Unfit for human consumption or total condemnation
- The affected organs must be condemned while the rest can be passed for human consumption (partially condemned).
- The condemned carcass/ organs should be disposed of following scientific procedure.

Diseases and conditions for which carcass is totally or partially condemned

The carcass is totally condemned for rabies, anthrax, glanders, rinderpest, foot and mouth disease, acute enzootic meningoencephalitis, acute pleurisy, contagious bovine pleuropneumonia, ovine foot rot, sheep pox, swine fever, swine erysipelas, salmonellosis, fibrinous rhinitis, black leg, bovine viral diarrhea, hemorrhagic septicemia, listeriosis, pasteurellosis, coccidiosis, calf diphtheria, calf diarrhoea, malignant edema, tetanus, etc.

The carcass in case of actinomycosis, actinobacillosis, and Johne′s disease, is totally condemned if accompanied with emaciation and in generalized form, otherwise, the carcass is passed for human consumption after local condemnation. In the case of corynebacterium infection, the carcass is passed after removal of affected organs.

In case of heavy infestation (more than 10 cysts) with *Cysticercus bovis* and *Cysticercus cellulose*, the carcass is totally condemned, otherwise, the carcass is passed after removal of head, heart, diaphragm, and esophagus. *Trichinella spiralis* infected carcass is totally condemned. If the carcass shows the sign of fascioliasis with emaciation then it is totally condemned, otherwise, it is passed after trimming of the liver.

The carcass is passed for consumption after removal of the lung in case of emphysema and bronchiolitis. If there is no fever, then the carcass with signs of gastroenteritis is unconditionally passed.

The judgment of a carcass suffering from tuberculosis depends on the method of spread, the extent of the disease, the character and age of the lesion, and the general condition of the animal. The carcass is totally condemned when tuberculosis spreads through the portal or pulmonary or systemic circulation. In the case of localized tuberculosis, the carcass is passed after the removal of the affected organs and associated lymph nodes.

Metabolic and nutritional disorders and intoxication

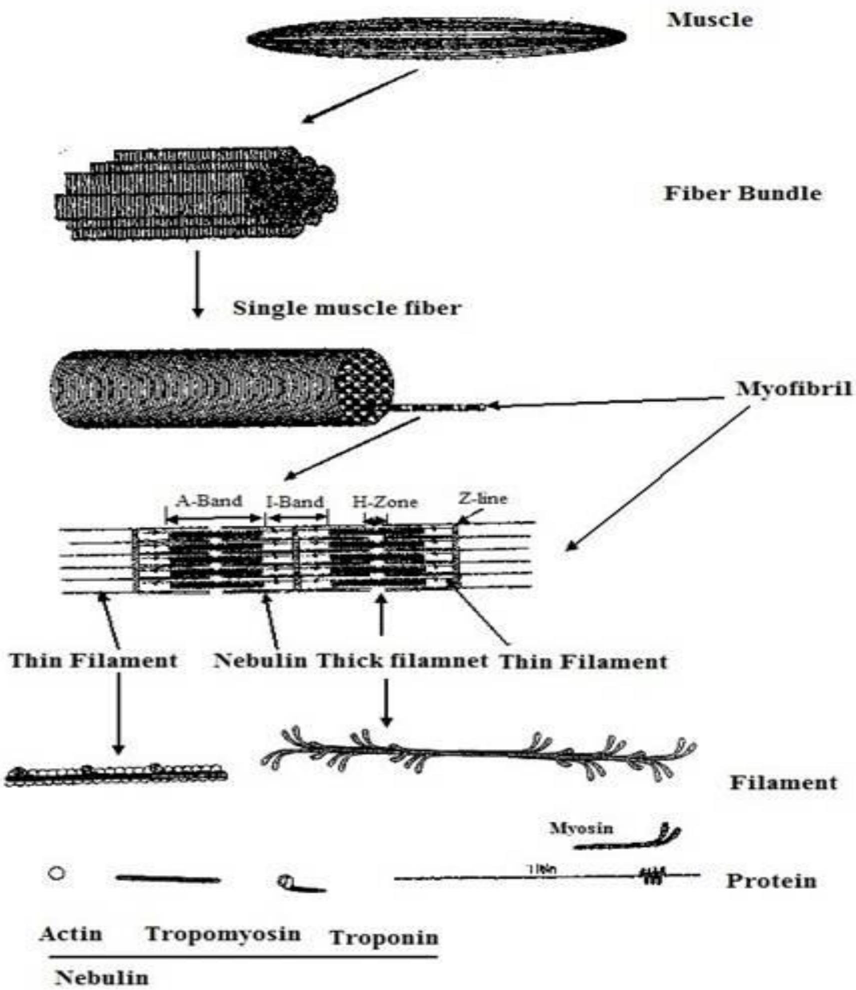
The carcasses are totally condemned if they show any of the following signs:
Anaemia with emaciation, (ii) grass tetany, (iii) hemoglobinuria, (iv) jaundice, (v) ketosis with chronic indigestion, (v) poisoning, (vii) bloat or (viii) impaction, etc.
Abnormal conditions: Abnormal conditions like abnormal color, taste, smell, buck smell, bore smell, etc. result in total condemnation of the carcass.

RIGOR MORTIS: BIOCHEMICAL AND HISTOLOGICAL CHANGES

Meat is basically defined as the flesh of animals used as food. The term meat generally differs from muscle in the sense of its structural and physicochemical nature as it (muscle) has undergone certain chemical and biochemical changes following the death of an animal which is a postmortem aspect. Thus, during the time elapsed between the death of an animal and its processing, a series of biochemical and physico-chemical changes takes place which lead to the conversion of muscle into meat.

Muscle: Structure, Composition & Functioning

Muscle is made of a number of fiber bundles (1.0 mm thick), comprised of a group of fibers, (0.1 mm thick) held together by a structure of connective tissues or perimysium. Connective tissues which provide edible texture, structure, and flexibility to the muscles, are comprised of fibrous protein collagen, reticulin, and elastin. Muscle fiber, a unit of muscle contraction, is a multinucleate, cylindrical cell bounded by an outer membrane or sarcolemma and is consist of myofibrils of 1-2 microns in size. Myofibrils are separated by the sarcoplasmic reticulum, a fine network of tubules. Each fiber is filled with sarcoplasm containing mitochondria, enzymes, glycogen, ATP, creatine, and myoglobin. The myofibrils are cross striated to give rise to an understanding of the physical structure of muscles (dark or A and light or I/Z bands). The unit of fibril is the sarcomere which lies between adjacent two Z- bands. Fibrils consist of two sets of filaments i.e. myosin and F-actin. Contraction and relaxation of striated muscles take place due to the interaction between actin, myosin, and ATP. In the presence of magnesium and calcium ions, myosin liberates ATP which results in muscle contraction.



Structure of Muscle

Composition (%) of muscle tissue

SPECIES	WATER (%)	PROTEIN (%)	LIPID (%)	ASH (%)
Beef	70-73	20-22	4-8	1.0
Pork	68-70	19-20	9-11	1.4
Chicken	73.7	20-23	1.0	-
Lamb	73.0	20.0	5-6	1.6
Cod	81.2	17.6	0.3	1.2
Salmon	64.0	20-22	13-15	1.3

General Consequences Following Death of an Animal (Post Mortem Changes)

Following the death of an animal, circulation of the blood ceases resulting in a complex series of changes within the muscle. As much as possible blood is removed from the animal carcass to increase the edibility and keeping qualities of the meat since blood is an ideal medium for the growth of spoilage microorganisms. Failure of blood circulation and its removal from the muscle tissue results in depletion of oxygen supply to the tissue leading to depletion of ATP and creatine phosphate levels (due to stoppage of the electron transport chain and oxidative phosphorylation) and most importantly to the onset of anaerobic metabolism of glycogen. Anaerobic metabolism of glucose and breakdown of ATPs by the continuing action of sarcoplasmic ATPase leads to depletion of ATP and creatine phosphate results in the onset of rigor mortis on the other hand breakdown of glycogen in the absence of oxygen leads to the production of lactic acid thus decrease in pH. Other postmortem physical changes in muscle are:

Change in pH

A decrease in pH due to lactic acid formation is accompanied by various exothermic reactions such as anaerobic glycolysis. pH changes from physiological pH i.e, 7.2-7.4 to ultimately post-mortem pH i.e, 5.3-5.5 in 24 hrs. This has a profound effect on the muscle portion of meat. Usually, glycolysis ceases even before the glycogen is depleted.

Change in temperature

The temperature of an animal increases from 37.6-39.0^{0}C. This is the reason why animal cools slowly during refrigeration as a result of the continuous production of heat. This phenomenon is known as animal heat. Removal of animal heat by chilling or refrigeration is essential to ensure a longer shelf-life of meat.

Change in proteins

Due to the change in pH and high temperature, the color of meat changes, and water holding capacity (WHC) also decreases. Sarcoplasmic proteins get denatured and attached to the surface of the myofilament, which produces a change in meat color which becomes light. The water-holding capacity of myofibril proteins decreases resulting in the exudation of fluid.

Sarcoplasmic proteins are more labile with respect to physiological conditions prevailing in the post-mortem muscles. These proteins are highly susceptible to disruption as compared with myofibrillar proteins. Sarcoplasmic proteins during rigor mortis denatured below pH 6.0 and at 37^0 C.

Change in water holding capacity

Water holding capacity is the function of respective proteins which bind with water. In the pre-rigor stage, meat possesses a high water-holding capacity but later it decreases during the first hour following the death of animals. The lowest water holding capacity is found at its iso-electric pH i.e. 5.3-5.5. After post-rigor aging water holding capacity is found to be increased because of an increase in osmotic.

During post-mortem movement of Na. K, Mg, and Ca in muscles take place. But during aging there is a continuous release of Na & Ca. and uptake of K ions continued up to 6-8 days. The movement of cations produces an increased electrical charge on muscle protein which facilitated the formation of hydrated ions. This is believed to be the reason for increased water-holding capacity during aging of meat.

Post mortem glycolysis

After the death of the animal, blood circulation stops, thus oxygen supply to muscle tissues decreases hence anaerobic conditions prevail in the muscle. The glycogen present in tissues is no longer converted into CO_2 and water instead, converted into lactic acid through anaerobic glycolysis. The conversion of glycogen takes place through two different pathways.

(a) Amyloytic pathway i.e. hydrolytic
(b) Phosphorolytic pathway

Due to this glycolysis pH changes from physiological pH i.e. 7.2-7.4 to ultimately post- mortem pH i.e. 5.3-5.5. This pH is attained within 24 hours and is related to ATP production, which falls in this pathway. The net fall in ATP is responsible for the onset of rigor mortis. The pH 5.3-5.5 is the ideal pH that can be obtained by well-rested and well-fed animals before slaughter.

Conversion of Muscle into Meat (Rigor Mortis)

The most important change that occurs in postmortem muscle is the development of rigor mortis, which means stiffness of the muscle. The primary cause of the onset of rigor is post-mortem decline in the level of ATP. The process takes from 7-24 hrs depending on the species; however, it is linked with the rate of depletion of ATP in muscle. The entire process of conversion of muscle into meat is broadly divided into three stages:

1. Pre-rigor stage

During the early stages of the postmortem or pre-rigor stage, the concentration of ATP more or less remains constant as the muscle tries to maintain ATP levels by an active creatine kinase. However, it will lead to the liberation of creatine from muscle. Thus, in this state creatine phosphate levels fall more rapidly than that of ATPs. ATPs are providing cushioning effect for the filaments of two proteins i.e. actin and myosin. This results in meat that is soft and pliable.

In pre-rigor stage, myosin dissociates from actin and can be extracted in a solution of high ionic strength. The water-holding capacity of the muscle proteins remains high during this stage.

2. Rigor mortis

This period is very important as meat becomes rigid and stiff. The onset of rigor mortis maybe 8-10 hours postmortem and it may last in 15-20 hours in meat. The onset of rigor is demonstrated by a fall in ATP, loss of extensibility of muscles, and contraction of tissues. The time difference between the death of an animal and the onset of rigor state is termed as delay phase. This period depends upon a number of factors such as age, health, size of carcass, the amount of fat cover, nutritional status of animal, pH and glycogen level, and temperature as well. ATP plays a very important role in this stage. As the ATP level falls two muscle proteins gradually form an associated actomyosin complex which is inextensible and is responsible for contraction. This is the necessary criterion for the development of rigor mortis. The extent of contraction of the muscles is determined by the estimation of the length of the sarcomere within the myofibril. Meat which is cooked in this state is very tough in texture. The water-holding capacity of the muscle protein remains minimum during this stage due to a drop in pH as it comes closer to its iso-electric point i.e. pH 5.3-5.5. If the ultimate pH (5.60) falls too quickly, the carcass would still be warm adversely affecting water holding capacity and prevailing partial denaturation of protein resulting in pale, soft, and exudative (PSE) muscle ultimately leading to a lower yield of the meat. This is often encountered in pigs having sufficient reserves of glycogen. On the other hand, if inadequately fed or fasting animal having a minimum reserve of glycogen is subjected to slaughtering; dark, firm, and dry (DFD) meat conditions. DFD meat is having pH not below 6.0 and is darker in color and susceptible to microbial growth.

3. Post-rigor (conditioning/aging)

During post rigor stage meat become tenderizes and organoleptically acceptable when it is kept cold for some time after rigor mortis. The muscle again becomes soft and pliable with improved flavor and juiciness. The post-rigor meat provides lesser problems in toughness when cooked compared to with that cooked in rigor. Meat gradually reaches an optimum tenderness period after an aging period of 10-18 days stored at 0 - 5^0C following the dissolution of rigor. However, prolonged storage of meat in some species may results in some problems viz. microbial spoilage, desiccation of proteins, and development of off flavors. Thus, it is recommended to consume meat before it gets spoiled. The aging which is also called conditioning or ripening of meat is sometimes accelerated by raising storage temperature for e.g. holding meat at 15^0C for 3 days period in UV to control the microbial growth at the surface. While in the case of pork, aging is not recommended rather eat fresh as it develops rapid onset of fat rancidity even at low temperatures. On the other hand, beef is generally aged and lamb & mutton are occasionally aged.

Aging is considered a very important aspect of meat processing as it imparts desirable flavor, textural, and other sensory attributes to the finished product. The responsible factors for these desirable changes are still been a researchable issue, however, it is now a fact that in post- rigor state, the actomyosin complex does not dissociate but other subtle changes occur like an increase in the water holding capacity due to increased osmotic pressure in the muscle fiber due to net inside movement of cations and breakdown of proteins by liberated proteolytic enzymes, the cathepsins may lead to tenderness. While cooking meat tenderizing agents such as the enzyme calpain etc are added which break down the stiff muscle protein to yield a soft and organoleptically acceptable meat.

PROCESSING OF MEAT AND MEAT PRODUCTS

Meat processing involves the slaughter of animals processing of the carcasses into cured, canned, and other meat products, and the rendering of inedible and discarded remains into useful by-products such as lards and oils. Meat is exposed to a series of wide range of processes viz. curing or preserving processes such as salting, wet pickling, drying, cooking and canning, sausage manufacture, and ham curing. All these processing techniques are aimed at inhibiting microbial spoilage and increasing the shelf life of the meat. Major principles involved in meat processing are the use of heat, low temperature, smoking, modified atmosphere packaging, and ionizing radiations. The methods of preservation are mainly grouped into three categories i.e. control by temperature, by moisture, and by lethal agents (bactericidal, fungicidal etc.)

Preservation of Meat

Use of low temperatures

Chilling and freezing are the most commonly used preservation system for meat and meat products.

a. Chilling

Chilling is the most widely used technique to preserve raw and processed meat. Chilling preserves muscle tissue by retarding the growth of microorganisms and by slowing many chemical and enzymatic reactions. Storage temperature may vary from 1.4 to 2.2^{0}C for storage of beef for 30 days depending upon the number of microorganisms. The carcass should go to the cooler as soon as possible and its innermost part should be able to attain below 10^{0}C within 12 hrs of slaughter in order to prevent undesirable off-flavors and bone taints due to bacterial growth. An ideal temperature of storage for meat should be 1^{0}C above its freezing point.

During post-mortem cooling and subsequent refrigerated storage, control of relative humidity (around 90%) is very important. The undesirable moisture is lost from the surface, the weight reduction becomes of economic importance, and meat pigments myoglobin might get oxidized to brown metmyoglobin. However, a small amount of moisture loss from the surface is desirable since this tends to retard the growth of microorganisms.

b. Freezing

Freezing is an excellent process for preserving the quality of meat for long periods. Freezing is often used to preserve meats during shipment over long distances or for holding until long times of storage. Its effectiveness depends on ice crystal formation and the rate of lowering of temperature. When the temperature of storage is below - 18^{0}C, changes occur at a very slow rate in the muscle of warm-blooded animals. The quality of frozen meat depends on various factors such as the rate of freezing, packaging etc. When muscle tissue is frozen rapidly, small both intra and extra-cellular ice crystals are formed which cause little damage to the meat structure. While large ice crystals are formed at a slow rate of freezing causing compactness of muscle fiber. The process of denaturation can be accelerated with a resulting decrease in the water-holding capacity of the tissue. Loss of water-holding capacity of the muscle along with mechanical damage to cells by ice crystals is responsible for large parts of thaw exudates. To protect against quality loss due to changes in protein, anti-freezing compounds or cryoprotectants i.e. polydextrose, and polyphosphate are added to meat formulations. Rapid freezing can be obtained by using air blast freezers either on a batch or continuous basis which employ -20 to -40^{0}C cold air. Large-size meat cuts are vacuum packaged to prevent lipid oxidation and discoloration due to the formation of metmyoglobin. Retail meat is packed in low permeability films with better mechanical strength e.g. Sarlyn.

Use of heat

The canning of meat is a very specialized technique in that the procedure varies considerably with the meat product to be preserved. Since meat products are low-acid foods so the rate of heat penetration is fairly low. Commercially canned meats can be divided into two groups on the basis of heat processing used;

(a) Meats that are heat processed in an attempt to make the can contents sterile.
(b) Meats that are heated enough to kill part of spoilage organisms must be kept refrigerated to prevent spoilage.

The processing temperature for shelf-stable canned cured meat is 98^{0}C. Treatment of meat surfaces with hot water to prolong the storage time has been suggested. Although this may result in a loss of nutrients and damage to color. Actin is the most heat-labile muscle protein becoming insoluble at 50^{0}C. Denaturation of muscle proteins decreases their water-holding capacity. This decrease in water holding capacity may produce desirable juiciness, provided free water is not expelled from the tissue. During heating, fat is melted. Adipose tissue cells are ruptured and there is a significant redistribution of the fat. When meat is eaten warm, the melted fat serves to increase the palatability of the product by giving a desirable mouth feel, especially at the end of the chewing period, when most of the aqueous juices are lost. Myoglobin also undergoes denaturation. The red pigment heme is oxidized to brown pigment hemin. Canned meatloaf can be manufactured substituting a part of the meat with high calcium coprecipitate. It is observed that 20% meat can be replaced with high calcium milk protein coprecipitate in chicken meatloaf without affecting the quality of the end product.

Dehydration

Deprivation of available moisture (reduction of water activity) for microbes not only prevent their growth but also kills them, thus resulting in increased shelf life and better-quality product. Water may be made unavailable either by dehydration, freeze drying or by increasing extracellular osmotic pressure as is done in curing. Drying meats can be successfully employed for both raw and cooked meat. However, the quality of the final reconstituted product is superior when meat is cooked prior to dehydration. There is a loss in the native structure of the protein as measured by loss of water-holding capacity during temperatures from 0 to 20^{0}C. This is caused by the denaturation of sarcoplasmic proteins. The next major loss in water holding capacity begins in the temperature range of 40 - 50^{0}C due to the denaturation of contractile proteins. Collagen is rapidly converted to gelatin at around 100^{0}C. The texture is most severely altered by dehydration. The tough texture of dehydrated meat can be overcome by preparing products with intermediate levels of water.

Smoking

Smoking is often used with salting and curing. It gives desired flavor, and aroma and aids in preservation. It was noted that preservative substances added to the meat together with the action of heat during smoking have a germicidal effect and that drying of the meat together with chemicals from the smoke inhibits microbial growth during storage. Smoke consists of phenols, alcohols, organic acids, carbonyl compounds, and hydrocarbons. The desirable effects of smoking meat can be listed below:

- Meat preservation through aldehydes, phenols, and acids (anti-microbial effect)
- Antioxidant impact through phenols and aldehydes (retarding fat oxidation)
- Smoke flavor through phenols, carbonyls, and others (smoking taste)
- Smoke color formation through carbonyls and aldehydes (attractive color)
- Surface hardening of sausages/casings through aldehydes (in particular for a more rigid structure of the casing)

Modified atmospheric storage

Fresh meat held at refrigerated temperature has a limited shelf life because of microbial growth. Modified atmosphere refers to the adjustment in the composition of the atmosphere surrounding the product. At higher concentrations of CO_2 surface browning of meat occurs due to the oxidation of myoglobin and hemoglobin pigments to a ferric state. The most desirable concentration of CO_2 to use in a modified atmosphere is a compromise between bacterial inhibition and product discoloration.

Ionizing radiation

Ionizing radiation constitutes a potentially useful form of preservation. Besides its desirable ability to inactivate microorganisms, it also has the undesirable effect of altering meat pigments. Sterilizing doses of ionizing radiation result in the breakdown of various lipids and proteins too often undesirable odors. Tenderization of muscle may also occur during this treatment. A temperature of $\leq$ 80^{0}C or below greatly reduces undesirable effects without affecting lethal effects on microorganisms. Generally, enzymes are not inactivated by irradiation treatment, it is necessary to heat approximately 70^{0}C prior to irradiation and storage.

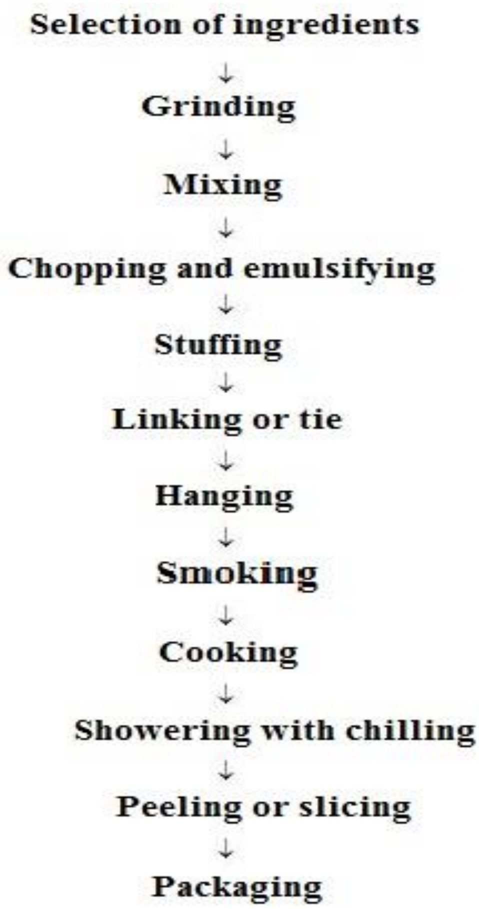
PROCESSING OF MEAT PRODUCTS

Comminuted meat products

Comminution is the mechanical process of reducing raw materials to small particles called as minced meat. Depending upon the final use of the comminuted meat the degree of comminution done differs among various processed products and is often a unique characteristic of a particular product ranging from very coarsely comminuted (to produce non-emulsified sausages like salamis and summer sausages), to finely comminuted, (to produce emulsified sausages like frankfurters, bologna, etc). Sausages are usually defined as comminuted seasoned meats, stuffed into casings; they may be smoked, cured, fermented and heated. They are made from any edible part of the slaughtered, veterinary-inspected animal, and a series of nonmeat ingredients.

a. Sausages

Sausages are meat products that are salted & usually seasoned or spiced and are an example of comminuted meat products that are generally recognized as emulsified, stuffed, linked, smoked, and cooked meat products. Based on the product characteristics and processing methods, they are broadly divided into three categories: **fresh sausages, cured sausages, and fermented sausages**. In all cases, meat is comminuted to reduce meat and fat particle size (grinding, mincing, chopping, or flaking), mixing with ingredients, stuffing into the specific casing, linking to obtain specific lengths, and finally, packaging. Sausages might be of ground and emulsion type. In the ground variety of sausages discrete particles of meat are seen on the other hand, in emulsion-type sausages fat is emulsified & stabilized by lean components. Sausages were developed to utilize low-quality meats such as trimmings head, shoulder & by-products of the meat. The processing of sausages is a continuous sequence of steps, which are all equally important.



Process flow diagram of sausage manufacture

i. Selection of Ingredients

Sausage ingredients include:

- Meat based on consideration of fat/protein; moisture/protein and myoglobin concentration
- Moisture - added as ice at the time of chopping in a number of fresh and smoked sausages
- Curing ingredients - salt, sodium nitrite, and/or nitrate and sugar
- Seasonings - may include spices, such as black pepper, paprika, mace, and cinnamon; herbs that may include thyme and savory; vegetables such as garlic and onion and other substances, such as flavor enhancers
- Fillers and binders - occasionally used to improve color, binding properties, slicing characteristics, altering flavor, or reducing costs
- Ascorbic acid - used to improve color in smoked sausages
- Other additives - may include liquid smoke

Milk proteins have been utilized as fillers, binders, and extenders in cooked, comminuted meat products to reduce cook shrink and formulation cost, as well as to improve emulsifying capacity, emulsion stability, water binding, potential nutritive value, and slicing characteristics. These proteins significantly increase the gel strength of meat proteins and it has been shown that there has a synergistic effect between milk proteins and salt-soluble meat proteins, through covalent cross-linkages.

The addition of caseinate stabilizes the meat emulsion as required in the sausage mix. It thickens the gravy during frying and prevents it from running out, but excess incorporation of caseinate may result in the drying up of the sausages. Further addition of water-absorbent materials becomes essential when sodium caseinate concentration in sausages exceeds 5%. The greater water holding capacity, lower viscosity, and lower cooking losses of sausage batters containing 2% sodium caseinate in comparison to all meat control were observed.

The coprecipitates have good potential in various meat products such as frankfurters, sausage batter, and luncheon meats as meat replacers or extenders. Sausage acts as a good medium for the use of coprecipitates. The finely, dispersed dairy protein matrix in sausages also can act as a moisture-binding agent, thus, developing the desirable chewy texture besides controlling shrinkage during storage and deformation while slicing. The addition of milk coprecipitate in combined boiled sausages resulted in increased pH, reduced nitroso pigments, and increased residual nitrites content in the end product. It is found that both high and low calcium coprecipitated improved the emulsifying capacity, emulsion stability, and water-holding capacity of meat emulsion in fresh sausages at the 20% replacement level. Supplementation with dairy coprecipitates into boiled beef pork sausage batters up to 30% of meat protein yields emulsion with increased pH, enhanced water binding ability, and improved adhesion properties.

ii. Grinding

Meat chunks of variable size and shape with variable fat contents are ground to form uniform cylinders of fat and lean. The screw feed in the barrel of the grinder conveys the meat & presses it into holes in the grinder plate. The rotating blade cut the compressed meat and aids in filling the grinder plate holes.

iii. Mixing

Cylinders of fat and lean obtained by grinding are tumbled in a mixer to give a uniform distribution of fat and lean particles. This can be used for coarse ground sausages or for emulsion-type sausages by utilizing a chopper or emulsifier and with suitable additions of required ingredients to obtain the desired texture & uniformity of composition.

iv. Chopping

It is often used as a means of batching the sausage mix, the mixed batch being transferred to an emulsifier, or acquiring the desired texture.

v. Emulsifying

This machine combines the principle of grinding and chopping. The Emulsifier machine handles large volumes of meat rapidly to produce the desired texture. Speed of handling material and a high degree of disintegration of meat tissue help in obtaining desired textures. In the preparation of sausage, the protein and water of the meat mixture form a matrix that encapsulates the fat portion. In a meat emulsion, the protein myosin acts as the primary emulsifying agent. The addition of salt to the product is to release the myosin from the muscle fiber. The emulsion is generally formed by mixing the meat with salt and other ingredients in a chopper, which aids in disrupting the fibers and facilitates the release of myosin.

vi. Stuffing

Sausage emulsion also known in the trade as mix sausage dough or batter is transferred to stuffers for extending the mix or emulsion into **casings**. At this point, the size and shape of the product is determined. Generally, three types of stuffing devices are used.

- Piston
- Pump
- Combination of piston & pump

In the past, the casing of the sausages was made from animal casings, however, this was a limiting factor for the production of sausages. Today, the casings are made of cellulosic and regenerated collagen. The limiting factor now is the supply of meat and the cost of it. Fermented sausages are further subjected to fermentation and maturation. Fermentation of meat constituents results in flavor development, improvement of shelf life, and improve quality and food safety. Sausage batter is inoculated with the started bacteria composed of **selected lactic acid bacteria (LAB)** i.e. homofermentative lactobacilli *(Lb pentosus, Lb plantarum, Lb sake, Lb curvatus),* pediococci (*Pediococcus acidilactici*, *Pediococcus cerevisiae*) and gram positive catalase positive cocci (GCC) i.e. non-pathogenic, coagulase-negative staphylococci

(*Staphylococcus carnosus, Staphylococcus xylosus, Staphylococcus piscifermentans)*. Small manufacturers use spontaneous fermentation without adding starter culture.

vii. Linking and tying

After the emulsion is stuffed into casings, the encased mass is tied with a thread fastened with metal clips. In the case of small sausages such as Frankfurters stuffed casings are twisted or drawn together to produce links either by hand or with mechanical devices.

Large sausage items are tied or slipped on one end with a hanging tie and suspended from a smoke stick or hook so the entire surface is free from contact with the equipment. This permits a good flow of air around the sausage in the smokehouse and prevents touch marks and spotting due to contact with adjacent hanging products.

viii. Smoking & cooking

The draped smoker picks are placed on smoke trees or trolleys with 12-18 specs per tree. The smokehouse operation is essentially a specialized drying and cooking operation in which sausage emulsion is coagulated. Encased sausage at the time of the introduction into the smokehouse usually has an internal temp of 60-70^{0}F. During cooking this rises to 155 to 160^{0}F.

ix. Chilling

After smoking and cooking the product is showered with cold water and then chilled by refrigeration chilling is frequently done with a brine solution by dipping or spraying the products. (a 6% salt brine) balanced within the leaching of salt from the sausage and imbibing of water by the sausage.

x. Peeling & packaging

After properly chilling the product usually to an ultimate temp of 35 to 40^{0}F, the cellulosic casings on frankfurter and slicing bologna are removed. This is known as the peeling operation.

b. Semi-dry sausages

Semi-dry sausages are usually made from pork or beef or a mixture of the two and are characterized by a moisture content ranging from 40 - 45%, e.g. summer sausage, Gteborg Sausage, Cerevelat, Thuringian, Holsteiner. They have excellent keeping quality with the need of little refrigeration because

(1) Some reduction in microbiological contamination is achieved in the cooking process
(2) A high salt-to-moisture ratio contributes to retarding bacterial growth
(3) A low pH (5.3 or less) provides the tangy flavor and serves as a protective food and good keeping quality is achieved with a pH of 4.8 to 5.0 and with a total acidity of 0.75 to 1% lactic acid.

Grind pork trimmings

↓

Place the trimmings in a mixer; add the salt sugar spices, cure and starter culture and mix for 2 to 3 minute.

↓

Regrind the mix

↓

Hold the mix for 12- 72 hr at 40°F

↓ stuff

Warm water shower for 2 min to wash the sausage surface free of any adhering particles

↓

Smoke the encased sausage for 16 hr at 110°F

↓ Shower with cold water /15 min

Allows to stand at room temp so the surface dies and then chill to 40°F

The manufacturing method of semi-dry sausages

c. Dry sausages

Semi-dried sausages are smoked and cooked to varying degrees, whereas dry sausages are not cooked and only with some products smoke is applied. The manufacture of dry sausages is more difficult to control than that of semi-dried sausages. Overall processing time may require up to 90 days. As a result of this prolonged holding, the sausages are vulnerable to chemical, and microbiological degradation. However, when prepared properly the finished sausages are usually stable and can be held with little or no refrigeration. Examples of dry sausages are Geneva salami, Pepperoni, mortadella etc.

CURING OF MEAT

The curing of meat involves the essential addition of **sodium chloride, sodium nitrite, or sodium nitrate** and adjuncts to meat for increasing shelf-life and obtaining desirable color and flavor. Sugar may or may not be added along with another ingredient to improve flavor. Curing can be done for both raw/cooked meat cut products as well for comminuted meat products e.g. sausages and similar preparations. Most popular raw cured meat includes ham and bacon which are pork products. However, the technique can be applied to any meat group.

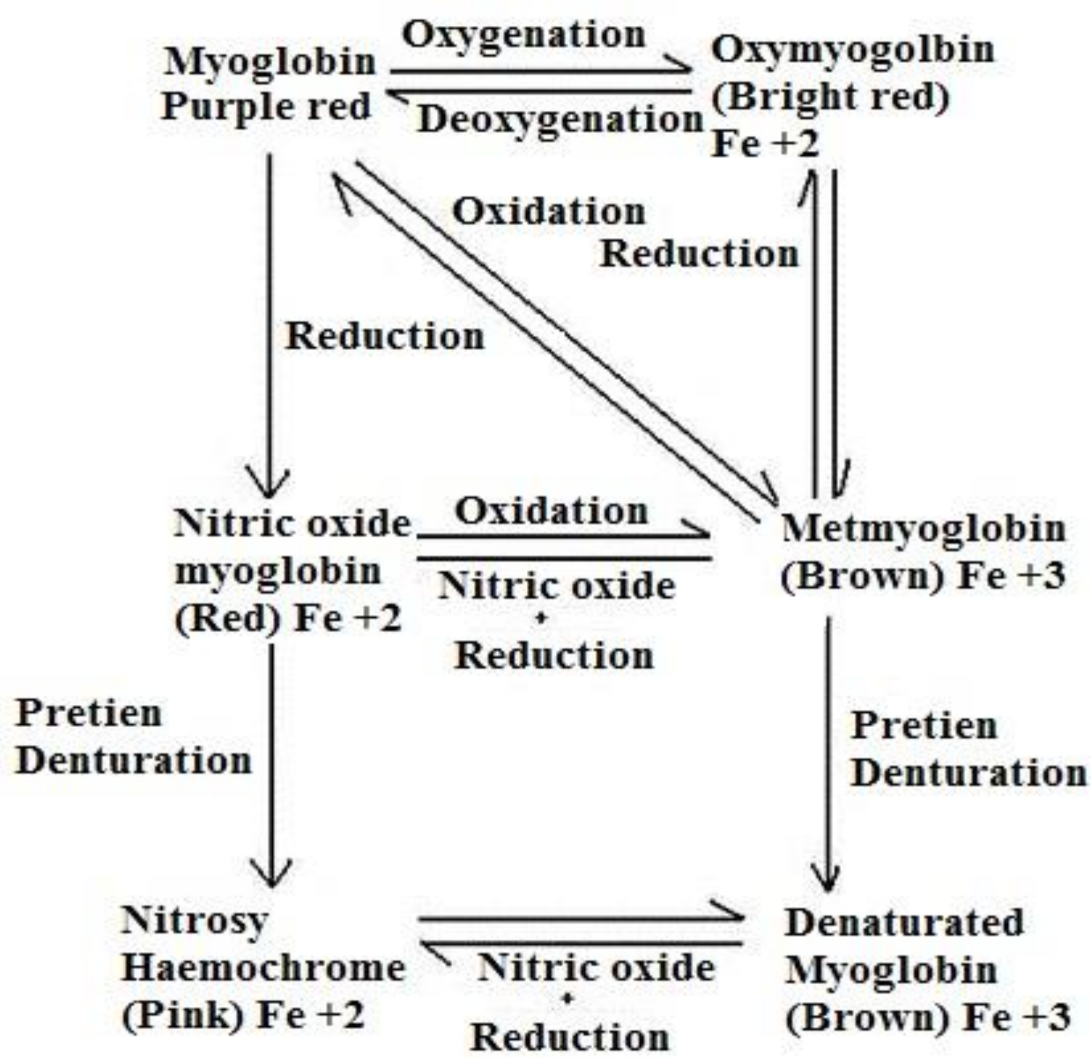
Ingredients used in curing

(i)	Salt	Essential curing ingredients
(ii)	Sugar	
(iii)	Nitrate or nitrite	
(iv)	Phosphates	Optional ingredients/curing adjuncts
(v)	Spices	
(vi)	Baking Soda	
(ii)	Sodium erythroborate	
(iii)	Ascorbic acid	
(iv)	Mono sodium glutamate	
(v)	Hydrolysed vegetable proteins,	
(vi)	vinegar	

Commonly used salt sodium chloride (occasionally KCl) is the most essential ingredient and it significantly inhibits the growth of microorganisms including *Clostridium botulinum* due to an increase in the osmotic pressure of the medium and dehydration of the muscle. Salt if used alone results in dark-colored, unpalatable dry harsh, and salty products. Therefore, it is recommended to be used in combination with sugar and nitrite, and nitrate. Salt should be of good quality. Generally, dry salting utilizes higher levels of salt; however, an acceptable level of salt is about 3% for most meats and about 2% for bacon. Nitrite/nitrate has as well a small inhibitory effect on *C. botulinum*. However, it plays a very important role in the color fixation of cured meat. On the other hand, sugar contributes to flavor and color development due to Maillard browning and also helps in increasing shelf life by controlling bacterial growth. Endogenous low molecular weight components in the sarcoplasm of the meat promote the formation of nitric oxide, myoglobin, and nitrite decomposition.

Chemistry of curing process and meat color development

During the dry curing process, salt in dry form is rubbed on the surface of the meat whereas in meat wet curing meat portion is immersed in the curing solution. The latest techniques of curing include the use of artery pumping, multiple needle injection, thermal or hot cures, tumbling, and massaging, which are employed to accelerate the curing processes. In all cases, salt diffuses into the meat, causing some of the expelled protein to diffuse back in and the meat to swell. The salt-protein complex binds the water well thus the water-holding capacity of proteins generally increases during curing. The final meat contains increased ash due to the absorbed salts. Generally salting results in the darkening of the color. To counteract the effect of salt nitrite/nitrates are added to salt which fixes the desirable pink color of the meat. In the curing, nitrite reacts with muscle pigment myoglobin to give purple-red colored nitroso-myoglobin. Upon cooking, this is further converted into nitrosomyochrome which gives typical pink color to the meat. It is further claimed that nitrite has a significant beneficial effect on the flavor of cured meats by preventing oxidation through the antioxidative activity of nitric oxide-myoglobin and s – nitro cysteine, a component found during the curing process.



Color fixation in meat

A major detrimental change that can occur in cured meat during storage is the oxidation of nitric oxide hemochromagen (pink) or nitric oxide myoglobin (red) to brown metmyoglobin. The rate of oxidation increases with increasing oxygen content, therefore cured meat should be preferably packaged in a container from which oxygen is excluded.

Acceptable levels of nitrite used in meat and meat products are 100-200 ppm. The use of nitrite in cured meat may be hazardous if it is used at higher concentrations with improper mixing, as it reacts with amines, especially secondary amines, to form N - nitrosamines, which may be carcinogenic. High temperatures may also induce nitrosamine formation.

METHODS TO INCREASE TENDERNESS OF MEAT

When meat is stored at < 0^0C, biochemical changes take place in meat leading to the development of tenderness in meat. This process is called conditioning of meat. The tenderness is due to

- Denaturation of the meat proteins and
- Mild hydrolysis of denatured meat proteins by the enzyme cathepsin present in meat

  The increase in tenderness is followed by an increase in water-soluble amino nitrogen indicating mild proteolysis of the muscle proteins. Contrary to the general belief, there is practically no change in the connective tissues and collagen. There is no increase in water-soluble hydroxyl proline peptides indicating collagen has not been acted upon by proteolytic enzymes.

Artificial tenderization of meat: Cold storage facilities are required for the natural tenderization of meat. Artificial tenderization of meat has been developed by using proteolytic enzymes such as papain (from papaya), bromelin (from pineapple), or trypsin (from pancreas). The enzyme is usually injected into the animal, half an hour before slaughtering. The meat obtained from such animals becomes tender within 24 hours.

UNIT – IV

EGG/POULTRY

PRESERVATION OF THE SHELL EGGS

Eggs can be preserved by 4 different methods

Wet immersion method

In this method, only infertile, fresh, good-quality eggs should be used

1. **Lime sealing method**

In this method saturated solution of lime water is used. Eggs are held in lime water for 14 -16 hr. During immersion CO_2 released from the egg combined with lime to form calcium carbonate which deposits and seals shell pores. Then it is removed and stored at room temperature. Such eggs can be stored for 3 - 4 weeks at room temperature

2. **Water glass method**

10% solution of sodium silicate is commonly called water glass. In this method water should be boiled and cooled to 24 – 26 ^{0}C, to remove the dissolved CO_2, before the addition of calculated amount of sodium silicate. Eggs are kept overnight and then removed and stored at room temperature.

Dry methods

1. **Oiling**

In this method the quality of eggs is preserved by sealing the shell pores using suitable oil and thus preventing evaporation of water, CO_2 and other changes. Oiling can be done by Dip method or Spray method. Oiled eggs can be preserved upto 3 weeks at room temperature.

2. **Gaseous atmosphere**

Modified atmosphere packing of eggs proved to improve its shelf life. Maintenance of higher CO_2 pressure surrounding the eggs prevent CO_2 loss from the egg thus improves the egg quality.

Thermization or heat treatment methods

Infertile, fresh eggs can be preserved by this method. Eggs are thermo- stabilized by immersing them in boiling water for 3 to 5 min while keeping the water stirred constantly. This heat treatment coagulates the albumin very close to the shell and thus prevents CO_2 loss. Thermized eggs can be stored at room temperature for 3-4 weeks.

Cold storage or refrigeration

Eggs can be stored well for a long time up to 5 - 6 months at -1.1^{0}C and 85-90% relative humidity. For storage up to 3 - 4 weeks a temperature of -12.8^{0}C and relative humidity of 60-70% is sufficient.

QUALITY CHECKS AND STORAGE OF EGG

Like any other food product, Eggs start deteriorating soon after it is laid. So it is very important to check the quality of the egg before its consumption. A good quality egg should possess the following qualities once it is broken.

1. Yolk is firm and stands up in the center of the white
2. Egg white forms a definite ring around the yolk and thick white holds its shape
3. No blood spots are present
4. No bad odour

Changes occur in the egg during storage

1. Increase in the size of air cell due to loss of moisture
2. Increased pH due to the escape of carbon dioxide. pH increases from 7.6 to 9.7
3. Percentage of thin white increases, thus egg white loses its shape and runs easily.
4. Water passes from white to yolk, thus fluid content of the yolk increases.

Indicators to Determine Spoilage in Eggs

1. White index

    White index = Height of thickest egg white portion/Egg diameter

    Range: 0.08 - 0.1

2. Yolk Index

    Yolk index = Height of Yolk/Yolk width

    Range: 0.35 - 0.45

3. Hough's Unit (HU)

    Commonly used index to check the egg quality

    HU = Height of thick white/weight of Egg

    For good quality eggs, HU is 72 and above and HU about 30 to 60 indicates poor quality.

4. Air cell size should be 2-3cm

PROCESSING OF EGG

Classification of Egg Products

Egg is processed to produce convenience forms of eggs for commercial, food service and home uses. Egg products can be classified as follows

1. Refrigerated liquid products

Egg whites, Egg yolk, various blends of Yolk and white

2. Frozen products

Egg white, Egg yolk, Salted yolks, Sugared yolks, Whole eggs, Salted whole egg

3. Dried/Dehydrated products

Spray dried egg white solids, Instant egg white solids, whole egg or yolk solids, free flowing whole egg or Yolk solids (sodium silicoaluminate added as a free flowing agent).

4. Specialty products

Freeze dried scrambled eggs, Frozen precooked products like Egg patties, Fried eggs, crepes, Egg pizza etc.

Egg products are preferred to shell eggs by commercial bakers, food manufacturers and the foodservice industry because they have many advantages including convenience, labor savings, minimal storage requirements, ease of portion control, and product quality, stability and uniformity.

As per egg product inspection act all egg processing plants must follow below conditions

- Pasteurization of all egg products is mandatory.
- Shell eggs used for egg products must be clean and of edible interior quality.

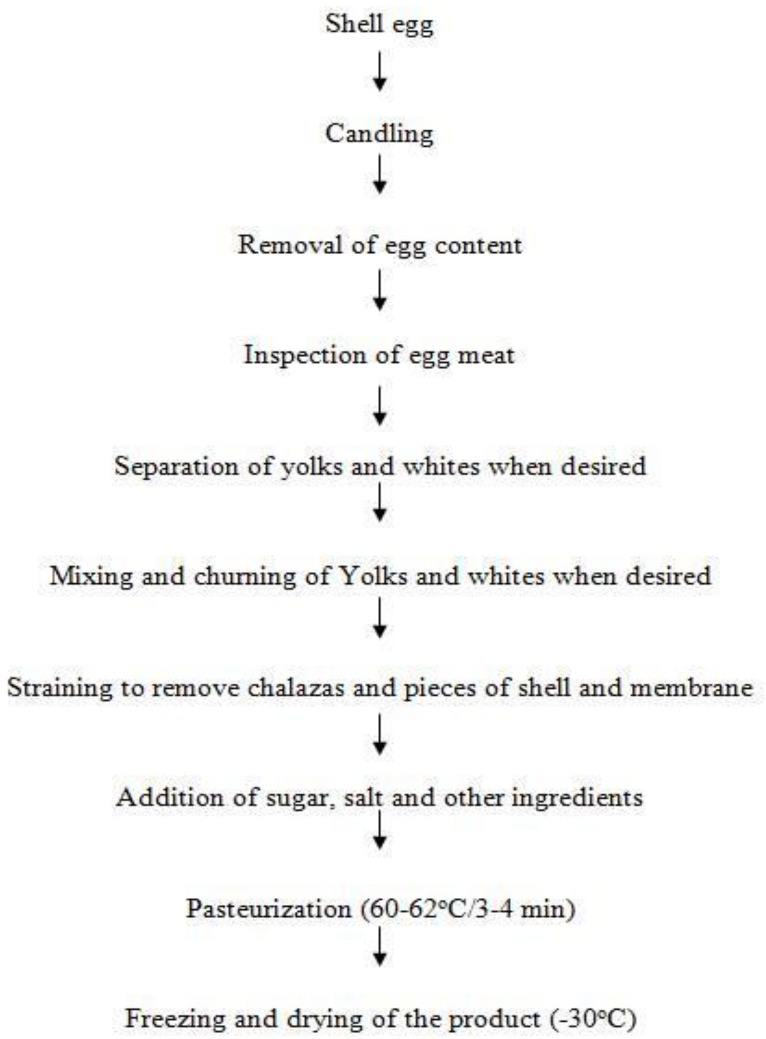
Frozen Egg Products

These include separated whites and yolks, whole eggs, blends of whole eggs and yolks or whole eggs and milk and these same blends with sugar, corn syrup or salt added.

Production of frozen egg

Eggs are frozen to preserve them for use in food manufacturing. Before freezing, egg contents are separated from the shell and which may be frozen as whole egg, Egg yolk, Egg white or various mixtures of yolk and white.

Freezing plants are generally combined with egg-breaking facilities where eggs are received, washed and dried. Then the eggs are broken to remove the egg content this could be done by hand or with the help of machines. While breaking the spoiled eggs are rejected as this could spoil the good product. The whole or separated eggs are mixed for uniformity, and filtered to remove chalazae, membranes or bits of shell. Thus, prepared egg contents are pasteurized at 60-62^{0}C for 3-4 min and filled into a suitable container for freezing. Freezing generally is done in a sharp freezer room with circulating air at -30^{0}C. Freezing may take about 48-72h. Egg white and whole egg can be frozen as such without any additives but it is difficult in case of egg yolk. While freezing egg yolk becomes gummy and thick due to gelation. This can be prevented by the addition of 10% sugar or salt or glycerin 5%. Sugar yolk will be used by bakers, confectioners and salted yolk may be used by mayonnaise manufacturers. These ingredients should be dissolved in the yolk during mixing and prior to screening.



Process flow chart for frozen eggs

Production of spray dried whole egg

The whites, Yolks and whole eggs may be dried by several methods, like spray drying, tray drying, foam drying or freeze drying. Egg white contains traces of glucose and galactose which react with egg protein leading to maillard browning. This discolors the dried egg white. Browning can be prevented by removing glucose through fermentation by yeast or with commercial enzymes. This is known as desugaring and this is practiced prior to the drying of all egg white.

Fresh eggs

↓

Cold storage (maintained at 4-5°C)

↓

Candling and Inspection (Candling room maintained at 15°C)

↓

Cleaning using Detergent-sanitizer solution (2% sodium hydrochloride solution, at 40°C/7min)

↓

Removal of egg content

↓

Chuming and Filtration (without beating air into egg mass)

↓

Pasteurization – 62.5°C/3-5min

↓

Desugaring (0.5% yeast, fermentation at 30°C for 90min)

↓

Repasteurization - 62.5°C/3-5min to kill yeast

↓

Spray drying (inlet air temperature 185°C and outlet air temperature 85°C, moisture content 1.5% in the dried powder)

↓

Packing (in tin container with inert gas)

↓

Storage

Process flow gram for spray dried whole egg

Functional Properties of Egg Content

Eggs provide many desirable attributes as a food ingredient. The functional properties derived by egg contents are Coagulation, Emulsification and Foam formation.

Coagulation

The egg protein coagulates upon heating accompanied by binding of moisture and increase in viscosity. Heating causes denaturation of egg protein and gradually aggregates to form a three dimensional gel network. Thus eggs can be used as **thickening agent** in many food formulations mainly custards, cakes, pie fillings, cream puddings etc. The coagulation temperature is influenced by pH, salts, other ingredients and duration of heating. Egg white coagulates at 62 - 65^{0}C and egg yolk at 65-70^{0}C.

Heat coagulated protein helps to hold the shape of the product in which these are used. Thus eggs are used as binding agent in cutlets, chops etc.

Emulsification

The phospholipids i.e. lecithin and certain proteins present in egg acts as an excellent emulsifying agent. In mayonnaise egg yolk acts as an emulsifier to keep oil suspended in vinegar.

Foaming

Eggs when beaten form elastic films, which can trap air. Egg and egg products are good foaming agents. They produce large foam volume and relatively stable for cooking. Thus entrapped air expands during baking and gives fluffy and spongy product. Thus eggs are extensively used as leavening agent in baked products such as cakes and muffins.

PROCESSING AND PRESERVATION OF POULTRY

In global meat production poultry meat is taking second place after pork. Due to its widespread availability and popularity and its mostly very competitive production cost, poultry meat has an increasing share as a raw material in processed meat. Turkey and chicken meat is very suitable for further processing purposes. Poultry meat is of higher nutritive value than that of other red meats, because of its higher protein content and better digestibility.

Characteristics of Poultry Meat

Muscle to bone ratio in the case of poultry is 1.8 thus the carcass yield is less as compared to other warm blooded animals.

Composition of carcass

Species	Meat %	Fat %	Bone %	Skin %
Broilers	52	6	30	12
Hen	37	12	40	11
Duck	34	18	38	10

Chicken meat is pinkish white in breast and wings and in other parts pink to light red. In general poultry meat is described as white meat while meat from other animals is called red meat. Total fat in chicken/broiler is 7.4g per 100 g portion of lean meat, of which is 27.53% saturated, 35.90% Mono-unsaturated and 22.81% Polyunsaturated fatty acids. The total conjugated linoleic acid (CLA) content of chicken and fresh ground turkey is 0.9 and 2.5 mg/g of fat respectively. On the other hand, typical composition chicken is moisture 73.7 %, protein 20-23% and fat 1.0%.

PROCESSING OF POULTRY MEAT

Either the entire carcass meat is used for further processing, or some of the cuts go into fresh meat sales and the remaining into the manufacture. Chicken carcasses are usually cut into **wings**, **legs** , and **breasts**. Legs can be further subdivided into *thighs* and *drumsticks***.** The breast consists of the larger *superficial breast muscle* and the smaller profound breast muscle, the latter is also called the *filet.* The primary objective of poultry meat processing is to inhibit microbial growth and to stop deteriorative quality changes in the meat. Poultry meat processing utilises the same principles viz. refrigeration, freezing, smoking, curing, dehydration, freeze drying, canning, and ionising radiations as applied in the beef and pork sector. Sometimes antibiotics are also added to preserve raw poultry meat.

Slaughter and Dressing of Poultry

Poultry birds are generally not fed for 12 hrs before their slaughter and are killed by the method which utilizes minimum effort/struggle. The poultry animal is stunned and made unconscious by attacking on the head. Larger poultry houses make use of electrical stunning devices. Jugular vein is cut in such a way that bleeding completes in 2-3 min of slaughter. The bird is then dipped in scalding water (temp. 60^0C for 45 sec or at 52^0C for 2 min). Scalding results in the loosening of feathers, thus easy removal of them. The evisceration of bird follows the de-feathering, where in various parts of the bird are removed for subsequent processing e.g. chilling, freezing , etc. Dressed chicken and other fowls may be canned whole or dissected in their own juice. Use of low temperatures may be applied to improve the shelf life of dressed chicken

a) Chilling - Chilling storage of poultry is for only less than a month. Birds to be stored longer should be frozen. The lower the temperature of storage, the longer the birds stored without undesirable changes. Compared to room temperature, the storage life was extended 2 days at 10^0C, 6 days at 4.4^0C and 14 days at 0^0C. However, the rapid chilling is always advisable in the cases of poultry meat as the onset and outset of rigor takes at early.

b) Freezing - Poultry can be kept in good conditions for months if freezing is prompt and rapid and storage temperature is low enough. Fairly rapid freezing is desirable since it produces a light golden colour because fine ice crystals are formed within the fiber while slow freezing causes the flesh to be darker. The storage temperature should be below -17.8^0C and RH above 95% to reduce surface drying. Rapid freezing of poultry is desirable since it causes tissues to become very pale, which is desirable. However, most poultry is sharp frozen at about - 29^0C or less in circulating air or on a moving belt in a freezing tunnel.

c) Modified atmospheric storage - Increasing carbon dioxide concentration to 10 - 20%in the atmosphere of store chickens inhibits the growth of psychrotrophs. The use of store chicken inhibits the growth of psychrotrophs. The use of films of both high and low gas permeability in combination with the Co_2 atmosphere shows that the Co_2 atmosphere is the significant factor in reducing microbial counts.

d) Ionising radiation - It is a potentially useful form of preservation. Besides from its desirable ability to inactivate microorganisms, it also results in the breakdown of various lipids and proteins to often undesirable odours.

UNIT – V

SEA FOOD

Fish, however, is more susceptible to spoilage than certain other animal protein foods, such as meat and eggs. To prevent spoilage of fish, some form of preservation is necessary. Preservation means keeping the fish, after it has landed, in a condition wholesome and fit for human consumption for a short period to a few days or for longer periods of over a few months. During the period of preservation, the fish is kept as fresh as possible, with minimum losses in flavor, taste, odor, form, nutritive value, weight, and digestibility of flesh. This preservation should cover the entire period from the time of capture of fish to its sale at the retailer's counter.

SELECTION OF FISH

The following points should be borne in mind while selecting fish:

1. Eyes should be bright and not sunken.
2. Gills should be red.
3. The tail should be stiff and scales firmly attached to the skin.
4. The flesh should be firm and not flabby.
5. There should be no unpleasant odour.
6. To test a cut piece, press down with a finger and if an impression is left then the fish is stale.
7. Any tendency for the raw flesh to come away from the bone is a dangerous sign.

HANDLING AND CLEANING OF FISHES

Since fish is a highly perishable commodity, it is to be immediately processed into various products to preserve its quality and to increase its shelf life. Fish requires proper handling and preservation to increase its shelf life and retains its nutritional attributes. Fish are particularly prone to rapid pathogenic contamination. The main safety concerns are unhygienic handling during and after fish harvest, insufficient refrigeration, substandard processing, and poor packaging. Maintaining the quality of the fish begins with harvest and carries through the harvest to the consumption chain.

Handling of fish varies with the type of fish, the processing methods, and the intended final product. The earliest practice of fish handling in many parts of the world is to keep caught fish alive until cooking and consumption. Till today, this remains to be one of the common fish-handling practices.

For harvested fish, the general handling practices after capture are

- Transferring catch from gear to vessel
- Washing/Sorting
- Bleeding/gutting

- Chilling
- Chilled storage and unloading

The most important factors to be considered in the initial handling and transport are the temperature, duration of storage/ transport, and hygiene in all respects including that of the handlers.

Washing and sorting of fish

The harvested fish should be washed well with potable water to free it from dirt and other extraneous matter. Slime accumulating on the skin surface of dying fish is a protection mechanism against harmful conditions. In some freshwater species slime constitutes 2-3% of body weight. Slime excretion stops before *rigor mortis*; it creates a perfect environment for the growth of micro-organisms and should be removed by thorough washing. Water chlorinated at 10ppm level is ideal for initial cleaning.

After washing the catch should be sorted species-wise and size-wise. Bruised, damaged and decomposed fish shall be separated from the catch during sorting.

Dressing

Dressing operations of the catch include **deheading, bleeding, and gutting.** This has to be carried out as fast as possible without significant bacterial contamination. Gills and viscera harbor several spoilage bacteria in large numbers. Therefore, where possible, it is advisable to remove the gills and viscera before the fish is preserved and stored.

Deheading

The head constitutes 10-20% of the total fish weight and it is cut off as an inedible part. Although many mechanized deheading machines had been developed for processing marine fish, freshwater fish are usually deheaded manually.

Bleeding

When fish dies, the blood in the fish can clot and turn black or brown in color adversely affecting the color and appearance of the meat. Therefore, bleeding is done to preserve the quality of the meat. Slitting the throat followed by hanging the fish by the tail or slitting the throat and immersing it in cold water are the methods for bleeding.

Gutting

The purpose of gutting is to remove those fish body parts most likely to reduce product quality, as well as to remove gonads and sometimes the swim bladder. Gutting consists of cutting down the belly (fish may be deheaded or not), removal of internal organs, and, optionally, cleaning the body cavity of the peritoneum, kidney tissue and blood.

Chilling and storage

Decreasing the temperature of the fish to about 0^0C slows down the microbiological, chemical, and biochemical decomposition processes and extends fish stability. Thus, when the raw material is cooled quickly, just after capture, and kept at a low temperature during transport, processing, and distribution, it meets the basic processing requirements. Its usefulness is extended and at the same time, fish quality is maintained.

The most common means of chilling is by the use of ice. Ice is available in several forms such as blocks, plates, tubes, shells, soft, and flakes. In modern fish processing plants, especially the small ones, flake ice generators dominate as flake ice ensures major contact surface with fish hence higher cooling capacity, low production cost, relatively dry, and will not stick together to form clumps when stored.

Fish spoil more quickly if

- It has struggled for long in the net or inboard, than a fish, which is killed quickly.
- Its stomach is full while catching,
- It is bruised while catching or handling

METHODS OF PRESERVATION

Preservation can be done, both for short and long duration

Preservation for a short duration

Chilling

This is obtained by covering the fish with layers of ice. Ice is effective for short-term preservation such as is needed to transport landed fish to nearby markets or to canning factories, etc. Here autolytic enzyme activities are checked by lowering the temperature.

Preservation for a long time

When preservation is required for a long period of time, the fish are passed through cleaning, gutting, conservation, and storage.

Cleaning and Gutting

During cleaning, the caught fish are first washed thoroughly in cold, clean water to remove bacteria, slime, blood, faeces, mud, etc. from the body surface of the fish. It is being done under proper sanitary conditions. Large fishes are gutted (i.e. all the internal organs or viscera are removed) and the body cavity is washed.

Conservation and Storage

Conservation is necessary to keep the dead fish in fresh condition for quite a long time. This is achieved by employing any one of the methods like freezing, drying, salting, smoking, and canning.

1. **Freezing**

Freezing means the removal of heat from the body. To check the enzyme, bacterial action, and putrefaction it is preferred to store the fish under lower temperatures. When fish is intended to be stored for a long period, quick freezing is preferred which inhibits bacterial action. During quick freezing, every part of the product comes within the range of 0 to -5^{0}C. Properly frozen fish at -20^{0}C retains its physical properties and nutritive values for a year or more and is almost as good as fresh fish. There are three ways affecting quick freezing:

a) Direct immersion of fish in the refrigerating medium,
b) Indirect contact with the refrigerant through plates
c) Forced convection of refrigerated air directed at heat transfer surfaces.

In general, different methods of freezing are adapted through sharp freezers, air blast freezers, contact plate freezers, immersion freezing, liquid freon freezing, liquid nitrogen freezing, fluidized bed freezer, cryogenic freezing, etc. Among the various types of quick-freezing plants installed in India, the carrier air blast type is widely used. The air blast freezer is in the form of a tunnel and heat transfer is affected rapidly by the circulation of air. The temperature used ranges from 0 to -30^{0}C and air velocity varies from 30 to 1050 meters/min.

2. Freeze drying

This is modified deep freezing, completely eliminating all chances of denaturation. The deep-frozen fish at -20^{0}C is then dried by direct sublimation of ice to water vapor without melting into liquid water. This is achieved by exposing the frozen fish to 140^{0}C in a vacuum chamber. The fish is then packed or canned in dried condition. The product is quite fresh looking in appearance, flavor, color, and quality.

3. Salting

Salting is a process where the common salt, sodium chloride, is used as a preservative that penetrates the tissues, thus checking bacterial growth and inactivating the enzymes. Some of the factors involved in the salting of fish that play an important role are the purity of salt, the quantity of salt used, the method of salting, and weather conditions like temperature, etc.

During the process, the small fish are directly salted without being cleaned. In medium and large-sized fish the head and viscera are removed and longitudinal cuts are made with the help of knives in the fleshy area of the body. Then the fish is washed and filled with salt for uniform penetration through the flesh. Large fish like sharks are cut into convenient-sized pieces. Generally, sardines, mackerels, seer fishes, catfishes, sharks, and prawns are used for salting.

Dry salting and wet salting are the methods employed in the salting of fish.

Dry salting

In this process, the fish is first rubbed in salt and packed in layers in tubs and cemented tanks. The salt is applied in between the layers of fish in the proportion of 1:3 to 1:8 salt to fish. The proportion of salt in fish varies with the fish since oily fish require more salt. At the end of 10 - 24 hours, the fish are removed from the tubs and washed in salt brine, and dried in the sun for 2 or 3 days.

Wet salting
The cleaned fish are put in the previously prepared concentrated salt solution. It is stirred daily till it is properly picked. With large-sized fishes, longitudinal slits are made in the flesh to allow the penetration of salt. After pickling for 7-10 days, the salty water that oozes out from the fish is allowed to drain off. This can be stored upto 3-4months.

4. **Smoking**

In this method, landed fish is cleaned and brined. It is then exposed to cold or hot smoke treatment. In cold smoking, first, a temperature of 38^0C is raised from a smokeless fire. After this heating, cold smoke at a temperature below 28^0C is allowed to circulate past the fish. In the case of hot smoking, first, a strong fire produces a temperature around 130^0C. This is followed by smoking at a temperature of 40^0C. The smoke has to be wet and dense. Good controls are necessary over density, temperature, humidity, speed of circulation, pattern of circulation, and time of contact with fish of the smoke. The phenol content of the smoke acts as an antiseptic and it also imparts a characteristic color and flavour. For making fire and smoke, only hardwood (Conifer wood, saw dust etc.) is used.

5. **Canning**

Canning is a method of preservation in which spoilage can be averted by killing microorganisms through heat. Oily fish are the most suitable for canning. Salmon, tuna, sardine, herring, lobster, shrimp, etc. are canned. The raw material should be processed properly since it contains the most dangerous Clostridium botulinum which should be destroyed. There are some other heat-resistant bacteria like Clostridium sporogenes which can be eliminated at a temperature of 5 - 6 times more than Clostridium botulinum. It needs a temperature of 120^0C for 4 minutes or at 115^0C for 10 minutes to kill them in large numbers.

Canning is done by putting cleaned dressed and cut fish into a saline solution. The cans holding the fish and the saline are then double-seamed under a vacuum. Thereafter, sterilization of cans takes place at 121^0C for 90min under steam pressure. Sterilization is followed by cooling the cans at room temperature with running water.

6. **Drying**

Drying involves dehydration i.e. the removal of moisture contents of fish, so that the bacterial decomposition or enzymic autolysis does not occur. When moisture contents reduce upto 10%, the fish are not spoiled provided they are stored in dry conditions. Fish drying is achieved either naturally or by artificial means. In natural drying, the fish after being caught are washed and dried in the sunshine. In artificial drying the killed fishes are cleaned, gutted, and have their heads removed. They are then cut lengthwise to remove large parts of their spinal column, followed by washing and drying them mechanically.

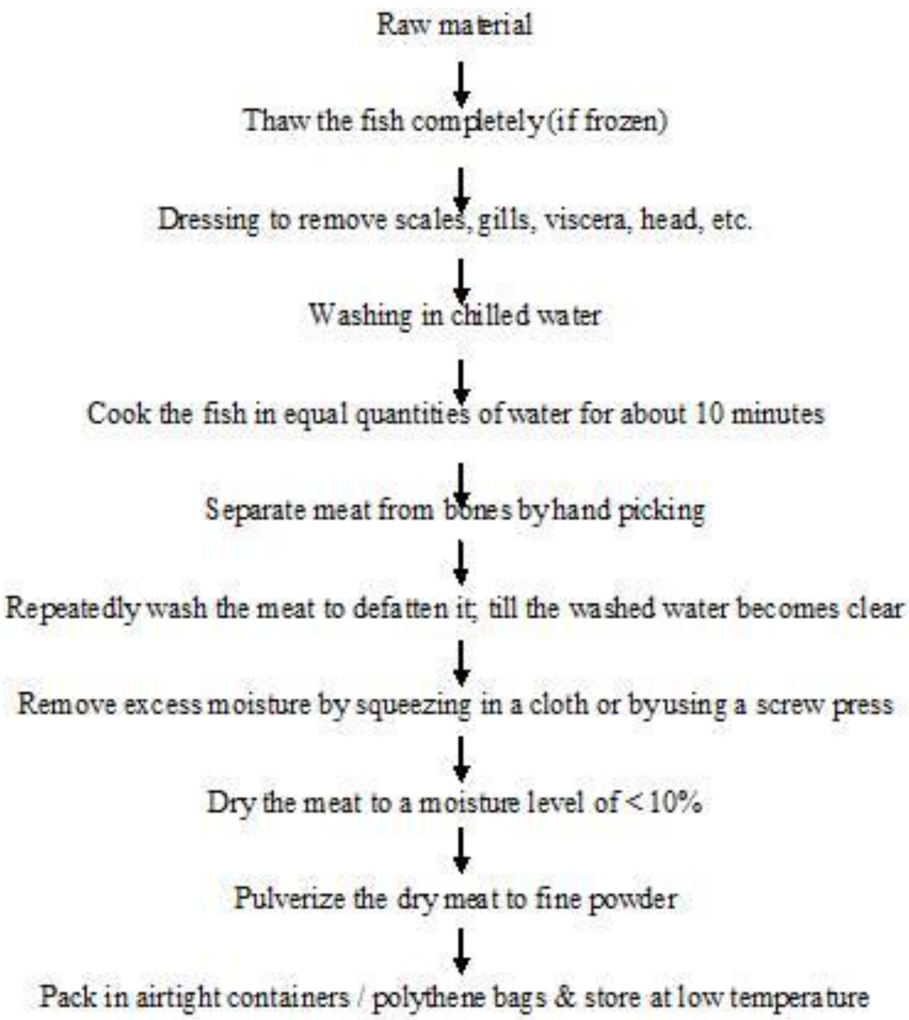
PREPARATION OF FISH PROTEIN CONCENTRATE (FPC)

Fish protein concentrate (FPC) is a collective term used for dried fish powders, which contain comparatively little fat.

Three grades of FPC available are:

1. FPC type C - fish meal (used for animal consumption).
2. FPC type B - fish meal of standard quality prepared mainly for human consumption. This has a strong taste and flavour of fish. Hence its use was restricted to countries where dried fish is common in their diet.
3. FPC type A – high-quality FPC used for human consumption. Solvents are used to remove lipids. It has only 0.05 - 0.75% lipid.

Method of preparation



Method of preparation

FISH LIVER OILS

Fish oils may generally be described as flesh oil, liver oil, or oil of the whole fish. It can be the by-product in fish meal plants or maybe the target product in fish oil production plants. The product, however, is versatile and finds many applications in the food and technical industries, and is still of considerable economic importance to producers.

Chemical structure of fish oil

It mainly consists of triglycerides of fatty acids (glycerol combined with three similar or different acid molecules) with variable amounts of phospholipids, glycerol ethers and wax esters. It is characteristic of the oils that they contain a wide range of long-chain fatty acids with the number of carbon atoms ranging mainly from 14 to 22, and a high degree of reactivity (unsaturation) ranging up to six double bonds per molecule.

Processing of fish oil

In general terms, all crude oils and fats contain minor amounts of nontriglyceride substances. While some of these are considered beneficial to the stability of the oil, such as tocopherols and astaxanthin (in salmon and krill oils) which protect the oil from oxidation, other impurities are objectionable because they render the oil dark-colored, causing it to foam or smoke or are precipitated when the oil is heated in subsequent processing operations. Other impurities reduce acceptability because of the flavors and odors they produce in the fat or because they reduce the stability and shelf life of the foods to which the fats are added. Some impurities are common to all fats regardless of the source or end use:

- Suspended matter (insoluble impurities).
- Naturally occurring color bodies.
- Free fatty acids.
- Volatile, malodorous compounds dissolved in the fat or oil.

These non-triglyceride substances have also been classified according to their effect:

- Hydrolytic - moisture, insoluble impurities, free fatty acids, mono and diglycerides, enzymes, and soap.
- Oxidative - trace metals, oxidation products, pigments, tocopherols, and phospholipids.
- Catalyst poisons - substances that inhibit the hydrogenation reaction e.g. phosphatides, oxidation products, and compounds containing nitrogen, sulfur, and halogens.
- Miscellaneous - hydrocarbons, terpenes, resins, sterols, waxes, trace metals and sugars whose effect is less well known but can be classified as contaminants and also may have an effect on the final flavor of the oil

Processing steps and the compounds removed by them in the purification of fish oil

Carbon Treatment

Removal of dioxins, furans, and polyaromatic hydrocarbons (PAH). This can be performed on the starting crude oil if the oil is to be sold into the non-industrial market.

Oil Storage
Insoluble impurities, trace moisture and some phospholipids will precipitate in the tanks. The combination is known as "foots".
Degumming
Phospholipids, sugars, resins, proteinaceous compounds, trace metals, and other materials.
Alkali Refining
Free fatty acids, pigments, phospholipids, oil-insoluble material, water-soluble material, trace metals
Water Washing / Silica Treatment: Soaps, oxidation products, and trace metals
Drying: Moisture
Adsorptive Bleaching& Carbon Treatment
Pigments, oxidation products, trace metals, sulfur compounds, dioxins, furans, PAH, and possibly some PCB's
Winterization
Higher melting triglycerides, and waxes. Used to enhance the unsaturated triglycerides
Deodorization
Free fatty acids, mono-diglycerides, aldehydes, ketones, chlorinated hydrocarbons, and pigment decomposition products. This is usually the finishing step and results in a bland-tasting oil.
Vacuum Stripping or Thin Film, Molecular or Short Path Distillation
Removal of chlorinated hydrocarbons, fatty acids, oxidation products, PCB, and free cholesterol. Sometimes this step is used as a replacement for the deodorization step