Consortium for Educational Communication

Module on

Processing of milk

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Processing of Milk

1.1 Filtration and Clarification of milk

i) Purpose

Raw milk as produced on the farm and transported to the collection centre or a dairy plant generally contains varying amounts of visible, invisible impurities. This foreign matter includes straw and hair pieces, dust particles, leukocytes (somatic cells or white blood cells), insects, etc. Relatively large pieces of such material e.g. straw, hair and insects, are usually removed by 'straining' (passing the milk through a fine metal–gauge strainer or metallic sieve on the farm, at the collection centre or at the processing plant. Tubular sieves located in the milk inlet pipe to the processing unit (e.g. pasteurizer) are also used. However, finer foreign matter to be eliminated requires clarification using a special filter or a centrifuged clarifier. These steps of aesthetic improvement of product are particularly useful for overcoming the problem of sediments in fluid milk and liquid milk products in general, and homogenized milk in particular.

ii) Filtration

Filtration refers to making the milk pass through a filter-cloth or filter-pad. The filtering medium has a pore size (25-100 mm) that permits most of the foreign matter to be retained on it. The milk filter consists of a nylon filter-bag or a filter-pad supported on a perforated stainless steel (SS) support held in an SS enclosure with a tight-fitting lid, milk distributor, and inlet- and outlet- connections. Milk usually passes from top to bottom. In case of twin filters, three way valves in the inlet and outlet lines enable switching from one filter to the other when the first is to be cleaned. Sometimes, filters may be provided in the form of cylindrical bags or 'stockings' fitted over perforated SS tubes as in the modern continuous pasteurizing plants (high-temperature short-time, or HTST pasteurizers Filtration can be carried out either on cold milk (about 10 °C) or warm milk (40-45 °C). Since warm milk filtration is more rapid due to lower viscosity of warm milk, it is universally used. For cold filtration, the filter is located in the line connecting the milk receiving tank or holding tank and the pasteurizer.

iii) Clarification

As an alternative to filtration, clarification can also be employed to remove insoluble impurities especially the finer ones. It involves the use of a centrifugal machine called 'clarifier'. Thus, clarification is a process of subjecting milk to a centrifugal force in order to eliminate the finer but heavier particles from milk, somatic cells, dust particles, etc. Although part of bacteria is also removed along with the extraneous matter, clarification cannot be considered an effective means of bacteria removal. In clarification process, when milk is introduced between two adjacent rotating conical discs (in a stack of several discs) of a centrifuge bowl, it is subjected to a centrifugal force. There is no separation of fat globules (cream) and skim milk in a clarifier. Raw milk is made to pass usually under a pump pressure, down a central pipe of a rotating bowl and led to the outer edge of the clarifier discs through a distributor in the bottom and then onto the spinning discs, where milk and dirt are separated. The milk is led to the discharge port at the top of the bowl whereas the dirt is accumulated in the sediment space. The accumulated sludge is removed from the bowl by dismantling the clarifier at regular intervals. The interval may range from 1 to 8 hours depending on size of the clarifier and the amount of impurities in the milk. As for the milk filter, clarifier may be located in the raw milk line between the raw milk tank and pasteurizer. Alternatively, milk may be clarified warm/hot by placing the clarifier at a suitable point in the regeneration section of the HTST unit or between the regeneration and heating sections. The clarifier sludge or clarifier 'slime' consists primarily of dust and dirt particles, blood cells, microorganisms and milk protein. Its composition will depend on whether it is liquid (82-86% water, 6-8 % protein), or solid (65-69% water, 24-28% protein).

iv) Separation of Milk

Milk contains fat and non-fat constituents, also called solids-not-fat (SNF). Fat is present as globules whereas the SNF form an ionic solution (e.g. certain salts), true solution (e.g. lactose and whey proteins), or a colloidal solution (e.g. casein micelles) in the water part of milk. Since fat globules are lighter as compared to other solids, they tend to readily separate out from the serum (or skim milk), as can be seen in the formation of a 'cream' layer on the top of milk held undisturbed in a container for a few hours. Cream is that portion of milk, which is rich in milk fat, but poorer in SNF. Therefore much of the fat can be easily separated in the form of cream from milk, leaving behind the skim milk containing very little fat. Cream separation enables the processor to manufacture a variety of fat-rich dairy products such as cream of various types, butter, ghee, etc. Cream separation also makes it possible to adjust the composition of milk with respect to its fat and SNF contents. Such compositional modification may be desired for products manufacture as also for meeting the legal requirements of different types of fluid milk

i) Methods of Separation

Two methods of separation of cream from milk are commonly used: (i) gravity separation and (ii) centrifugal separation.

Gravity Separation: When milk is allowed to stand undisturbed for some time, a layer of cream forms on the top due to rising of the fat globules which are initially dispersed throughout the bulk of milk. The upward movement of the lighter fat globules (density, 0.93 g/cc at 20 o C) in the heavier serum (density, 1.035 g/cc) takes place owing to gravity. Creaming may become evident in as short time as half an hour. As the temperature rises, the ratio of the density difference and the serum viscosity increases favouring the separation process. This increase is particularly prominent between 10 $^{\circ}$ and 30 $^{\circ}$ C and much less above 50 $^{\circ}$ C. Cream separation by gravity is, however, a very slow and inefficient process. It is of little practical value for commercial purposes. **Centrifugal Separation:** In principle, this method of cream separation is similar to gravity separation but gravity as the driving force is replaced by the centrifugal force for which a rotational machine is used. Since the latter force is much larger than the gravitational force, separation is greatly accelerated. The centrifugal separator is similar to the clarifier but milk entering through the bottom of the separator bowl holding a stack of conical discs rises up through holes located somewhere in the middle of the inner and outer edges of the discs. The milk between discs is subjected to a centrifugal force in the rotating bowl and thereby tends to fly out from the centre. The skim milk fraction, being heavier, moves away and forms a layer on the outer edge of the discs, whereas the fat globules gather on the inside edge.

Other centrifugal process for milk:

The principle of differential movement of heavy and light components of milk subjected to a centrifugal force has been utilized in a few applications other than clarification and cream separation. These include bactofugation and clarifixation.

i. Bactofugation

The process known as 'bactofugation' is particularly applicable to removal of bacterial spores from milk, which are not only difficult to inactivate by heat treatment but also heavier (or denser) than vegetative cells. The bactofuge is kind of high-speed (up to 20,000 rpm) clarifier provided with discharge nozzles in the bowl wall. The centrifugal force generated in it is upto 10,000 g (g = gravitational acceleration). The bacteria in milk being bactofuged are collected in the form of 'bactofugate' in the sludge space. The bactofugate is approx. 3% of the feed volume and contains primarily bacterial spores and milk proteins. Anaerobic spores are removed to an extent of 98-99%. A double-bactofuge treatment at 73 ^{o}C yields more than 99.9% reduction in bacterial spore count of milk. However, since bactofugation does not effectively eliminate all microorganisms, pathogens in particular, the milk must ordinarily be pasteurized so as to ensure safety of consumption. The main application of this expensive process is in the field of cheese making where removal of anaerobic (clostridial) spores from milk is useful in avoiding the problem known as 'late blowing' in hard and semi-hard cheeses. Clarified and standardized milk is bactofuged at 60-75

°C followed by pasteurization employing the HTST process. The bactofugate is deaerated in a vacuum chamber and sterilized at 130-140 ° C for 3-4 sec using steam injection, and finally mixed with chilled bactofuged milk for further processing.

ii. Clarifixation

A clarifixator is a machine working on the same principle as that of the centrifugal separator but has an additional provision to effect reduction of the size of fat globules in the cream fraction before it is remixed with the outgoing skim milk. The resulting milk, sometimes called 'stabilized' milk has a reduced tendency to creaming upon undisturbed storage because of small-size fat globules. The break-down of fat globules is brought about by the peripheral spikes or protrusions on the 'paring disc' provided in the cream passage at the top of the centrifuge. A paring disc is a fixed circular structure acting as a stationary centripetal pump. The cream separated from milk strikes the protruding obstacles before entering the paring disc. The fat globules thus experiencing an intense turbulence or shearing action are broken down to a smaller size (less than 2 mm). The cream is then mixed with the incoming milk to be recycled through the bowl. The fat globules of sufficiently reduced size will not get re-separated when the cream passes through the bowl discs again and will therefore; exit the separator through the skim milk outlet which thus discharges 'homogenized' whole milk. However, because of its lower effectiveness as compared to pressure homogenization, clarifixation has not been used to any significant extent in the dairy industry.

1.2 Standardization of Milk

i) Purpose and Definition

A product must conform to the legal standards prescribed for it, or the quality standards set by the manufacturer. Product manufacture without appropriate compositional manipulation of milk may lead to poor quality product, or a product that does not meet legal requirements, or it may be an economical loss to the processor. Standardization thus refers to the process by which the milk composition is adjusted to the desired level. The most commonly considered compositional parameters are fat and SNF for market milk, although sometimes fat alone may be taken into account for standardization. For certain specific, product,-manufacturing applications even protein content may be adjusted. Accordingly, the process of standardization involves lowering or raising the level of a particular constituent(s) to the desired value especially fat.

1.3 Pasteurization

Purpose

Milk is pasteurized for two purposes:

- To make safe for human consumption by destroying pathogenic microorganisms

  present in milk.
- To improve its keeping quality.

The word 'pasteurization' has been named after an eminent French scientist, Louis Pasteur. In general terms it is heating milk or its products to such a temperature, which destroys nearly all the microorganisms, present in it without affecting the composition or properties of the product. Thus it is important to monitor the pasteurization process as improperly/under pasteurized milk can cause the infection.

Fresh milk produced from healthy milch animals generally contains minimum load of microorganisms. In the course of handling at the farm, milk is liable to be contaminated by various microorganisms mainly bacteria. Rapid chilling to below 4°C temperature slows down the growth of microorganisms in the milk. Milk must be treated by an established process so that all pathogenic microorganisms are killed before it is consumed as fluid milk. This is achieved by heat treatment.

i. Time-Temperature Combination

The time-temperature combinations normally used for pasteurization of fluid milk are as follows:

- 63°C (145.4°F) and held at that temperature for at least 30 minutes
- 72°C (161.6°F) and held at that temperature for at least 15 seconds.

The milk is then immediately cooled to a temperature not greater than 4°C. The selected heat treatment shall be applied only once. This means pasteurization includes heating to a specific time-temperature combination followed by immediate cooling to 4°C.

ii. Types of Heat Treatment

The heat treatment given in form of (i) holding and (ii) continuous correspondingly relate with two methods of pasteurization i.e.

i) Batch, holding or Low Temperature Long Time (LTLT) method and

ii) Continuous, High Temperature Short Time (HTST) method.

In the batch method, the milk is heated to 63°C in a tank or vat equipped with a hot water or steam jacket and agitators to keep the milk agitated; held for 30 minutes and then partly cooled in the batch pasteurizer. The further cooling is done by surface/plate cooler. This method is mostly used for processing of around 5000 liters of milk.

High Temperature-Short Time (HTST) pasteurization is the process, which is commonly used now a day all over the world. Plate Heat Exchanger (PHE) is used to heat, hold and cool the milk. Milk is heated to a temperature of at least 72°C and held at that temperature for not less than 15 seconds and then immediately cooled to a temperature not greater than 4°C.

Test for Pasteurization efficiency

Phosphatase Test: Phosphatase test is done to determine whether milk has been properly pasteurized or not immediately after pasteurization of milk. The test is based on the principle that alkaline phosphatase, a natural enzyme present in raw milk, is simultaneously deactivated by heat treatment as specified for pasteurization. **Homogenization**

Milk is an oil-in-water emulsion. Fat globules in the milk are dispersed in a continuous water phase (skim milk) and normally vary in sizes ranging from 1 mm to 22 mm, with a mean size of approximately 3-4 mm. As the density of milk fat is less than that of skim milk, the fat globules tend to rise to the surface during storage and form a cream layer. The rise of fat globules follows Stoke's law where the velocity of rising fat globules is expressed as:

$$V = \frac{2G}{9} \frac{(ds - df)\, r^2}{\eta}$$

Where:

V = velocity or rate at which a single fat globule rises

G=acceleration due to gravity

ds= density of skim milk

df= density of fat

r= radius of fat globule

n= viscosity of skim milk

Very small fat globules (<1 mm) remain suspended in the serum phase due to brownian motion and adversely affect the creaming phenomenon. The presence of cryoglobulins in the raw milk causes agglomeration of fat globules, which subsequently have increased tendency to rise to the surface.

Homogenization with reference to milk/ dairy applications thus refers to a mechanical process that is used to reduce the size of fat globules such that milk fat does not rise to form a cream layer during storage of milk. Although homogenization renders fat globules uniformly distributed in the body of the milk, upon prolonged storage it does not remain completely dispersed.

1.4

i) Definition of Homogenized Milk

United State Public Health Service has proposed one of the most comprehensive definitions for homogenized milk. This has been the most widely accepted and referred definition. It states that "Homogenized milk is milk which has been treated in such manner as to ensure break-up of the fat globules to such an extent that after 48 hours of quiescent storage no visible cream separation occurs in the milk and the fat percentage of the milk in the top 100 ml of milk in a quart bottle (946ml), or of the proportionate volumes in containers of other sizes, does not differ by more than 10 per cent of itself from the fat percentage of the remaining milk as determined after thorough mixing.

In single stage homogenization, upto 6 percent fat milk, usually a pressure of 2000-2500 pounds per square inch is sufficient. For milk with more than 6 percent fat, two stage homogenization is used to prevent fat clumping: a pressure of 2000 pounds per square inch at the first stage and 500 pounds per square inch at the second.

iii) Advantages and Disadvantages of Homogenized Milk

Advantages

- Prevents removal of fat/cream from milk
- Homogenized milk results in softer curd and therefore easily digested by infants
- Churning of fat does not occur during bulk transportation
- Fat is uniformly distributed and therefore gives uniform consistency
- Homogenized milk is comparatively resistant to development of oxidized flavour defect

Disadvantages

- Homogenization offers possibility of incorporation of foreign fat into milk

- Homogenized milk is prone to development of 'sunlight' or 'activated' flavour defect
- Homogenized milk if returned unsold from the market is difficult to salvage as centrifugal separation of fat is not possible

1.5 Sterilization

i) Definition

Sterilized milk refers to a product obtained by heating milk in a container in a commercial cooker/ retort to temperatures of 110-130^{o}C for 10-30 min. The process is also referred as in-container sterilization. Sterilized milk is generally intended for prolonged storage at room temperature (up to 6 months). The major objective of heat sterilization is to destroy microbial and enzymatic activity. The length of time and magnitude of temperature employed during processing depend on the type of the product, number and heat resistance of microorganisms and enzymes present in milk. The heat resistance of microorganisms or enzymes is generally evaluated in terms of D-value or Z-value. Sterilization load or heat load for sterilization is generally expressed in terms of Fo value.

ii) Theoretical Basis

Clostridium botulinum is considered as the index organism for assessing thermal sterility in foods. Under anaerobic conditions, inside a sealed container, it can produce botulin, a toxin, which can be 65% fatal to humans. Therefore, destruction of this organism is a minimum requirement of heat sterilization. As milk is a low acid (pH>4.5) food, it is recommended to achieve 12 decimal reductions for C. botulinum. This can be achieved by heating the product at 121^{o}C for 3 min (F o = 3). However, this minimum treatment may produce milk that is safe but not necessarily commercially sterile. This is so because there are more heat-resistant spores present in milk. There is B. stearothermophilus or B. sporothermodurans. These spores are not pathogenic. Their presence may require heat treatment equivalent to two (2) or more decimal reductions. This may correspond to an Fo values of 8. Target spoilage rates should be less than one survivor in every 10,000 containers.

v) Quality of Sterilized Milk

Sterilized milk has a rich creamy appearance and a distinct cooked flavour (rich, nutty, caramelized). It is considerably browner in colour than raw milk. The brown colour develops due to formation of coloured pigments resulting from interactions between free amino groups of proteins and aldehyde group of lactose through Maillard reactions. The intensity of cooked flavour and brown colour depends upon the severity of heat treatment. In-container sterilization causes loss of nearly half of the ascorbic acid (Vitamin C) and sizeable loss of thiamine (30-40%). Vitamin B12 is almost completely destroyed. Fat soluble vitamin A, carotene, riboflavin and nicotinic acid are not affected. Biological value of proteins is only marginally affected. Sterilized milk cannot be coagulated with rennet unless calcium chloride is added externally.

1.6 UHT Processing

i) Definition

UHT milk can be defined as a product obtained by heating milk in a continuous flow to a temperature in excess of 125^{o}C for not less than two seconds and immediately packaging in sterile packages under aseptic conditions. In India, UHT milk is generally processed at 140 ^{o}C for 2 seconds.

ii) Theoretical Basis

Heating of milk results in death of microorganisms. While some bacteria are destroyed by pasteurization (71.7^{o}C/15 sec.) only, some survive this thermal treatment. Bacillus subtilis and Bacillus stearothermophillus spores are very heat resistant. Of the two, Bacillus stearothermophillus spores are most heat resistant. It is therefore, considered index organism for evaluating performance of UHT processing. Heating of milk at higher temperatures also result in undesirable changes in chemical quality. Browning reactions are particularly important. Higher thermal load results in more browning and therefore loss of flavour and quality. In the temperature range of 100-120^{o}C, time required for death of almost all B. stearothermophillus spores are more. This may therefore result in more browning in the product. However, if milk is treated in the UHT range i.e. 135-150 °C for only few seconds, almost all spores may get killed and browning would be minimum. Loss of nutrients and total quality also will be minimum. A product processed in this temperature range will be thus microbiologically safe and yet superior in terms of overall quality

iii) Types of Sterilization Plants

There are two types of UHT plants: Direct type and indirect type. In direct type plants, heating is done by mixing product and steam. In indirect type plant, product is heated by steam or hot water without the two coming in direct contact. Heating in direct type plant is very rapid particularly between 80-140°C and total heat load is less. Changes in the product quality are therefore minimum. In indirect plant, rise in temperature is very gradual. Therefore, heat load on the product is more. Changes in chemical quality are comparatively more in indirect type than in direct type plants.

(i) **Direct Heating Plant:** There are two types of direct heating plants (a) Injection type and (b) Infusion type.

Injection type: Processing is through steam-into-milk arrangement. Steam injector is the heart of this plant. Preheated milk at 80-90 °C enters the injector nozzles from one side. Steam at slightly higher pressure enters the injector from the other side. As the steam mixes with milk, steam condenses and the product is rapidly heated. Rapid condensation of steam prevents entry of air in holding tube. Air in holding tubes results in improper heating. Backpressure is maintained on the discharge side. Backpressure ensures that product does not boil in holding tube. Boiling may result in fouling and improper heating of milk. Several designs of injector are available.

Infusion type: In this system, milk is heated by milk-into-steam arrangement. The processing unit consists of a chamber filled with pressurized steam. Milk enters the chamber from the top. There are two alternative arrangements for distribution of milk. In the first type, milk flows to a hemispherical bowl with loose circular disc closing the top. When the bowl is full, milk overflows and falls in droplets through the steam environment. In an alternative arrangement, milk flows through a series of parallel and horizontal distribution tubes. These tubes have slits along the bottom and milk flows like a thin film through the chamber. As milk reaches the bottom of the chamber, it is heated to desired temperature. This system is particularly suitable for thicker liquids and for liquids suspended with smaller chunks.

iv) Changes in Milk during Processing

UHT processing does not cause reduction in biological value of proteins. There is only small loss of available lysine (6-7%). UHT processing changes the casein micelle structure. This slows rennet action during cheese manufacture. Serum proteins are denatured (direct processing – upto 50-75%, indirect processing upto 70-90%). Denatured serum proteins interact with casein and increase casein micelle size. This reflects more light and UHT milk appears whiter. Aggregates of denatured serum proteins and casein also give 'chalky' mouth feel to the product.

There is no physical or chemical change in milk fat. The total mineral content also does not change during UHT processing. The vitamin content of UHT milk is comparable to pasteurized milk. Losses in B-complex vitamins are not more than 10%. Folic acid and ascorbic acid are destroyed up to 15% and 25%, respectively. Fat soluble vitamins A, D, E and K are not affected by UHT processing. Fresh UHT milk has slightly cooked flavour. The cooked flavour is due to oxidation of the SH (Sulphydryl) groups from the denatured serum proteins.

v) Changes in UHT Milk during Storage

Chemical, physical or sensory changes in stored UHT milk are dependent on storage temperature. Changes are rapid if storage temperature exceeds 30^{o}C. Browning reactions between protein and lactose progress during storage. At higher storage temperature (>30^{o}C) UHT milk may become little brown after 3-4 months. Refrigerated storage of raw milk before UHT processing favours growth of psychrotrophs. They liberate heat resistant proteases and lipases. Proteases that survive UHT treatment act on proteins during storage. Bitter peptides are released causing bitterness in the product. Extensive proteolysis and other physico-chemical changes occurring as a result of interaction of proteins and salts during storage may cause thickening or sweet curdling also referred as age thickening after longer storage (more than 6 months). Lipases surviving ultra-high-temperature treatment act on lipid fraction. Short and medium chain free fatty acids are released. Short chain fatty acids particularly butyric acids contribute to development of rancid flavour in the product. Air in the product or in the packet reacts with unsaturated fatty acids. This auto oxidation reaction causes formation of aldehydes and ketones. These compounds cause oxidative rancidity (flavour defect) in the product. The cooked flavour in UHT milk disappears in first few days and milk tastes best after this period. Few weeks after this, depending on the temperature of storage, oxidized flavour defects appear which becomes more pronounced with progressive storage. In milk stored for considerable period of time, which could be 3-4 months at >30 O C, stale flavour is a common defect. Several compounds that form during the progress of Maillard reactions in stored milk are associated with the appearance of this defect. Sometimes coconut like flavour defect also appears in UHT milk stored for longer period. Compounds such as d–dodelactone and d–dodecalactones are responsible for this.

1.7 Aseptic Packaging

Aseptic packaging can be defined as the process in which UHT processed or sterilized milk is filled in pre-sterilized containers under aseptic/sterile environment. This ensures that there is no post processing contamination of the milk so that the product has longer shelf life. Since aseptic packaging systems are complex, great care is needed to prevent contamination. Before the start of product packaging, trial runs are routinely conducted with sterile water. Critical parts of the filling machine and carton forming systems are thoroughly checked. The seal integrity of the package and overall microbial quality of the packaging material are monitored properly. Generally, for a good processing plant permissible spoilage rate is one in every 5000 sterilized, filled and sealed package of one litre carton.

i.) Types of Sterilizing Medium

Sterilizing mediums to be used in aseptic packaging systems could be broadly classified under two categories: physical sterilization mediums and chemical sterilization mediums.

Physical sterilization mediums: Steam under pressure or hot water is the most simple and reliable sterilant for high sterilization efficiency in short time. In aseptic packaging, its use is however restricted to sterilization of the milk tubes and valve and fittings coming into product contact.

Dry heat/ super heated steam:

Hot air is generally used to sterilize the closed space where the filling of milk takes place. Air heated to 300 ^{O}C may be taken to the areas surrounding electric resistances used for sealing the packages. Dry air at 330-350 ^{O}C is also used for sterilizing the milk filling tubes. Sterilized air (180-200 ^{O}C) is used for evaporating residual H_2O_2 (chemical sterilant) from the package.

Ultraviolet radiation:

UV rays (optimum wavelength 250 nm) alone are not a very effective sterilizing medium for aseptic packaging units. Two major reasons for this are: (i) intensity of radiation is not uniform on the entire package surface (ii) bacteria adhering to packages could be protected by dirt/ dust particles present on the surface. UV radiations are therefore used as a complementary sterilizing medium.

Ionizing radiations:

Gamma rays are often used for sterilizing packaging materials unable to withstand high temperature. Usually 2.5 Mrad intensity is suitable for sterilizing plastic laminates used in aseptic bag-in-box.

ii. Chemical Sterilization Mediums

Ethylene oxide:

Ethylene oxide has slow sporicidal action. It is sometimes used as a pre-sterilization agent to reduce microbial load on packaging films so that a shorter time is required for final sterilization.

Hydrogen Peroxide (H_2O_2):

H_2O_2 has poor sporicidal effect at room temperature. However, with increasing application temperature and concentration, sterilization performance improves. H_2O_2 is the most popular sterilant for aseptic packaging system. H_2O_2 is applied on the package surface by either dipping or spraying. As its boiling temperature is slightly above 100^oC, supply of heat by either sterilized hot air or infrared elements can evaporate the residual H_2O_2 from the package surface. Thus there is little H_2O_2 left for contaminating the product. Safety regulation recommended by IDF requires that atmospheric concentration of H_2O_2 in the packaging hall should not exceed 1 ppm. Further more, residual concentration in milk immediately after filling should not exceed 100 ppb and should reduce to 1 ppb within 24 hours. The most successful combination of sterilizing medium being used in commercial aseptic packaging units are H_2O_2 coupled with heat supplied by radiant heating element. Some packaging systems also use a combination of H_2O_2 and UV radiation.

Other sterilizing agents which are rarely used in such applications are sodium hypochlorite and per acetic acid. These agents leave the residues of chloride and acetic acid on the package, which may finally contaminate the product.

ii. Type of Packaging Materials

Metal container: Cans made of tin plate or drawn aluminium are generally used for packaging of condensed milk, viscous liquids and chunk-in-gravy type of products. These are expensive and unsuitable for low cost products like liquid milk. They are bulky and require large storage and shipment space. The empty cans are carried in a conveyor to a tunnel for sterilization with steam super heated with gas flame at atmospheric pressure and require about 40-45s. The cans then move to filling chamber for product filling. The can lids are separately sterilized, placed on the cans and seams sealed. The can sterilizing, filling and sealing zones are sterilized before the filling begins with the same mixture of superheated steam and flue gas, which fills them during operation. Cans have been used for in-package sterilization for a long time. Manufacturers of UHT milk who want to impress the consumers with the advantages of the new technology therefore do not prefer to use cans which are so identified with a old technology

Laminates/cartons: Different layers of flexible films of different materials viz. paper, polyethylene and aluminum foil are co-extruded to form a laminate. These materials have specific properties viz. water vapour transmission, burst strength, etc; and hence when co-extruded form an ideal packaging film. Such laminates could be 3, 4 or 5 ply and are generally used for products like, milk, cream, fruit juices, soups, etc. These laminates are supplied as film rolls, which can be mounted on FFS (form-fill-seal) machines. Alternatively, cartons made of laminates are supplied as preformed blanks, which are assembled into cartons for filling and sealing at the top.

Plastic films: Black and transparent polyethylene films are co-extruded for packaging of UHT processed milk intended for 2-3 weeks shelf life. The co-extruded film protects the product against light but not oxygen. The packaging machines also need to operate at not more than 45-50^{0}C filling environment. A co-extrusion of polyvinylidine chloride (PVDC) or ethylene vinyl alcohol (EVOH) with black or white polyethylene film is also used as packaging film. Such a combination imparts protection against oxygen as well as light and shelf life of milk can be extended upto 3 months.

Other forms of packaging materials: Preformed packages of different shapes and sizes are also used for aseptic packaging of value added dairy products. Blow-moulded plastic bottles of polyethylene or polypropylene are used as cheap substitutes. However, these are transparent and permeable to oxygen. Multilayer materials with better light and oxygen barrier properties have also been developed. Pre-formed plastic cups of polypropylene (PP) or polystyrene (PS) are now gaining popularity. Bulk filling bags are made of laminates of 3 or 4 layers of which one will be barrier material such as metalized polyester (polyester with a coating of aluminium particles) or ethyl vinyl alcohol (EVOH). The bag with filling valve is sterilized by r-radiation (2.5 Mrad dose) before shipping. Bags remain sealed and internal surface therefore remains sterile. At the filling station, the sterilized bags are opened, filled and sealed under aseptic condition. All product contact surfaces in the filler however need to be sterilized with steam before the filling operation begins. iii. Description of the Packaging System

Most of the aseptic packaging machines being used in the country are of form-fill-seal (FFS) type. Packaging material used generally is laminate of polyethylene – paper – polyethylene – Al foil – polyethylene. Packaging film in the form of a roll is mounted on the packaging machine. The film moves continuously downward in the form of a strip and a shaping roll gives it a cylindrical shape. Heat sealing forms an overlapping longitudinal seal. Simultaneously extra polythene strip is heat bonded along inside of longitudinal seam. This is done to prevent filled product penetrating the paper layer. As this continuous cylinder moves downward, jaws at the bottom make transverse heat seal. The product is filled instantly and another jaw seals the package at the top. Depending on the type of machine, different shapes can be given to the package. The most popular is brick shaped package. Tetrahedron shapes were also being used some times back. Some new innovations that are now being used for packaging of fruit juices are Fino packs. To cut down on costs some dairies have introduced pillow packs for packaging of milk.