Unit IV – Topic III

PRINCIPLE AND METHODS OF PASTEURIZATION

28.1 Introduction

The word pasteurization is derived from the name of an eminent French scientist Louis Pasteur (1860), who found that heating certain liquids specially wines to a high temperature improved their keeping quality. Pasteurization came into use on a commercial scale in the dairy industry shortly after 1880 in Germany and Denmark. This process is widely employed in all branches of dairy industry. Heat treatment destroys microorganisms present in milk. Further, a more or less complete inactivation of enzymes occurs, depending on temperature and treatment time. In order to retain as many sensory and nutritive properties of the raw materials as possible, different heating methods have been developed to destroy pathogenic organisms (pasteurization) or destroy all microorganisms and inactivate enzymes (sterilization).

28.2 Definition

According to International Dairy Federation (IDF), pasteurization can be defined as 'a process applied to a product with the object of minimizing possible health hazards arising from pathogenic microorganisms associated with milk by heat treatment, which is consistent with minimal chemical, physical and sensory changes in the product'.

In general, the term pasteurization as applied to market milk refers to the process of heating every particle of milk to at least 63°C for 30 min or 72°C for 15s or to any temperature-time combination which is equally efficient, in a properly operated equipment. After pasteurization, the milk is immediately cooled to 5°C or below.

28.3 Importance of Pasteurization

- To render milk safe for human consumption by destroying all the pathogenic microorganisms.
- To improve the keeping quality of milk by killing almost all spoilage organisms (88-99%).

28.4 Drawbacks of Pasteurization

- It may encourage slackening of efforts for hygienic milk production and may mask low quality milk.
- It diminishes the cream line or cream volume.
- Pasteurized milk may increase the renneting time.
- It fails to destroy bacterial toxins
- In India, pasteurization is not necessary as milk is invariably boiled on receipt by the consumer

28.5 Time-Temperature Combination for Specific Requirements

All pathogenic organisms are destroyed by pasteurization, except spore forming organisms. The thermal death point of tuberculosis germs (Mycobacterium tuberculosis) is slightly higher than that for inactivation of phosphatase enzyme. Pasteurization is carried out at a heat treatment temperature above that for phosphatase inactivation and yet below that for cream line reduction. The pasteurization ensures complete destruction of pathogens, a negative alkaline phosphatase test and least damage to the cream line which is shown in the table below:

28.6 Methods of Pasteurization

28.6.1 Low-temperature long-time (LTLT)/Batch pasteurization

Milk is heated, held and cooled in the inner vessel. The space between vessel and the outer casing forms a jacket, through which the heating or cooling medium is circulated. To heat the milk, hot water or low-pressure steam is circulated through the jacket and milk is continuously agitated for rapid and uniform heating. The heating process could be manually or automatically controlled. The milk is heated to a minimum of 62.7°C and held at this temperature for minimum 30 min. It is then cooled as rapidly as possible to 4°C. A cooling medium is circulated in the jacket for chilling the milk, but more often the heated milk is discharged to a surface cooler where a film of milk flows down the corrugated metal plates or series of interlocked tubes. A cooling medium such as brine or chilled water is circulated on the other side of the plates or through the tubes (Fig.28.1).

The LTLT pasteurizer may be of three types

28.6.1.1 Water – jacketed vat

This is double-walled around the sides and bottom of the vat in which hot water or steam under partial vacuum circulates for heating, and cold water for cooling. The outer wall (lining) is usually insulated to reduce heat loss. The heat-exchange takes place through the wall of the inner lining. The difference between temperature of the hot water and the milk is kept to a minimum. The milk is agitated by slowly revolving paddles/propellers. When heating, the vat cover is left open for escape of off-flavors; and when holding, the cover is closed. During the holding period, an air space/foam heater (steam or electrically heated) prevents surface cooling of milk.

Advantage: Flexibility in usage - multipurpose vat.

28.6.1.2 Water–spray type

A film of water is sprayed from a perforated pipe over the surface of the tank holding the product which is continuously agitated. A rapidly moving continuous film of water provides rapid heat transfer.

28.6.1.3 Coil-vat type

The heating/cooling medium is pumped through a coil placed in either a horizontal or vertical position, while the coil is turned through the product. The turning coil agitates the product (but additional agitation may be necessary).
Disadvantage: Coils are difficult to clean.

28.7 High-Temperature Short-Time (HTST) Pasteurization

This was first developed by A.P.V. Co. in the United Kingdom in 1922. It is the modern method of pasteurizing milk and is invariably used where large volumes of milk are handled. The HTST pasteurizer gives a continuous flow of milk which is heated to 72°C for 15s and then promptly cooled to 5°C or below.

28.7.1 Advantages

1. Capacity to heat treat milk quickly and adequately, while maintaining rigid quality control over both the raw and finished product

2. Less floor space required

3. Lower initial cost

4. Milk packaging can start as soon as milk is pasteurized

5. Easily cleaned and sanitized (system adapts itself to CIP)

6. Lower operating cost (due to regeneration system)

7. Reduced milk losses

8. Development of thermophiles is not a problem

9. Automatic precision controls ensure proper pasteurization.

28.7.2 Disadvantages

1. The system is not well-adapted to handling small quantities of liquid milk products

2. Gaskets require constant attention for possible damage and lack of sanitation

3. Complete drainage is not possible (without losses exceeding those from the holder system)

4. Margin of safety in product sanitary control are so narrow that automatic control precision instruments are required in its operation

5. Lethal effect on high-thermoduric bacteria in raw milk is not as great as compared to LTLT system

6. Accumulation of milk-stone in the heating section.

28.7.3 Milk flow

The following steps or stages are involved as milk passes through the HTST pasteurizer:

1. Balance tank
2. Pump
3. Regenerative heating
4. Heating
5. Holding
6. Flow diversion valve (FDV)
7. Regenerative cooling
8. Cooling by chilled water or brine

An arrangement for incorporation of the filter/clarifier, homogenizer, etc., in the circuit is also made possible. There is some variation in the use or order of these steps in different milk processing plants.

28.7.4 Functions of specific parts

28.7.4.1 Float-controlled balance tank (FCBT)

Maintains a constant head of the milk for feeding the raw milk pump; also receives milk diverted by FDV (if at all diverted).

28.7.4.2 Pump

Either a rotary positive pump between the regeneration and heating sections (USA), or a centrifugal pump with a flow control device to ensure constant output, after FCBT (UK and Europe) is used.

28.7.4.3 Plates

The Plate Heat Exchanger (PHE) (also called Paraflow) is commonly used in the HTST system. The PHE is a compact, easily cleaned unit. Its plates may be used for heating, cooling and regeneration. These plates are supported in a press between a terminal block in each heating and cooling sections. The heat moves from a hot to a cold medium through stainless steel plates. A space of approximately 3 mm is maintained between the plates by a non-absorbent rubber gasket or seal which can be vulcanized to them. The plates are numbered and must be properly assembled. They are tightened into place, and designed to provide a uniform, but somewhat turbulent flow for rapid heat transfer. Raised sections (corrugations) on the plates in the form of knobs, diamonds and channels, help provide the turbulent action. Greater capacity is secured by adding more plates. Ports are provided in appropriate places, both at the top and bottom of the plates, to permit both the product and the heating/cooling medium to flow without mixing.

28.7.4.4 Filter

Filter units are connected directly to the HTST system, placed after the pre-heater or regenerative (heating) section. These units, using 40-90 nylon mesh cloth are usually cylindrical in shape. Usually two filters are attached; when one is being used, other can be subjected to cleaning. This permits continuous operation.

28.7.4.5 Regeneration

The raw chilled incoming milk is partially and indirectly heated by the heated outgoing milk (milk-to-milk regeneration). This adds to the economy of the HTST process, as the incoming milk requires less heating by hot water to raise its temperature to pasteurization temperature in the heating section.

28.7.4.6 Heating

The preheated milk from regeneration section passes through heating section of HTST, where it is heated to 72°C or more with the help of hot water from hot well. Thereafter, the heated milk enters into the holding section (plates/tube).

28.7.4.7 Holding

The holding tube ensures that the milk is held for a specified time, not less than 15s., at the pasteurization temperature of 72°C or more.

28.7.4.8 Flow diversion valve (FDV)

This routes the milk after holding section. If the milk is properly pasteurized, it flows forward through the unit. In case the milk is not heated to the set heating temperature, it is automatically diverted by the FDV back to the Float Controlled Balance Tank (FCBT) for reprocessing. It is usually operated by air pressure working against a strong spring. If the temperature of heated milk falls below set temperature, air pressure is released and the valve snaps shut immediately. When the temperature is regained, air pressure builds up and the valve opens up for the forward flow to occur. The system is so arranged that any failure of electricity moves the valve in the diverted position.

28.7.4.9 Regeneration (cooling)

The pasteurized hot outgoing milk is partially and indirectly cooled by the incoming cold milk (milk-to-milk regeneration). This again adds to the economy of the HTST process. In fact, when pre-cooled (raw) milk is received, regeneration efficiency is 90% and above which obviates cooling using well water altogether.

28.7.4.10 Control panel

Contains instruments, controls, FDV-mechanism and holding system, all centralized in one moisture-proof panel. The lower half of the panel forms an air-insulated chamber which carries the holding tube.

28.7.4.11 Automatic control devices

These include (a) steam pressure controller, (b) water temperature controller and (c) milk temperature recorder.

28.7.4.12 Steam pressure controller

Maintains a constant hot water temperature for heating milk accurately to the required pasteurization temperature. It acts as a reducing valve in the steam supply line to give a constant steam pressure.

28.7.4.13 Water temperature controller

Regulates the amount of steam entering the hot water circulating system.

28.7.4.14 Milk temperature recorder

Records the temperature of milk leaving the holding tube/plate. This is an electric contact instrument that operates either a FDV or a milk pump, automatically preventing milk from leaving the holding section at temperatures below the one set in the control panel. Both the frequency and duration of the flow diversion (if at all) and the temperature of milk leaving the heating section are recorded in the thermograph (recording chart) by means of two different colored pens.

28.7.4.15 Hot water

Circulates hot water through the heating section of the machine to maintain the correct milk heating temperature within very fine limits.

28.7.4.16 Pressure in the system

The normal pressures maintained in the HTST system are:

28.8 Testing of Holding Time

The holding time is calculated between the points at which the heated milk leaves the heating section and reaches the FDV. The efficiency of pasteurization in the HTST system depends on attaining the requisite temperature along with the desired holding time. Hence, the latter should be checked periodically. Several methods are used for determining the holding time, viz. the electrical conductivity method (of a salt solution); the dye injection method; the electronic timer method; etc. The requirements for heat treatment and modifications which can occur in milk, time-temperature profiles have been established for heat treatment processes.

28.9 Devices for Controlling the Heat Treatment Process

1. Automatic temperature control and recording devices.
2. Automatic safety device to avoid insufficient heating of the milk (bypass installation) with recording device for time/temperature and valve position for the flow, as well as passage and recirculation of the milk or cleaning.
3. Safety device with automatic recording against unplanned blending of pasteurized or sterilized milk with non-heated milk based on pressure increase after the heating or holding section of the heat exchanger.

The most widely used installation for the heat treatment of milk is plate heat exchanger. For reason related to the flow conditions, tubular heat exchangers are used when operating at temperature level >100°C.