Chapter 9

Sterilization

Objective

The purpose of this chapter is to understand sterilization process and equipments required for it.

Introduction

Sterilization is a severe heat treatment designed to destroy all microorganism in milk. Sterilization of milk on commercial scale was started long back in 1894. Milk can be sterilized either in glass bottles, cans etc or by using ultra-high temperature (UHT) processing, which involves continuous sterilization followed by aseptic packaging.

Principle

The sterilization effect is quantified using D, Z and F_o values defined as follows:

D Value

At a given temperature, D is the time required for 90% destruction of a given microbial load. The heat resistance of bacteria and spores at a constant temperature is characterized by their decimal reduction time (D value). D value is the time required to reduce the microbial population of 90% or one decimal reduction (one log cycle). The number of decimal reductions (log N_o/N) can be evaluated from:

$\log (N_o/N) = \text{heating time}/D$

Where,
N_o = the initial microbial population,
N = final microbial population

For example, if initial microbial count was 100,000 and heat treatment of product at a temperature of 116°C for 4 minutes reduced the count to 10000, the D value 116°C would be 4 minutes.

Z value

Z is the temperature variation giving a 10 times variation of D.

Sterilizing value F_o

At a given point in a bottle where the temperature has a constant value T for the time t, the sterilizing value Fo will be :

$Fo = (10^{(T-121)/Z}) \times t/60$

Z value = 10 (for many heat resistant spores)

Methods

Sterilization can be done by any of the following methods:

i. **Direct heating:** Steam is used for direct heating by injection or infusion followed by vacuum flash cooling to remove undesirable odours and added moisture.

   a. **Injection:** Steam is sprayed in to the milk through steam injector in a mixing chamber.

   b. **Infusion:** milk is sprayed into a chamber where steam environment is maintained.

ii. **Indirect heating**: Indirect method employs heat exchangers for heat treatment. The systems used for indirect heating are plate heat exchangers, concentric tube and multiple tube-in-tube systems.

Equipments

In Bottle Sterilization

The original form of sterilization, still used, is in-container or bottle sterilization, usually at 110-120°C for some 20-40 minutes. As the thermal conductivity of glass is low, temperature of milk rises slowly specially when bottles are not agitated. The bottles cannot withstand extreme or sudden temperature change, therefore milk sterilization is done by low temperature long time process. This causes development of cooked flavour and brown colour. In bottle sterilization could be done using:

a. Autoclaves

b. Batch retort/sterilizer (Horizontal or vertical)

c. Hydrostatic vertical steriliser

d. Horizontal steriliser

Ultra High Temperature (UHT) processing

Milk starts to undergo browning reaction under lower sterilization temperatures. Therefore sterilization is done at very high temperature (135 to 150°C) for short time (6-2 s) to prevent browning and development of cooked flavour (Table 9.1). The process is commonly known as Ultra High Temperature (UHT) and operation is followed by aseptic packaging. Advantages of UHT processing are:

- Higher D and Z valves for better quality and food safety
- Reduction in process time due to higher temperature
- Longer shelf life. (> 6 months)
- Product can be stored at ambient temperature
- Product can be marketed to far off distances

Table 9.1. Effect of temperature on bacteria destruction rate and relative rate of browning

Sterilization Temperature°C	Bacteria destruction rate	Relative rate of browning
100	1	1
110	10	2.5
120	100	6.2
130	1000	15.6
140	10000	39.0
150	100000	97.5

REVIEW QUESTIONS

1. What is the difference between pasteurization and sterilization?
2. Differentiate between injection and infusion methods of sterilization.
3. Define D value
4. Define Z value
5. Define F value
6. What do you understand by UHT sterilization?