COURSE TITLE: MICROBIOLOGY OF MILK PRODUCT

COURSE NO. - DTM-222: CREDIT HRS-2 (1+1)

MICROBIOLOGY OF CONCENTRATED MILK

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MICROBIOLOGY OF CONCENTRATED MILK

Concentrated milk is produced by partial removal of water from fresh milk for direct sale to the consumer, which can be used as food ingredients for providing a source of milk solids in manufacturing of a variety of other products. The removal of water from milk gives an advantages in reducing storage and transport costs, ease / convenience in use and increasing shelf life. Concentrated milk is further reconstituted by the consumer with water, to give a similar composition of fresh milk. It is generally produced as a 3:1 concentrate containing approximately 10 - 12% milk fat and 36% total milk solids.

Introduction

Condensed milk is an important source of milk solids in confectionery, bakery products, ice cream, concentrated yoghurt, choclates, bakely products and other newer kind of food mix preparation. It may be made from whole, skimmed, or reduced fat milks, depending on the consumer need and requirements.

Uses of Condensed milk

1- Condensed milks are mainly used for reconstituation into sweet milk drinks.
2- Condensed milks are very commonly utilised in the preparation of tea or coffee.
3- They are also used in the ice-cream preparation.
4- They are used in candy and confectionary products.
5- They are frequently used in prepared foods in various ways and form.

Indian desserts

Cakes and cookies

Ice cream

Puddings

Drinks

Chocolate fudge

History of condensed milk

Invented by Gail Borden in the early 1850s, canned condensed milk proved invaluable as a military ration in the 1860s. Fresh milk was spoiled due to long distance / supply chains and it was observed that the canned milk was nutritious, portable, long-lasting and, crucially, safe. At the same time, sales were exploded in US towns and cities after the war.

Objectives of manufacturing condensed milk

1- Preservation of milk, and

2- Reduction in bulk for the purpose of long distance transport

Shelf life of Condensed milk

1- While still in the can and sealed container, condensed milk will have a shelf life about a year.

2- Once opened, the shelf life is reduced

- Sweetened condensed milk; two to three weeks.
- Unsweetened condensed milk; only for two week.

Mostly condensed milk is made by evaporation process under vacuum drying and the degree of concentration is usually within the range 2.5:1 to 4:1. Condensed milk prepared from whole milk should contain at least 8% fat and 28% total milk solids while made from skim milk contains at least 0.5% fat and 24% milk solids. After evaporation, sufficient sugar amount of sugar is added as sucrose or glucose specially to prevent microbial growth. The sugar concentration in the aqueous phase (known as sugar ratio, sugar number or sugar index) of final products is usually in the range of 63.5 - 64.5, giving a water activity (aw) of about 0.86, but it is much lower in bulk products. For bulk, whole milk products the sugar index is about 42; this is because the product is stored under refrigerated condition for fairly short periods. The product is packed in hermetically sealed metal containers for retail marketing and milk SS cans, SS barrels, steel drums or bulk tanks for industrial use. Now a days huge quantities of sweetened condensed milk are used in the confectionery, bakery and prepared food industries.

Evaporated milk is same in composition to condensed whole milk, but it is additionally heat processed as well as canned to give a commercially sterile product. Evaporated milk is produced by the removal of about 60% water from whole milk, which results in the lactose content being about 11.5%. Evaporated milk contains at least 7.5% fat and 25 - 26% total milk solids and also contain permitted stabilising salts for maintaining required viscosity level after sterilisation. Some products are made from skimmed milk, and some are ‘filled milk’ where other fats are used to replace milk fats. Mostly, evaporated milk is sold directly to consumers for use in home cooking.

Condensed milk is relatively a new type of dairy product made from evaporated milk with added sugar. Mostly found in the market and known as sweetened condensed milk. Used in numerous dessert recipes. Water content is partially removed from this milk.

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

BIS Specification for Condensed Milk: (IS: 1166-1986 (1&3)

Sr. No.	Characteristic	Full Cream Sweetened	Full Cream Unsweetened	Skim Sweetened	Skim Unsweetened
1	Total Milk Solids, % by Wt., Min.	31.0	31.0	26.0	20.0
2	Fat, % by Wt.,	NLT 9.0	NLT 9.0	NMT 0.5	NMT 0.5
3	Sucrose, % by Wt., Min.	40.0	-	40.0	-
4	Titratable Acidity (as lactic acid), % by Wt. Max.	0.35	0.30	0.35	0.30
5	Colour	Whitish to light brown	Whitish to light cream	Whitish to light brown	Whitish to light cream
6	Bacterial Count, per g, Max.	500	-	500	-
7	Test for Coliform Organisms	Negative	-	Negative	-
8	Yeast & Mould Count per g., Max.	10	-	10	-

Nutritive value of condensed milk

It is having high nutritive value and are rich in fat and fat-soluble vitamins A, D, E and K as all body building proteins, bone forming minerals and energy-giving sucrose is present.

SWEETENED CONDENSED MILK

- Concentrated whole or nonfat milk
- 60% of H2O removed
- Sweetened with sucrose or dextrose prior to concentration 40-45% sugar level,
- may cause grittiness
- Pasteurized, not sterilized due to high concentration of sugar

Global Sweetened Condensed Milk Manufacturers

- Nestle
- Arla
- Fraser and Neave
- Friesland Campina
- Marigold
- DMK GROUP
- Eagle Family Foods
- Holland Dairy Foods
- DANA Dairy

Physico-chemical properties of sweetened condensed milk

- Specific gravity/density: Evaporation of water in the manufacture of condensed milks increases its specific gravity/density, which is important in controlling their composition. Baume hydrometers are industrially used for getting idea about specific gravity.

- 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 milks darken its colour and develop cooked flavour, the darkening / browning-discoloration results from the interaction of the amino-compounds with sugar (casein and lactose). This is based on Maillard reaction (browning). The brown pigment formed is called melanoidin.

Processing of condensed milk

1.Receiving milk

2.Filtration/clarification (pre-heating)

3.Standardization

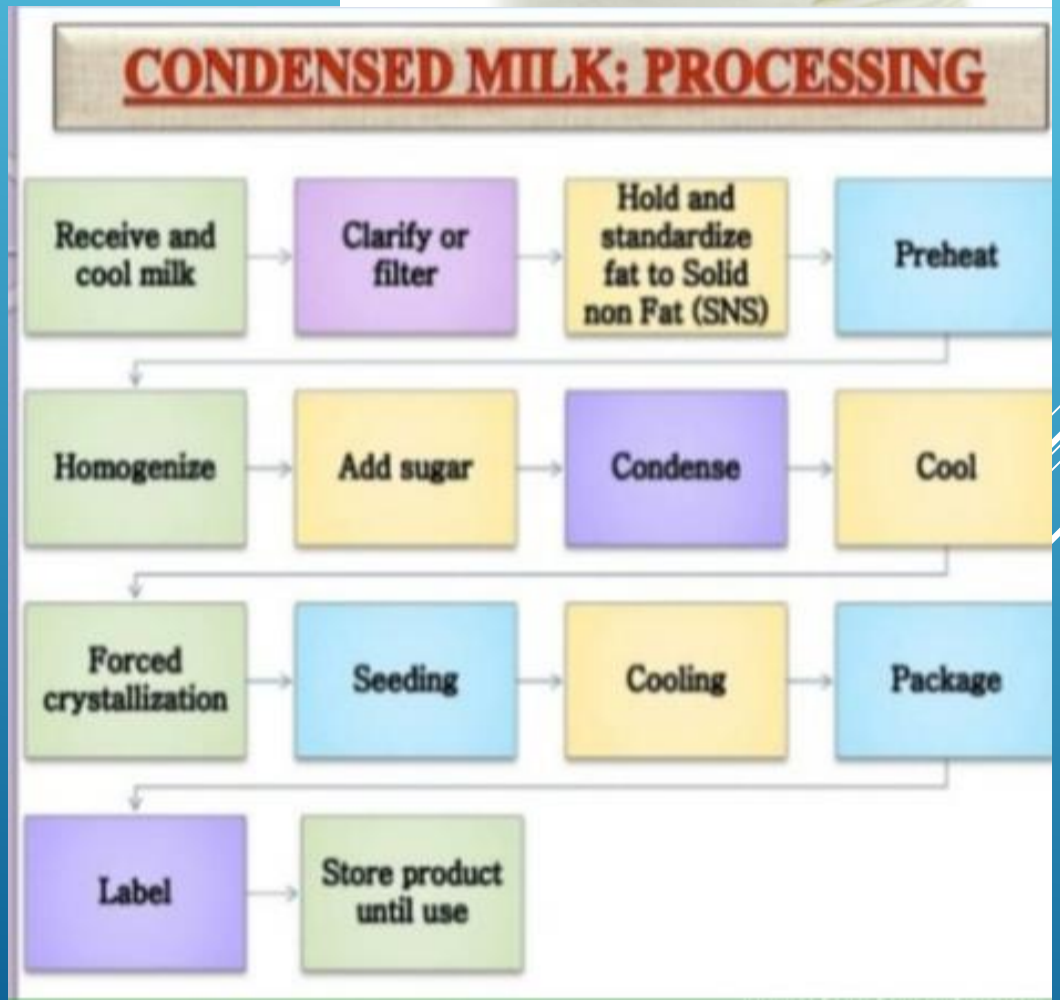
4.Fore-warming / pre-heating

5.Addition of sugar

6.Condensing

7.Homogenization

8.Cooling and Crystallization



Initial Microflora

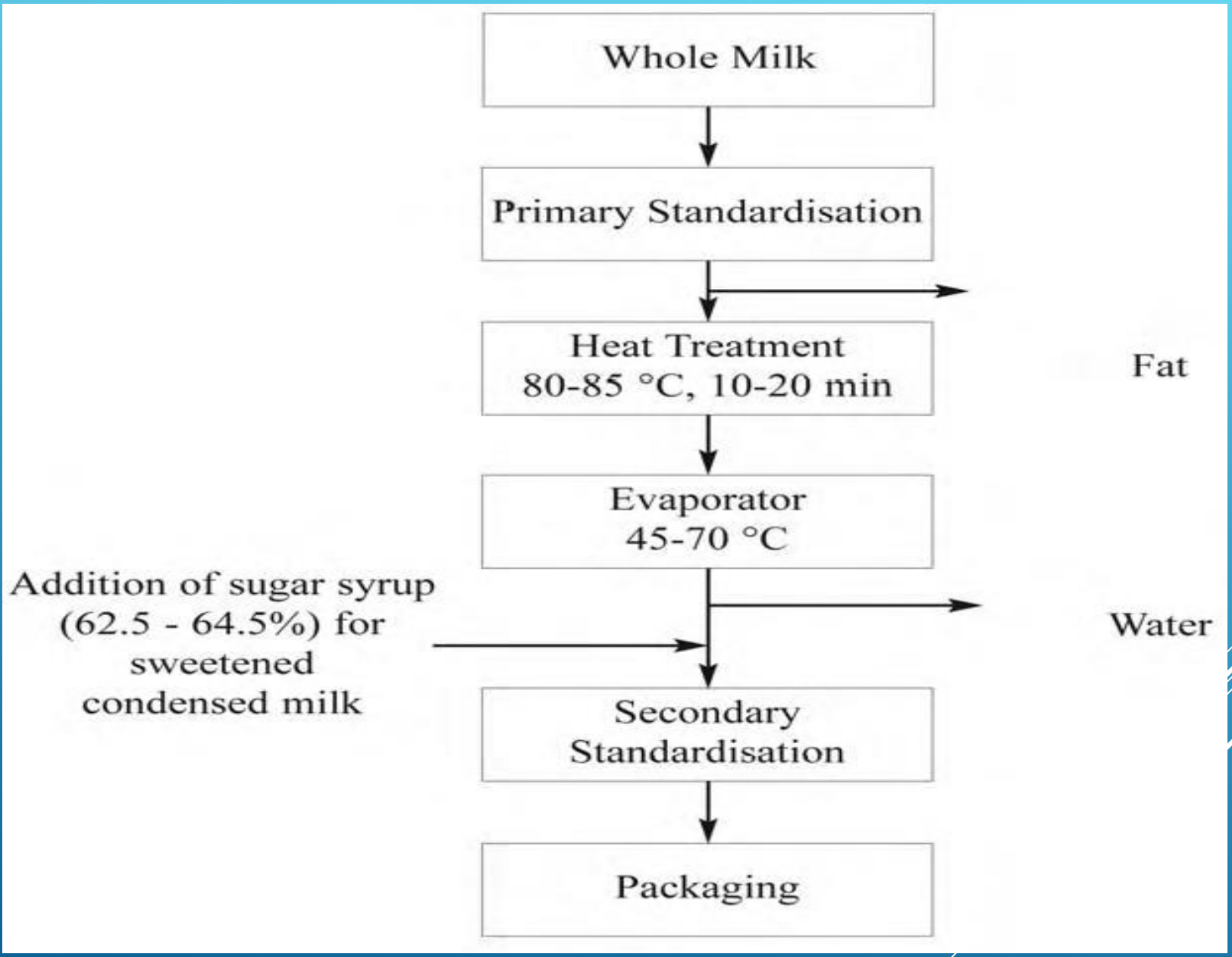
The initial microflora of concentrated milk is same as the raw milk which is used for the production. Sugar used during production of sweetened condensed milk is an additional source of yeasts and molds and bacterial spores especially thermophilic spores.

Processing and its Effects on the Microflora

Processing steps used in manufacturing condensed milk are shown in Figure. The initial steps of milk collection, storage, transport, separation and standardisation are the same as used in fluid milk. Pasteurisation or pre-heating process is the first important step. The time and temperature generally applied as same as milk pasteurisation (72 °C for 15 seconds). In some cases, much higher processing temperature is used. In large-scale continuous production system of evaporated milks, temperatures as high as 121°C may be applied for several minutes to stabilise milk proteins. Depending upon the nature of the product required, more severe processing temperature than pasteurisation may be used in the manufacturing operation of Condensed milk.

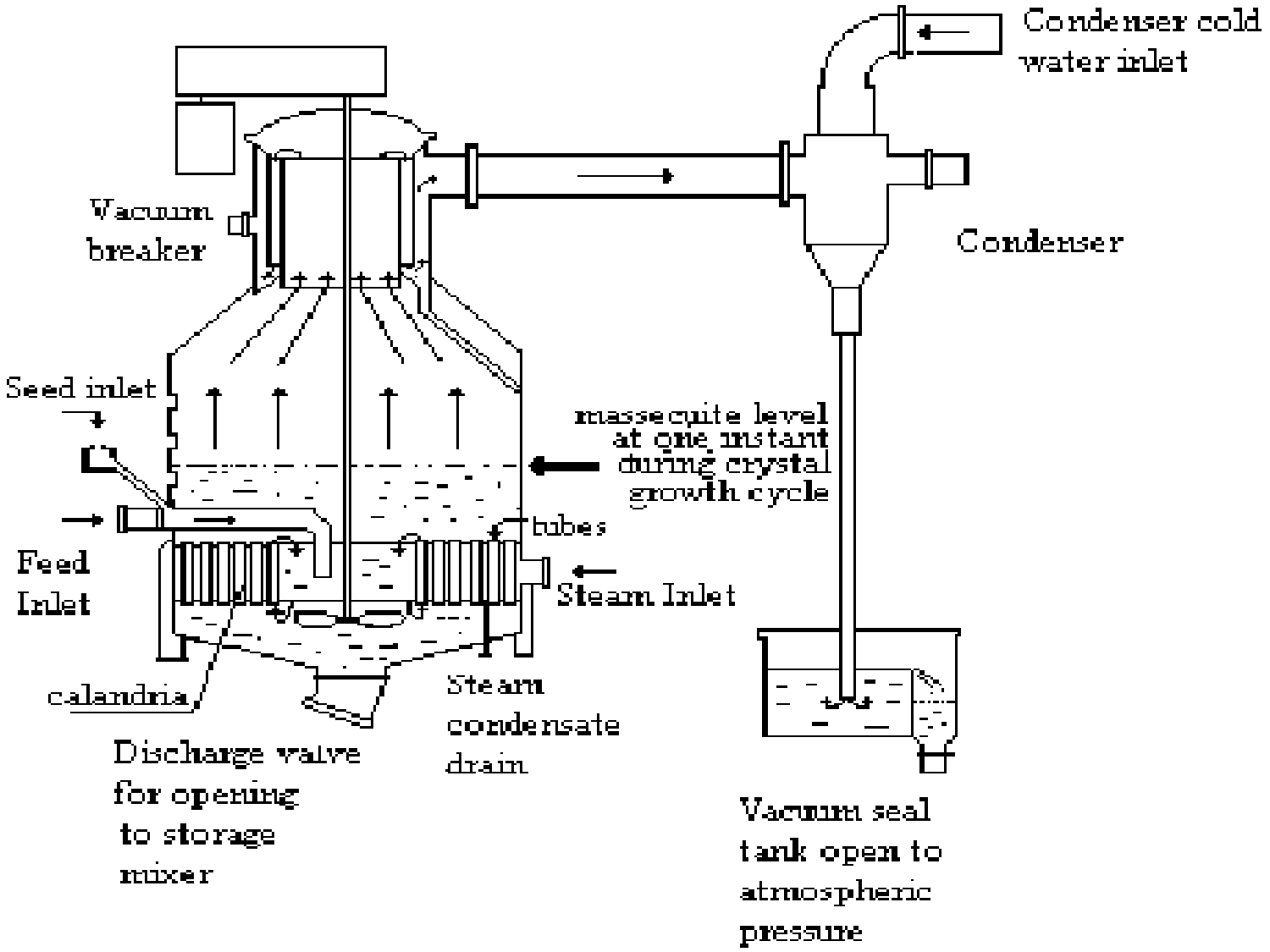
Preheating or application of heat helps to increase viscosity and improve other characteristics of the final product. The process of preheating may be less controlled than conventional pasteurisation method, but it is always better to maintain safe minimum process. In case of fresh milk, most vegetative bacteria will be destroyed during heating, but some thermoduric types and bacterial endospores are likely to survive but the severe treatment may remove all these microorganisms. This preheated milk is now concentrated in a vacuum-pan or in a multiple-effect evaporator at a temperature range of 54.4 - 57.2 °C. After evaporation, sugar is added usually as sucrose or glucose which restrict or prevent most microbial growth. The sugar concentration in the aqueous phase of the product known as sugar ratio/index is usually in the range of 63.5 - 64.5 having a water activity (aw) level is about 0.86 and much lower in bulk packing. For bulk, whole milk products the sugar index is about 42; this is because the product is stored under refrigerated condition for short periods. The product sealed in metal containers for retail marketing and milk cans, barrels, steel drums or bulk tanks for industrial purposes. Significant quantities of sweetened condensed milk are used in the confectionery, bakery and different food industries.

Production of condensed milk



Complete Condensed milk processing plant

Processing of condensed milk



Microbiological defects

Condensed milk

Unsweetened condensed milks are not commercially sterile. Although, it is a favourable medium for the microbial growth and the spoilage caused by heat-resistant organisms present in the raw milk viz *Bacillus* spp., enterococci or post processing contaminants such as pseudomonads and speces of Enterobacteriaceae. Only thermoduric and thermophilic organisms will grow slowly if the product is handled and stored at low temperature (<7°C). Shelf life of unsweetened condensed milks varies from few days to few weeks, depending on the degree of post processing contamination, the severity of the heat treatment used during the manufacturing process, and the temperature control during cooling and storage. The pattern of spoilage is same as pasteurised fresh milk, although lower aw values of the product may have some advantage compare to pasteurised milk.

Microbiological defects

Sweetened condensed milk

The low aw (0.85) of sweetened condensed milks restrict the bacterial growth and only osmophilic and osmotolerant organisms can grow in this condition. Sometimes canned products may be spoiled by the growth of osmophilic yeast - *Torulopsis* spp., which enter in the product after processing treatment and may produce sufficient amount of gas to cause blowing of cans. In few cases, oxygen is present in the headspace of canned packing or have a small pinhole leakage in the container then molds such as *Aspergillus* and *Penicillium* spp. may grow and produce 'buttons' on the surface of the product. This problem is because of the poor plant hygienic condition. Bulks packing with lower sugar concentrations are more susceptible to spoilage. Mould growth may be observed on the surface of stored milk. Again, *Penicillium* and *Aspergillus* are the main genera responsible for the defect. However, bacterial spoilage created by osmotolerant micrococci and some species of *Bacillus* may create age thickening, and sometimes lipolysis and proteolysis problem.

Evaporated milk

Evaporated milk is fresh, homogenized milk from which 60 percent of the water has been removed. After the water has been removed, the product is chilled, stabilized, packaged and sterilized. It is commercially sterilized at 240-245°F (115-118 °C) for 15 minutes. Reconstitution and substitution Evaporated milk is sometimes used in its reduced form; however, to reconstitute evaporated milk to be equivalent to normal milk, mix 1 part by volume of evaporated milk with 1 1/4 parts of water. Where evaporated milk is required but not available, it can be replaced by simmering 2 1/4 parts of fresh milk down to 1 part. A comparable result is obtained by simmering down 2 parts of almond milk.

Evaporated milk

• Evaporated milk is a concentrated and sterilized milk product having a concentration twice that of standard milk.

• The method of manufacturing evaporated milk involves standardisation, heat treatment and evaporation of the milk under reduced pressure and low temperature between 60ºC and 65ºC.

• The evaporated milk is then homogenized to make it stable and prevent separating during storage and then it is cooled.

• As a result of severe processing treatment, evaporated milk is having a characteristic cooked flavour and a characteristic colour.

• The shelf-life of canned evaporated milk is about one year when stored at ambient temperatures but in practice the product can be keep for longer period.

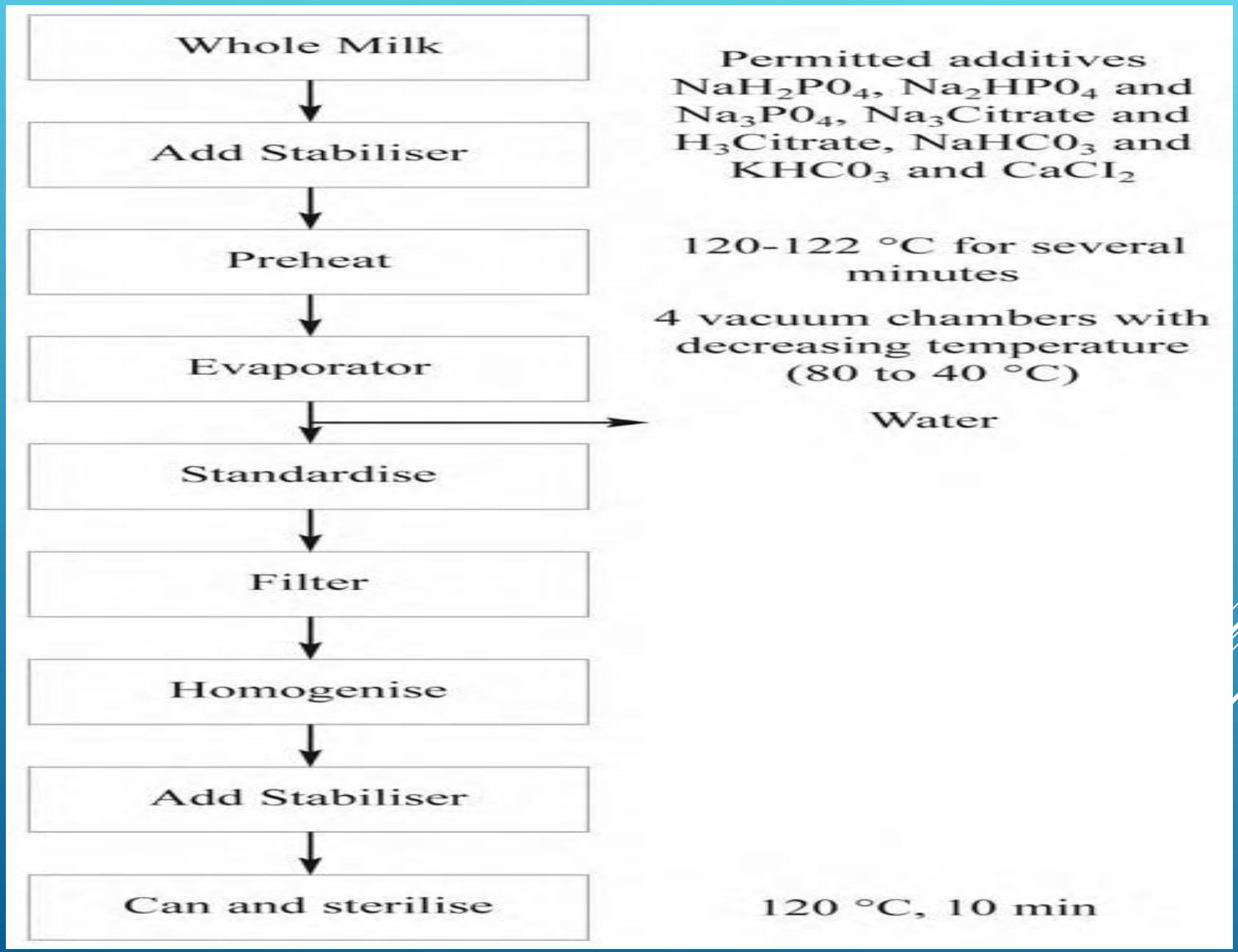
Processing and its Effects on the Microflora

In the manufacture of evaporated milk water is removed by evaporation. The evaporator generally used in the dairy industry is the falling film evaporator because it is energy-efficient and easily controllable. It is common to link several evaporators in series to form generally known as a 'multiple effect evaporator' with a common condenser and vacuum pump. The vapour produced in the first effect utilised to heat the second and so on, producing a gradual decrease in temperature from 70 - 80°C in the first effect to about 40°C in the last effect. The vacuum is maximum in the lowest temperature evaporator and the milk flows from higher to lower temperature. This process is very efficient and fast and produces evaporated milk of desired concentration without no time. But the lower temperature range within the lower temperature effects of the evaporator permits the growth of thermophilic and mesophilic spores and there may be chances to reach high numbers in the multi effects evaporator during prolonged production runs.

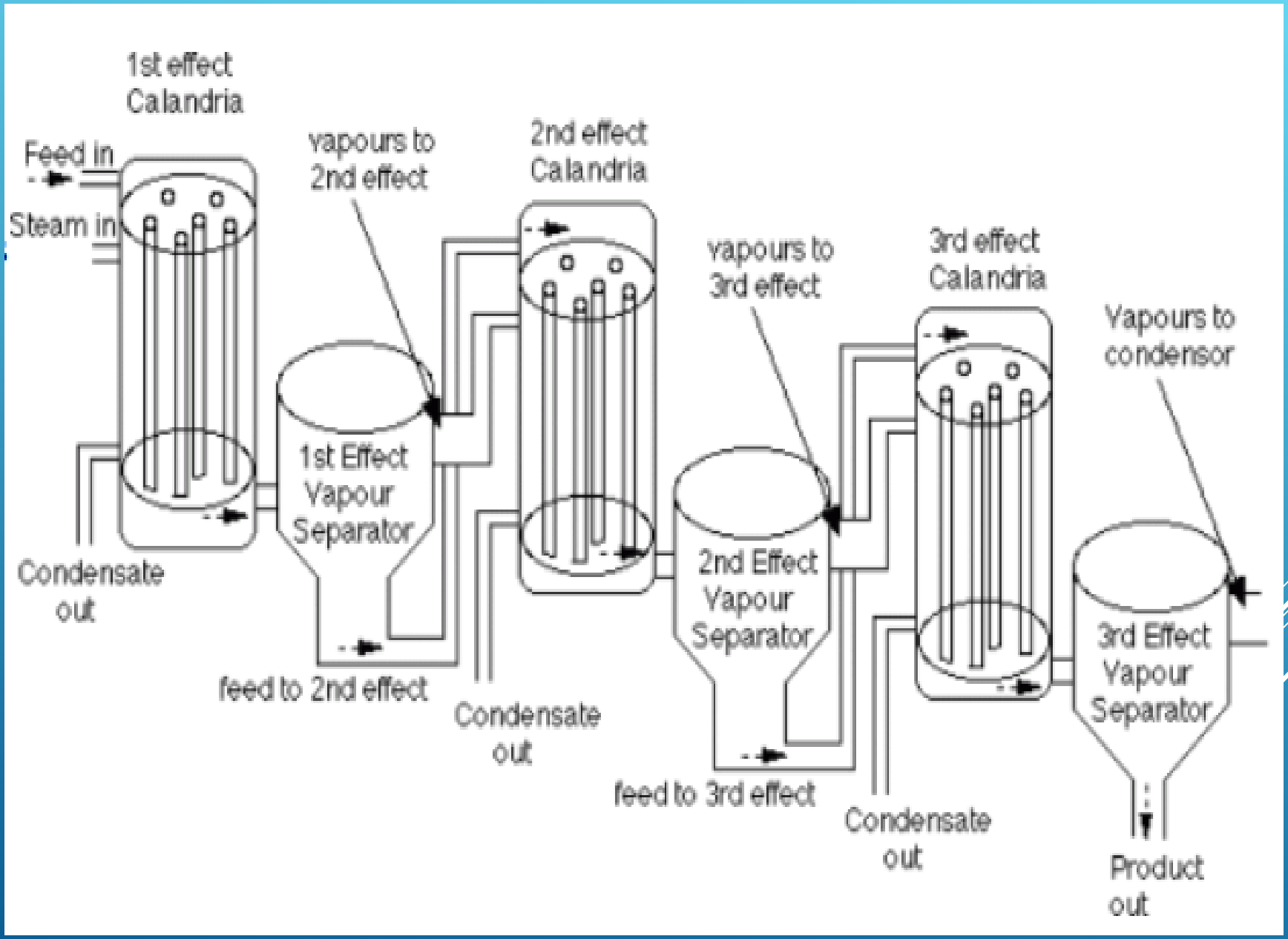
It has been reported that certain thermophilic species can grow in milk even at temperatures as high as 70°C. So, it is important to control the growth of thermophiles by reducing the length of production runs, effectively using CIP cleaning and sanitation process of plant for ensuring an adequate standards of plant hygiene are implemented.

The product is finally filled into cans, hermetically sealed and further sterilised using batch retorts or continuous sterilisers. Processing treatment of 115°C / 15-20 minutes or 120°C / 10 minutes is used in traditional method but now a days it is recommended to go for UHT processing followed by aseptic filling into pre-sterilised packaging materials (cans or cartons). Heating at 130°C for 30 seconds / 150°C for less than one second may be used in few cases. Retorted canned milk is commercially sterile and there are possibility of surviving heat-resistant spores of *Bacillus stearothermophilus*. These spores do not germinate unless the cans are again stored at high ambient temperatures (>43 °C). Evaporated milk which are aseptically packed may be recontaminated during filling / packing if proper hygiene procedures used in filling other UHT milk products are not properly used.

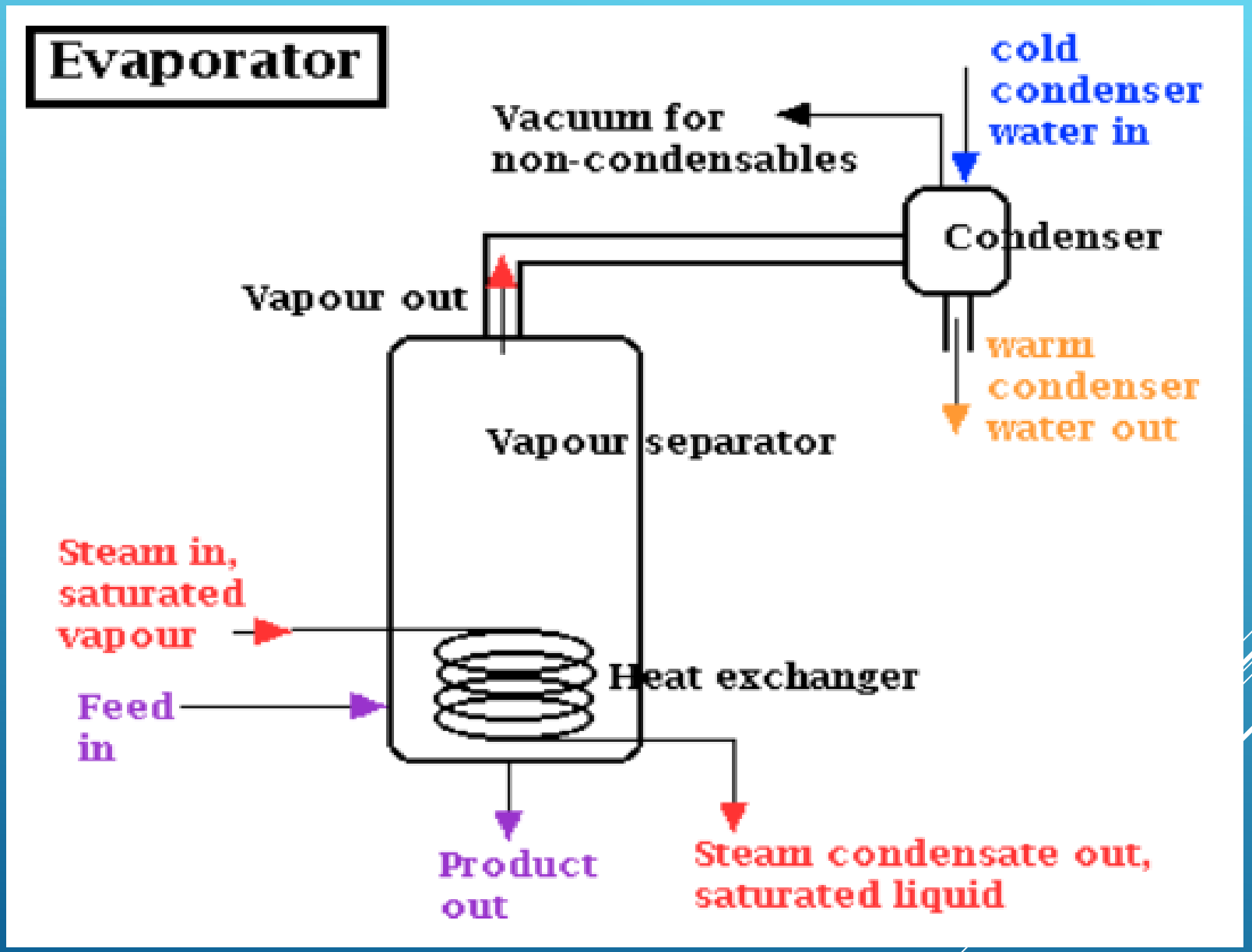
Production of evaporated milk



Processing of evaporated milk in multiple effect evaporator



Process diagram of evaporated milk



Nutritional Importance of Evaporated Milk

- Good source of Calcium
- Good source of protein
- Contains good amount of Vitamins
- Government regulations ensure that vitamins A, D, and C are all fortified into the final product.

Health Benefits

- Presence of calcium makes teeth strong & healthy
- Provides energy
- Strengthens bones
- Gives a smoother skin
- Natural skin softener
- Presence of calcium aids in bone health

General Benefits

- Does not require refrigeration.
- Easy to store.
- Higher concentrate of vitamins and nutrients fortified.
- Evaporated milk is suitable for infant feeding since it makes a soft curd which is easily digested.

Microbiological defects

A very few spoilage reports are available in commercially sterile canned evaporated milk, but sometimes under-processing and post-process contamination may create this type of defect. Some species of bacillus group such as *B. stearothermophilus*, *Bacillus coagulans* and *Bacillus licheniformis* may survive the heat treatment employed in manufacturing process and cause acid coagulation with cheesy odour defect and flat sour spoilage in the final product. However, many strains are thermophilic in nature and create problem at elevated storage temperatures or if the batch is not immediately cooled. *Bacillus subtilis* produces non-acid curd and this can be digested to a brownish liquid with a bitter taste. *Bacillus megaterium* is responsible for coagulation problem accompanied with cheesy odour and gas. Occasionally, a defect like blowing of cans problem observed which is associated with the growth and activity of putrefactive spoilage organism - *Clostridium* spp.

Microbiological defects

Evaporated milk

Spoilage caused by faulty / under-processing is not so common in recent times because of improvements in process technology and a good control during the whole operation. Post-processing spoilage can be caused by a wide range of species and owing to that the spoilage characteristics in the products are varied. The spoilage problem is found similar to that observed in other sterilised and UHT milk products. Bacteria may enter in the product as a result of faulty can seaming or subsequent damage in seam, corrosion in the container and breakdown in the continuity of the aseptic filling process in aseptically filled products.

Pathogens in Condensed / evaporated milk : Growth and Survival

Concentrated milks are not considered as high-risk products because of the severe heat treatments used during manufacture operation. The main concern for microbial quality of condensed and evaporated milk is based on the post heat-treatment contamination by pathogens as pasteurised and UHT processed milks.

Listeria spp.

Incidence of *L. monocytogenes* has been studied in these products. The organism reduced its number during storage of sweetened condensed milk at 21°C but the population remained stable when stored at 7°C. In case of evaporated milk, growth was observed at both temperatures .

Clostridium spp.

Incidence of clostridium showed that about 40% of the samples contained >100 cfu/100g in sweetened condensed milk. Mainly *Clostidium butyricum* and *Clostridium perfringens* were identified as contaminants. Although, the aw is too low to allow the germination of spores and vegetative cell growth in these products.

Staphylococcus aureus

There is no reported cases of food borne disease found incanned sweetened condensed milk as its aw of 0.85 is close to the minimum value that would required by *Staph. aureus* to grow and there is no chance of toxin at this aw level. In case of bulk container having these products with much lower sugar contents might be at risk if they become contaminated. Therefore, adequate hygiene control should be maintained.

THANK YOU