

COURSE TITLE: MICROBIOLOGY OF MILK PRODUCT

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

MICROBIOLOGY OF CONCENTRATED MILK

Evaporated milk



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Evaporated milk

- ✓ Evaporated milk known as unsweetened condensed milk and it is a shelf-stable canned milk product which differs from sweetened condensed milk which contains added sugar.
- ✓ Sweetened condensed milk requires less processing to preserve since the added sugar inhibits bacterial growth.
- ✓ 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, homogenized, canned / packed and sterilized.
- ✓ It is commercially sterilized at 115-118°C for 15 minutes. Reconstitution of evaporated milk is sometimes done by using 1 part of evaporated milk by volume with 1 to 1/4 parts of water to get a composition of normal milk.

- ✓ Evaporated milk is made by removing half of the milk's moisture by evaporation before it is canned.
- ✓ Evaporated milk is sometimes used in cooking, because it is easy to store and because it curdles less easily when heated compare to other milk.
- ✓ Unopened, it can be kept at room temperature for up to six months. However, the keeping quality of evaporated milk depends on the storage temperature which is relatively on the high side in a tropical climate as in India.
- ✓ It has been observed that the numbers of spores in the treated samples were low, they could germinate into vegetative cells which could reach populations high enough to cause spoilage or constitute food safety risk within a few days.

Composition of evaporated milk

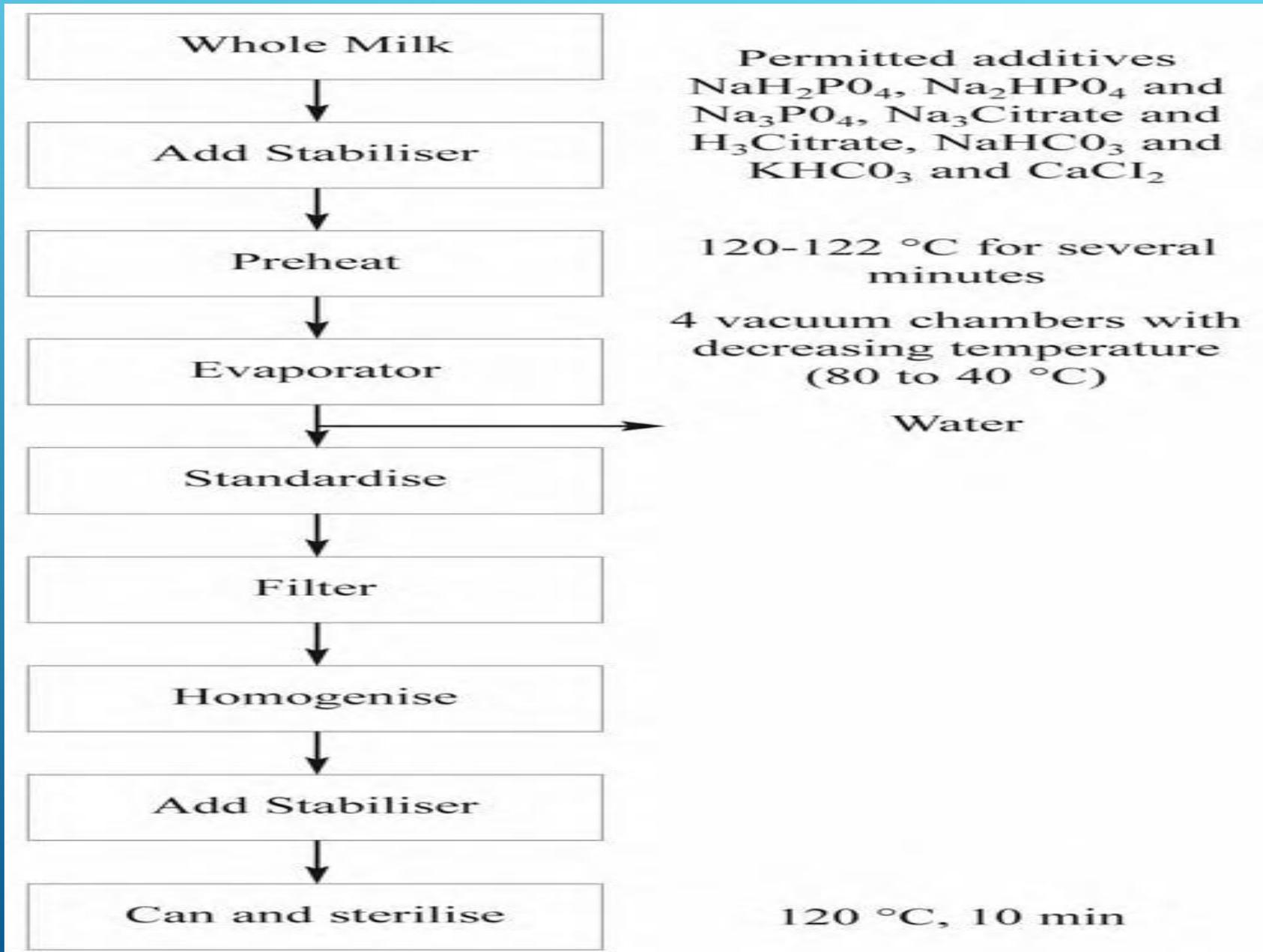
| Component | Percentage |
|-------------------|------------|
| Moisture | 69 |
| Total solids | 31 |
| Fat | 9 |
| Milk SNF | 22 |
| Protein | 8.3 |
| Lactose | 12.2 |
| Ash | 1.5 |
| Total milk Solids | 31 |

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 standardization, heat treatment and evaporation of the milk under reduced pressure and low temperature between 60°C and 65°C.
- 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.

- Dairy plants should ensure that adequate hygiene is observed during the preparation of the unsweetened evaporated milk in order to reduce the incidence of spore forming bacteria in this important food material.
- Contaminations in storage tanks, pipe and from air source should be prevented. It is recommended that higher temperature should be applied in milk processing.
- Ultra-High Temperature (UHT) pasteurization, a relatively new technique used to sterilize foods for aseptic packaging is recommended for trial in the dairy industry. In UHT pasteurization, foods are heated to 138° C (280° F) for 2 to 4 secs allowing the food to retain more nutrients and better flavour.

Production 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.



Processing 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.

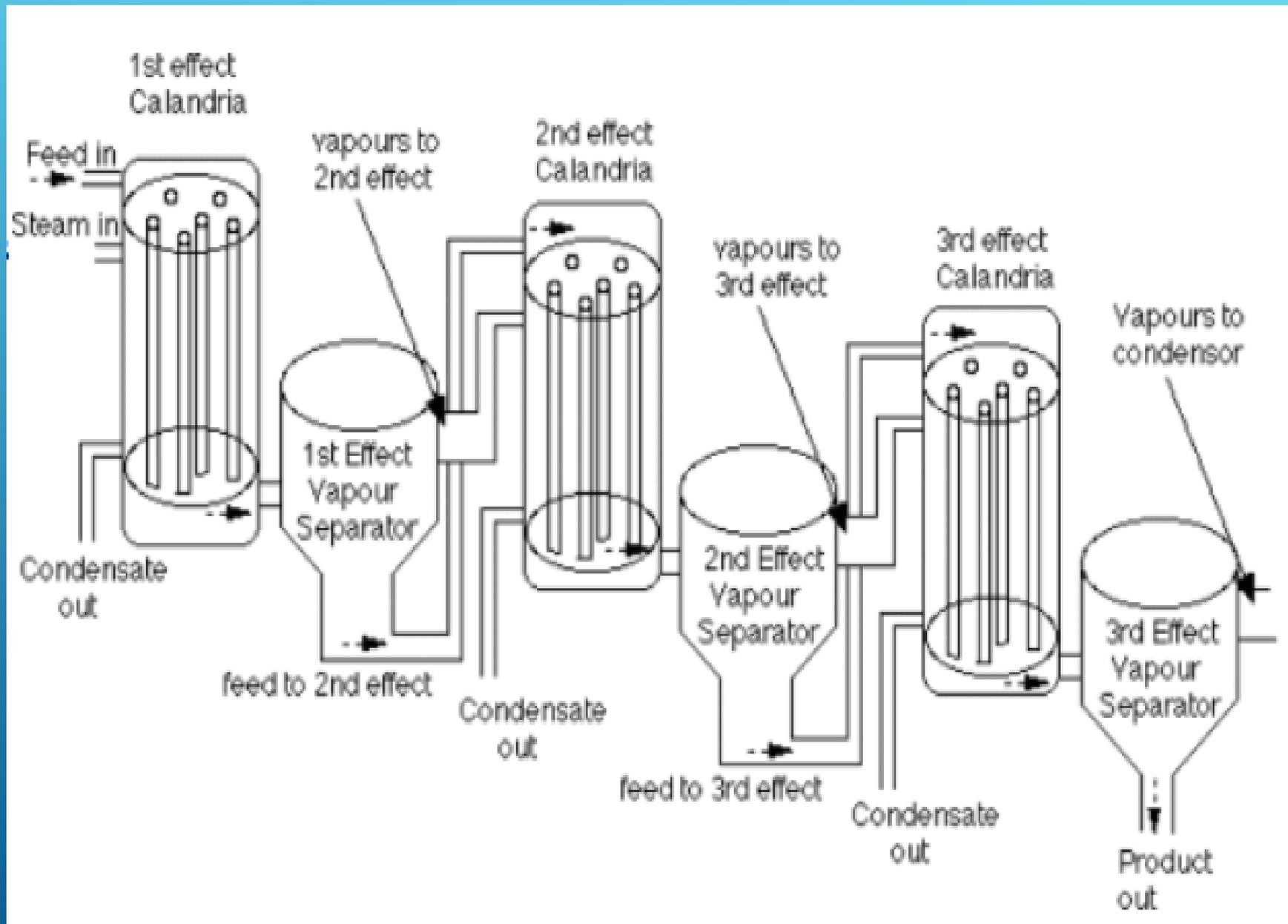
Evaporated milk

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 species of *Enterobacteriaceae*. Only thermotolerant 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.

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.

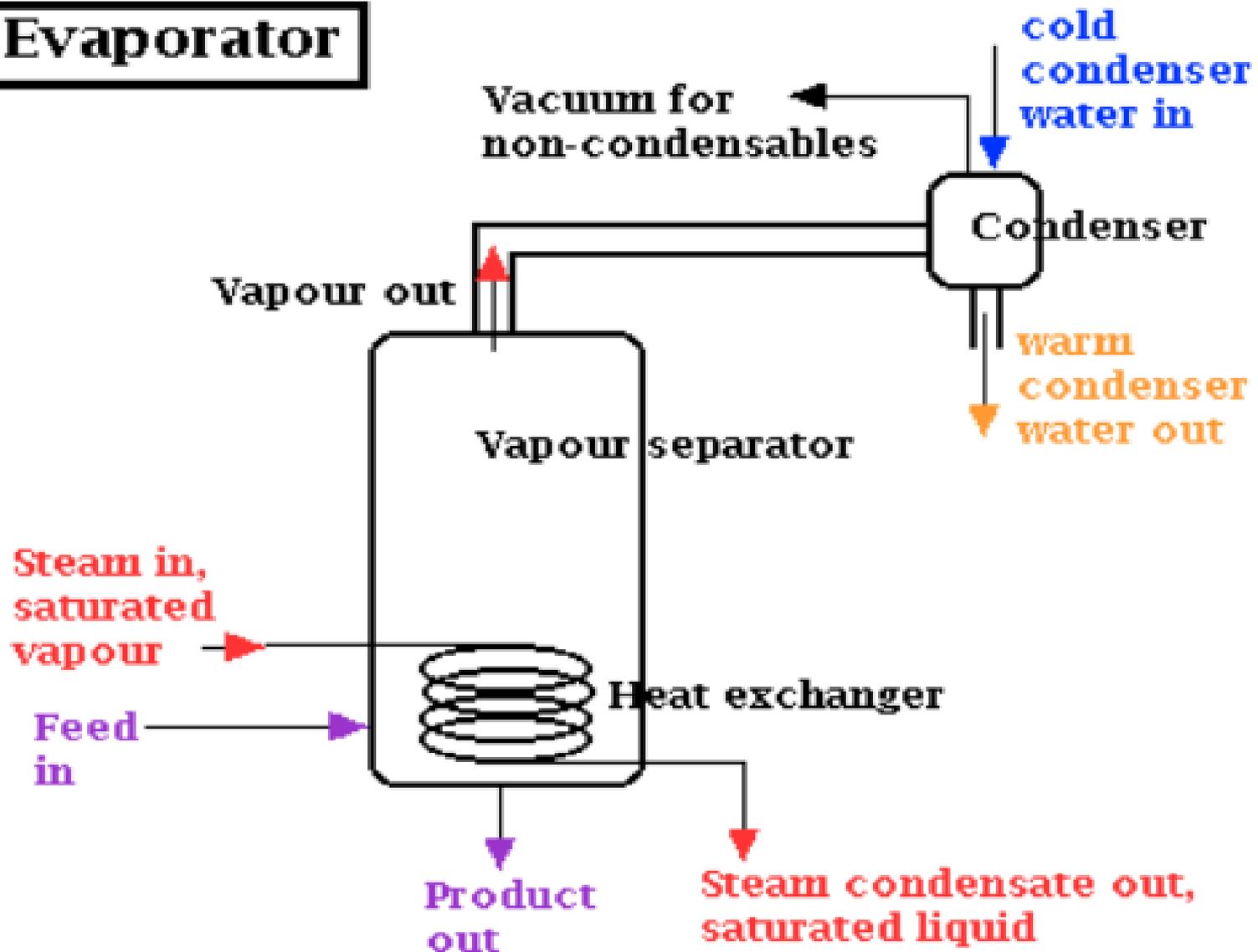
The product is finally filled into cans, hermetically sealed and further sterilised using batch retorts or continuous sterilisers. Processing treatment of 115°C / 15-20 minutes or 120°C / 10 minutes is used in traditional method but now a days it is recommended to go for UHT processing followed by aseptic 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.

Processing of evaporated milk in multiple effect evaporator



Process diagram of evaporated milk

Evaporator



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 produce 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.

Common bacterial defects of evaporated milk are

- Bloat caused by gaseous fermentation
- Bacterial coagulation and
- Off flavors due to bacterial causes of which bitter flavour is most frequently encountered.

Bloats of Evaporated Milk

Bloats mainly caused by gaseous fermentation in commercial packing and it is the most serious bacterial defect found in evaporated milk. The commonly responsible organism are not always responsible for this defect. Sometimes, it may be because of post processing contamination of evaporated milk.

Characteristic organisms causing bloats

Characteristic serious out-breaks of bloats problem in commercial produce evaporated milk are caused by microorganisms of higher heat resistance. Such fermentation is due to anaerobic bacteria belonging to the butyric acid group and in most cases though not always the putrefactive condition created. Gas formation is very vigorous and is accompanied by putrid odour (foul odour).

The responsible organisms as reported are *Plectridium foetidum*. It is a spore forming bacteria and motile. At 32°C, it ferments milk in four days under anaerobic conditions. The milk first curdles and curd gradually digests leaving a clear yellow liquid similar in appearance to butter oil. The fermentation is accompanied by the production of intense foul, putrefactive odour because of H₂S. The organisms survive for 15 mins at 118°C.

Coagulation of Evaporated Milk

Bacterial coagulation is the most common bacterial defect in evaporated milk.

The coagulum found in this type of outbreaks has varied from the sweet curdling to a sour curd and sometimes an intense bitter curd. Some reported curd to be sweet and no bitter taste when no acid was developed and curd was of varying firmness with absence of wheying off.

Causative organism identified is *Bacillus cereus*. *Bacillus coagulans* was also separated and identified from commercial coagulated milks. These organisms were not destroyed by a 10 min exposure to 80°C but failed to survive 112°C.

Bitterness in evaporated milk

Many instances of bacterial coagulum showed intense bitterness, suggesting protein breakdown and formation of peptone and other decomposition products of known bitter flavour. The coagulum was firm and striking whiteness. The content had wheyed off. This was practically clear. Acidity was normal 0.35 to 0.4%. Inoculation with sterile milk yielded pure culture of very small spore forming rods. Organism was facultative anaerobic with an optimum incubating temperature 32°C but failed to survive 110°C for 15 minutes.

Fishy flavour

Coagulated milk with fishy flavour development is reported by the causative organism *Proteus ichthyormis* in evaporated milk.

Control of 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.

The organisms often isolated from evaporated milk samples of different brands collected from different parts of the world were identified as *Bacillus cereus*, *Bacillus licheniformis*, *Bacillus coagulans*, *Bacillus stearothermophilus*, *Bacillus subtilis* and *Clostridium perfringens*.

Presence of these organisms reported by a number of workers from samples of evaporated milk showed flat sour taste.

It was reported that these strains produced various concentrations of acid in milk and concluded that these organisms may be responsible for the flat sour spoilage in evaporated milk.

Spore-forming bacteria can survive food-processing treatments and *Bacillus* and *Clostridium* species determine the shelf-life of a variety of heat-treated milk products in dairy industry,

(a) Standard Agar Plate Method

Preparing Dilutions:

It is desirable to follow already recognized practical method as standard procedures. For that reason the method of bringing the volume or weight up to 100, as used in the Standard Methods of milk analysis is preferred to the method of adding the material to be tested to 10 ml or grams. It is recommended that for normal evaporated milk the volumetric method be used, transferring 1 ml or 10 ml of the product to the 99 ml or 90 ml water blanks, respectively. Samples that are abnormal physically, such as "curdled" or "lumpy," are best brought to dilution by the gravimetric method. For direct plating of a low-count milk, one ml or gram of the sample is placed directly in the petri plate. For a one to ten dilution, it is preferred to measure 10 ml or weigh 10 grams of the evaporated milk directly into the dilution bottle containing 90 ml of sterile distilled water.

(b) Test for Sterility

For the purpose of determining whether or not the product in the cans is sterile, it is recommended that sample cans be held at 37°C for one week. At the expiration of the period the cans should be plated as described above. Cans in which an abnormal physical condition of the milk has developed may have large numbers of organisms present and should be plated in high dilutions. Cans which show the milk in normal condition and which yield no colonies on any of the plates, including 1 ml direct. It may be assumed to be sterile and of good quality for all practical purposes.

(c) Direct Microscopic Count (Breed Method)

The direct microscopic count as applied to milk, would normally be of little value for evaporated milk because of the low bacterial content of the product, however, in the study of cases of spoilage the method is of value. If it is used for this purpose, it should be carried out according to directions given for ice cream.

(d) Anaerobic Agar Plate Method

In evaporated milk it is often desirable to get information of the numbers of anaerobic organisms present in the sample. Same procedure as outlined under "Standard Agar Plate method" may be carried out, except for the addition of 1 per cent of dextrose to the standard nutrient agar. The methods of incubation must necessarily be carried out as described in text books dealing with the study of anaerobic bacteria. This method will be of special value in the study of abnormal products and may find a place in certain routine work.

(e) Examination for Thermophilic Bacteria

For the determination of the presence of thermophilic organisms plates may be prepared from standard nutrient agar. The plates should be incubated for 48 hours at 55°C. At least 15 ml of medium should be used in each plate to prevent excessive drying during the incubation. Water should be placed in the incubator in order to reduce the drying of the plates to a minimum.

Pathogens in evaporated milk

Evaporated milk is not considered as high-risk products because of the severe heat treatments used during manufacture operation. The main concern for microbial quality 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. In case of evaporated milk, it should be absent.

Clostridium spp.

Incidence of clostridium presence showed by a number of research findings in evaporated milk. *Clostridium butyricum* and *Clostridium perfringens* were mainly identified as contaminants in those investigation. Although, the aw is too low to allow the germination of spores and vegetative cell growth in this product.

Staphylococcus aureus

There is no reported cases of food borne disease found in canned evaporated milk as aw level is very low which is unfavourable for *Staph. aureus* to grow and at the sometime there is no chance of toxin formation at that aw level. Adequate hygiene control should be maintained for ensuring good quality product.



THANK YOU