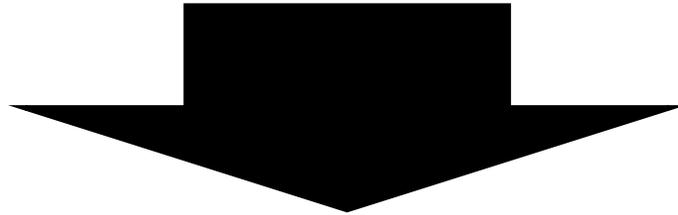


Microbiology of Concentrated Milks



Objectives of Concentrated Milks

Concentrated Milks are the products of reduced moisture content.



To improve keeping quality of milk

To reduce cost of transportation

To save storage and package space

To use as an additive for manufacture of ice-creams, candies etc.

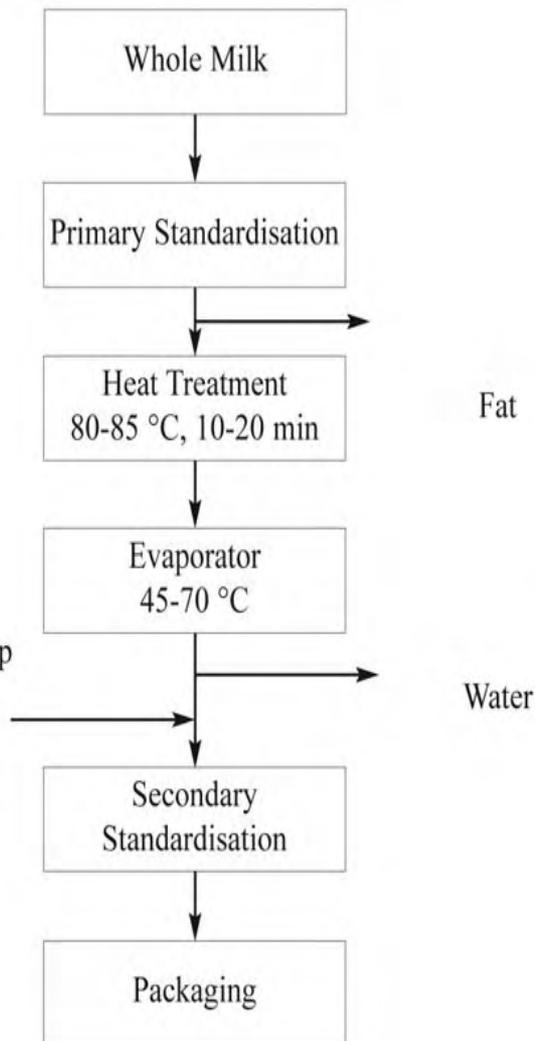
Types of Concentrated Milks

Condensed Milk: The product obtained from cow or buffalo milk or from standardized milk by the partial removal of water and addition of cane sugar

Unsweetened/Evaporated Milk: The product obtained from cow or buffalo milk or a combination or from standardized milk by the partial removal of water.

They may contain added calcium chloride, citric acid and sodium citrate, sodium salt of orthophosphoric acid not exceeding 0.3% by weight of the finished product.

Production of Condensed Milks



Bulk condensed milk is manufactured using either whole or skim milk. Typically, milk is pasteurized and then concentrated by heat in an evaporator until the product contains 40–45% total solids. Following concentration, the product may be dried or distributed for use as a concentrated milk.

The primary difference between condensed and sweetened condensed milks is addition of sugar. Sweetened condensed milk is preserved by addition of sugar, which reduces water activity to a point inhibitory to most microorganisms. The increased milk solids content also decreases the water activity. The sugar-in-water concentration of sweetened condensed milk is called the sugar ratio:

$$\frac{\% \text{ Sugar in condensed milk}}{100 - \text{Total milk solids in condensed milk}} \times 100 = \text{Sugar ratio}$$

Microbiological Quality of Sweetened Condensed Milks

With modern processing, storage, and handling practices, spoilage seldom is encountered. If the bulk product is improperly handled or held for extended periods before use, surface growth of yeasts or molds may occur. The oxygen present in the headspace of incompletely filled or poorly sealed containers may offer chances of proliferation of organisms. The presence of these microorganisms is indicative of unsanitary post-pasteurization conditions.

Microbial Numbers: The presence of organisms in different proportions in this product.

Type of Microflora: The high incidence of micrococci in SCM is attributed to their marked resistance to unfavourable conditions like high osmotic pressure.

- ❖ Micrococci: *M. varians*, *M. candidus*, *M. luteus*, *M. freudenreichii*
- ❖ Staphylococci: *S. aureus*, *S. epidermidis*
- ❖ Coliforms: *E. coli*, *Proteus sp.*, *Enterobacter aerogenes* (present in low nos.)

- ❖ **Aerobic sporeformers: *B. subtilis*, *B. stearothermophilus*, *B. mycoides*, *B. mesentericus***
- ❖ **Anaerobic sporeformers: *C. butyricum*, *C. sporogenes*, *C. welchii***
- ❖ **Streptococci: *S. faecalis*, *S. faecium***
- ❖ **Other groups: *Pseudomonas* sp., *Serratia marcescens***
- ❖ **Yeasts and Molds: *Saccharomyces*, *Candida*, *Torulopsis*, *Rhodotorula*, *Aspergillus*, *Penicillium***

Factors Affecting Microbiological Quality of Sweetened Condensed Milks

Quality of raw materials

- ❖ **Milk:** The quality of raw milk determines the microflora in the finished product. The raw milk used should usually be of manufacturing grade. MBRT of raw milk should be <3.5 h.
- ❖ **Sugar:** Sugar normally does not contain microorganisms but precautions are taken to avoid any type of contamination. It should not contain osmophilic yeasts, mold spores and bacteria producing acid and gas. The standards for sugars should be total colony count (100), yeasts (nil) and molds (10). Sugar should be stored at dry place free from dust, insects and rodent contamination.
- ❖ **Skim Milk Powder:** Skim milk powder is sometimes used for standardization of milk before condensing operations. Sometimes they may have some heat-resistant micrococci and streptococci. To reduce the counts, skim milk is subjected to high temperatures.

Processing time and temperature conditions

- ❖ **Pre heat treatment:** The temperature used in pre-heat treatment kills all spoilage and pathogenic microbes with exception of heat resistant proteases and lipases as a result of growth of microorganisms.
- ❖ **Holding in the hot-well:** The development of viscosity of SCM subsequently during storage is influenced by the time-temperature combination. The surviving organisms would be mostly sporeformers as pre-heat treatment has destroyed all heat-labile organisms.
- ❖ **Addition of sugar:** Sugar should not be added to milk before pre-heating because it increases the resistance of microorganisms.
- ❖ **Super heating (70C):** This process enables to obtain desired viscosity of the product.

❖ **Condensing (3-4 h):** Milk and sugar mixture is subjected to vacuum operation in a vacuum pan at 52.7C at which it boils. The vacuum pan may act as a source of contamination for the product. The sticky nature of product increases the difficulty in cleaning and cooked on material may also become potential source of problem. Vacuum pan heads should be properly cleansed.

Finishing and Seeding

When the condensation is over, the vacuum in the pan is broken. This process is called finishing. Over-condensation can be done and adjust the composition by adding sterile water or under-condensed milk. Such a process is prone to post-contamination.

Seeding is the process of providing nuclei for the development of lactose crystals. It can be done either by adding sterilized lactose or good quality condensed milk from a previous batch. The lactose should be previously sterilized and the total count should not exceed 10-15 per g. Milk is seeded at 30 C.

Sterility of cans

Cans used for filling should be sterilized before use. Lids should also be sterilized properly before use and cans should be checked. The cans must be filled as possible to minimize head space, otherwise if aerobic microorganisms if any present, may grow and cause defects. Imperfect seals or can damage may permit the entry of microorganisms.

Sterility of equipments

The equipment used should be sterilized by use of chlorine, steam or other sterilants. The pipelines, filling machines should be washed, cleaned and sterilized. Gaskets and valves are major hazard.

Storage conditions

The keeping quality of SCM is chiefly dependent upon the concentration of sugar, total solids and the degree of destruction of organisms. The shelf-life of SCM is considerably longer even if allowed to stand at open conditions. SCM lacks sterility and micrococci, sporeformers and yeasts and molds predominate.

Microbiological Defects of Sweetened Condensed Milks

Gassy Fermentation

Symptoms	Causative organisms	Mechanism	Control measures
Gas or bloat may develop suddenly in the product during storage after 10 days to few weeks. The gas produced causes bulging of cans, blowing of cans or leakage. The other signs are high acidity, lumpiness and darkening of internal surface of containers as well as product in contact.	Yeasts: <i>Torulopsis lactis</i> <i>condensis</i> <i>Torulopsis globosa</i> Bacteria: Coliforms, <i>Bacillus cereus</i> , <i>Clostridium butyricum</i>	Sucrose is inverted by enzyme invertase produced by yeast cells. Molecule of sucrose is converted to glucose and fructose. Glucose and fructose molecules are fermented by the causative organisms with subsequent production of CO ₂ .	<ul style="list-style-type: none">❖ Avoiding sugar condensation❖ Equipments must be properly sanitized❖ Protect the product from long exposure to air by filling as soon as possible

Bacterial Thickening:

Symptoms	Causative organisms	Mechanism	Control measures
<p>Progressive thickening either due to the action of microorganisms or due to aging on storage at room temperature. The defect is accompanied by high bacterial count, a disagreeable cheesy odour and taste and an increase in acidity. When the thickened product is diluted with water and heated, the curd separates.</p>	<p>Bacteria: <i>Micrococcus pyogenes</i>, <i>Stap. aureus</i>, <i>Bacillus subtilis</i></p>	<p>Due to the production of rennin like enzyme by the causative microorganisms which act on milk proteins. When sugar contents are high, the growing conditions are rather unfavourable and thickening proceeds slowly.</p>	<ul style="list-style-type: none">❖ Avoiding contamination❖ Storing at low temperatures❖ Using optimum sugar concentrations

Mold Button Formation:

Symptoms	Causative organisms	Mechanism	Control measures
<p>Mold buttons are lumps of variable sizes, cheesy consistency, disagreeable taste and whitish yellow to reddish brown colour. Buttons are found on the surface or subsurface layers of product. Molds grow until the availability of oxygen in headspace is exhausted.</p>	<p>Bacteria: <i>Aspergillus repens</i>, <i>A. glaucus</i>, <i>Penicillium</i> sp.</p>	<p>Molds may develop and produce certain milk clotting enzymes which affect casein stability and form brown buttons. Buttons are composed of coagulated casein and mold mycelia usually coloured white to brown. When molds lost their activity owing to lack of oxygen, these buttons still continue to grow owing to activity of enzymes.</p>	<ul style="list-style-type: none">❖ Avoiding contamination❖ Storing at low temperatures❖ Inversion of stored cans at regular intervals

Rancidity, fruity and fishy odour are some of other defects of SCM

Public Health Significance of SCM

SCM is not a sterilized product. Reliance is mainly produced upon low moisture content and preservative action of sugar. There can be presence of pathogens:

- Aerobic and anaerobic sporeformers
 - *S. aureus* and its enterotoxins
 - *E. coli*
- Pathogenic yeasts and molds



Staphylococcal
penetrate the
gut lining

Activate local
and systemic
immune
response

Release
inflammatory
mediators

Vomit



Microbiological Requirements of Sweetened Condensed Milk

SPC	Coliform count	<i>S. aureus</i>	Yeast and mold	<i>E. coli</i>	<i>L. monocytogenes</i>	<i>Salmonella/Shigella</i>
5X10 ² /g	Absent/0.1 g	10/g	10/g	Absent/ 0.1 g	Absent/g	Absent/25 g



Microbiological Quality of Evaporated Milks

Evaporated milk contains no sugar and therefore, long term keeping quality of the product at room temperature can be achieved by sterilization.

Microbial Numbers: The presence of organisms can vary depending on defective processing and packaging.

Type of Microflora: The most predominating types are heat resistant bacteria specifically sporeformers.

❖ Heat resistant bacteria: *B. cereus*, *B. subtilis*, *B. coagulans*, *B. circulans*, *B. mycoides*, *B. panis*, *B. brevis*, *C. butyricum*

❖ Post-processing contaminants: *E. coli*, *Pseudomonas ichthyosmia*, *Enterobacter* sp.

Factors Affecting Microbiological Quality of Evaporated Milk

Quality of raw milk:

The quality of raw milk determines the microbiological quality in the finished product. In order to retard the growth of contaminating bacteria, the raw milk is cooled as soon as it is received and if not cooled, undesirable levels of bacteria might develop. Sediment test, MBRT (>2.5 h) and resazurin-reduction test can be assessed.

Standardization: The raw milk is frequently clarified before diverted for processing in order to remove some bacteria and somatic cells. The microbiological quality of clarified raw milk can be further affected by standardization of fat with the help of cream or skim milk.

Heat treatment:

Proper heat treatment of standardized milk destroys pathogenic non-sporulating bacteria present in milk as contaminants. However, faulty heat treatment may leave residue of surviving bacteria which may spoil the bacteria on their subsequent growth. Pre-formed staphylococcal enterotoxins are not inactivated by heat treatment and may be carried over to finished product.

Condensing operations:

In condensing operations (54.5 C), bacteria are destroyed which survived pre-heating but however, some thermophilic bacteria grow under these conditions.

Homogenization:

The homogenizer used is also a possible source of contamination during processing of evaporated milk. Hence, it should be clean and free from bacterial contamination.

Sterilization and packaging: First the product is sterilized followed by hermetically sealed packaging. The fillers used for packaging milk in the final container are very complex and difficult to clean. If not cleaned properly, the fillers can act as point of contamination. The cans intended for packaging are fabricated in an adjacent plant and heat treatment used during fabrication is enough to ensure that the cans will be almost free of bacteria that could spoil the product. The keeping quality of aseptically packaged UHT treated evaporated milk is improved. Damage to the packet, mishandling and weakening the lid can lead to microbial contamination.

Public Health Significance

Since evaporated milk is relatively a sterile canned product, there is little possibility of the presence of potential pathogens, as most of the pathogenic bacteria are destroyed during processing stages. Anaerobic sporeformer (*Clostridium botulinum*) can grow and proliferate in the anaerobic conditions.

Microbiological Defects of Evaporated Milk

Gassy Fermentation or Bloat

Symptoms	Causative organisms	Control measures
Bulging of cans	Anaerobic sporeforming gas producer (<i>Clostridium foetidum</i>) can withstand a temperature of 118 C for 15 min. It causes putrefactive changes and produces hydrogen persulphide which gives foul smell.	<ul style="list-style-type: none">❖ Improved sanitation in production of milk on the farm❖ Proper time-temperature combination for sterilization.

Bacterial Coagulation

Symptoms	Causative organisms	Control measures
Sweet coagulation: Brownish liquid and disagreeable taste	<i>Bacillus subtilis</i>	<ul style="list-style-type: none">❖ Storage of product at cold temperature❖ Proper sterilization
Sour coagulation: Milk coagulates and tastes sour and cheesy	<i>Bacillus coagulans</i>	<ul style="list-style-type: none">❖ Adequate cooling

Bitterness

Symptoms	Causative organisms	Control measures
Breakdown and formation of peptones and other decomposition products sometimes accompanied by wheying off.	<i>Bacillus amarus</i> , <i>B. panis</i>	<ul style="list-style-type: none">❖ Heat distribution should be uniform❖ Proper time-temperature combination for sterilization.

Fishy Flavour: *Proteus ichthyosmius*

Bacterial deterioration due to leaky cans: Leaks may be due to improper closure, corrosion or mechanical injury during handling.

Gas Production: Coliforms

Coagulation: Lactic streptococci

Fishiness: *Proteus ichthyosmius*

Control Measures: During cooling, suitable pressure relationships should be maintained to prevent bulging cans. Opened products should be kept at refrigeration temperatures.