# CONCENTRATED MILK

Dairy Processing Technology

2012/2013

# Introduction

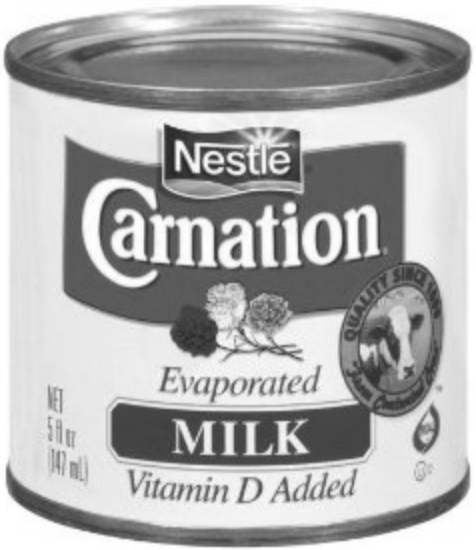
- Concentrated milks are liquid milk preserves with a considerably reduced water content.
- Water removal is done by evaporation.
- Two type of concentrated milk:
  - Evaporated milk
  - Condensed milk

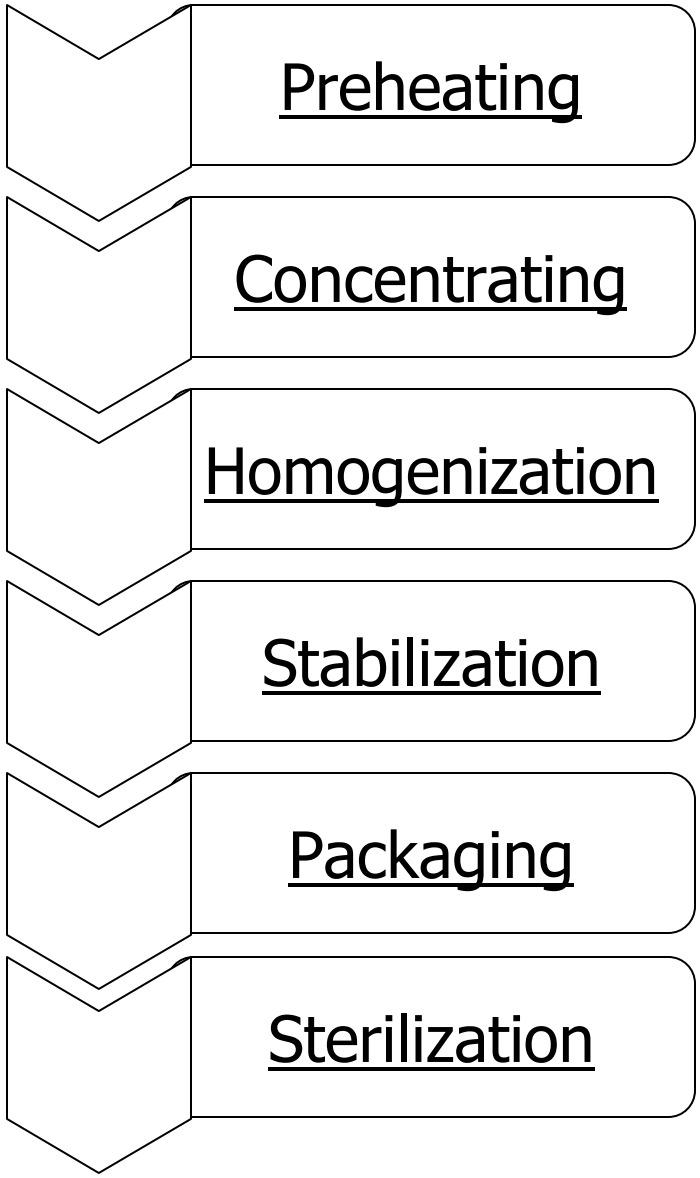
# Evaporated Milk

- Evaporated milk is sterilized, concentrated, homogenized milk.
- Evaporation is done until reach 22% solids-non-fat in the evaporated milk.
- The product can be kept without refrigeration and has a long shelf life.
- After dilution, flavor and nutritive value of the product are not greatly different from that of fresh milk.

# Evaporated Milk

- Manufacturing steps:



# Preheating

- Heating for 20 min at a temperature below 100$^{o}$C or using UHT treatment
- Inactivating enzymes
- Killing microorganisms (including bacterial spores)
- Enhancing the heat stability of evaporated milk

# Concentrating

- Using evaporation/ reverse osmosis (rarely done).
- Dry matter content must be standardized → based on mass density or refractive index determination.
- A higher concentration of dry matter content will lead to a lower yield and a poorer heat stability.

# Homogenization

- To prevent creaming and coalescence.
- It should not be too intensive because the heat stability becomes to low.

# Stabilization

- To ensure that evaporated, homogenized milk does not coagulated during sterilization.
- To acquire a desirable viscosity.
- Using a stabilizing salt (such as $Na_2HPO_4$).
- The addition of salt means adjusting the pH of evaporated milk, due to the lessen pH to 6.1 – 6.2 after preheating and evaporation steps.

# Stabilization

- The stabilizing salt is added as an aqueous solution, which dilutes evaporated milk slightly → need to re-standardize to the correct dry-matter content during stabilization.

# Packaging

- The common packaging used for evaporated milk is can.

  Can → tin plate of the cans is coated (provided with a protective layer of a suitable polymer) to prevent iron and tin from dissolving into the product.
- Evaporated milk intended for use in coffee is usually packaged in bottle.

# Sterilization

- To kill all bacteria spores.
- To inactivate plasmin.
- At 121$^{o}$C for 4 -7 minutes (D value of the spores)
- The most heat-resistant spores are those from *Bacillus stearothermophilus*.
- If the sterilizing effect is adequate to *B. stearothermophilus, then B. subtilis, C. botulinum* and *C. perfringens* are also absent.

# Sterilization

- UHT sterilization kills bacterial spores more effectively than in-bottle sterilization.
- The combination of preheating & UHT treatment of the milk concentrate suffices to inactivate plasmin.
- Lipases & proteinases from psycothrophs should be absent from raw milk because these enzymes would be insufficiently inactivated during sterilization.

# Recombined Evaporated Milk

- Recombination: the addition of skim milk powder in order to comply with strict requirements.
- The powder must have been made from skim milk that is heated intensely (130$^{o}$C for 1 min) → resulting heat stable recombined concentrated milk

# Product Properties

- Flavor & color
  - Ongoing Maillard reactions occur during storage, esp. at high temperature → resulting the development of a stale flavor.
- Viscosity
  - Many consumers prefer the milk to be viscous.
  - Desirable viscosity can be achieved by sterilization in such a way that visible heat coagulation is barely prevented.

# Product Properties

- UHT evaporated milk is always less viscous → k-carrageenan is often added
- If the original milk contains bacterial lipases & proteinases, these enzymes will remain inactive and lead to deterioration (soapy-rancid & bitter flavor, more/less transparent)

■ Nutritional value

- Sterilization step can destroy up to 10% lysine; half of vitamins $B_1$, $B_{12}$, and C; smaller proportions of vitamin $B_6$ and folic acid.

# Heat Stability

- Concentrated milk is far less stable during sterilization.
- Evaporated milk should increase in viscosity during sterilization by incipient coagulation → the process should be optimized in order to prevent the low heat stability.
- HS is related to heat coagulation of milk → the formation of gel during sterilization due to high concentration of serum proteins in milk.

# Heat Stability

- Preheating (for example 3 min at 120$^{o}$C) must be done before evaporation in order to denature serum proteins.
- Heat stability of evaporated milk also can be improved by:
  - Lowering the calcium content of milk before evaporation using ion exchange method
  - The addition of 0.05% $H_2O_2$ or 15mol $Cu^{2+}$ after preheating but before evaporation.

# Sweetened Condensed Milk

- Milk that is concentrated by evaporation, to which sucrose is added to form an almost saturated sugar solution.
- The high sugar concentration is primarily responsible for the keeping quality of the product and for its fairly long shelf life.

# Composition of SCM

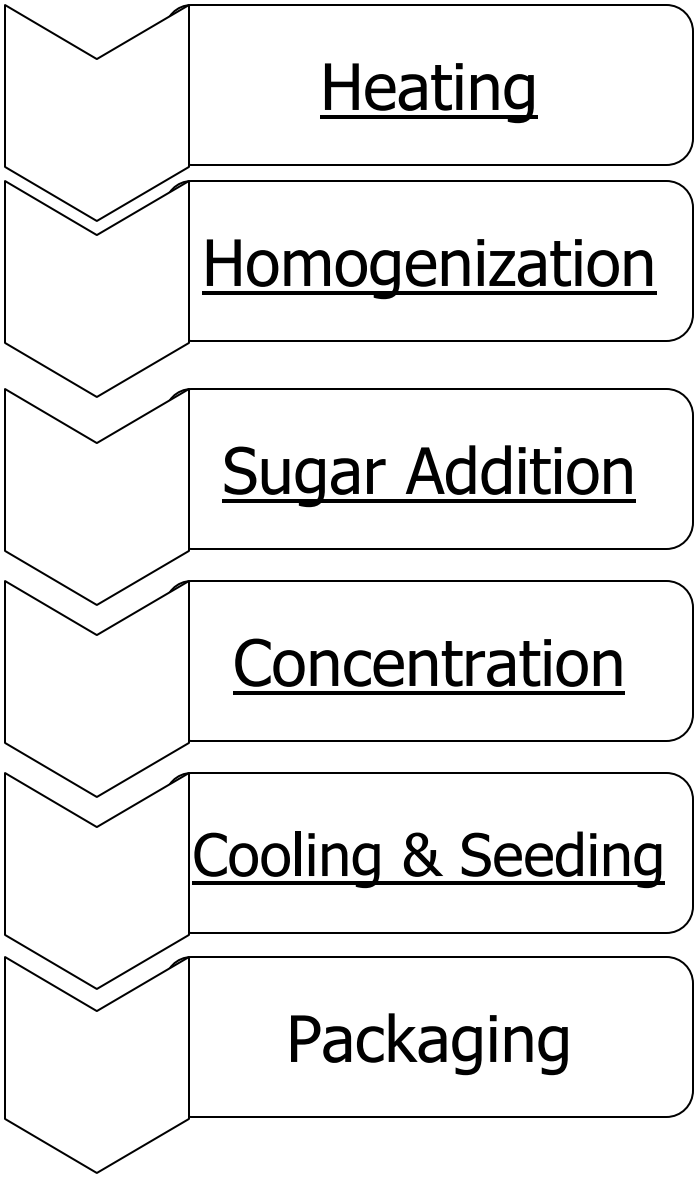
**Approximate Compositions of Two Kinds of Sweetened Condensed Milk**

| | American Standard | British Standard |
|---|---|---|
| Fat content (%) | 8 | 9 |
| Milk solids-not-fat (%) | 20 | 22 |
| Lactose (%) | 10.3 | 11.4 |
| Sucrose (%) | 45 | 43.5 |
| Water (%) | 27 | 25.5 |
| Lactose/100 g water (g) | 38.3 | 44.6 |
| Sucrose/100 g water (g) | 167 | 171 |
| Concentration factor $Q$ | 4.60 | 5.00 |

Walstra et al. (2006)

# SCM

- Manufacturing steps:



# Heating

- Killing pathogens and potential spoilage microorganisms
- Inactivate milk lipase, but not bacterial lipases.
- UHT heating at about 130 – 140$^{o}$C is commonly applied.

# Homogenization

- Creaming is often not a major problem, and therefore homogenization is not always done.

# Sugar addition

- Sugar can be simply added to the original milk & the sugar is pasteurized along with the milk → may cause extensive Maillard reactions during heating & evaporation.
- Alternatively, a concentrated sugar solution is added at the end of the evaporation step → the sugar solution must be sufficiently heat-treated to kill any osmophilic yeasts.

# Concentration

- It is done by evaporation at high temperature (up to 80$^{o}$C) → resulting a lower viscosity during heating but a higher viscosity of the final cooled product.
- The low water content of SCM implies a high viscosity and boiling point.

# Cooling & Seeding

- After evaporation, SCM must be cooled to a temperature at which lactose is supersaturated, but the temperature must not so low.
- During cooling, formation of large lactose crystals must be avoided → by the addition of seed lactose.
- After seeding, cooling should be continued to crystallize the lactose.

# Cooling & Seeding

- Cooling is the most critical & important stage in the whole process.
- The water in the SCM can only hold ½ the quantity of lactose in solution. The remaining half will therefore be precipitated in the forms of crystals
- Controlling the crystallization of lactose is required so desirable size of lactose crystals could be achieved.

# Cooling & Seeding

- The required crystallization is accomplished by cooling the SCM rapidly under vigorous agitation, without air being entrapped.

# Keeping Quality of SCM

- Microbial Spoilage
  - SCM is not sterile. It may contain living microbes & spores.
  - The low aw (about 0.83) & high sugar content prohibits growth of most but not all microbes.
  - Deterioration usually occurs by osmophilic yeasts, genus *Torulopsis* → gas formation (bulging cans), a fruity flavor, & coagulation of protein (due to ethanol production).

# Keeping Quality of SCM

- Microbial Spoilage
  - Some micrococci may grow in SCM, especially if aw & temperature are high → resulting coagulation of protein & the development of off-flavor.
  - The growth of micrococci requires the presence of oxygen.
  - Some mold, such as *Aspergillus repens* & *A. glaucus* can grow as long as oxygen is present → formation of colored lumps & the development of off-flavors.

# Keeping Quality of SCM

- Chemical changes
  - Age thickening & gelation can occur during storage, which can be affected by:
    - Type of milk → variation among batches of milk
    - Preheating of milk → the more intense the heat treatment, the higher the initial viscosity, the sooner a gel can form
    - Stage at which sugar is added → the later in the evaporating process, the less the age thickening

# Keeping Quality of SCM

- Concentration factor (Q) → the higher Q, the more age thickening
- Stabilizing salts → adding a small amount of sodium tetrapolyphosphate (0.03%) mostly delays age thickening considerably, whereas adding more may have the opposite effect
- Storage temperature → age thickening considerably increases with storage temperature

# Lactose Crystals

- SCM contains around 38 – 45 g lactose per 100 g water.
- The solubility of lactose is lower in SCM
- 75% of the lactose tends to crystallize → the high viscosity leads to the formation of large lactose crystals → sandy mouthfeel
- Preventing crystallization is not possible, thus a large number of crystals should be obtained → adding seed lactose (0.03%)