CONCENTRATED MILK

Dairy Processing Technology
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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
  - Concentrating
  - Homogenization
  - Stabilization
  - Packaging
  - Sterilization
Preheating

- Heating for 20 min at a temperature below 100°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 too low.
Stabilization

- To ensure that evaporated, homogenized milk does not coagulated during sterilization.
- To acquire a desirable viscosity.
- Using a stabilizing salt (such as $\text{Na}_2\text{HPO}_4$).
- 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°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 psychrotrophs 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°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 B₁, B₁₂, and C; smaller proportions of vitamin B₆ 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°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$_2$O$_2$ 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

<table>
<thead>
<tr>
<th></th>
<th>American Standard</th>
<th>British Standard</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fat content (%)</td>
<td>8</td>
<td>9</td>
</tr>
<tr>
<td>Milk solids-not-fat (%)</td>
<td>20</td>
<td>22</td>
</tr>
<tr>
<td>Lactose (%)</td>
<td>10.3</td>
<td>11.4</td>
</tr>
<tr>
<td>Sucrose (%)</td>
<td>45</td>
<td>43.5</td>
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<tr>
<td>Water (%)</td>
<td>27</td>
<td>25.5</td>
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<tr>
<td>Lactose/100 g water (g)</td>
<td>38.3</td>
<td>44.6</td>
</tr>
<tr>
<td>Sucrose/100 g water (g)</td>
<td>167</td>
<td>171</td>
</tr>
<tr>
<td>Concentration factor Q</td>
<td>4.60</td>
<td>5.00</td>
</tr>
</tbody>
</table>

Walstra et al. (2006)
SCM

- Manufacturing steps:
  - Heating
  - Homogenization
  - Sugar Addition
  - Concentration
  - Cooling & Seeding
  - Packaging
Heating

- Killing pathogens and potential spoilage microorganisms
- Inactivate milk lipase, but not bacterial lipases.
- UHT heating at about 130 – 140°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°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 be too 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 $\frac{1}{2}$ 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%)