INTRODUCTION

- Cream products have various fat content, i.e. 10% - 48% (double cream).
- The importance of cream products: excellent flavor → luxurious products, however the biggest concern is related to the development of off-flavor.
- Thus, the milk should be impeccable with regard to lipolysis and fat oxidation.
Regulations in several countries with regard to lipid content in cream

<table>
<thead>
<tr>
<th>Country</th>
<th>Cream type</th>
<th>Lipid content (g 100 g⁻¹)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Australia and New Zealand</td>
<td>Cream</td>
<td>18–40</td>
</tr>
<tr>
<td>France</td>
<td>Light cream</td>
<td>12–30</td>
</tr>
<tr>
<td></td>
<td>Cream</td>
<td>30–40</td>
</tr>
<tr>
<td>Germany</td>
<td>Coffee cream</td>
<td>10–30</td>
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<tr>
<td></td>
<td>Whipping cream</td>
<td>30–40</td>
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<tr>
<td>United Kingdom</td>
<td>Half cream</td>
<td>12–18</td>
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<tr>
<td></td>
<td>Single cream</td>
<td>18–35</td>
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<tr>
<td></td>
<td>Whipping cream</td>
<td>35–48</td>
</tr>
<tr>
<td></td>
<td>Double cream</td>
<td>48–55</td>
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<tr>
<td>United States</td>
<td>Half and half cream</td>
<td>10–18</td>
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<tr>
<td></td>
<td>Light cream</td>
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<tr>
<td></td>
<td>Light whipping cream</td>
<td>30–36</td>
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<tr>
<td></td>
<td>Heavy cream</td>
<td>36–45</td>
</tr>
</tbody>
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Data collated from Hoffmann (2002b).
TYPE OF CREAM PRODUCTS

- Sterilized cream (e.g. coffee cream, dessert cream)
- Sour cream (cultured & fermented cream)
- Whipping cream
- Ice cream
- Cream liqueur
1. Sterilized Cream

- This cream has about 20% fat.
- The cream is usually sterilized to guarantee microbial stability.
- Chemical stability is generally not a problem because intense heat treatment will prevent oxidative deterioration and lipolysis.
- Creaming, fat clumping, age thickening, gel formation, lumpy may occur during storage requires homogenization.
Basic Cream Processing

- The basic technology for the preparation of cream products, including:
  - separation of the cream phase from the milk
  - standardization the cream to the desired fat content and heating the cream to increase its shelf-life
  - Homogenization in order to improve product properties or to increase the physical shelf-life of the product
The manufacture of sterilized cream

Milk → Pasteurize phosphatase negative → Centrifuge 40–50°C → Cream

Skim milk → Standardize 20% fat, pH

Homogenize 11 + 3 MPa → Heating 70–75°C → Bottle filling

Sterilize 20 min 115°C → Cool to 25°C

Bottles, crown corks

Coffee cream

Walstra (2006)
The manufacture of sterilized cream

Milk → Pasteurize phosphatase negative → Centrifuge 40–50°C → Cream

Cool to 50°C → UHT treatment 10 s 140°C → Aseptically homogenize 10 MPa → Aseptic packaging → Cool to 10°C → Stabilizing salt

Skim milk → Standardize 20% fat, pH

Packaging material

Coffee cream Walstra (2006)
Heat Treatment

- Inactivating spoilage and pathogenic microorganisms, as well as enzymes.
- The higher fat content of cream → more severe heat treatment required.
- HTST pasteurization of cream, heating at 75°C for 15 s for cream containing <20 g fat/100 g or to >80°C for 15 s for cream containing >20 g fat/100 g is recommended by the International Dairy Federation.
- Pasteurization can not inactivate spore-forming thermoduric bacteria such as *Bacillus* spp.
Heat Stability

- It is hard to avoid coagulation during sterilization while at the same time the product is sufficiently homogenized to prevent rapid creaming of fat globules.
- Homogenization is responsible for the poor stability to heat coagulation as the surface area of fat globules covered with casein increases, the cream becomes less stable.
- The higher the homogenization pressure, the lower the heat stability. However, creaming will cause problems at lower homogenization pressures.
Quality of cream

- Viscosity is one of important factors in determining consumer acceptability of cream.
- Many factors may influence cream viscosity, including:
  - Raw milk composition (triacylglycerol content)
  - The processing (separation temperature, fat content, heat treatment, homogenization temperature)
  - Storage (duration and temperature)
Quality of cream

• Formation of homogenization clusters can improve cream viscosity, due to the effective volume fraction of the fat globules increase (because the plasma entrapped between the fat globules).
Quality of cream

- Cream must have an excellent flavor.
- Since cream contain high amount of fat, it is very susceptible to off-flavor formation.
2. Whipping Cream

- Containing 35% fat.
- Whipped cream is valued by consumers for its taste and texture.
- It is primarily designed to be beaten into a stiff-foamed product, often with sugar added.
- It is widely applied in desserts and cakes.
Important Properties of Whipped Cream

- **Flavor**
  - The flavor must be perfect.
  - Rancid and tallowy flavors in the original milk should be avoided.

- **Whippability**
  - In a few minutes the cream should easily whip up to form a firm and homogenous product, containing 50-60% (v/v) of air, corresponding to 100-150% overrun. Overrun: the percentage increase in volume due to gas inclusion.
Important Properties of Whipped Cream

- Stability after whipping
  - The whipped cream should be firm enough to retain its shape, remain stable during deformation, not coarsening of air cells, and show negligible leakage of liquid.

- Keeping quality
  - The original milk should contain not more than a few heat resistant bacteria (*Bacillus cereus* is a disastrous microorganism in whipping cream, since it influences the stability of fat emulsion).
Important Properties of Whipped Cream

- The growth of psychotrophs should not occur in the original milk because they form heat-resistant lipases.
- The pasteurized cream should be packaged under strictly hygienic or aseptic conditions.
- Contamination of copper causes autoxidation and hence off-flavor.
- Some coalescence of the fat globules during processing can readily lead to cream plug formation during storage.
Whipping Cream Manufacture

- The pasteurization of the cream should at least be sufficient to inactivate milk lipase.
- The heat treatment is far more intense in order to improve the bacterial keeping quality, and to form antioxidants ($H_2S$) e.g. pasteurization at $85^\circ C$ for 30 minutes.
Whipping Cream Manufacture

- The cream should be handled gently to avoid the occurrence partial coalescence of fat globules.
- To be readily whippable, the cream needs first to be kept refrigerated for a day in order to ensure that all fat globules contain some solid fat.
- To prevent creaming during storage, a thickening agent is generally added (say, 0.01% -carrageenan).
Whipping Cream Manufacture

- UHT whipped cream
  - The cream can be sterilized by UHT heating followed by aseptic packaging.
  - To keep the cream stable during processing and storage, it has to be homogenized → tends to impair whippability.
- Aerosol whipped cream
  - Cream is packaged in an aerosol can in an $N_2O$ atmosphere under a pressure (8 bar).
  - Upon pressure release, the cream leaves the can through a nozzle that causes it to be instantly converted into a foam.
Whipping Process

1. Air is beaten into the cream → formation of a coarse foam, which contains air bubbles with an average diameter 150 µm.
2. The air bubbles in the foamed cream rapidly become covered by milk proteins, which stabilize them against collapse.
3. A large proportion of the protein absorbed on the bubble surface is formed by the surface-active β-casein.
Whipping Process

4. On further whipping, air bubble size is reduced approximately three-fold, and milk lipid globules displace some of the proteins from the bubble interface creating an air–lipid interface.

5. Prolonged whipping leads to stiffening of the cream, as a result of the creation of a network of partially coalesced lipid globules.

6. Partial coalescence may be induced as a result of mechanical damage to the milk lipid globules during whipping or the collapse of air bubbles in the foam.
Whipping Process

7. The resulting decrease in bubble surface area pushes the adsorbed globules closer to each other, and the liquid fat on the air–water interface can act as a sticking agent.
8. Eventually, fairly large clumps are formed.
Characterization of whipped cream

- **Overrun**
  A measure of the amount of air incorporated into the whipped cream and can be calculated from the density of the cream before and after whipping.

- **The stiffness of the whipped cream**
  A measure of the degree of textural development in the product by texture analysis.

- **The whipping time**
  The time required to reach a set end point in the whipping process.
3. Ice Cream

- There are numerous types of edible ice, essentially mixtures of water, sugar, flavor substances, and other components, which are partly frozen and beaten to form a rigid foam.
- In most types, milk or cream is an important ingredient.
- In some countries, the milk fat is often substituted by vegetable fat.
The additives are: emulsifier, stabilizer (thickening agent, usually polysaccharides), flavor, and colorants.
Types of ice cream

- Soft ice cream
  - Soft ice is eaten while fresh. It is made on the spot, its temperature is usually $-3$ to $-5$ °C, and, therefore, it still contains a fairly large amount of non-frozen water, and the overrun are rather low.
  - Soft ice cream often causes microbiological problems, though it is kept cold and its high sugar content.
  - Large numbers of enterobacteria (\textit{E. coli}, \textit{Salmonella} spp.) are frequently found, due to poorly cleaned processing equipment and in the mix, if stored for too long $\rightarrow$ requires strict hygienic application
Types of ice cream

- Ordinary ice cream
  It has a lower temperature than that of soft ice cream (−10 to −15 °C), but is not so cold as to be entirely solid; it is stored for a few weeks at the most in cans, from which portions can be ladled out.

- Hardened ice cream
  The ice cream, usually packaged in small portions and sometimes supplied with an external chocolate coating, is much lower in temperature (−25 °C) and has a shelf life of several months.
Basic Ice Cream Manufacture

Liquid Ingredients → Blending → Batch Pasteurization → Homogenization → Cooling

Dry Ingredients → Blending → Continuous Pasteurization/Homogenization/Cooling

Liquid Ingredients → Batch Pasteurization → Homogenization → Cooling

Dry Ingredients → Batch Pasteurization → Homogenization → Cooling

Continuous Pasteurization/Homogenization/Cooling → Continuous Freezing → Ageing

Continuous Freezing → Batch Freezing/Whipping

Batch Freezing/Whipping → Hardening

Storage/Distribution → Packaging

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Ice Cream Manufacture

- **Blending**
  - First, the ingredients are selected based on the desired formulation, then the ingredients are weighed and blended together to produce what is known as the "ice cream mix".
  - Blending requires rapid agitation to incorporate powders, and often high speed blenders are used.
Ice Cream Manufacture

- Pasteurization
  - To kill pathogenic and spoilage microorganisms. Additives added after homogenization should usually be pasteurized separately.
  - To inactivate lipase and bacterial lipases.
  - Quite intense heating of the mix is desirable (especially for hardened ice cream) to decrease its susceptibility to autoxidation; a cooked flavor may be undesirable, according to the added flavor substances.
Ice Cream Manufacture

- Homogenization
  - Giving the ice cream a sufficiently fine, smooth texture due to the reduction of fat globules
  - Giving a greater apparent richness and palatability
  - Giving better air stability
  - Increasing resistance to melting
  - Homogenization of the mix should take place at the pasteurizing temperature. The high temperature produces more efficient breaking up of the fat globules at any given pressure and also reduces fat clumping and the tendency to thick, heavy bodied mixes.
Ice Cream Manufacture

- Ageing/ ripening
  - Keeping the mix at least 4 hours and usually overnight.
  - Improving whipping qualities of mix, and body & texture of ice cream.
  - Providing time for fat crystallization, so the fat can partially coalescence.
  - Allowing time for full protein and stabilizer hydration and a resulting slight viscosity increase.
  - Allowing time for membrane rearrangement and protein/emulsifier interaction, as emulsifiers displace proteins from the fat globule surface.
Ice Cream Manufacture

- Freezing
  - Freezing implies rapid cooling of the mix to a few degrees below zero; in this way, ice is formed while air is beaten in.
  - Beating must run simultaneously, since once the bulk of the water is frozen, any beating in of air becomes impossible, and can damage the foam structure.
  - The vigorous beating enables rapid cooling, because of which small ice crystals can be formed.
  - As the ice cream is drawn with about half of its water frozen, particulate matter such as fruits, nuts, candy, cookies, or others, is added to the semi-frozen slurry which has a consistency similar to soft-serve ice cream.
Ice Cream Manufacture

- **Hardening**
  - The *hardening* process serves to rapidly adjust the temperature of the ice cream to such a level as to retain its shape and to give it a sufficient shelf life with respect to chemical and enzymatic reactions, as well as to the physical structure.
  - The packaged ice cream can be passed through a so-called hardening tunnel, in which very cold air (−40 °C) is blown past the small packages for some 20 min.
  - Likewise, packaged ice cream can be passed through a brine bath of low temperature.
The structure of ice cream (-5°C)
Role of various components

- Fat
  - Giving specific flavor.
  - Forming a solid structure during freezing → influence consistency, appearance & melting resistance.
  - A high fat content leads to a dry, almost grainy texture, a low fat content to a smooth, homogeneous, somewhat slimy texture.
- MSNF
  - Contribute to flavor.
  - They are also responsible for part of the freezing-point depression and for an increased viscosity.
Role of various components

- The protein partly serves to stabilize the foam lamellae during air incorporation; it is essential for the formation of fat-globule membranes during homogenization.
- Lactose can crystallize at low temperature. The crystals formed should be small in order to prevent sandiness.

Sugar
- Sucrose, is essential for the taste and for the freezing-point depression.
- Too little sugar may cause too much ice to be formed; too much sugar often makes the ice cream overly sweet.
Role of various components

- Part of the sucrose may be replaced by a substitute such as glucose syrup, which is less sweet and leads to a greater freezing-point depression per kg sugar.
- Sugar also causes a higher viscosity and it causes far less water to freeze → the consistency of the ice cream is softer and its mouthfeel less cold.

- Stabilizers
  - Gelatin, alginate, carrageenan, pectin, locust bean gum, guar gum, xanthan, CMC, and mixtures are used as stabilizers/thickening agents in ice cream.
Role of various components

- These substances affect the consistency of ice cream. However, it also may cause the consistency of product to become slimy in the mouth.

- **Emulsifiers**
  - It serves to stimulate the fat globules to clump and to become attached to the air bubbles.
  - The emulsifiers used include egg yolk, monoglycerides, poly(oxyethylene) sorbitan esters (Tweens), and esters from citric acid and monoglycerides.