DETERMINATION OF PERCENTAGE COMPOSITION OF ICE CREAM

The percentage composition of ice cream should be determined primarily by taking the following factors into account:

- Legal requirements with regard to fat content, solid content, etc.
- Consumer preferences with regard to sweetness, creaminess, etc.
- The ratio between quality and economy, particularly with regard to the competition
- Other conditions, e.g. availability of raw materials, machinery, etc.

This technical memorandum concentrates solely on the quality of the finished ice cream.

SUGARS

Sugar and sweeteners are added to lower the freezing point of the mix and provide a sweet taste that enhances flavour. They are also used as bulking agents, raising the total solids content and adding more body to the ice cream.

Freezing point depression factor (FPDF)

The depressive effect on freezing point produced by a sugar or another sweetening or bulking agent, compared with sucrose, is described as the freezing point depression factor (FPDF). Sucrose has a FPDF value of 1.

The freezing point of an ice cream mix is initially dependent on the amount of solids dissolved. The more solids dissolved, the lower the freezing point.

The use of sugars causes the freezing point to drop. Since the number of molecules per gram of sugar depends on the sugar’s molecular weight, sugars with a low molecular weight lower the freezing point more per gram than sugars with a high molecular weight.

Milk solids non fat (msnf) also lower the freezing point. To make it easier to calculate the FPDF of a mix, we regard the amount and composition of the milk solids as being constant. This means we consider its freezing point depression to be constant. In this way, we can eliminate milk solids when calculating the FPDF.

To calculate the FPDF for a recipe, multiply the FPDF with the amount (in %) of each single sugar and summarise for all the sugars.

Sweetness

The use of different sugars results in different levels of sweetness, which is important to consider when calculating their effect in an ice cream mix.

As with the FPDF, sucrose has been chosen as the reference for relative sweetness (Rel S) and has a Rel S of 1.

Rel S and FPDF for the most common sweeteners used in ice cream are listed in table 1.

When calculating the composition of sugars in an ice cream mix, it is important to consider both Rel S and FPDF. The Rel S is based on consumer preferences and the FPDF on the type of ice cream. A scoopable ice cream should be softer than a stick novelty, and thus needs a higher FPDF. A FPDF of 14-20 will produce a relatively hard and non-scoopable ice cream, suitable for stick novelties and extruded products. For scoopable ice cream, a FPDF of 20-25 is recommended.

To calculate the Rel S of a recipe, multiply the Rel S with the amount (in %) of each single sugar and summarise for all the sugars.

Two examples of altering the FPDF of an ice cream mix without altering the level of sweetness are shown in example 1.

Recipe 1 produces a hard ice cream suitable for sticks or extruded products. If the ice cream is intended to be scoopable, the FPDF can be raised by varying the sugar composition. If the taste of the ice cream should remain the same, the Rel S should not be changed. Recipes 1a and 1b show how the FPDF can be raised without changing the Rel S or TS content considerably. In recipe 1a, dextrose is used instead of glucose syrup, and in recipe 1b sorbitol is added instead of glucose syrup solids to lower the freezing point.

<table>
<thead>
<tr>
<th>AVERAGE MOLECULE WEIGHT</th>
<th>FPDF</th>
<th>REL S</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sucrose</td>
<td>342</td>
<td>1.0</td>
</tr>
<tr>
<td>Glucose syrup 42 DE</td>
<td>445</td>
<td>0.8</td>
</tr>
<tr>
<td>HFCS (42% fructose)</td>
<td>190</td>
<td>1.8</td>
</tr>
<tr>
<td>Dextrose</td>
<td>180</td>
<td>1.9</td>
</tr>
<tr>
<td>Fructose</td>
<td>180</td>
<td>1.9</td>
</tr>
<tr>
<td>Invert sugar</td>
<td>180</td>
<td>1.9</td>
</tr>
<tr>
<td>Lactose</td>
<td>342</td>
<td>1.0</td>
</tr>
<tr>
<td>Galactose</td>
<td>180</td>
<td>1.9</td>
</tr>
<tr>
<td>Sorbitol</td>
<td>182</td>
<td>1.9</td>
</tr>
<tr>
<td>Glycerol</td>
<td>92</td>
<td>3.7</td>
</tr>
<tr>
<td>Ethanol</td>
<td>46</td>
<td>7.4</td>
</tr>
<tr>
<td>Litesse®</td>
<td>570</td>
<td>0.3</td>
</tr>
<tr>
<td>Lactitol</td>
<td>362</td>
<td>1.0</td>
</tr>
</tbody>
</table>

Table 1. Freezing point depression factor and relative sweetness of the sweeteners most commonly used in ice cream.
MILK SOLIDS NON FAT (MSNF)

The msnf factor is defined as a number of parts msnf per 100 parts of water. The factor is calculated according to the following equation:

\[
\text{Empirical trials have shown that the optimum msnf factor is 17. A factor that is too high gives an emulsion that is over stable due to the emulsifying properties of the proteins and phospholipids in the milk. This can cause problems with insufficient fat agglomeration in the freezer. The lactose content also limits the amount of msnf due to lactose crystallisation.}
\]

\[
\text{Remember that:}
\begin{align*}
\text{• % water} &= 100 – \text{total solids} \\
\text{• total solids = other solids + msnf}
\end{align*}
\]

\[
\text{Thus:}
\begin{align*}
\text{% msnf} &= \frac{\text{msnf factor} \times 100}{\text{% water}} \\
\end{align*}
\]

\[
\text{Example 2 shows how to use the formula to optimise the content of milk solids in recipe 1.}
\]

Example 2: Optimising msnf

\[
\begin{align*}
\text{% msnf} &= \frac{7(100-10.0+12.0+3.0+0.7)}{117} = \frac{17 \times 74.3}{117} = 10.8\%
\end{align*}
\]

Since skimmed milk powder (SMP) contains 95% msnf, 11.37% skimmed milk powder should be used in the recipe. Recipe 2 is the same recipe with the optimum amount of skimmed milk powder:

\[
\begin{align*}
\text{RECIPE 2} \\
\text{Fat} &= 10.00\% \\
\text{Skimmed milk powder} &= 11.37\% \\
\text{Sucrose} &= 12.00\% \\
\text{Glucose syrup solids, 42 DE} &= 3.00\% \\
\text{Emulsifiers/stabilisers} &= 0.70\% \\
\text{Total solids} &= 37.07\%
\end{align*}
\]

CALCULATION OF MSNF

\[
\begin{align*}
\text{SMP} &= 11.37 \times 95/100 = 10.80\% \\
\text{Total msnf} &= 10.80\% \\
\end{align*}
\]

LACTOSE

The optimum msnf factor of 17 is based on the use of skimmed milk powder to raise the recipe’s total solids content. The msnf factor does not, however, say anything about the lactose content. Lactose has a limited solubility in water so too much can cause lactose crystallisation during storage, giving the ice cream a sandy, gritty texture.

As long as fresh milk or skimmed milk powder are used as a source of msnf, the lactose content will not cause any trouble. For economic reasons, some SMP is commonly replaced by various alternatives, mostly whey products. Most whey products contain a high amount of lactose, making it necessary to calculate the lactose content to avoid sandy ice cream.

The total amount of lactose should not exceed 10% of the total water content. This limits the amount of SMP that can be replaced. Example 3 shows how to replace SMP with traditional whey powder without running the risk of lactose crystallisation during storage.

Example 3: Calculating lactose content

In recipe 2, the aim is to replace as much SMP as possible with whey powder to obtain a less expensive mix, but without running the risk of obtaining a sandy ice cream.

Standard sweet whey powder contains 79% lactose while SMP contains 50.5%. (Note that the lactose content differs for different whey products).

Since the mix contains 37.07% TS, the amount of water will be 62.93%.

10% of 62.93% = 6.29%

\[
\begin{align*}
\text{I} &= x + y = 11.37 \\
\text{II} &= 0.505x + 0.790y = 6.29 \\
\end{align*}
\]

where \( x = \% \text{ skimmed milk powder} \)

\( y = \% \text{ whey powder} \)

This means

\[
\begin{align*}
\text{x} &= 9.45 \\
\text{y} &= 1.92
\end{align*}
\]

Thus, the maximum amount of skimmed milk powder that can be replaced by whey powder is 1.92%.

Recipe 3 is based on recipes 1 and 2 but the SMP has been partly replaced with whey powder.
Different fat sources can be used in ice cream. Although the choice of source will not be discussed here, the following explains how to calculate the required levels of vegetable fat and milk fat. The emulsifier also contributes to fat content.

**Vegetable fat or butter**
Vegetable fat contains 100% fat. This makes it easy to calculate the amount to use – simply decide how much fat is required in the ice cream and add the same percentage.

**Milk fat**
There are several milk fat sources commercially available. When calculating, it is important to consider the fat content of the raw material and also remember that it contributes both msnf and lactose. In example 4, cream is used as the fat source for recipe 2.

**Example 4: Calculation of fat and msnf when using milk products as the fat source**

### RECIPE 3

<p>| | | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Fat</td>
<td>10.00%</td>
<td></td>
</tr>
<tr>
<td>Skimmed milk powder</td>
<td>9.45%</td>
<td></td>
</tr>
<tr>
<td>Whey powder</td>
<td>1.92%</td>
<td></td>
</tr>
<tr>
<td>Sucrose</td>
<td>12.00%</td>
<td></td>
</tr>
<tr>
<td>Glucose syrup, 42DE</td>
<td>3.00%</td>
<td></td>
</tr>
<tr>
<td>Emulsifiers/stabilisers</td>
<td>0.70%</td>
<td></td>
</tr>
<tr>
<td>Total solids</td>
<td>37.07%</td>
<td></td>
</tr>
</tbody>
</table>

#### THE RAW MATERIALS AVAILABLE ARE:

- **Cream**: 35% fat
- **Skimmed milk**: 9.45% msnf
- **Whey powder**: 1.92%
- **Sucrose**: 12.00%
- **Glucose syrup, 42DE**: 3.00%
- **Emulsifiers/stabilisers**: 0.70%

**The fat contribution from skimmed milk and SMP is so small that it is not necessary to consider it. Instead, calculate the fat contribution from the cream alone.**

### Example 4: Calculation of fat and msnf when using milk products as the fat source

#### Calculation of the Lactose Content:

- **SMP**: 9.45 \times 50.5/100 = 4.77%
- **Whey powder**: 1.92 \times 79/100 = 4.52%
- **Total lactose**: 6.29%

#### Fat

**Different fat sources can be used in ice cream. Although the choice of source will not be discussed here, the following explains how to calculate the required levels of vegetable fat and milk fat. The emulsifier also contributes to fat content.**

**Vegetable fat or butter**
Vegetable fat contains 100% fat. This makes it easy to calculate the amount to use – simply decide how much fat is required in the ice cream and add the same percentage.

**Milk fat**
There are several milk fat sources commercially available. When calculating, it is important to consider the fat content of the raw material and also remember that it contributes both msnf and lactose. In example 4, cream is used as the fat source for recipe 2.

Example 4: Calculation of fat and msnf when using milk products as the fat source

<p>| | | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Fat</td>
<td>10.00%</td>
<td></td>
</tr>
<tr>
<td>Msnf</td>
<td>10.80%</td>
<td></td>
</tr>
<tr>
<td>Sucrose</td>
<td>12.00%</td>
<td></td>
</tr>
<tr>
<td>Glucose syrup, 42DE</td>
<td>3.00%</td>
<td></td>
</tr>
<tr>
<td>Emulsifiers/stabilisers</td>
<td>0.70%</td>
<td></td>
</tr>
</tbody>
</table>

**The final recipe is as follows:**

### RECIPE 4

<p>| | | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Cream</td>
<td>28.57%</td>
<td></td>
</tr>
<tr>
<td>Skimmed milk</td>
<td>50.95%</td>
<td></td>
</tr>
<tr>
<td>Skimmed milk powder</td>
<td>4.78%</td>
<td></td>
</tr>
<tr>
<td>Sucrose</td>
<td>12.00%</td>
<td></td>
</tr>
<tr>
<td>Glucose syrup solids, 42 DE</td>
<td>3.00%</td>
<td></td>
</tr>
<tr>
<td>Emulsifiers/stabilisers</td>
<td>0.70%</td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>100.00%</td>
<td></td>
</tr>
</tbody>
</table>

#### Calculation of the Total Solids:

- **Cream**: 28.57 \times 40.85/100 = 11.67%
- **Skimmed milk**: 50.95 \times 9.1/100 = 4.64%
- **Skimmed milk powder**: 4.78 \times 95/100 = 4.59%
- **Sucrose**: 12.00%
- **Glucose syrup solids, 42 DE**: 3.00%
- **Emulsifiers/stabilisers**: 0.70%
- **Total solids**: 36.60%

#### Calculation of the Fat Content:

- **Cream**: 28.57 \times 5.85/100 = 10.00%
- **Total fat**: 10.00%

#### Calculation of the Msnf Content:

- **Cream**: 28.57 \times 5.85/100 = 1.67%
- **Skimmed milk**: 50.95 \times 9/100 = 4.59%
- **Skimmed milk powder**: 4.78 \times 95/100 = 4.54%
- **Total msnf**: 10.80%

#### Calculation of Mix Size

When converting the recipe into normal mix size, the specific gravity of the mix should be considered. The specific gravity depends on the raw materials, although, for practical purposes, it can be set to 1.1 kg/litre. When calculating the mix, all amounts are calculated in kilos.

**Overrun**
Overrun is a very important parameter when it comes to cost per litre. It also has a great effect on the texture and mouthfeel of the ice cream. Overrun is defined as follows:

\[
\text{Overrun} = \frac{(\text{volume of ice cream} - \text{volume of mix}) \times 100}{\text{volume of mix}}
\]

or, in other words, the percentage of air in the ice cream based on the amount of original mix. This formula can be used to calculate the average overrun of an entire

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**FAT**

Different fat sources can be used in ice cream. Although the choice of source will not be discussed here, the following explains how to calculate the required levels of vegetable fat and milk fat. The emulsifier also contributes to fat content.
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The easiest and most accurate way of calculating the actual overrun is to use a modified formula based on weight instead of volume.

\[
\text{weight of mix} \times 100 \quad \text{weight of same volume of ice cream} - 100 \quad = \quad \% \text{ overrun}
\]

This formula can be used to show, among other things, that the following yields can be obtained from 100kg of the above-mentioned mix:

- approximately 182 litres of ice cream with 100% overrun
- approximately 191 litres of ice cream with 110% overrun

day’s production. However, the resulting figure reveals nothing about the actual overrun, since it is influenced by product loss and possible miscounting.