Overcoming the hurdles towards sustainable food production - Advanced measurement needs

Fredrik Innings
Tetra Pak
Lund University
Tetra Pak

We specialise in providing customers with complete solutions for the processing, packaging and distribution of food products.
Present in more than 170 countries and operations in all continents

- 80 sales offices
- 32 market companies
- 6 R&D units
- 11 Technical Training Centres
- 48 manufacturing sites

Employees: 24,000
Net sales billion €: 12
Total world deliveries 2015

Carton packaging material, billions of packs: 184

Processing units: 2,118

Packaging machines: 411

Distribution machines: 1,047
Well-proven processing systems
Total number of delivered processing units 2015: 2,118

- Dairy 46%
- Beverage 16%
- Ice Cream 7%
- Cheese and Whey 21%
- Prepared Food 6%
- Other powder 1%
- Cosmetics 3%
Our development focus has shifted over time

- **60’s**: Rationalization of production
- **70’s**: Rationalization of distribution
- **80’s**: Consumer in focus
- **90’s**: Environment in focus
- **2000’s**: Integrated solutions
- **2010**: Sustainability
Providing more sustainable business

Environment
- Energy efficiency
- Carbon footprint
- Water efficiency
- Effluents (COD)

Drivers
- Brand reputation
- Retailer demands
- Legal requirements

Energy
- Product cost
- Utility cost

Water

Waste

Drivers
- Production efficiency
- Operational cost

Economy
Ensure customer value from the very beginning

Technology Development should

Create a meaningful change in total cost of ownership of your production solutions.
Ensure product quality, food safety, and environmental performance.
Result in high-level innovation solutions from strong collaborations with customers, universities and industry partners.
Milk fouling on heat exchangers
UHT with Tubular heat exchanger
Fouling is a deposit formed when processing milk

- Good quality
- Sufficient shelf-life
- Deposit with a mix of protein and mineral
Different temperatures give different fouling

Low temperature fouling
~100°C

- Ca 20 wt-%
- PO₄ 25 wt-%
- Protein 40 wt-%

High temperature fouling
137°C

- Ca 20 wt-%
- PO₄ 45 wt-%
- Protein 10 wt-%
UHT fouling
High temperature milk fouling

<table>
<thead>
<tr>
<th>Ca</th>
<th>PO₄</th>
<th>Protein</th>
<th>Ca/P</th>
<th>Water content</th>
</tr>
</thead>
<tbody>
<tr>
<td>27± 2%</td>
<td>44± 3%</td>
<td>11± 1%</td>
<td>1.5</td>
<td>40-60%</td>
</tr>
</tbody>
</table>

- Close to metal surface
- Close to product flow

- Calcium
- Carbon

$\text{CaPO}_4$
High temperature milk fouling

<table>
<thead>
<tr>
<th></th>
<th>Ca</th>
<th>PO₄</th>
<th>Protein</th>
<th>Ca/P</th>
<th>Water content</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>27±2 %</td>
<td>44±3 %</td>
<td>11±1 %</td>
<td>1.5</td>
<td>40-60 %</td>
</tr>
</tbody>
</table>

![Graph showing Calcium and Carbon concentration changes](image)

- **Calcium**: Close to metal surface
- **Carbon**: Close to product flow
Short Acid Etching

A

1±0 %
23±5 %
26±4 %

500 μm

B

1±1 %
1±0 %
21±9 %

400 μm
Questions/Measurment needs

► What proteins build up the fouling?
  - We can only measure carbon content
► Is the fouling built up of 5µm spheres?
► Are the spheres only $\beta$-Ca$_3$(PO$_4$)$_2$?
► Is the protein network a result of rearrangement during time?
Induction Heating

Sealing packages at Tetra Pak
Making a composite material an efficient solution

High demand pushed on to our packages

Outside polyethylene: protection

Paperboard: stability and print

Laminate polyethylene: adhesion

Aluminium foil: oxygen, flavour and light barrier

Inside adhesive polyethylene: adhesion

Inside polyethylene: sealing, product contact
Aseptic sealings in Tetra Pak

- Transversal Sealing
- Longitudinal Sealings (LS and SA)
- PullTab
- Front Panel
Forming of the tube

The principle of Induction Heating

- Inductor coil (copper tube)
- Ferromagnetic material
- Pressure jaw
- Cutting jaw
- Transversal sealing TBA
- Packaging material (aluminium foil)
- Counter rubber

1. Inductor coil
2. Ferromagnetic material
3. Pressure jaw
4. Cutting jaw
5. Transversal sealing TBA
6. Packaging material (aluminium foil)
7. Counter rubber
Macro scale: SEM picture of a seal (Cross-section)

- Aluminium
- Polyethylene
- Paper
Questions/Measurement needs

► Does the food and the polyethylene interact?
  - Does the fat droplets in the food dissolve into the polyethylene?
► Does the food mix with the polyethylene or will it form regions?
Proteins on fat drops X2
Fat droplets (in milk)

1. Phospholipid
2. Protein
3. Glycoprotein
Improving product shelf-life for milk

Rising velocity is given by
\[ g \times \text{particle size}^2 \times (\text{dens. SM} - \text{dens. fat}) \]
\[ 18 \times \text{visc. milk} \]

- 3.2 micron
- 0.8 micron
- 0.2 micron
Process in the homogenizing device

Homogenized product

Unhomogenized product
Pressure up to 400 bar
Increase in surface area
Questions/Measurement needs

- What is the surface composition of homogenized milk?
- What is the density of the surface layer? (and the complete drop?)
- What changes when we change protein type? (Soy or oats)
- How fast does the proteins unfold and cover the surface?
Mayonnaise

- Oil in water emulsion
- Egg as emulsifier
- Semi-solid behaviour
Ingredients

Dispersed phase
► Oil
  - High volume fractions 65-80%

Emulsifier
► Egg yolk

Water phase
► Vinegar
  - pH 4
  - Charged proteins
► Mustard
► Salt
  - Screening of charges
► Sugar
Egg yolk

- **Granules**
  - HDL 70%
  - Phosvitin 16%
  - LDLg 12%

- **Plasma**
  - Livetins 15%
  - LDL 85%

---

**Lipoprotein**

- **a)**
  - phospholipids
  - proteins
  - triglycerides and cholesterol ester

- **b)**
  - air-water interface
    - Initial anchorage by a protein
    - Denaturation of the protein
    - Disruption of the LDL structure
  - diffusion
  - spreading
Impact of egg yolk type

- Liquid egg yolk (salted and pasteurized)
- Egg yolk powder (spray-dried)
- Heat stable egg yolk powder (enzymatically treated and spray dried)
- Peak in quality
- Egg adhesion properties destroyed by time
- Over-shear
Questions/Measurement needs

- How does the lipoproteins interact with the fat drops?
- How do they create adhesion between the drops?
- Do we break or agglomerate the lipoproteins during over-shear?
Sustainable production

Optimized processes

Mechanistic understanding

Measurement data

Sustainable production