Conjugated linoleic acid and milk processing

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Main Objectives of our Study

I. Composition
   I. Review comparing impact of food processing on CLA content of dairy products
   II. Product analysis of butter to show impact

II. Shelf Life
   I. Evaluation of methods (chemical, sensory, holistic)
      Determination of secondary products of lipid oxidation
   II. Shelf life analyses to identify differences in product stability of different butter samples by evaluated methods

III. Novel Processing Procedures
   I. Novel processing procedures to maintain or increase the CLA content in dairy products
Background of our Study

• Demand for foods with properties that promote human health is growing
  • Development of new dairy products with a nutritional-physiological functionality

• Recent studies indicate:
  Conjugated linoleic acids (CLA) may have positive effects on human health (naturally present in fat of ruminants)

• Aim of processing standards for organic foods:
  Preserving or enhancing specific bio-active or functional components of raw material
Conjugated linoleic acid (CLA)
Conjugated linoleic acid (CLA)

• CLA are found in food of animal origins, in the fat of ruminants (i.e. meat, milk)
  • Content of CLA is influenced by cow's ambient conditions (i.e. feed, breed, age, lactation period, altitude, seasonal influences)
  • CLA exhibit several important health-promoting attributes (animal studies)
Results:

Does food processing influence the CLA content of the end product?

Literature research findings:

Overview of current knowledge

- Normal processing procedures for dairy products such as fermentation steps, heat treatments, storage and ripening do not change the content of CLA or the CLA isomer profile.
Results:

Literature research findings:

Overview of current knowledge

• Organic dairy products show:
  • higher levels of CLA than standard products: Differences between 14% and 50%
  • higher contents of linolenic acid (+ ≈ 50%), trans-vaccenic acid (+ ≈ 50%), β-carotene (+76%) and α-tocopherol (+≈ 50%)
Results:

Own investigations:

- Butter making process (butter made from fermented cream of conventional and organic origin):
  - no significant influence on CLA content
- Significant differences in total CLA content between cream of organically produced milk and conventional milk

<table>
<thead>
<tr>
<th>No.</th>
<th>Origin</th>
<th>CLA cream g/100 g fat</th>
<th>CLA butter g/100 g fat</th>
<th>Difference butter-cream g/100 g fat</th>
</tr>
</thead>
<tbody>
<tr>
<td>∅</td>
<td>conventional</td>
<td>1.35&lt;sup&gt;a&lt;/sup&gt;&lt;sup&gt;x&lt;/sup&gt;</td>
<td>1.31&lt;sup&gt;c&lt;/sup&gt;&lt;sup&gt;x&lt;/sup&gt;</td>
<td>-0.04</td>
</tr>
<tr>
<td>∅</td>
<td>organic</td>
<td>1.54&lt;sup&gt;b&lt;/sup&gt;&lt;sup&gt;y&lt;/sup&gt;</td>
<td>1.48&lt;sup&gt;d&lt;/sup&gt;&lt;sup&gt;y&lt;/sup&gt;</td>
<td>-0.06</td>
</tr>
</tbody>
</table>

n = 7 (conventional)
n = 5 (organic)
a, b and c, d: different letters in columns mean significant differences (p < 0.005).
x,y: different letters in rows mean significant differences (p < 0.01)
Literature research findings:

Procedures to enrich CLA in dairy products

- **Production:**
  Increase of CLA content through diet of dairy cattle

- **Microbiological** processes:
  CLA production in culture media by selected strains
  [e.g. bifidobacteria, propionibacteria]

- **Chemical** processes (not suitable for low input processing)

- **Physical** separation processes
Results:

- Evaluation of physical separation process to increase CLA content: **dry fractionation process**
  - Acceptation by international organic farming groups
  - Permission of application of CLA-rich fractions in organic products
- Collaboration with industry and an university of applied sciences
- Highland butter as a suitable raw material (high CLA content)
CLA content of highland butter

Dependent on altitude and feed:
• Decrease of saturated fatty acids and increase of MUFA, PUFA, CLA and ratio of $\omega_3 : \omega_6$ FA

→ nutritional-physiological advantages

Higher CLA content is probably attributable to:
• grazing in natural pastures
• species-rich alpine meadows with secondary plant ingredients
• energy deficiencies and metabolism → mobilizing of body-fat

→ further investigation required
Fractionation

- **Definition**: Defined fractions can be extracted from the raw material fat by means of partial crystallisation at defined temperature intervals which indicate the melting point of the fraction.

- Process produces two different products:
  - High-melting fraction: **stearin** (clear melting point at 41-48°C)
  - Low-melting fraction: **olein** (clear melting point at 15-30°C)
Process for CLA enrichment

• Evaluation of suitable fractionation conditions
  • by changing time, temperature and multiple fractionation
    • temperature range between 32°C and 9.5°C
    • crystallisation times between one and 20 hours

• Aim:
  • Obtainment of a higher CLA content in a fraction
  • Optimal Separation of the two fractions
  • Commercially interesting yield of the CLA rich fraction

• Determination of CLA content/isomers of olein and stearin fraction in laboratory ALP
  • Comparison against raw material
Evaluated process

- Melt water-free butterfat at 75°C
- Fat slowly cooled down at room temperature to 24°C
- Fractionation: 20.0°C, 4 h
- Separation of crystal-liquid fat suspension (vacuum filtration)
  - Stearin fraction I (CLA-reduced)
  - Olein fraction I (CLA-enriched)
- Warm olein fraction I at 75°C
- Fat slowly cooled down at room temperature to 24°C
- Fractionation: 16.0°C, 4 h
  - 12.5°C, 15 h
- Separation of crystal-liquid fat suspension (vacuum filtration)
  - Stearin fraction II (CLA-reduced)
  - Olein fraction II (CLA-enriched)

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### Results

<table>
<thead>
<tr>
<th></th>
<th>CLA content</th>
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<tbody>
<tr>
<td>Product</td>
<td>[°C]</td>
<td>[mg/g fat]</td>
</tr>
<tr>
<td>butterfat (reference)</td>
<td>-</td>
<td>7.7</td>
</tr>
<tr>
<td>olein fraction I</td>
<td>20.0</td>
<td>8.6</td>
</tr>
<tr>
<td>olein fraction II</td>
<td>12.5</td>
<td>10.2</td>
</tr>
</tbody>
</table>

**Average increase of CLA content from reference to olein fraction I:** 1.2

<table>
<thead>
<tr>
<th>Product</th>
<th>CLA content</th>
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</thead>
<tbody>
<tr>
<td>alpine butter (reference)</td>
<td>-</td>
<td>21.6</td>
</tr>
<tr>
<td>olein fraction I A</td>
<td>20.0</td>
<td>22.8</td>
</tr>
<tr>
<td>olein fraction I B</td>
<td>20.0</td>
<td>22.7</td>
</tr>
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</table>

**Average increase of CLA content from olein fraction I to olein fraction II:** 2.1

<table>
<thead>
<tr>
<th></th>
<th>CLA content</th>
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</thead>
<tbody>
<tr>
<td>olein fraction II A1</td>
<td>12.5</td>
<td>25.1</td>
</tr>
<tr>
<td>olein fraction II A2</td>
<td>12.5</td>
<td>24.5</td>
</tr>
<tr>
<td>olein fraction II B1</td>
<td>12.5</td>
<td>25.1</td>
</tr>
</tbody>
</table>

**Average increase of CLA content from olein fraction I to olein fraction II:** 15.3 %
Tests conducted demonstrate:

- Selected physical separation process enables CLA enrichment
- CLA found in olein and stearin fraction
  - higher CLA content is found in olein fraction
- Anhydrous butterfat: CLA enrichment of **32.5 %**
- Highland butter: CLA enrichment of **15.3 %**
- CLA enrichment too minor to achieve decisive positive impact on human health
- High processing costs
  - industrial-volume CLA enrichment is too costly

Results
Summary

• Normal processing procedures for dairy products do not change the content of CLA or the CLA isomer profile in fat.

• During processing, CLA pass from raw material into final product (proportionally to content and CLA isomer profile in fat).

• Organic dairy products show higher levels of CLA than standard products.

• Enrichment of CLA by low-input processes is possible but limited (industrial-volume is too costly).
Summary

- Enrichment of CLA by diet of cattle (and altitude) has an influence on quality of milk products
  - Butter: nutritional-physiological advantage; softer texture
- Methods to determine secondary products of fat oxidation (and shelf-life) are established
Acknowledgement

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Dry fractionation process:
Thanks to all ALP colleagues, to Dr. Walter Bisig from the Swiss college of agriculture and to Margherita Vass from the Emmi AG.