Milk protein profile: measure from mid infrared spectra and identification of influence factors

Session 71 « Milk and meat quality - highlighting knowledge gaps in the supply chain »

M. Gelé (marine.gele@idele.fr)
M. Ferrand-Calmels, G. Miranda, N. Ballot, L. Bianchi, M. Brochard, P. Martin
Milk protein profile: a strategic issue for the dairy sector

1. How to measure concentrations of major milk proteins in routine?
2. What are the nutrition and physiology-related factors that influence their concentration?
Milk protein profile: measure from mid infrared spectra and identification of influence factors

The methodology at a glance

Data collection (from nov 2009 to oct 2010)
1000 French dairy farms

MI R spectroscopy

Data collection

MIR analysis
Spectral data

DNA samples
Genotypes

Field surveys
Management

Genetic determinism
/ QTL

Non-genetic influence factors

Estimated protein profile

PRE D I C T I O N E QUAT I O N S

Calibration set

LC-MS

MIR: mid infrared ~ LC-MS: liquid chromatography ~ mass spectrometry ~ QTL: quantitative trait locus
The methodology at a glance

MIR spectroscopy

Calibration set

LC-MS

PREDICTION EQUATIONS

MIR: mid infrared ~ LC-MS: liquid chromatography - mass spectrometry ~ QTL: quantitative trait locus
1st step: quantifying protein profile

- 280 milk samples
- 3 breeds: Holstein, Normande & Montbeliarde
- Several French regions
- Large diversity of lactation stages and feeding systems

Milk analysis labs (Foss machines only)

INRA Jouy-en-Josas
Dionex «Ultimate 3000» Chromatography column linked with a Brucker Daltonics «micrOTOF II» mass spectrometer

Proteolysis kinetics → proteolysis attributed to each protein

MIR: mid infrared ~ LC-MS: liquid chromatography – mass spectrometry
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1st step: quantifying protein profile

Partial Least Square regression
Cross-validation (LOO)

PREDICTION EQUATIONS

Relative $S_{y,x}$ (%)

Possible use

😊 Routine, any application
😊 Analytic use, quantitative information
😊 Screening, high or low levels
😊 Not recommended

LOO: leave one out ~ PC: protein content ~ cn: casein ~ la: lactalbumin ~ lg: lactoglobulin
The methodology at a glance

MIR spectroscopy

Data collection (from nov 2009 to oct 2010)
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MIR analysis
→ Spectral data

DNA samples
→ Genotypes

Field surveys
→ Management

Genetic determinism / QTL

Non-genetic influence factors

Estimated protein profile

Calibration set

LC-MS
2nd step: screening a population

Data collection (from nov 2009 to oct 2010)
1000 French dairy farms

- Very similar protein profile between breeds
- Very low variability of protein contents (Std <1.2 point)

MIR: mid infrared spectrometry ~ cn: casein ~ la: lactalbumin ~ lg: lactoglobulin
The methodology at a glance

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**MIR spectroscopy**

Data collection (from Nov 2009 to Oct 2010)
1000 French dairy farms

**Genetic determinism / QTL**

**Non-genetic influence factors**

**LC-MS**

**DNA samples**

**Field surveys**

**MIR analysis** → Spectral data

**Estimated protein profile**

miR: mid infrared ~ LC-MS: liquid chromatography – mass spectrometry ~ QTL: quantitative trait locus
3rd step: identifying influence factors

Sanchez et al publications from 2013

Data collection (from nov 2009 to oct 2010)
1000 French dairy farms

DNA samples → Genotypes
Field surveys → Management

Genetic determinism / QTL

Estimated protein profile

Non-genetic influence factors

QTL : quantitative trait locus
3rd step: identifying influence factors

Data collection (from Nov 2009 to Oct 2010)
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DNA samples → Genotypes
Field surveys → Management

Estimated protein profile
Genetic determinism / QTL
Non-genetic influence factors

SAS proc mixed

Nutrition-related factors

<table>
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<th>FOOD TYPE</th>
<th>αs1-cn</th>
<th>αs2-cn</th>
<th>β-cn</th>
<th>κ-cn</th>
<th>β-lg</th>
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<tbody>
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<td>=</td>
<td>=/+=</td>
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<tr>
<td>Pasture</td>
<td>+</td>
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<td>+</td>
<td>-</td>
</tr>
</tbody>
</table>

- More caseins with hay and pasture
- Very limited impact of food type on protein profile (<1 point)

cn: casein ~ lg: lactoglobulin
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**3rd step: identifying influence factors**

Data collection (from nov 2009 to oct 2010)
1000 French dairy farms

- Estimated protein profile
  - Genetic determinism / QTL
  - Non-genetic influence factors

SAS proc mixed

**Physiology-related factors**

- No significant impact of the number of lactation
- Impact of udder health
- Impact of lactation stage during the first 2 months on β-cn and β-lg

**Evolution of protein profile from calving to the end of lactation (Holstein cows)**

- Peak lactation
- Weeks of lactation

- as1-cn
- as2-cn
- β-cn
- κ-cn
- β-lg

\(cn\): casein  \(\sim\) \(lg\): lactoglobulin
Some conclusions

- Quantifying protein profile in routine IS possible
- Protein profile is not (a lot) dependent on breed or food type
- Lactation stage is the most impactful non-genetic factor
- $\beta$-cn and $\beta$-lg are responsible for the change in protein profile

What about future prospects?

- Improving LC-MS method $\rightarrow$ Improving the equations
- Using the equations to phenotype new traits such as cheese-making properties of milk

TO BE CONTINUED...
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MANY THANKS TO...

- Farmers
- Financial partners
- Technical partners
- You!