Potential Estimation of Minerals Content in Cow Milk Using Mid-Infrared Spectrometry

H. Soyeurt¹, D. Bruwier¹, N. Gengler¹,², J.-M. Romnee³, and P. Dardenne³

¹ Gembloux Agricultural University, Animal Science Unit, Belgium
² National Fund for Scientific Research, Belgium
³ Walloon Agricultural Research Centre, Quality Department, Belgium

Introduction

- Interest for human and animal health:
  - Ca : osteoporosis, milk fever
  - Na : milk fever, alkalosis, indicator of mastitis?

- Dairy products with high Ca content are commercialized to prevent osteoporosis (e.g., Belgium,…)
Introduction

- Regular analysis
- Inductively Coupled Plasma Atomic Emission Spectrometry: ICP-AES
  - Fast
  - Expensive
- Previous studies on the measurement of milk components by Mid-Infrared (MIR) Spectrometry:
  - Fast and cheap
  - %fat, %protein, %fatty acids, %lactose, urea,…

General Objective

- Estimate the contents of the major minerals in cow milk (Ca, Na, and P) by MIR spectrometry
Milk Samples

- 1,609 milk samples:
  - March 2005 and May 2006
  - 478 cows in 8 herds belonging to 6 dairy breeds:
    - dual purpose Belgian Blue, Holstein Friesian, Jersey, Montbeliarde, Normande, and non-Holstein Meuse-Rhine-Yssel type Red and White

- 2 samples:
  - MilkoScan FT6000 during the Walloon milk recording
  - Conserved at -26°C

Calibration

- Selection of samples:
  - Principal Components Approach (PCA)
  - 70 selected samples
    - 9 samples with bad conservation
    - 4 outliers

- Reference analysis:
  - ICP-AES without mineralization
Calibration

- Equations:
  - 57 samples
  - Partial Least Squares (PLS) regressions
  - Repeatability file:
    - Walloon part of Belgium
    - Luxembourg
  - Accuracy: Full cross-validation

Results

<table>
<thead>
<tr>
<th></th>
<th>N</th>
<th>Mean</th>
<th>SD</th>
<th>SECV</th>
<th>R²cv</th>
<th>RPD</th>
</tr>
</thead>
<tbody>
<tr>
<td>Na</td>
<td>57</td>
<td>431.39</td>
<td>102.10</td>
<td>57.31</td>
<td>0.69</td>
<td>1.78</td>
</tr>
<tr>
<td>Ca</td>
<td>57</td>
<td>1251.58</td>
<td>157.44</td>
<td>66.98</td>
<td><strong>0.82</strong></td>
<td><strong>2.35</strong></td>
</tr>
<tr>
<td>P</td>
<td>57</td>
<td>1071.02</td>
<td>107.03</td>
<td>51.87</td>
<td><strong>0.77</strong></td>
<td><strong>2.06</strong></td>
</tr>
</tbody>
</table>

SD = Standard deviation; SECV= Standard error of cross-validation; R²cv = Cross-validation coefficient of determination; RPD = the ratio of SD to SECV

- If RPD > 2, good indicator
- Good prediction of Ca and P (high contents)
### Real MIR absorbance?

<table>
<thead>
<tr>
<th></th>
<th>Ca (mg/l of milk)</th>
<th>P (mg/l of milk)</th>
<th>%fat (g/dl of milk)</th>
<th>%prot (g/dl of milk)</th>
<th>lactose (g/dl of milk)</th>
<th>urea (g/dl of milk)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Na</td>
<td>-0.25</td>
<td>-0.08</td>
<td>-0.49</td>
<td>0.33</td>
<td>-0.76</td>
<td>0.46</td>
</tr>
<tr>
<td>Ca (mg/l of milk)</td>
<td>0.58</td>
<td>0.52</td>
<td>0.21</td>
<td>0.19</td>
<td>-0.37</td>
<td></td>
</tr>
<tr>
<td>P (mg/l of milk)</td>
<td>0.38</td>
<td>0.56</td>
<td>-0.02</td>
<td>0.14</td>
<td></td>
<td></td>
</tr>
<tr>
<td>%fat (g/dl of milk)</td>
<td>0.29</td>
<td>-0.41</td>
<td>0.39</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>%prot (g/dl of milk)</td>
<td>0.19</td>
<td>-0.12</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Lactose (g/dl of milk)</td>
<td>-0.33</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Rcv = 0.90**
### Real MIR absorbance?

<table>
<thead>
<tr>
<th></th>
<th>Ca</th>
<th>P</th>
<th>%fat</th>
<th>%prot</th>
<th>lactose</th>
<th>urea</th>
</tr>
</thead>
<tbody>
<tr>
<td>Na</td>
<td>-0.25</td>
<td>-0.08</td>
<td>-0.49</td>
<td>0.33</td>
<td>-0.76</td>
<td>0.46</td>
</tr>
<tr>
<td>(mg/l of milk)</td>
<td>0.58</td>
<td>0.52</td>
<td>0.21</td>
<td>0.19</td>
<td>-0.37</td>
<td>0.38</td>
</tr>
<tr>
<td>P</td>
<td>0.38</td>
<td>0.56</td>
<td>-0.02</td>
<td>0.14</td>
<td></td>
<td></td>
</tr>
<tr>
<td>(mg/l of milk)</td>
<td>0.38</td>
<td>0.56</td>
<td>-0.02</td>
<td>0.14</td>
<td></td>
<td></td>
</tr>
<tr>
<td>%fat</td>
<td></td>
<td></td>
<td>0.29</td>
<td>-0.41</td>
<td>0.39</td>
<td></td>
</tr>
<tr>
<td>(g/dl of milk)</td>
<td>0.29</td>
<td>-0.41</td>
<td>0.39</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>%prot</td>
<td>0.19</td>
<td>-0.12</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(g/dl of milk)</td>
<td>0.19</td>
<td>-0.12</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Lactose</td>
<td></td>
<td>-0.33</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(g/dl of milk)</td>
<td></td>
<td>-0.33</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

### Validation

- **Validation:**
  - **Internal validation:**
    - cross-validation
  - **External validation:**
    - samples not used for the calibration procedure
- **30 milk samples**

\[ Rcv = 0.88 \]
Validation

Calcium

Phosphorus

$R^2 = 0.95$

$R^2 = 0.84$
Conclusion

- Potential estimation of Ca and P directly on bovine milk

- Prospects for the calibration:
  - Increasing the samples used for the calibration
  - Executing a larger external validation

Prospects

- Genetic variability of minerals
  - Prevent osteoporosis
    - Feeding has a low influence on Ca content
    - Heritability (26,086 data):
      - Calcium: 0.42
      - Phosphorus: 0.47
  - Prevent milk fever?
  - Indicators of mastitis??
Thank you for your attention

Acknowledgments

FNRS:
2.4507.02F (2)
F.4552.05
FRFC 2.4623.08

soyeurt.h@fsagx.ac.be