Genetic parameters for milk protein composition of dairy cows

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Introduction
- Bovine milk is a unique source of nutrients, which include proteins.
- Caseins are important for e.g. cheese yield, whereas β-lactoglobulin is related to heat stability of milk.
- Many studies have reported heritabilities for total milk protein content.
- Few studies reported heritabilities and genetic correlations for milk protein composition.

Objective
Estimate heritabilities for milk protein composition and genetic correlations among the major milk proteins.

Materials & Methods
- 1940 milk samples of Dutch Holstein-Friesians collected during the winter period of 2005.
- Cows located on 398 farms spread throughout The Netherlands.
- Milk samples analyzed for 6 major proteins using capillary zone electrophoresis.
- Statistical model:

\[ y_{ijklmn} = \mu + b_1 \cdot \text{lactst} + b_2 \cdot e^{0.05 \cdot \text{lactst}}_i + b_3 \cdot \text{ca}_j + b_4 \cdot \text{ca}^2_j + \text{season}_k + \text{scode}_l + \text{animal}_m + \text{herd}_n + \varepsilon_{ijklmn} \]

where \( y \) = dependent variable; \( \mu \) = overall mean; lactst = day of lactation; ca = covariate for age at calving; season = fixed effect for calving season (summer, autumn, or winter); scode = fixed effect for sire group (proven or young sires); animal = random additive genetic effect; herd = random herd effect; \( \varepsilon \) = random residual effect.

- Proportional phenotypic variance due to genetics (\( h^2 \)) was calculated as:

\[ h^2 = \frac{\sigma^2_a}{\sigma^2_a + \sigma^2_r} \]

where \( \sigma^2_a \) = additive genetic variation and \( \sigma^2_r \) = residual variation.

Results
- Low CV for casein index; 90% of cows had a casein index between 85 and 90.
- Range heritabilities for six major milk proteins: 25% for β-casein to 80% for β-lactoglobulin.

Table 1. Mean, coefficient of variation (CV), heritability (\( h^2 \)) and the ratio of additive genetic variation and herd variation (\( \sigma^2_a / \sigma^2_{\text{herd}} \)) for milk protein composition.

<table>
<thead>
<tr>
<th>Trait</th>
<th>mean (%)</th>
<th>CV (%)</th>
<th>( h^2 ) (%)</th>
<th>( \sigma^2_a / \sigma^2_{\text{herd}} )</th>
</tr>
</thead>
<tbody>
<tr>
<td>αSL-casein (%, w/w)</td>
<td>33.62</td>
<td>5</td>
<td>47</td>
<td>3.5</td>
</tr>
<tr>
<td>αSZ-casein (%, w/w)</td>
<td>10.38</td>
<td>14</td>
<td>73</td>
<td>4.7</td>
</tr>
<tr>
<td>β-casein (%, w/w)</td>
<td>27.17</td>
<td>6</td>
<td>25</td>
<td>1.4</td>
</tr>
<tr>
<td>κ-casein (%, w/w)</td>
<td>4.03</td>
<td>14</td>
<td>64</td>
<td>4.9</td>
</tr>
<tr>
<td>α-lactalbumin (%, w/w)</td>
<td>2.44</td>
<td>13</td>
<td>55</td>
<td>2.8</td>
</tr>
<tr>
<td>β-lactoglobulin (%, w/w)</td>
<td>8.35</td>
<td>14</td>
<td>80</td>
<td>13.9</td>
</tr>
<tr>
<td>Casein index (( % ))</td>
<td>87.45</td>
<td>2</td>
<td>70</td>
<td>9.0</td>
</tr>
</tbody>
</table>

- Genetics has a substantial larger effect than herd.
- 80% of genetic correlations among major milk proteins were between -0.38 and 0.45.
- Strong negative genetic correlation between β-lactoglobulin and casein index (-0.98).

Conclusions
- Moderate to high heritabilities for milk protein composition.
- Milk favorable for cheese production has a high casein index and the genetic correlation showed that consequently the β-lactoglobulin concentration is low.
- Possibilities to change cow’s milk protein composition using selective breeding.