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:

$$y_{ijklmn} = \mu + b_1*lactst_i + b_2*e^{-0.05*lactst}{}_i + b_3*ca_j + b_4*ca_j^2 + season_k + scode_l + animal_m + herd_n + e_{ijklmn}$$

where y = dependent variable, μ = 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; e = random residual effect.

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

$$h^2 = \frac{\sigma_a^2}{\sigma_a^2 + \sigma_e^2}$$

where σ^2_a = additive genetic variation and σ^2_e = 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[1] (h^2) and the ratio of additive genetic variation and herd variation ($\sigma^2_A / \sigma^2_{herd}$) for milk protein composition.

Trait	mean	CV (%)	h^2 (%)	$\sigma^2_A / \sigma^2_{herd}$
α_{S1}-casein (%,w/w)	33.62	5	47	3.5
α_{S2}-casein (%, w/w)	10.38	14	73	4.7
β-casein (%, w/w)	27.17	6	25	1.4
κ-casein[2] (%, w/w)	4.03	14	64	4.9
α-lactalbumin (%, w/w)	2.44	13	55	2.8
β-lactoglobulin (%, w/w)	8.35	14	80	13.9
Caseinindex[3]	87.45	2	70	9.0
Protein (%)	3.51	9	66	2.8

[1] s.e. between 8 and 12, [2] Only κ-casein in the mono-phosphorylated form,
[3] Casein index = α_{S1}-CN+α_{S2}-CN+β-CN+κ-CN/(α_{S1}-CN+α_{S2}-CN+β-CN+κ-CN)+(α-LG+β-LG)*100

- 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 caseinindex (-0.98).

Conclusions

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

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