Genetic Parameters for Casein and Urea Content in the Italian Brown Swiss Dairy Cattle

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ABSTRACT: A total of 137,753 test day records of 20,745 Italian Brown Swiss dairy cows from 26 provinces of Italy were used to estimate heritability for casein and urea content in milk and their genetic correlations with other production traits and milk somatic cell score. Milk component values were obtained by Fourier Transformed Infrared (IR) Spectroscopy from milk samples collected during national routine recording and were analysed using test day repeatability animal models. Fixed effects included 1,001 levels of herd-test date, 15 classes of days in milk, and 13 classes of age at calving within parity. The variation among cows was large for most of the traits. The heritability value for casein content was 0.31, as for protein content, and genetic and phenotypic correlations between these two traits were large (0.99 and 0.97 respectively). Milk urea content had a heritability of 0.17 and a positive genetic relationship with fat (0.12), null with protein (0.03) and casein (0.002) content and a negative genetic correlation with milk yield (-0.17) suggesting that the genetic improvement for milk urea content would be possible, but genetic gain would be affected by other traits included as selection criteria in the economic index and by their relative economic emphasis.

Keywords: Dairy Cows, Italian Brown Swiss Breed, Casein Content, Milk Urea

Introduction – Selection for milk quality and animal functionality is of primary importance for the Italian Brown Swiss dairy breed. In the selection index a relative emphasis of 58% is assigned to protein yield and 12% to protein content (Ghiroldi et al., 2005). Protein content in milk samples, also named total protein, is normally estimated from the overall amount of nitrogen (N) multiplied by 6.38, to express results on a protein equivalent basis, and includes, therefore, both protein and non-protein N (NPN). According to Rowlands (1938) the total protein is composed of 76.3% of casein, 17.9% of whey proteins and about 5.8% of NPN. Nevertheless, the milk NPN content varies, with extremes values from 0.12 to 0.25% (http://www.fmmaseattle.com/lab/FAQ.htm) of the crude protein, depending primarily on farm management and feeding practises. While NPN has little nutritional value and whey proteins are dispersed in the cheese whey, caseins have a primary determinant role in cheese production. Moreover, although a large genetic correlation exists between casein and protein content (Ikonen et al., 2004*)*, the first one shows larger genetic and phenotypic correlations with milk coagulation measures and less occurrence of non-coagulating milk than the second one (Ikonen et al., 2004).

The content of urea represents approximately 48% of NPN (Harding, 1992), is an important parameter of milk quality and is an indicator of the correctness of herd nutritional practices. Large values of urea content indicate an unbalance ratio of protein vs. energy in the ration and an inefficient utilisation of protein. Additionally the milk urea content affects reproduction (Godden et al., 2001, Mitchell et al., 2005).

Recent studies on urea and casein contents indicate that variability among cows exists (Wood et al., 2003; Ikonen et al., 2004; Mitchell et al., 2005). However estimates of genetic parameters on field data collected during routine milk recording are limited (Stoop et al., 2006). The only available estimates of genetic parameters for casein and urea content in the Italian Brown Swiss were obtained from a small data set (Ghiroldi et al., 2004) and need to be confirmed. The availability of

new instruments used in milk analysis allows to record regularly casein and milk urea content on a monthly basis within the routine milk recording scheme. The possible use of these phenotypes as traits in breeding selection of Italian Brown Swiss is currently under investigation.
Using field data of Italian Brown Swiss lactating cows collected over three years across the country during the routine milk recording, this study aimed to estimate: 1) heritabilities for milk casein and urea contents; 2) correlations between milk yield, fat, protein, casein, lactose, and milk urea contents and milk somatic cell score (SCS).

Material and methods - A total of 296,599 test day records from 58,573 cows in 3,176 herds in 26 provinces of Italy were available. The data set was edited for the outliers and in order to guarantee a minimum of two records per cow within parity and a minimum of two test days per herd-test day level. Traits considered were milk yield, fat (%), protein (%), casein (%), urea content (mg/dL), lactose (%) and somatic cell scores (SCS). Contents of milk components were obtained by Fourier Transformed Infrared (IR) Spectroscopy with MilkoScan^{TM} FT6000 (Foss Electric, Denmark), from milk samples collected during national routine recording. The data set used for variance components estimation included 137,753 test day records from 20,745 cows. Three generation pedigree information were obtained from the Italian Brown Swiss Herd Book for a total of 66,537 animals. The same test day repeatability animal model was applied to all traits. The model included, as fixed effects, herd-test date (1001 levels), days in milk (15 classes of 30 days) and the age at calving within parity (4 classes for each of the first three parities and one class for later ones). Additive genetic and permanent environmental effects, and residual error were included as random effects. Twenty one REML bivariate analyses were performed using the program VCE 5.1 (Kovač e Groenveld, 2003). Heritabilities and standard errors presented in this study are the averages of the estimates resulting from the 6 bivariate analyses performed for each trait.

Results and conclusions – Phenotypic data showed a quite large variability for all traits, except lactose. The coefficients of variation were 0.27 for milk urea and 0.11 for casein content (Table 1).

Table 1 – Descriptive statistics of data used in variance components estimation.

Variable	Num	mean	standard deviation	CV (%)*	minimum	maximum
Milk (kg)	137,753	22.4	8.18	37	5.00	63.70
Protein (%)	137,753	3.6	0.41	11	1.68	5.95
Fat (%)	137,753	4.1	0.74	18	1.00	7.00
Casein %)	137,753	2.8	0.32	11	0.95	4.80
Urea (mg/dL)	81,899	25.9	7.04	27	0.38	45.00
Lactose (%)	71,035	4.9	0.26	5	1.56	5.69
SCS	137,753	3.5	2.00	57	0.00	10.00

*CV is the coefficient of variation, calculated as standard deviation/mean

Genetic parameter estimates are in Table 2. Protein (%) and casein (%) showed a heritability of 0.31 similar to the estimates reported by Ikonen et al. (2004), equal to 0.29 and 0.30 for protein and casein content, respectively. Genetic and phenotypic correlations between protein and casein were large (0.99 and 0.97). Ikonen et al. (2004) also reported large values, 0.91 and 0.92 for the phenotypic and genetic relationship respectively. The heritability estimated for urea content was 0.17. Estimates reported in the literature range from 0.09 to 0.47 depending on the method (chemical or IR) used to analyse the components, the population considered, the parity, and the model used to estimate variance components. In studies analysing urea determined with an IR spectroscopy, Stoop et al. (2006) found a heritability of 0.l4 for milk urea, while Mitchell et al. (2005) of 0.22 and Wood et al. (2003) of 0.44 for Milk Urea Nitrogen. Estimates of heritability and additive variability (CV Additive, Table 2) showed that it is possible to select for milk urea content and that enough additive variation among cows exists. Nevertheless urea resulted in a negative genetic correlation with milk yields (-0.17), in a null correlation with protein content (0.03), and in a positive correlation (0.12) with fat content; therefore, the inclusion of urea in a selection index should consider its relationship with other traits. Wood et al. (2003), in the Holstein population, found values closer to zero and remarked changing urea content would have little effect on productive measures.

Table 2: Heritabilities (on diagonal), genetic (upper triangle) and phenotypic (lower triangle) correlation values, coefficient of additive genetic variation (CV), and repeatability estimates.

	Milk (%)	Protein (%)	Fat (%)	Casein (%)	Urea (%)	Lactose (%)	SCS
Milk (kg)	0.10	-0.34	-0.26	-0.34	-0.17	0.03	-0.04
Protein (%)	-0.28	0.31	0.71	0.99	0.03	-0.03	0.03
Fat (%)	-0.12	0.40	0.14	0.69	0.12	-0.03	-0.03
Casein (%)	-0.25	0.97	0.40	0.31	0.002	0.06	-0.03
Urea (mg/dL)	0.06	0.09	0.09	0.07	0.17	-0.02	-0.08
Lactose (%)	0.30	-0.18	-0.07	-0.06	0.07	0.17	-0.40
SCS	-0.28	0.18	0.07	0.11	-0.06	-0.52	0.07
CV Additive*	7.02	28.02	19.52	25.04	16.29	43.3	3.32
Repeatability	0.51	0.48	0.25	0.50	0.30	0.46	0.44

* CV Additive is the coefficient of additive variation (mean/√additive genetic variance)
Standard errors: heritability below 0.02; genetic correlations below 0.06.

The large genetic correlation between casein and protein content suggests that the two measures underline the same trait. Nevertheless it should be remembered that the use of true protein content instead of total nitrogen content would better reflect the economic value of milk, improving the accuracy of payment for quality. This would also improve, as a consequence, the quality of data used for breeding values estimation and in farm management.

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