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Genetic variability of milk rheological parameters in Italian Friesian dairy cows

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The aim of this study was to estimate the heritability of coagulation parameters (r, clotting time; k_{20}, curd firming time; a_{30} and a_{45}, curd firmness measured at 30 and 45 min after rennet addition, respectively), somatic cell count (SCC) and titratable acidity. Milk samples were taken from 238 Italian Friesian cows reared in a single herd located in the province of Pisa (northwestern Tuscany, Italy). All individual sample were taken from the morning milking. The heritability coefficient of the clotting time (r) was 0.26 (± 0.142), while for the other technological parameters the coefficient was rather low (0.08 ±0.162 for k_{20}, 0.09±0.195 for a_{30} and 0.12±0.204 for a_{45}). Also the heritability coefficient of the SCC was low (h^2= 0.07±0.122) but not different from values reported elsewhere, as for titratable acidity (h^2= 0.03±0.201) too.

Genetische Variabilität von rheologischen Parametern der Milch bei italienischen Friesian-Kühen

Ziel dieser Studie war es, die Heritabilität der Koagulationsparameter (Gerinnungszeit r; Bruchfestigungszeit k_{20} ; Bruchfestigkeit a_{30} bzw. a_{45} gemessen 30 und 45 min nach Zusetzen des Labs), der somatischen Zellzahl (SCC) und des titierbaren Säuregrads festzustellen. Milchproben wurden von 238 italienischen Friesian-Kühen aus einer einzelnen Herde in der Provinz Pisa, nordwestliche Toscana, Italien, genommen. Alle Einzelproben wurden den Morgengemelken entnommen. Der Heritabilitätskoeffizient der Gerinnungszeit r lag bei 0,26 (±0,142), während die Koeffizienten für die

anderen technologischen Parameter recht niedrig waren (0,08±0,162 für k_{20}, 0,09±0,195 für a_{30} und 0,12±0,204 für a_{45}). Auch der Heritabilitätskoeffizient des SCC war niedrig (h^2= 0,07±0,122) und unterschied sich nicht von den Werten anderer Autoren. Gleiches gilt für den titrierbaren Säuregrad (h^2= 0,03±0,201).

50 Cheese milk (rheological parameters, genetic variability)

50 Käsereimilch (rheologische Parameter, genetische Variabilität)

1. Introduction

The limits imposed by milk quotas on quantity production as well as the European Community regulations concerning marketing and prices based on quality, stimulate producers to seek higher qualitative standards for milk destined for commercial purposes. Therefore, great importance must be given not only to percentages of fat and protein, but also to all other quality parameters, such as somatic cell count (13), and when transformation is involved, technological parameters (milk coagulation time, curd-firming time and curd firmness). It's well known that milk that coagulates and form a firm curd soon after addition of the clotting enzyme produces higher cheese yields than milk that coagulates slowly. Moreover, the somatic cell count, lactose, pH and titratable acidity of the milk, are all good indicators for diagnosing mastitis in lactating cows (1).

The choice of product direction (*i.e.*, milk for fresh consumption) can frequently lead to neglecting milk quality in parameters which are fundamental to other product directions.

Furthermore, the study of the genetic variability fraction emphasizes the importance of environmental sources and their control. Also of fundamental importance is determining the genetic variability of the somatic cell count: the possibility of selection against somatic cells may lower the incidence of mastitis and lead to considerable economic benefits resulting from an increase in milk quality (18).

In this study we have attempted to evaluate the genetic variability of the technological parameters and of the SCC in milk from a single herd of Italian Friesian cattle raised in the Province of Pisa (Tuscany), with the aim of devising possible strategies for improvement.

2. Material and methods

The study was carried out on 238 Italian Friesian cows reared in the same herd in a medium-temperate climatic zone in the province of Pisa (northwestern Tuscany, Italy). All animals were fed the same diet: the cows were allowed to range freely, and were fed a unifeed diet; about 16 kg/head of the ration was distributed three times a day. The ration consisted of corn mash, polyphyte meadow silage, alfalfa hay first and second cut, straw, mixed feed (crude protein 21%), corn, barley, soybeans, cotton seeds, Na bicarbonate, zeolite and water.

The individual milk samples were collected from the morning milking from each cow and analyzed in triplicate. No preservatives were added.

The following procedures were carried out on every sample of fresh milk:

- SCC (Fossomatic 360), titratable acidity;
- rheological parameters were measured: rennet clotting time (r=min), rate of curd firming (k_{20}=min), and curd firmness 30 and 45 min after rennet addition (a_{30} and a_{45} = mm) (Formagraph, Foss Electric).

For Somatic Cell Count a logarithmic transformation of data was effected to normalize the variance.

For the evaluation of the heritability the following mixed linear sire model was performed using JMP, ver. 5.0 for PC, of the SAS Institute (7):

$$Y_{ijk} = \mu + s_i + O_j + bX_{ijk} + \varepsilon_{ijk}$$

where Y_{ijk}= considered parameters; μ = overall mean; s_i = random effect of the i^{th} sire (i=1, ..., 6); O_j = fixed effect of the j^{th} parity (j = 1,..,4); b = regression coefficient on the time elapsed since calving in days (X_{ijk}); ε_{ijk} = residual error.

All estimates of variance components for estimates of heritability were obtained with a REML procedure using a Newton-Raphson method (5, 16, 17). Because a sire model was used, estimates of ratios of sire to total variance were multiplied by 4 to yield heritability estimates.

Standard errors of heritabilities were approximated according to BECKER (3).

3. Results and conclusions

Table 1: Means values of a milking

Trait		Means	s.d.
CCS*; Somatic Cell Count	CCS/ml	12.75	1.444
pH; pH		6.70	0.164
r; Clotting time	min	27'33"	10'36"
k_{20}; Curd firming time	min	9'03"	7'21"
a_{30}; Curd firmness (1)	mm	11.55	10.692
a_{45}; Curd firmness (2)	mm	17.72	12.489
AT; Titratable acidity	°SH/50 ml	3.10	0.448

*A logarithmic transformation of data was effected. (1) Curd firmness measured 30 min, (2) 45 min after rennet addition.

Table 2: Estimates of variance components and heritabilities for coagulation parameters

Trait	Additive genetic variance	Phenotypic variance	h^2	SE
Log CCS	6.07	86.71	0.07	0.122
pH	0.07	7.00	0.01	0.235
AT	0.06	2.00	0.03	0.201
R	19.74	75.92	0.26	0.242
k_{20}	2.00	25.00	0.08	0.205
a_{30}	9.77	108.55	0.09	0.261
a_{45}	14.97	124.75	0.12	0.208

As shown in Table 1, milk resulted of scarce reactivity. The heritability of clotting time "r" with the value of 0.26 (Table 2) is in line with previously described values (6, 8, 9, 10, 15, 19) in cattle, while the heritability coefficients of curd firming time and curd firmness are rather low (0.08 for k_{20}, 0.09 for a_{30} and 0.12 for a_{45}).

On the contrary other authors, in studies carried out on buffalo (14), and on Massese sheep (3, 4), report low heritability coefficients for all coagulation parameters.

Studies that have estimated the heritability coefficient of the SCC (11, 12, 13) report values ranging between 0.11 and 0.23, somewhat higher than those determined in this study (h^2=0.07). At the sight of the heritability value it is not expected to obtain an important genetic response to the selection of SCC in dairy cows belonging to the Italian Friesian breed. So, for the time being, a reduction in SCC should particularly be based on improving hygiene and environmental conditions on farms.

The heritability values reported in this study are somewhat low for all parameters considered, the majority being close to zero, with the exception of clotting time, with a value of 0.26. The existence of a strong extra-genetic variability, probably due to the aims of the company (i.e., production of fresh milk) as well as to sample size, suggests and confirm the importance of further study in order to verify not only the accuracy of heritability values within the parameters themselves, but also to determine possible plans for environmental improvement.

4. References

(1) BABIC, S., MARKOVIC, R., PESIC, D., MIOCINOVIC, D.: Veterinarski Glasnik **48** 287-290 (1994)

(2) BECKER, W.A.: Manual of quantitative genetics. Academic Enterprises 4th edn. Pullman, Washington (1984)

(3) CECCHI, F., GIULIOTTI, L., BENVENUTI, N., LEOTTA. R., CIANCI, D.: Atti XII Congr. Naz. S.I.P.A.O.C., Varese 1996, 419-423 (1996)

(4) GIULIOTTI, L., BENVENUTI, N., CECCHI, F., RUSSO, C., LEOTTA, R., CIANCI., D.: Atti XII Congr. Naz. S.I.P.A.O.C., Varese 1996, 425-429 (1996)

(5) HARVILLE, D.A.: J. Am. Stat.Ass. **72** 320 -338 (1977)

(6) HORTIEN, K., SCHULTE-COERNE, H., PABST, K., GRAVERT., H.O.: Züchtungsk. **64** 27-34 (1992)

(7) J.M.P. User's Guide ver. 5.0, S.A.S Institute Inc., Ed. Cary, NC, USA (2002)

(8) IKONEN, T., AHLFORS, K., KEMPE, R., OJALA, M., RUOTTINEN, O. J.: Dairy Sci. **82** 205-214 (1999)

(9) LEOTTA R., CECCHI F., SUMMER A.: Proc. 54th Ann. Meeting EAAP, Rome, 1985 (2003)

(10) LINDSTRON, UB., ANTILA, V., SYVAJARVU, J.: Acta Agricult. Scand. **34** 349-355 (1984)

(11) KIIMAN, H.: Transactions of the postgraduate and doctoral students (Estonia) **193** 186-189 (1997)

(12) KIIMAN, H.: Transactions of the Estoinan Academic Agricult. Society (Estonia) **7** 39-40 (1998)

(13) KIIMAN, H., SAVELI O.: Agraarteadus **11** 152-168 (2000)

(14) MATASSINO, D., GRASSO, F., ZULLO, A., GIORGIO, G., SALATTI IANNITTI, E.: Prod. Anim. **4** 1-25 (1991)

(15) OLOFFS, K., SCHULTE COERNE, H., PABST, K., GRAVERT, H.O.: Züchtungsk. **64** 35-42 (1992)

(16) PATTERSON, H.D., THOMPSON, R.: In Proc. Int. Biometric Conf., Constanza, Romania, 1974., Washington, DC (1974)

(17) SEARLE, SR.: Linear Models, New York: John Wiley & Sons (1971)

(18) SCHUTS, MM.: J. Dairy Sci. **77** 2113-2129 (1994)

(19) TERVALA, HL., ANTILA, V., SYVAJARVU, J.: Meijeritieteellin Aikakauskirja **43** 16-25 (1985).