Estimation of the milk urea course during lactation

Němcová Eva[*1]*(nemcova.eva@vuzv.cz), Štípková Miloslava*[1]*, Jílek František*[2] *and Krejčová Michaela*[1]
[1]*Research Institute of Animal Production, P.O.Box1, 104 01 Prague 10, Czech Republic*
[2]*Czech University of Agriculture Prague*

Abstract
This work was part of a project focused on the description of the relationship between milk urea and reproduction parameters. The aim of this study was to model the course of the urea concentration in milk during the lactation. Approximately 18,000 test-day records from official milk performance recording from 5 selected Holstein herds in the Czech Republic were available. Several test-day models differing in the definition of factors and factor levels were compared. All effects were considered to be fixed and each parity was treated in a separate analysis. The model including fixed effects of herd-test-day, season of calving, age at first calving (first lactation only), length of previous calving interval (2nd and subsequent lactations only) and the animal effect modeled by a 4th order Legendre polynomials was chosen to be the best. For all lactations, the milk urea concentration showed the lowest values at the beginning and at the end of lactation, an increase of these values during the first 3 months of lactation and a slow decrease in following months were observed. The smallest level of milk urea concentration was found in the first lactation and the highest in the second one. This analysis confirms our previous findings from animal model concerning the statistical significance of the animal effect, days in milk and HTD.

Introduction

Milk urea can be used as a tool to monitor protein feeding efficiency and dietary protein-energy ratio in dairy cows (Hof et al., 1997 and Eicher et al., 1999). For this purpose, available results from measurements of milk urea at time of milk recording can be used. It may help to indicate the level of metabolic stress and the nutritional status and health of cows (Rajala-Schultz et al., 2001). The majority of studies about milk urea have been based on experiments and have used relatively small sample sizes; some studies have used field data from several herds (e.g. Eicher et al., 1999 and Rajala-Schultz et al., 2001) or from part of the population (e.g. Wood et al., 2003). Wood et al. (2003) suggest to evaluate a magnitude of genetic and environmental factors that influence milk urea concentration. The aim of this study was to model the course of the milk urea concentration during the lactation.

Material and methods

The data analyzed in this study origin from six selected Holstein herds in the Czech Republic. The data were collected on a monthly basis within the regular system of milk recording from 2000 to 2003. Totally 17,796 test-day observations of milk yield, protein content, fat content and concentration of milk urea from 1 603 cows were available. Extreme observations and those obtaining after 320th day in milk were excluded from analysis; the final dataset thus included 16,661 observations.

An analysis of variance of certain systematic effects influencing test-day milk urea concentration (MU) was performed using the GLM procedure in the program package SAS (version 9.1) to test their contributions to the variation of MU. The more detailed evaluations of stage of lactation were performed using fixed regression test-day model without information about relationship between animals. Each lactation was treated in a separate model.

The contemporary groups were defined using herd-test-day effect (HTD). The effect of age of first calving was included into the model equation for first lactation only. In the model for later lactations, this effect was substituted by effect of preceding calving interval. Both these effects were divided into three subclasses. Season of calving in three months intervals was also included into the

model. To model stage of lactation, fixed regression on days in milk (DIM) using different combinations of Legendre polynomials up to 5th order was included.

$$y_{mnkitjl} = HTD_i + S_j + A_k + \sum_{l=1}^{n} \beta_{lm} z_{tn} + e_{mnkitjl} \quad \text{, where:}$$

$y_{mnkitjl}$ is the observed trait *n*,
HTD_i is the fixed effect of herd-test day *i*,
A_k is the fixed effect of age at first calving (for first lactation), respectively the fixed effect of previous calving interval
S_j if the fixed effect of season *j* of first calving
β_{lm} are fixed regression coefficients specific to animal *m*,
z_{tn} are covariates associated with DIM,
$e_{mnkitjl}$ is the residual effect.

Results and discussion

The overall unadjusted mean MU concentration, milk yield, protein and fat content were 5.61 mmol/l, 27.16 kg, 3.36 % and 4.18 %, respectively. The distributions of all observed traits in each lactation were not significantly different from normal distribution. Means for yield traits were within the range usually observed in Holstein cows in the Czech Republic. The mean milk urea concentration for primiparous cows was lower than the means for either second or third lactation (table 1). Similar situation was reported by De Peters et Cant (1992), Wood et al. (2003) and Hojman et al. (2004). On the other hand, opposite (Johnson et Young, 2003) or no (Ferguson et al., 1997 and Shepers et Meijer, 1998) relationship between parity and MU concentration were reported.

Our findings concerning the statistical significance of certain systematic factors and their contribution to the variation of observed traits from ANOVA analysis were discussed in the study of Jílek et al. (2005). The authors concluded that milk urea significantly varied among herds, control years, parities, seasons and stages of lactation. These conclusions were used for the model bulding in the detailed analysis of the effect of lactation stage.

The form of regression function (Legendre polynomials) and definition of environmental effect were used according to the test-day model developed for application in the Czech Republic. Legendre polynomials of order 4 was chosen as the optimal. The same order of this polynomials was used by Wood et al. (2003) for estimation of genetic parameters for this trait. Figures 2 to 5 show regression fitting by models with different order of polynomials.

The model used in our study explained the highest amount of variability in MU concentration; the R-square of the model ranged between 0.91 – 0.95 for all three lactation. Residual standard deviation was approximately 2.5 times lower than SD of raw data.

The course of milk production and milk urea concentration during the lactation is displayed on figure 1.

The pattern of milk urea concentration during lactation is similar to the shape of lactation curve. It is contradictory to many previous studies which generally reported a mirror image of typical curve for yield (DePeters et Cant, 1992; Broderick et Clayton, 1997; Wood et al., 2003). According to study of Carlsson et al. (1995), Spicer et al. (2000), Godden et al. (2001) and Hojman et al. (2004) MU concentration was the lowest immediately after calving and then it progressively increased, leveled of and slowly declined toward the end of lactation. The highest values were found in the fourth month of lactation. Other authors reported this peak between 60 and 150 days in milk (Godden et al., 2001), between third and sixth month of lactation (Carlsson et al., 1995) and next to 300 days in milk (Hojman et al., 2004). In our study, the MU concentration peak was

preceded by the lactation peak for 60 days, whereas protein content has the lowest value at that time.

Milk urea concentration is lower in first lactation than in second or third. The greatest differences among first and latest lactations are at the beginning of lactation and the peak of MU concentration in first lactation occurs later than in following lactations. Second and third lactation have very similar values from beginning of lactation till peak of MU concentration; subsequent decrease in the second lactation is slower than in the third one.

Conclusions

The optimal submodel for modeling course of milk urea concentration during the lactation is the one with 4th order of Legendre polynomials. It will be used in future investigations of relationships between milk urea and reproduction performance in dairy cows.

The financial support from the project MZe 0002701402 is acknowledged.

References

Broderick, G.A. et Clayton, M.K. (1997): A statistical evaluation of animal and nutritional factors influencing concentrations of milk urea nitrogen. J.Dairy Sci., 80, 2964 – 2971.

Carlsson, J.; Bergstrom, J. et Pehrson, B. (1995): Variations with breed, age, season, yield, stage of lactation and herd in the concentration of urea in bulk milk and in individual cows milk. Acta vet. Scand., 36, 245 – 254.

De Peters, E.J. et Cant, J.P. (1992): Nutritional factors influencing the nitrogen composition of bovine milk: a review. J.Dairy Sci., 75, 1043 – 2070.

Eicher, R.; Bouchard, E. et Bigras-Poulin, M. (1999): Factors affecting milk urea nitrogen and protein concentrations in Quebec dairy cows. Prev. Vet. Med., 39, 53 – 63.

Ferguson, J.D.; thomsen, N.; Slesser, D. et Burris, D. (1997): Pensylvania DHIA milk urea testing. J. Dairy Sci., 80 (Suppl.1): 161.

Godden, S.M. et al. (2001): Factors associated with milk urea concentrations in Ontario dairy cows. J.Dairy Sci., 84, 107 – 114.

Hof, G.; Vervoorn, M.D.; Lenaers, J.P. et Tamminga, S. (1997): Milk urea nitrogen as a tool to monitor the protein nutrition of dairy cows. J. Dairy Sci., 80, 3333 – 3340.

Hojman, D. et al. (2004): Relationships between milk urea and production, nutrition, and fertility traits in Israeli dairy herds. J. Dairy Sci., 87, 1001 – 1011.

Johnson, R.G. et Young, A.J. (2003): The association between milk urea nitrogen and DHI production variables in western commercial dairy herds. J. Dairy Sci., 86, 3008 – 3015.

Jílek, F. at al. (2005): Differences in milk urea content in dependency on selected non-nutritive factors. 56th Annual Meeting of the European Association for Animal Production, Uppsala, Sweden.

Rajala-Schultz, P.J.; Saville, W.J.A.; Frazer, G.S. et Wittum, T.E. (2001): Association between milk urea nitrogen and fertility in Ohio dairy cows. J. Dairy Sci., 84, 482 – 489.

Shepers, A.J. et Meijer, R.G.M. (1998): Evaluation of the utilization of dietary nitrogen by dairy cows based on urea concentration in milk. J. Dairy Sci., 81, 579 – 584.

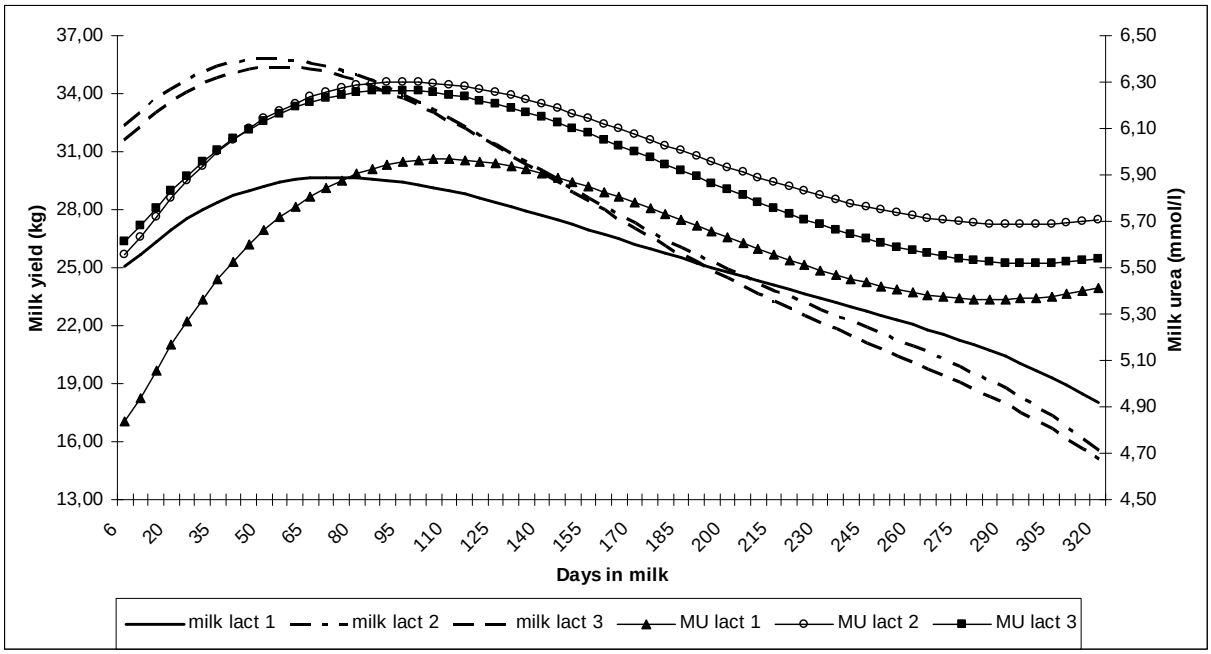
Spicer, L.J.; Francisco, C.C.; Jones, D. Et Waldner, D.N. (2000): Changes in milk urea nitrogen during early lactation in Holstein cows. 2000 Animal Science Research Report. 2000, 169 – 171.

Wood, G.M.; Boettcher, P.J.; Jamrozik, J.; Jansen, G.B. et Kelton, D.F. (2003): Estimation of genetic parameters for concentrations of milk urea nitrogen. J. Dairy Sci., 86, 2462 – 2469.

Table 1: Basic statistics of data – overall means and standard deviations (in parentheses)

Trait	First lactation	Second lactation	Later lactations
No of observations	7,830	4,334	4,497
Milk yield (kg)	26.01 (6.91)	28.26 (9.74)	27.82 (9.99)
Protein content (%)	3.36 (0.36)	3.37 (0.39)	3.33 (0.42)
Fat content (%)	4.18 (0.87)	4.13 (0.88)	4.22 (0.94)
Milk urea (mmol/l)	5.48 (1.92)	5.83 (2.34)	5.62 (2.13)

Figure 1: The course of milk production and milk urea concentration during the first, second and later lactations



Figures 2 to 5: Regression curves of milk urea concentration on days in milk using different order of Legendre polynomials and means of milk urea concentration in first, second and later lactations