Predicting bovine milk urea concentration for future test-day records in a management perspective

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Introduction Urea is the major contributor to nonprotein nitrogen fraction of milk which represents 5 to 6% of the total nitrogen in milk. Milk urea (MU) nitrogen is closely related to blood urea nitrogen which is derived from at least two sources: the liver detoxification of ammonia diffused from the rumen and the amino acid catabolism in the liver (Depeters and Ferguson, 1992). Thereby, MU concentration could reflect the protein metabolism in the cow and be related to the diet. Several studies showed significant links between MU concentration and nutritional variables (mostly dietary crude protein and energy:protein ratio) or environmental factors (e.g. season or stage of lactation) (Broderick and Clayton, 1997; Schepers and Meijer, 1998; Godden *et al.,* 2000). MU has proved to be an interesting management tool for breeders (Jonker *et al*., 2001). The aim of our research is to provide feed management tools to Walloon dairy farmers based on the detection of 'abnormal' values. To develop such a tool, MU concentrations need to be predicted for future test days. Given the nature of MU, this presents a special challenge and this study will show first results obtained when testing two different models.

Materials and methods Data used in this study were MU test-day concentrations measured by Mid-Infrared spectrometry and collected from January 1997 to June 2007. Only data from first lactation cows and from days in milk < 365 were used. Milk urea records <10mg/l and >2000mg/l were also deleted. Data set represented 1,749,257 test-day records from 223,969 cows. Data for 17,100 test-day records observed in June 2007 was considered unknown and use to test prediction ability. Pedigree data were extracted from the database of the official Walloon genetic evaluation. Prediction of future MU test-day results was made using two single-trait random regression test-day models. Both models included 4 fixed effects (overall mean, herd, month of test and stage of lactation combined with parity, breed and age at calving) and one random effect (herd test-day) and three random regression effects (herd by year of calving, permanent environment and genetic). Regression curves were modelled using Legendre polynomials of order two. The second model tested also included an autoregressive covariance structure for the herd test-day effect as described by Wade and Quaas (1993). It allowed to model correlations between successive test-day records. Covariances were obtained from 10 random samples using AI-REML (Misztal, 2007). Model fit for the two models were compared by studying distribution of residuals on data prior to June 2007. Accuracy of prediction for MU concentrations in June 2007 were studied by computing prediction errors (PE) for both models.

Results The average MU concentration for the dataset was 288.5 ± 100.9 mg/l. The (co)variance structure showed that the total variance was mainly explained by the residual (± 25% of total variance) and the herd test-day effects (± 50% of total variance). Base on these results, we can speculate that the influence of local events (e.g., diet related) have large implications on the predictability of successive urea records. Table 1 indicated that both models did not fit perfectly the data even if overall fit was equivalent. The average PE was positive with both models, indicating that MU concentrations were systematically underestimated. There was a large range of prediction error standard deviation. However, the second model limited the bias (10.7 instead of 14.3) and improved the accuracy of prediction (0.53 instead of 0.51).

Table 1 Adjustment and accuracy of prediction for the models tested

	Adjustement (1,732,157 records)		Accuracy of prediction (17,100 records)	
	Distribution of residuals	Correlation between observed and predicted MU	Distribution of PE	Correlation between observed and predicted MU
Model 1	0.0 ± 41.1	0.95	14.3± 87.4	0.51
Model 2	0.0 ± 41.1	0.95	10.7± 85.9	0.53

Conclusions and perspectives Our research identified some problems for the modelling and the prediction of milk urea concentration. Results demonstrated the interest of the autoregressive covariance structure. Further improvements are needed. Alternative ways to model seasonal trends or to take into account the residuals in a given herd could be necessary.

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