MILK UREA CONCENTRATION TO THE EVALUATION OF NITROGEN EFFICIENCY TRANSFORMATION ON DAIRY FARMS

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ABSTRACT

The aim of this study was to evaluate the effects of nutrition on the milk urea nitrogen (MUN) concentration; on the transformation of N in the farm's conditions; and there-by allow the milk urea nitrogen concentration to serve as a tool to maximize the protein nutrition and the metabolism of the cows. The relations evaluated by linear or multiple regression confirmed that the highest nutritional effects of the crude protein (CP) on the MUN concentration, which represented a 69.3 % variation in the MUN content. According to the CP content in the total mix ration (TMR) and MUN content (3150 milk samples) under farm conditions, a regression relationship was determined for the estimated of MUN ($\text{mg} \cdot \text{dl}^{-1}$) = $-13.2 + 0.16 \times \text{CP}$ ($\text{g} \cdot \text{kg}^{-1}$ dry matter). For multiple regression, the rate of variation expressed by this relationship increased to 72 for nutrient content and 78.3 % for nutrient intake in the TMR. The efficiency of nitrogen utilization (ENU) determined by calculations based on the MUN content according to the regression equations represented a negative correlation ($P < 0.0001$; $R^2 = 0.854$)

with respect to the CP content in the TMR and that the increased CP content by 1 % in the range of 14 to 18 % in the TMR decreased the ENU by 1.48 %. Validation of the models for prediction of nitrogen transformation (ENU) for practical application on the farms determined the best equation, which used the available data from the routine analysis of Breeding services of Slovakia. After taking into consideration of our breeding conditions, it was confirmed that the equation of ENU had taken into account the MUN, in addition to the amount of the milk produced.

Key words: milk urea nitrogen MUN; N utilization efficiency; protein nutrition

INTRODUCTION

Protein metabolism in ruminants is a complex process influenced by the fermentation of carbohydrates and the degradation and synthetic capacity of rumen microorganisms. The optimal content of nitrogen in the formulation

of daily ration presents such an amount of crude protein (CP) in the total mix ration (TMR) which on the one hand prevents production losses at the lower intake of CP, and on the other hand does not lead to metabolic load and losses of nitrogen in the urine when the content of CP in TMR increases. In dairy cows, the proteins supplied from the feed undergo five major metabolic transformations, which include:

1. degradation of feed proteins and microbial protein synthesis in the rumen,
2. enzymatic digestion and absorption of amino acids in the small intestine,
3. metabolic transformation in tissues, synthesis and secretion of milk proteins,
4. catabolism and excretion of unused proteins,
5. their metabolites being excreted in the faeces and urine [14].

The level of protein nutrition in farm conditions can be evaluated:

- a) by analysing the nutritional composition of TMR and assessing daily intake of nutrients. This requires an accurate assessment of the daily CP intake of the production group, which is in practice limited mainly due to inaccuracy in the prediction of dry matter intake [17];
- b) by monitoring the production parameters by evaluation of milk production and milk protein [8];
- c) by monitoring the metabolites (the concentration of urea in milk and/or blood) for evaluation of protein transformation [16].

A significant tool for the evaluation of protein nutrition is the determination of the efficiency of nitrogen utilization (ENU), defined as the ratio between the content of nitrogen excreted in the milk and the amount of nitrogen intake utilized as CP from the TMR. The ENU is influenced mainly by the protein concentration in the TMR and the content of the urea nitrogen in the milk [16]. Urea presents the final metabolite of nitrogen transformation of ammoniacal nitrogen absorbed from the rumen after degradation of feed proteins [22], as well as deamination products of the absorbed amino acids (aAA) not used in proteosynthesis, due to aAA imbalances or lack of energy [25]. Thus, transformed nitrogen compounds form a proportion of urea in the blood that has three metabolic pathways in dairy cows: (I) recycling of urea through saliva and through the rumen wall back into the rumen, which is an important source of nitrogen for the synthesis of microbial proteins;

(II) excretion of urea into milk;

(III) urea excretion which via the kidneys is the major route of excretion of excess nitrogen from metabolism into the urine [13].

Milk urea is mainly derived from blood urea, and a direct relation between milk urea and blood urea has been confirmed [2, 4]. The results of the measurements of the milk urea (MU) or milk urea nitrogen (MUN) provides valuable information on the nutritional status, the level of excretion of N, and is an ecological burden of the environment [16] and enables the evaluation of the efficiency of nitrogen utilization (ENU) from feed into milk protein [24]. Nitrogen, which is not transformed into milk protein, is metabolized in the tissues, where it presents metabolic load and also an ecological burden for the environment after excretion from the body.

The aim of our study was to analyse the relation of nutrition (nutrient concentration and daily nutrient intake in TMR) to MUN concentration under farm conditions and to evaluate the efficiency of metabolic transformation of nitrogen to milk protein and validation of models for ENU prediction.

MATERIALS AND METHODS

The evaluations were carried out in 30 herds with an average annual production of milk of between 8,500 and 9,500 kg per cow. For evaluations, we selected dairy cows in the first lactation phase according to days in milk (DIM; 21–130 DIM), or according to daily milk production. Feed rations of dairy cows were predominantly based on corn and alfalfa silage, supplemented with different carbohydrate's feeds (cereal grains and cereal grain by-products) and protein supplements (soybean meal and rapeseed meal) provided as TMR *ad libitum*. At the farms studied, the daily feed intake and nutritional composition of TMR were intensively monitored throughout the year and dairy cows of all of the farms were kept in a free-stall housing system.

Analysis of TMR

The samples of the prepared TMR on the farms were taken from the feed manger on the control day and were analysed for dry matter (DM), which consisted of: crude protein (CP), acid and neutral detergent fibre (ADF, NDF),

and starch and ether extract (EE) contents according to conventional methods [6]. DM was determined by weight upon drying the sample at 105 °C under the prescribed conditions. The CP content was determined by Kjeldahl method using a 2300 Kjeltec Analyser Unit (Foss Tecator AB, Hoganas, Sweden). Fat (as ether extract) was determined by the device Det-Gras (JP SELECTA, Spain). And ADF and NDF were determined using Dosi-Fiber Analyser (JP SELECTA, Spain) and the content of starch was determined by polarimetry. The net energy of lactation (NEL) was calculated using regression equations according to National Research Council (NRC) [17].

Analysis of production parameters

All farms were evaluated by the Breeding Services of the Slovak Republic on the control day of milk collection, in the framework of checking the performance of milk yield. Milk samples were analysed for the total protein content, fat, lactose, and urea concentration by a near-infrared spectrophotometric assay using MilkoScan FT⁺ and BENTLEY FTS at the Central Analytical Laboratory of Milk with accreditation under the registration number 096/5878/2015/2. The analysed urea in milk (MU) was converted to urea nitrogen in milk (MUN) using the MUN equation (mg.dl^{-1}) = MU (mg.dl^{-1}) $\times$ 0.4667 [19].

Statistical analysis

The average values, descriptive statistics, and variability of the examined markers, as well as the influence of factors on these properties, were studied using software XLSTAT2018. The evaluation of the regression equations for the determination of the ENU have consisted in the validation of models to the correctness and accuracy based on the mean bias [12] and the root mean square prediction error (RMSPE) [3] or residual error [12].

RESULTS

Nutrient content of rations, feed intake and milk production in groups of dairy cows

The average concentration of nutrients in TMR, daily intake of nutrients and the production parameters of dairy cows on the farms are presented in Table 1.

The average milk production was $35.4 \pm 6.4 \text{ kg.d}^{-1}$ (range 23.2 to 47.9), the content of milk protein was $3.15 \pm$

0.2% and milk fat was $3.62 \pm 0.4 \%$. The content of MU was $27.4 \pm 3.6 \text{ mg.dl}^{-1}$ and MUN $12.79 \pm 1.67 \text{ mg.dl}^{-1}$ (with ranges 19.74 to 35.7 and 9.21 to 16.64 respectively). Fluctuations of production parameters reflect the different content of nutrients and the composition of ration, genetic production potential, and the order of lactation. The parameters of milk production and composition of TMR showed significant differences in the chemical composition of nutrients against actual production and composition of the milk.

The relation of milk urea concentration to management of nutrition

A total of 30 TMRs were analysed and evaluated to confirm the dependence between the variable concentrations of nutrients in daily rations for the production groups and the MUN concentrations in 3150 individual milk samples of dairy cows. The analysed nutritional and production parameters (concentration or daily nutrient intake in TMR, milk production, and composition) were statistically processed to test in their relation as independent variables to MUN concentration as a dependent variable.

The relationships were evaluated by simple linear regression (Table 2) based on the determination coefficient (R^2) and the level of statistical significance (P). The independent variables that were statistically significant ($P < 0.05$) in models of simple linear regression were transferred to a model of multiple linear regression (Table 3) to identify the causes of variation of MUN concentration.

In single linear regression, the evaluation of the relation of the nutrient content in the TMR and the MUN confirmed the most statistically significant positive relationship ($P < 0.001$) between the average concentration of the MUN and the CP content ($R^2 = 0.693$). In contrast, the negative correlation was confirmed between the MUN concentration and the content of starch, NFC, and NEL ($P < 0.001$). The content of crude protein in the TMR was the best single marker for the MUN estimation on average for the production group and represented 69.3 % of the total variance determined by the regression relationship $\text{MUN (mg.dl}^{-1}\text{)} = -13.2 + 0.16 \times \text{content CP (g.kg}^{-1}\text{ DM; Fig. 1)}$. The nutrient intake confirmed the positive correlation between the CP intake and the concentration of MUN ($R^2 = 0.307$, $P < 0.001$) and negative correlation with the starch intake ($R^2 = 0.224$, $P < 0.01$) and NFC intake ($R^2 = 0.185$, $P < 0.05$).

Table 1. Nutritional composition of TMR, production and composition of the milk

	Average	SD	Minimum	Maximum
Nutrients in TMR [% DM]				
Crude protein	16.20	0.8	14.42	17.85
NEL	6.76	0.2	6.38	7.13
NDF	34.44	2.6	28.04	38.75
ADF	20.69	1.6	16.07	24.68
Starch	25.01	3.3	16.93	29.78
NFC	37.99	3.4	31.65	48.95
NEL/CP	0.42	0.03	0.37	0.48
Starch/CP	1.55	0.3	1.02	2.07
NFC/CP	2.35	0.3	1.89	3.17
Daily intake of nutrients [kg.day ⁻¹]				
Dry matter	22.35	1.3	20.76	24.90
CP intake	3.62	0.2	3.20	4.02
NEL intake	150.89	10.6	134.09	171.83
NDF intake	7.68	0.7	6.07	8.69
ADF intake	4.62	0.5	3.42	5.40
Starch intake	5.60	0.9	3.66	7.03
Production and composition of milk				
Milk yield [kg.d⁻¹]	35.40	6.5	23.20	47.90
Milk protein [%]	3.15	0.2	2.77	3.46
Milk fat [%]	3.62	0.4	2.95	4.55
Yield of milk protein [kg.d⁻¹]	1.11	0.2	0.77	1.46
Yield of milk fat [kg.d⁻¹]	1.26	0.20	1.00	1.67
Milk urea [mg.dl⁻¹]	27.40	3.58	19.74	35.66
Milk urea nitrogen [mg.dl⁻¹]	12.79	1.67	9.21	16.64

TMR—total mix ration; CP—crude protein; ADF—acid detergent fibre; NDF—neutral detergent fibre; NEL—net energy of lactation; NFC—non-fibre carbohydrate; SD—standard deviation

The independent variables from the single linear regression were added in the statistical evaluation into the multiple regression by the “stepwise method” at the significance level of $P < 0.05$ and eliminated variables at the significance level of $P > 0.1$. The accuracy of the model was evaluated by the adjusted R^2 , P -value, Akaike information criterion, and the root mean square error. The relation of the average of concentrations of the MUN of dairy cows in the production groups in multiple regression (Table 3) to

the nutrient concentration in the TMR confirmed a high correlation ($P < 0.0001$) to the CP and NDF with a 72.0 % level of variability on the concentration of the MUN.

The multiple regression confirmed the impact of the nutrient intake on the level of the average concentrations of the MUN, with a significant relation of the daily intake of the CP ($P < 0.0001$) on the MUN concentration and with a minor impact of the daily starch intake and dry matter intake of the TMR. Selected nutritional factors affected the

Table 2. Linear regression between MUN in milk and nutrients content of TMR, daily intake of nutrients, milk yield and composition

Items	Slope	SD	r	R ²	P
Concentration of nutrients in TMR [% DM]					
CP	1.600	0.201	0.832	0.693	< 0.0001
NEL	-3.223	1.329	0.417	0.174	0.022
NDF	0.181	0.105	0.310	0.096	0.096
Starch	-0.247	0.072	0.542	0.294	0.002
NFC	-0.233	0.072	0.649	0.273	0.003
Starch/CP	-4.208	0.816	0.698	0.487	< 0.0001
NFC/CP	-3.895	0.698	0.726	0.527	< 0.0001
NEL/CP	-44.05	6.119	0.806	0.649	< 0.0001
Daily intake of nutrients in TMR [kg.d⁻¹]					
Dry matter	-0.118	0.214	0.105	0.011	0.587
CP intake	3.791	1.076	0.554	0.307	0.001
NEL intake	-0.040	0.026	0.281	0.079	0.133
NDF intake	0.388	0.421	0.170	0.029	0.365
Starch intake	-0.786	0.276	0.473	0.224	0.008
NFC intake	-0.623	0.247	0.430	0.185	0.018

TMR—total mix ration; CP—crude protein; ADF—acid detergent fibre; NDF—neutral detergent fibre; NEL—net energy of lactation; NFC—non-fibre carbohydrate;

Table 3. Multiple regression of nutritional effect on MUN concentration

Concentration of nutrients in TMR [% DM]			
Items	Coefficient	SD	P
Intercept	-16.799	3.473	< 0.0001
CP	1.552	0.190	< 0.0001
NDF	0.216	0.099	0.038
Precision of the model			
Adjusted R ²	–	–	0.720
RMSE	–	–	0.803
AIC	–	–	-10.302
P	–	–	< 0.0001
Daily intake of nutrients [kg.day⁻¹]			
Intercept	5.171	2.425	0.043
CP intake	6.359	0.968	< 0.0001
Starch intake	-0.576	0.192	0.006
Dry matter intake	-0.548	0.205	0.013
Precision of the model			
Adjusted R ²	–	–	0.783
RMSE	–	–	0.707
AIC	–	–	-17.074
P	–	–	< 0.0001

TMR—total mix ration; CP—crude protein; NDF—neutral detergent fibre; AIC—Akaike information criterion; RMSE—root mean square error

concentration of the MUN at the level of 78.3 % in dairy cows. The statistical evaluation of the multiple regression confirmed more significant effects of the daily intake of nutrient on the variability of the MUN concentration compared to the content of nutrients in the TMR.

Evaluation of the efficiency of nitrogen utilization from feed to milk

The efficiency of nitrogen utilization (ENU) determined as a percentage of the nitrogen ingested that is transformed into milk protein (empiric model), that is calculated from the production of milk protein (yield of milk protein) and CP intake in the ration according to equation $ENU (\%) = [100 \times N \text{ milk} / N \text{ intake}]$ [7, 17]. In the farms, the estimated efficiency of utilization (Table 4) was determined on average at 30.1 ± 5.0 % with significant fluctuations in farm values with the range from 2" 1.1 % to 39.5 %.

The efficiency of the nitrogen utilization according to the MUN content for the production group of dairy cows was estimated by using the regression equations from meta-analytical assessments of the balance experiments [15, 24] or

in combination with the amount of milk produced [11]. Thus, the calculated ENU according to individual authors (Table 4) gives a lower range of value fluctuation of the mean and in relation to the CP content in the TMR the higher negative correlation was confirmed.

The dynamics of the ENU changes, calculated from the analysed MUN content, expressed as the average value of regression equations of selected authors in farms (Fig. 1), shows a negative correlation ($P < 0.0001$; $R^2 = 0.729$) in relation to the CP content in the TMR, where a 1 % increase in the CP in the range of 14 to 18 % in the TMR, reduces the efficiency of the use of nitrogen from feed to milk by 1.48 %.

The ENU determined by the transformation of N to milk protein (empiric model) in relation to the CP content of the TMR is expressed by the equation $ENU \% = 90.5 - 3.73 \text{ CP \%}$ confirmed a negative correlation ($R^2 = 0.350$; $P = 0.001$), where a 1 % increase in the CP in the range of 14 to 18 % in the TMR, reduces the efficiency of the use of nitrogen from feed to milk by 3.73 %.

Table 4. Predicted efficiency of N utilization (ENU) in relation to CP content in TMR

Author	ENU [%]	Range	R ²	P
N Milk/N Intake	30.1 ± 5.0	21.1—39.5	0.350	0.001
Nousianen et al., 2004 [16]	28.7 ± 1.1	26.0—31.2	0.693	< 0.0001
Huhtanen et al., 2015 [11]	30.6 ± 1.8	26.7—33.2	0.363	0.0004
Wattiaux, Ranathunga, 2016 [24]	28.2 ± 1.9	23.6—32.5	0.666	< 0.0001
Average (1—2—3)	29.2 ± 1.4	26.0—32.1	0.729	< 0.0001

TMR—total mix ration; ENU—efficiency of nitrogen utilization

Regression calculated from the evaluated data:

$ENU \% = 90.5 - 3.73 \times CP \%$; $R^2 = 0.350$; $P = 0.001$

$ENU \% = 53.217 - 1.4823 \times CP \%$; $R^2 = 0.729$; $P < 0.0001$

Regression equations by authors:

Nousianen et. al. [16]:

$ENU \% = -0.73 \times MUN + 38$

Huhtanen et al. [11]:

$ENU \% = 23.8 + 0.7 \times MY - 0.0064 \times MY2 - 0.27 \times MUN - 0.01 \times BW$

Wattiaux, Ranathunga [24]:

$ENU \% = 44 - 1.24 \times MUN$

Fig. 1. Effect of CP content on MUN concentration and efficiency of N utilization

Table 5. Validation models for predicting the ENU according to the MUN content compared to the calculation by the empirical model

	Model A Huhtanen et al. [16]	Model B Nousiainen et al. [11]	Model C Wattiaux, Ranathunga [24]
ENU % by Empiric model	30.15 ± 5.0	30.15 ± 5.0	30.15 ± 5.0
ENU % by Equation by MUN	30.63 ± 1.8	28.74 ± 1.1	28.23 ± 1.9
Mean bias	0.48	-1.41	-1.92
Residual error	3.39	4.52	4.47
RMSPE	3.43	4.73	4.87
Regression of bias against empirical model for the ENU evaluation			
R ²	0.976	0.976	0.923
Slope (probability) ^a	-0.678 (P < 0.0001)	-0.9029 (P < 0.0001)	-0.848 (P < 0.0001)

A—coefficient of determination and statistical probability of existence of slope coefficient (F test); RMSPE—root mean square predictive error

Validation of models for determining efficiency of nitrogen utilization

Selected models of the regression equations to determine the ENU based on the MUN content were validated for accuracy and precision compared to the empirical model of the ENU according to the metabolic transformation of nitrogen (N milk/N intake). The results are summarized in Table 5. The precision of the model was evaluated by residual error (RE) and root mean square predictive error (RMSPE). By evaluation of the regression of the individual values of bias in the models, was confirmed with the negative linear relationships with coefficients of the slope at the statistical significance level of $P < 0.0001$ (Table 5).

The determination of accuracy in our studies were assessed by the mean bias [12] as the mean value of bias between values of the ENU estimated from the models of the equation according to the MUN and the values of the ENU empirical model according to metabolic transformation N (N milk/N intake). Using the appropriate parameters to determine accuracy and precision, model A was the most accurate to predict the ENU in breeding conditions compared to models B and C. The observed differences were based on the fact that model A, in the calculation of the ENU values took into account, in addition to the urea nitrogen in the milk, also, the amount of produced milk whereas B and C only took the content of the MUN. According to these parameters of precision and accuracy of model A, using a regression relationship [11] was best suited to predict the ENU in breeding conditions and was a good way to evaluate programs of nutrition to maximize the efficiency of nitrogen utilization from feed to milk.

DISCUSSION

Urea nitrogen in milk (MUN), is commonly used to monitor feeding programs and control the nitrogen load on the environment [1]. At the feeding trials, where the TMR contained corn and alfalfa silage, average the milk production of 35.4 ± 6.6 kg per day in high producing dairy cows in the first lactation phase we analysed the concentrations MUN as an average of 12.8 ± 1.7 mg. dl⁻¹ on a large number of farms (30/3150) with the CP content (16.2 ± 0.8 %), starch content (25.1 ± 3.3 %) and NEL (6.76 ± 0.2 MJ). At comparable nutritional and production parameters the published values from the meta-anal-

ysis [23] confirmed the MUN content of 13.1 ± 3.6 mg.dl⁻¹ for North America.

In north-western Europe, the MUN content achieved an average value of 12.5 ± 5.1 mg.dl⁻¹, at lower production (25.5 ± 4.5 kg) and at half the starch content (13.2 ± 8.4 %). The MUN level ranging from 8 to 12 mg.dl⁻¹, indicate optimal intake and utilization of nitrogen from the feed ration [16, 23]. Levels of MUN above 12 mg.dl⁻¹ indicate an increased loss of ingested nitrogen, excreted in the urine in the form of urea urinary nitrogen. For high producing dairy cows with an annual milk yield of 12,000 kg, the recommended MUN is an average value of above 14.5 mg.dl⁻¹ [13] or more precisely from 10 to 16 mg.dl⁻¹ [24].

The observations confirm that the content of the CP in the TMR is the most important nutritional factor affecting the concentration of MUN, which is closely associated with the excretion of nitrogen in urine and can be applied in commercial herds as a biomarker of protein nutrition in dairy cows [16]. The higher level of regression dependence between the concentration of MUN and CP content was confirmed in experimental conditions with the coefficient of determination in the range of $R^2 = 0.78$ [16] and 0.84 [4] than our analysis ($R^2 = 0.69$ [3]. Evaluation of the analysed nutritional relations in farming conditions by the multiple regression method, together with the content of the CP, confirmed the influence of the energy concentration (NEL) and the NDF ($R^2 = 0.720$) with minority proportion on the increase of the coefficient of determination and variations in the concentration of the MUN. The same tendencies with comparable results in experimental conditions in the evaluation of nutritional influences were confirmed by N o s i a i n e n [15], where the expressed CP/ME ratio on fluctuations of the MUN was most affected by different CP contents ($R^2 = 0.876$) in the feed ration.

The efficiency of N conversion from feed into milk protein ranges from 25 to 35 % in dairy cows and is mainly influenced by the content of the CP in feed and level of milk production [10]. The observed ENU in the farms showed proximity according to the evaluation method at the level of values of the mean, but a different range of fluctuations of individual values for some of the farms. Studies by some authors [9, 10, 21] found the ENU under commercial conditions at the level of 28 %, with a fluctuation between 18 % and 35 %. Also, a study by P a c h e c o [20] reported the average value of ENU at the level of 29 % with a range of fluctuations from 19 to 40 % between farms, which are

values comparable to our results obtained from calculation according to the metabolic conversion.

By calculation of ENU, according to analysed content of the MUN, there was observed a decrease in ENU by 1.48 % when the content of the CP in the TMR increased by about 1 %, which was a lower decrease as compared to the value of 1.86 % determined by Olmos Colmenero, Broderick [18], or 1.76 % determined by Broderick [5]. On the other hand, the ENU determined according to a nitrogen metabolic transformation evaluation (N milk/N intake) confirmed a negative correlation ($R^2 = 0.350$, $P = 0.001$), with a decrease efficiency of N utilization of 3.72 % at the increase of the CP content in the TMR by 1 %. The regression relationship, expressed by equation $y = -0.372x + 90.5$, at the values of the CP below 15 % in DM TMR, overestimates the ENU and at the values over 17 % of the CP underestimates the ENU, compared to the biologically accepted efficiency of nitrogen transformation from feed to milk [10]. The performed evaluations of efficiency according to metabolic transformation (empiric model) obtained from production records of the farms are loaded by the degree of inaccuracy of the evaluation of dry matter intake.

CONCLUSIONS

The highest nutritional effect on the urea nitrogen content in milk (MUN) has the CP concentrations in the TMR (with a coefficient of determination $R^2 = 0.693$), where an increase in the CP content by 1% resulted in an increase in the MUN by 1.6 mg.dl⁻¹. The efficiency of nitrogen utilization (ENU) from feed to milk, determined by the balance method, expressed as a percentage of nitrogen intake, varied from 21.1 to 39.5 with a decrease in N utilization efficiency of 3.72 % while increasing the content of the CP in the TMR by 1 %. The efficiency of nitrogen utilization calculated according to the MUN content using regression equations gives on average ENU 28.2—30.6 % with a decrease in the ENU by 1.48 % with an increase in the content of the CP in the TMR by 1 %. The validation of ENU models from the MUN concentration under farm conditions confirmed the ENU as the most accurate regression equation for determining the ENU (%) = $23.8 + 0.7 \times MY - 0.0064 \times MY^2 - 0.27 \times MUN - 0.01 \times BW$. The evaluation of milk urea nitrogen at the farm level provides the possibility

to adjust the content and proportion of proteins and carbohydrates in the feed ration to optimize the protein needs of lactating dairy cows, increasing the efficiency of nitrogen transformation from feed to milk and reduces the excretion of nitrogen in urine as a tool to reduce environmental degradation.

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