MILK UREA CONTENT AS INDICATOR FEED PROTEIN UTILIZATION AND ENVIRONMENTAL POLLUTION IN FARMS

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Abstract
Advances in milk production and the expansion of dairy herds have increased the need for improved manure management and whole farm nutrient balance. It is well known in dairy management that the balanced feeding and holding technology is an important level by which milk production and milk composition can be modified. The objective of this study was to evaluate urea content and urea yield in different farms with different holding technologies. Four farms represent three cow breeds (Holstein Black and White, Latvian Brown, and cross breed XP). Individual cow milk samples (n=2740) were collected monthly from September 2009 to November 2010. Milk samples were analyzed for total protein, casein, fat, lactose, and urea content with instrumental infrared spectroscopy method. The average milk yield per cows in farms was significantly different (from 27.9 to 17.0 kg per control day). The urea content in cow milk was between 20.3 to 46.6 mg dL^{-1}. The average urea content in farms A, B and D was up to standard (from 15.0 to 30.0 mg dL^{-1}). In the farm C, average urea content ranged between 17.4 and 79.9 mg dL^{-1}, which indicated problems in feeding or management in the farm. It was established that milk urea content and yield significantly ($p<0.05$) varied in farms with different dairy cow holding and feeding technologies. Urea content can be used to evaluate feed protein utilization in farms and predict environmental pollution.
Key words: dairy cow, milk yield, urea content and urea yield.

Introduction

Urea is a small organic molecule composed of carbon, nitrogen, oxygen, and hydrogen. Urea is a common constituent of blood and other body fluids. Urea is formed from ammonia in the kidney and liver. Ammonia is produced by the breakdown of protein during tissue metabolism. Ammonia is very toxic. The conversion of ammonia to urea, primarily in the liver, prevents ammonia toxicity. Urea is then excreted from the body in urine.

Urea is therefore a normal constituent of milk and comprises part of the nonprotein nitrogen fraction. Although opinions do vary to some extent, milk urea levels between 20 and 30 mg dL^{-1} are generally considered as normal for cow's milk. Urea accounts for roughly 50% of the non-protein nitrogen fraction in herd bulk milk of dairy cows, although this may vary from 35 to 65%. For milk from individual cows, this variation may be even larger (Bijgaart, 2003). The urea content may be used to monitor nutritional status of lactating dairy cows and improve dairy herd nutrition.

Urea in milk has proven to be an easily measurable indicator for protein metabolism efficiency in dairy cattle. The obtained figures can help to identify and correct imbalances in the protein/energy ratio in the diet, sub-optimal feed nitrogen utilization, the potential for reducing ammonia emissions from dairy farms, and fertility problems.

The variation in milk urea concentrations between herds and between cows indicates a wide variation in protein, energy and water intake within dairy cows and herds. If the milk urea content is outside of normal concentration it would suggest problems with the feeding program. Urea concentration in milk may provide an opportunity to look at problems with the feeding and system within farm.

In several countries, essential legislation is for to limit the mineral surplus in animal production. That development forces the farmer to evaluate thoroughly the mineral flows on their farms and in the animals. The main tools for them to avoid mineral, and in cattle especially nitrogen, losses are: reduce the amount of artificial fertilizer, decrease the ammonia emission from the stable, and fine - tune the balance between the protein and energy in take by the cows (BANR, 2001).

For monitoring the last aspect, representative and easily measurable parameters are of great practical value for the farmer. Urea excretion has the potential to serve as a biological tool to monitor nitrogen losses in dairy cows. From 50 to 70% of the nitrogen which is not retained by the cow or used for milk synthesis is excreted in the urine, and the remainder is lost via faeces. The correlation between total urea extraction in urine with the urea content in blood or milk has been 0.88 and 0.77, respectively (Hof et al., 1997).

In order to protect water quality across Europe by preventing nitrates from agricultural sources polluting ground and surface waters, the Nitrates Directive was implemented in the European Union in 1991 Council Directive 91/676/EEC. This directive has put firm ceilings to fertilizer and manure application and rate of N emissions to the environment. Specialization, fertilizer nitrogen (N) applications to grasslands, purchase of concentrate feed and improvement of the management and genetic potentials of the herd have played dominant roles in the intensification of

ruminant production that is increasing the output of milk per farm. High inputs of N fertilizers and protein-rich feeds contribute to allow high production levels, but most of the N ingested is not retained in milk but excreted again in urine and faeces (Dijkstra et al., 2011).

The objective of this study was to evaluate feed protein utilization in farms and predict environmental pollution used urea content and urea yield in different farms with different holding technologies.

Materials and Methods

In the study, individual cow milk samples (n=2740) were collected monthly from four dairy farms (Farm A, B, C, and D) from September 2009 to November 2010. Dairy herds represent three breeds: Holstein Black and White (HB), Latvian Brown (LB), and cross breed XP (cross breed from HB and LB).

Dairy farms were with different number of animals in herds, and with different milking and holding technologies. Farms A and C had a small (n=113 and n=119 accordingly) number of animals and the traditional holding technology in the pasture-based seasonal dairying system. In these farms cows were managed in one feeding group. Whereas farms B and D were big farms (n=1829 and n=679 accordingly) with a balanced feeding and total mixed ration in all years without pasture period. Management in these farms was organized in feeding groups according to lactation stage. Milking frequency was two times per day. The herds were under official performance and pedigree recording.

The monthly control milk samples were analyzed for urea content. Parameter was analyzed in accredited milk quality laboratory SIA 'Piensaimnieku Laboratorija' with accredited instrumental infrared spectroscopy method.

Data regarding breed of cows and date of milk analysis were available from monthly records of the herds from state agency "Agricultural Data Centre" program.

Control day was grouped into four seasons: winter (W) – (December, January, February, n= 601), spring (Sp) – (March, April, May, n=745), summer (S) – (June, July, August, n=693), and autumn (A) – (September, October, November, n=701). Milk urea content unit (mg dL^{-1}) was transformed to % (FOSS, 2005), and afterwards the urea yield (g) in control day was calculated according to International Committee For Animal Recording (ICAR) guidelines (ICAR, 2011).

The statistical analyses were performed using SPSS program package and Microsoft Excel for Windows.

The obtained data were analyzed using descriptive statistics and Pearson correlation analysis. The significance of the differences between the samples was assessed using ANOVA.

Results and Discussion

The study results were analyzed separately for each farm to evaluate cow milk yield, urea content, and urea yield in milk in the different farms (Table 1).

Average milk yield per cow (from 27.9 to 17.0 kg per control day) in farms significantly differed. The significantly lowest milk yield was in farm C. The highest milk yield was in farm D with several breeds' cows, from which HM breed cows predominated and management in this farm was organized in feeding groups according to lactation stage.

The urea content and urea yield per cow in control day in farms varied (20.3 to 46.6 mg dL^{-1}, and 5.1 to 8.2 g) and was statistical significantly difference. The average urea content and urea yield in farm C

Table 1

Average milk yield, urea content, and urea yield in milk per cow in control day during the research

Farms	Traits	$\bar{x} \pm s_{\bar{x}}$	Minimum	Maximum
A	Milk yield, kg	25.2±6.05[a]	9.0	36.8
	Urea content, mg dL^{-1}	20.3±6.76[a]	2.4	37.1
	Urea yield, g	5.1±2.10[a]	0.7	10.0
B	Milk yield, kg	23.7±6.84[b]	5.3	53.7
	Urea content, mg dL^{-1}	27.2±8.42[b]	5.2	56.7
	Urea yield, g	6.4±2.70[b]	1.1	20.4
C	Milk yield, kg	17.0±5.72[c]	6.2	28.8
	Urea content, mg dL^{-1}	46.6±15.78[c]	17.4	79.9
	Urea yield, g	8.2±4.63[c]	1.7	21.9
D	Milk yield, kg	27.9±9.49[d]	3.8	61.1
	Urea content, mg dL^{-1}	26.8±5.48[b]	12.0	44.5
	Urea yield, g	7.4±2.76[d]	0.6	19.0

[a; b; c; d] – traits with unequal letter differed significantly between the farms ($p<0.05$).

were significantly higher (46.6 mg dL^{-1} and 8.2 g accordingly) than in other farms, which indicates problems in cow feeding balance and management. Also Lithuanian researchers (Savickis et al., 2010) have established influence of a farm on the contents of to urea. Farm C had LB breed cows, and management in this farm was organized in one feeding group.

The next in study were established that from seasons and farms had influence urea content in milk (Table 2).

The average urea content and urea yield were higher and significantly different in farm C in summer month. The lowest urea content and yield were in farm A in winter month. A significant difference was established between all farms and between all seasons. In the farm D, urea yield was highest in winter and lowest in autumn. In farms A and C, urea yield was significant high and did not differ between spring and summer. But in farm D, the urea yield decreased and did not differ among the spring, summer and autumn months. The results of this study confirm results of previous researchers (Meijier et al., 1996; Savickis et al., 2010) that milk urea content differ between the periods of sampling and individual cows.

To evaluate relation between cow milk yield and urea content and urea yield, the correlation was estimated in all farms (Fig.1).

Overall, in different farms the correlation between milk yield and milk urea yield was significantly high or very high. A closely positive significant correlation (0.830) was in farm D. Correlation between milk yield and milk urea content in farms B and D was significantly negative low (-0.075 and -0.125 accordingly), but in farms A and C a low positive correlation was observed. In farm C was significant low positive correlation (0.244).

Control day milk yield influenced urea content and urea yield in milk and was different between the farms (Fig. 2 and Fig. 3).

Table 2

Average urea content and yield in milk per cow in control day at different seasons

Farms	Traits	Seasons			
		W	Sp	S	A
A	Urea content, mg dL^{-1}	$13.3\pm1.28^{a,A}$	$19.2\pm1.01^{b,A}$	$22.6\pm1.03^{c,A}$	$23.9\pm1.04^{c,A}$
	Urea yield, g	$3.2\pm0.42^{a,A}$	$5.4\pm0.33^{b,A}$	$6.0\pm0.34^{b,A}$	$5.2\pm0.36^{b,A}$
B	Urea content, mg dL^{-1}	$19.6\pm0.35^{a,B}$	$30.1\pm0.31^{b,B}$	$31.8\pm0.36^{c,B}$	$26.2\pm0.34^{d,A,C}$
	Urea yield, g	$5.1\pm0.12^{a,B}$	$8.1\pm0.11^{b,B}$	$7.0\pm0.11^{c,B}$	$5.0\pm0.11^{a,A}$
C	Urea content, mg dL^{-1}	$38.1\pm3.11^{a,C}$	$49.0\pm2.76^{b,C}$	$55.3\pm2.58^{b,C}$	$42.3\pm2.40^{b,a,B}$
	Urea yield, g	$5.6\pm0.89^{a,B}$	$9.6\pm0.79^{b,C}$	$10.7\pm0.74^{b,C}$	$6.4\pm0.69^{a,A,B}$
D	Urea content, mg dL^{-1}	$25.7\pm0.4^{a,D}$	$25.0\pm0.39^{a,D}$	$29.3\pm0.42^{b,D}$	$27.2\pm0.38^{c,C}$
	Urea yield, g	$8.4\pm0.22^{a,C}$	$7.2\pm0.20^{b,D}$	$7.4\pm0.22^{b,B}$	$6.8\pm0.20^{b,c,B}$

$^{a; b; c; d}$ milk urea content and urea yield with unequal letter differed significantly between seasons ($p<0.05$);
$^{A; B; C; D}$ milk urea content and urea yield with unequal letter differed significantly between farms ($p<0.05$).

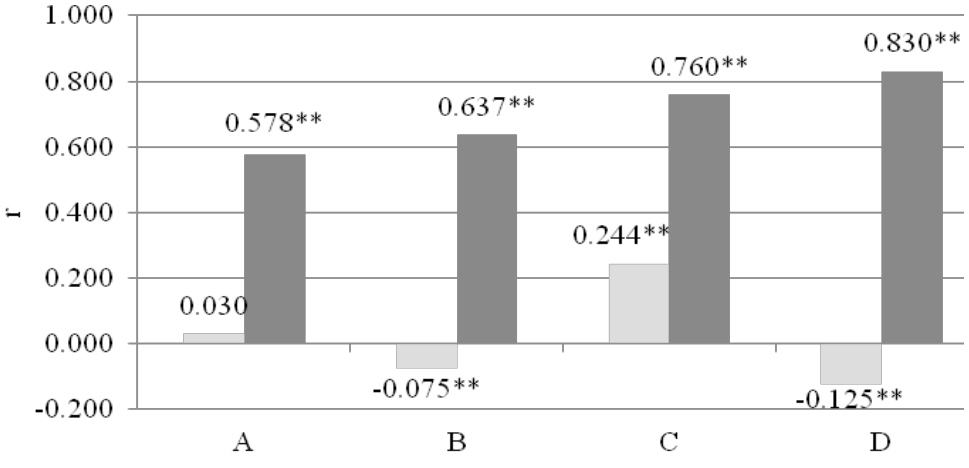

Figure 1. Correlation between cow milk urea content, yield and milk yield in farms (**$p<0.01$):

Urea content in farms B and D was similar with no significant differences between milk yield levels, whereas in farm C it was significantly higher and increased with increase in milk yield. Farm A had the lowest urea content in milk in all milk yield levels. The results of our study confirm previous researchers (Oltner et al., 1985) that milk urea content increase than increase milk yield.

Milk urea yield differed between farms and between milk yield levels (Fig.3). Our study demonstrated that milk urea yield increased with increase in milk yield. In farms B and D urea yield were similar which can suggests a good balanced feeding management according to the lactation stage in farms. Whereas in farm C, average urea yield was higher than in other farms, indicating problems with the feeding balance and management. Also German researchers (Spiekers and Obermaier, 2012) have established influence of the milk yield level on urea content in cow milk.

Many researchers (Jonker et al., 2001; Dijkstra et al., 2011; Gruber and Poetsch, 2012) indicate usability of milk urea content in practice to control protein utilization in farm.

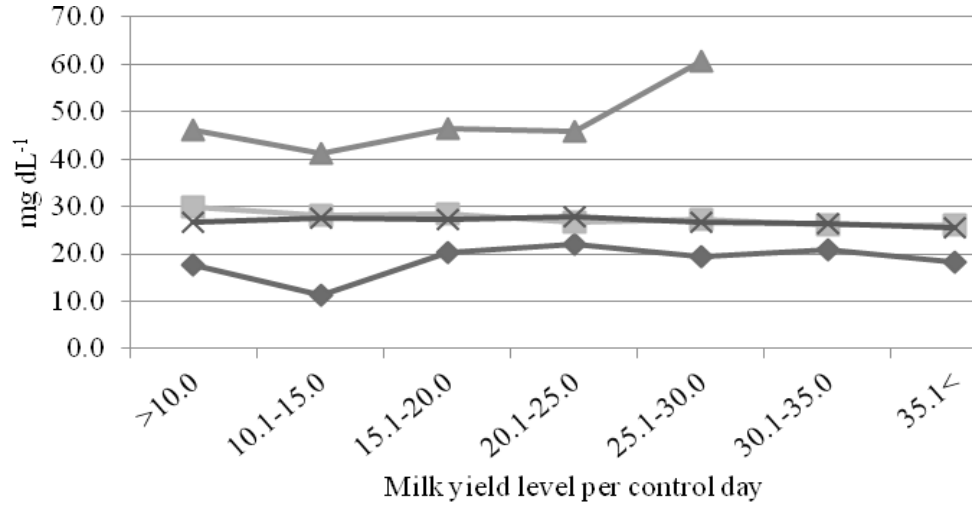

Figure 2. Urea content depending on the level of control day milk yield per cow:

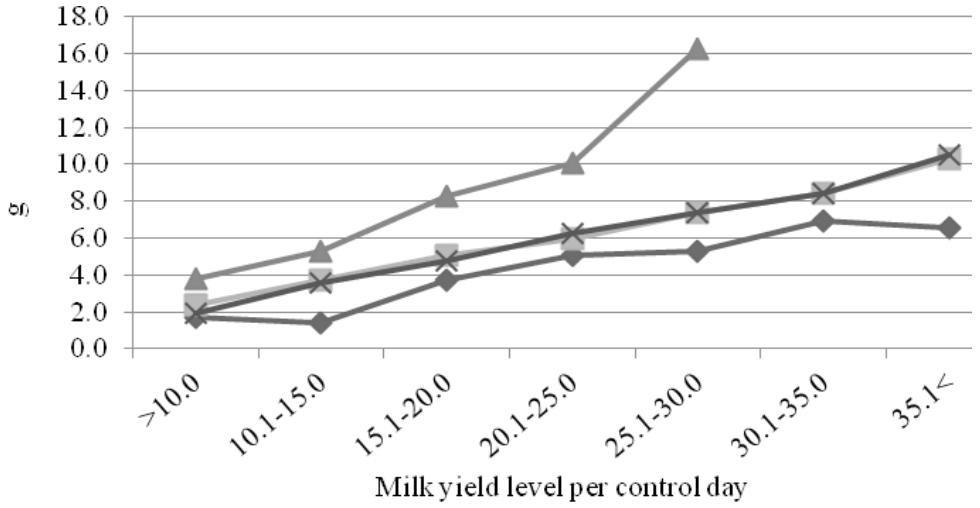

Figure 3. Urea yield depending on the level of control day milk yield per cow:

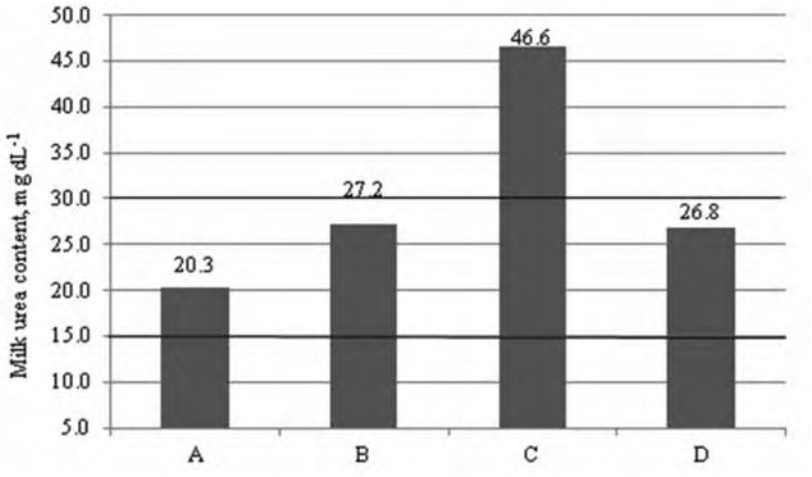

Figure 4. Milk urea content per control day in farms.

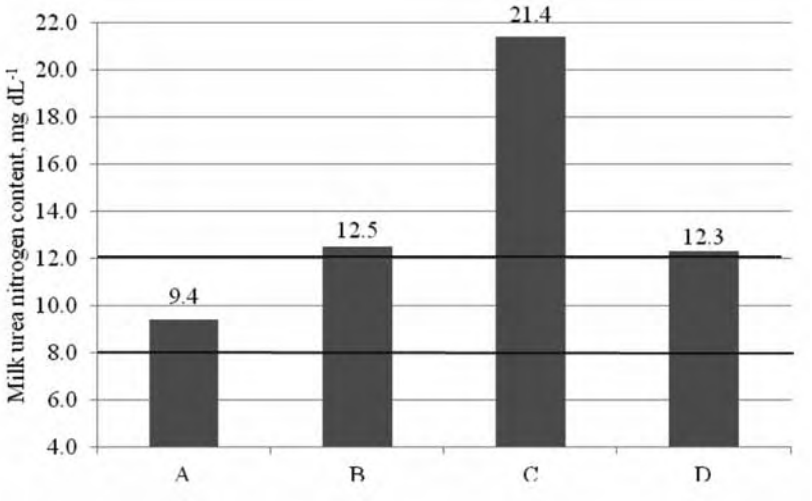

Figure 5. Milk urea nitrogen content per control day in farms.

Researchers from Europe (Bijgaart, 2003) confirm that normal milk urea content in milk is from 15.0 to 30.0 mg dL^{-1}. In our study, milk urea content differed among the farms. Farm C were urea content in milk significantly highest than recommended. The measurements of milk urea content could be used to assess the adequacy of protein feeding in dairy cows and the efficiency of N utilization for milk production (Jonker et al., 1998; 2002; Nousiainen et al., 2004). The value of 20.8 mg 100 mL^{-1} milk urea content has turned out to correspond to an optimal crude protein content of the ration, i.e., a ruminal N balance of zero. The statistical evaluation of the official milk recording and breeding organisation in Austria indicates that the average milk urea content is around 20 – 22 mg 100 mL^{-1} in the relevant milk yield classes (3000 – 7000 kg milk) (Gruber and Poetsch, 2012).

Researchers from United States use milk urea nitrogen (MUN) content for evaluation of the utilization of feed protein (Depeters et al., 1992). Milk urea nitrogen content makes 46% from the milk urea content (Spiekers and Obermaier, 2012). We estimate milk urea nitrogen content for our study results following the principles (Fig. 5).

In the United States, normal MUN content in milk is from 8.0 to 12.0 mg dL^{-1}. In our study, farm A had the recommended MUN content, which suggests a good feed protein utilization in the farm. Farms B and D had a similar MUN content, which was higher than the normal content, whereas farm C had a two times higher MUN content than the norm, which indicates the problem with farm feeding or management technology. The MUN content used for evaluation of nitrogen utilization is more sensitive than urea content.

The results of our study approval monitoring nitrogen utilization in the farms urea content are useful to indicate problem with feeding management and potential nitrogen loses.

Conclusions

1. It was established that milk urea content and yield significantly ($p<0.05$) varied in farms with different

dairy cow holding and feeding technologies and in different seasons.
2. In farms A, B, and D, milk urea content was not higher than the allowable level (from 15.0 to 30.0 mg dL^{-1}) which suggests balanced feeding or good management in the farm.
3. The evaluation between milk yield with milk urea content and yield were significant from low negative (r= -0.125) to high positive (r=0.830) was established.
4. The milk urea content significantly ($p<0.05$) varied for cows with different milk yield per day. The cow with the highest milk yield had the highest milk urea content.

Acknowledgements

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