# INTERRELATIONS BETWEEN THE MILK UREA CONCENTRATION AND PRODUCTION AND REPRODUCTION PERFORMANCE OF DAIRY COWS

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**Abstract**
The objective of the study was to investigate the correlation between the milk urea (MU), milk yield and reproductive performance using milk recording tests and the health check results. Weak to average negative correlation was found between MU and the milk yield ($r = -0.44$ and $r = -0.34$; $p>0.05$), milk protein ($r = -0.22$; $p<0.05$) and milk freezing point ($r = -0.33$; $p<0.01$). Higher milk fat was found in cow milk with MU below 30 mg $dL^{-1}$ in comparison with cow milk which had MU above 30 mg $dL^{-1}$, $4.0 \pm 0.77\%$ and $3.9 \pm 0.75\%$, respectively. High MU fluctuations within a cow group can be observed if cows of different productivity levels are grouped together or if there are too many animals in one group. Correlations between MU and times of artificial insemination or the service period were not established, possibly due to successful veterinary measures. In conclusion we emphasize the necessity on large dairy farms to analyse MU concentration in relation to milk protein and fat concentration for individual animals and in each feeding group separately. The study was the part of the State Research Project (*AgroBioRes*) No. 2014.10-4/VPP-7/5; subproject VP29.
**Key words:** cow, productivity, milk urea, freezing point.

## Introduction

With increasing productivity of dairy cows special attention should be paid to properly balanced feeding so, that achieving of a high milk yield would also allow to avoid diseases and promote longevity of cows. In large-scale dairy operations, frequent re-grouping and feeding of cows in line both with their productivity and the physiological period, each time ensuring a different energy and protein level sometimes can be highly cumbersome. One of the feeding quality testing methods is evaluation of the chemical milk ingredients: fat and protein levels, their interrelations, as well as the urea concentration assay. Milk urea (MU) or milk urea nitrogen (MUN) can be established in the laboratory. In Latvia, MU is tested at Dairy Laboratory Ltd; its optimum level in milk is prescribed at 12 − 16 mg $dL^{-1}$ (Young, 2001), 15 − 30 mg $dL^{-1}$ (Bijgaart, 2003), or 20 − 30 mg $dL^{-1}$ (Noordhuizen, 2012).

Urea is a decomposition side-product of amino acids or nitrogen substances ($NH_3$): a substance of low molecular weight that is formed in liver and distributed with blood stream over the whole body system reaching the uterus cavity, ovarian follicular fluid, as well as secreted with milk and urine (Hammon, Holyoak, & Dhiman, 2005; Latimer, Mahaffey, & Prasse, 2003). MU describes the amount of rumen protein and its balance with highly digestible carbohydrates. This indicator and its compensation is easily influenced also by the quality of feed materials, the nitrogen amount they contain, rumen-degradable protein (Noordhuizen, 2012; Godden, Lissemore, & Kelton, 1984), as well as the dry matter content of the feed ingested (Husband & Vecqueray, 2012) and genetic traits (Rzewuska & Strabel, 2015). An excess urea level in cow's organism has an adverse impact on reproductive performance (Nourozi *et al.*, 2010; Butler, 2005; Melendez, Donovan, & Hernandez, 2000) and the body condition score (Kessell, 2015). It has been established that at low milk protein concentration related to elevated or lowered MU concentration, cows would have silent heats, breeding problems and early embryonic mortality (Noordhuizen, 2012).

Freezing point of milk is one of the milk quality indicators. Despite the fact that the milk composition is subject to certain fluctuations within the physiological range, this parameter is relatively constant and its physiological boundaries are set between − 0.468 and − 0.531 °C (Buchberger, 2000) or between − 0.527 °C and − 0.535 °C (Jonkus *et al.*, 2008). In Latvia Dairy Laboratory Ltd. according to the European Cooperation for Accreditation has prescribed that the freezing point of milk should not be higher than − 0.520 °C. This parameter is actually fixed for practical purposes to enable the detection of water in milk as the latter is known to materially decrease the value of this temperature approximating it to zero degrees. Freezing point of milk could be influenced by the particular breed of the cows, lactation period, feeding, geographic area where the cows are located, season of the year, as well as the composition of milk (Ruska, 2014; Kedzierska-Matysek *et al.*, 2011; Hanuš *et al.*, 2011; Jonkus *et al.*, 2008). The cows with a higher urea level in milk have also a higher freezing point of milk which is explained by higher milk protein concentration (Kedzierska-Matysek *et al.*, 2011; Hanuš *et al.*, 2011). Other authors in their turn (Jonkus *et al.*, 2008) draw a conclusion that neither MU nor milk yield has any impact on freezing temperature of milk nor these factors have any correlation.

The aim of the study was to investigate the correlation between the MU and the milk yield and reproductive performance using milk recording tests obtainable in the herd health check visits on productive dairy farms.

**Materials and Methods**

The study was performed on the basis of the milk recording data and herd health visit results on two dairy farms: X and Y. The correlation between the MU and the milk yield and reproductive performance was analysed for cows in early lactation period in the herd X, but in the herd Y only MU and productivity interrelations were evaluated.

The milk yield in the herd X was 8500 kg per cow in a year, but in the herd Y it was 8000 kg per cow in a year. On both farms, cows were kept in free stall barns and fed with the total mixed ration (TMR) calculated with software. On both farms, TMR consisted of grass silage, rape cakes, wheat grain and mineral additives. The cows were grouped according to their physiological period. On farm X with 350 lactating cows, data analysis was carried out for early lactating cow group from December of 2014 to December of 2015. The overall number of lactating cows in this group was 123 ± 4 cows each month despite the fact that 70 cows were planned in project sites. Within the study, quantitative, qualitative and biochemical data of milk were analysed: milk yield, freezing point of milk, concentration of fat, protein, lactose and MU as well as the amount of energetically corrected milk (ECM) were calculated. On the farm Y, the average quantitative data of the entire lactating herd of 250 cows were calculated over the period of 10 months.

The milk tests were performed at Dairy Laboratory Ltd., ISO 9622 / IDF 141:2013. Laboratory registration number LATAK-T-283-11-2003, accreditation standard: LVS EN ISO/IEC 17025:2005. ECM was calculated according to the formula prescribed by Agricultural Data Centre:

$$ECM = milk(kg)x\frac{(0.383xMF)+(0.242xMP)+0.7832}{3.140} \quad (1),$$

where ECM - energetically corrected milk, MF- milk fat and MP-milk protein. Reproductive data of cows were obtained from the computerised archives of the Farm X and analysed across the period of 12 months: service period and number of artificial inseminations. On farm Y, data were obtained just to evaluate the tendencies of milk yield and urea correlations in the herd with similar productivity and nutrition. On both farms, different was only the feeding management: on the farm X, TMR was given two times per day – every time more than two hours cows were without feed, but on the farm Y, TMR was given one time per day – cows were less than 2 hours without feed every day. The feed secondary fermentation was established organoleptically during the farm visits. Data statistical analyses were performed with *SPSS17* software (to calculate independent samples t-test, average, standard deviation, bivariate Pearson's correlation as well as to establish p-value) and graphic figures were prepared with *Excel* program.

**Results and Discussion**

In 2015, on farm X, the monthly average milk yield for cows on the upward lactation curve varied within the limits from 31.0 ± 5.8 kg to 38.0 ± 7.6 kg reaching the peak in December, while the MU average concentration was from 24.8 ± 5.8 mg dL$^{-1}$ up to 38.3 ± 5.8 mg dL$^{-1}$, respectively, peaking in May (Figure1). It should be noted that the milk yield increase stabilised when the MU level had decreased below 35 mg dL$^{-1}$.

In farm Y in 2015, the average monthly milk yield varied within the limits of 29.1 ± 7.8 kg to 32.7 ± 8.40 kg while the MU level in monthly yield ranged from 20.0 ± 9.2 mg dL$^{-1}$ to 31.3 ± 5.9 mg dL$^{-1}$ (Figure 2). The MU level and the milk yield maximum did not coincide in this test version between farms

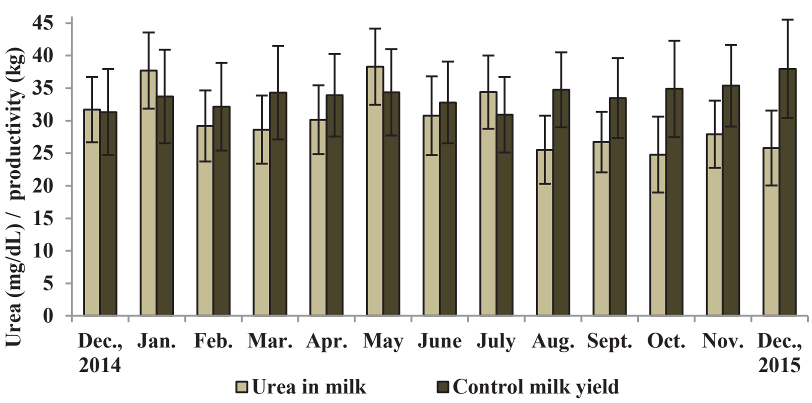


Figure 1. Dynamics of MU and milk yield on Farm X on lactation day 5-60, (n = 123), (r = -0.44; p>0.05).

X and Y. In both herds, a weak negative correlation was established between the milk yield and MU: on Farm X, r = -0.44, while on farm Y was r = -0.34. It is known that high amounts of nitrogen substances in feed increase the formation of ammonia in the rumen. In its transformation to urea, liver uses up more energy which is also required for the synthesis of milk in the udder. This results in less milk and more MU in milk than in a situation when the amount of nitrogen substances in feed ration stays on an optimum level (Noordhuizen, 2012). It is possible that the MU level was increased due to secondary fermentation of silage in poorly sealed silos. Furthermore, over lengthy storage period in the second half of winter, the material has been exposed to air after opening of the bulky storage bunker, in the process of daily removal of the silage or due to excessively long use of silage from the same bunker silo.

Analysing data of the farm X in greater detail, it has been established that in the course of one year for 16.4% of cows (n = 219) in the early lactation period, the protein level in milk was below 2.9%. The MU level for these cows was 32.8 ± 7.8 mg $dL^{-1}$, while the ECM amount was 38.2 ± 8.6 kg. For 12% of cows in their turn (n = 160), the protein level in milk was above 3.5% with MU in milk 25.7 ± 6.3 mg $dL^{-1}$and ECM 40.7 ± 9.9 kg. Concerning cows with low milk protein, the urea level stays higher 30 mg $dL^{-1}$ and the milk yield is lower, and it should be concluded that the amount of rumen-digestible proteins in their feed has been insufficient. Cows with high milk protein however had optimum MU level suggesting that they were fed with a well-balanced ration. If, over early lactation curve period the milk protein level is low for more than 20% of cows, it suggests that feed energy deficient exist (Noordhuizen, 2012). On Farm X, a trend was observed that cows with varied MU level have different milk protein level, as well as the calculated ECM. For animals with MU below 20 mg $dL^{-1}$, the milk protein was 3.3 ± 0.0.41% and ECM 39.8 ± 8.97 kg, respectively, while for cows with an optimum MU (20-30 mg $dL^{-1}$), it was 3.2 ± 0.31% and 40.4 ± 8.72 kg, respectively. For cows with MU exceeding 30 mg $dL^{-1}$, it was 3.1 ± 0.27% and 39.8 ± 7.90 kg, respectively. Thus, the highest ECM was obtained from cows with optimum MU amount. The present study established a weak negative but significant correlation between MU and the milk protein level (r = -0.17, p<0.001).

On farm X over the whole period of study, the group of early lactation cows had received feeding ration not appropriate to all animals because of highly varied daily milk yield: from below 20 kg to above 50 kg (Figure 3). For low-producing cows, the urea level was elevated indicating ineffective use of nitrogen in the animal system. The feed ration was the most effective for cows with the milk yield above 50 kg, the MU of which was lower than for other cows in the same group. To avoid over-conditioning of low productivity cows or their falling sick with metabolic or reproductive tract diseases, it is advisable to group animals not only on the basis of their days in lactation but also the production level. Besides, wasteful consumption of protein feeds for low producers would increase the leakage of nitrogen in the surrounding environment through faeces.

The conclusion drawn from the data obtained in 2015 is that the first calf heifers on farm X had lower productivity than mature cows − 33.8 ± 6.6 kg and 39.7 ± 8.7 kg per cow per day (p<0.001), respectively,

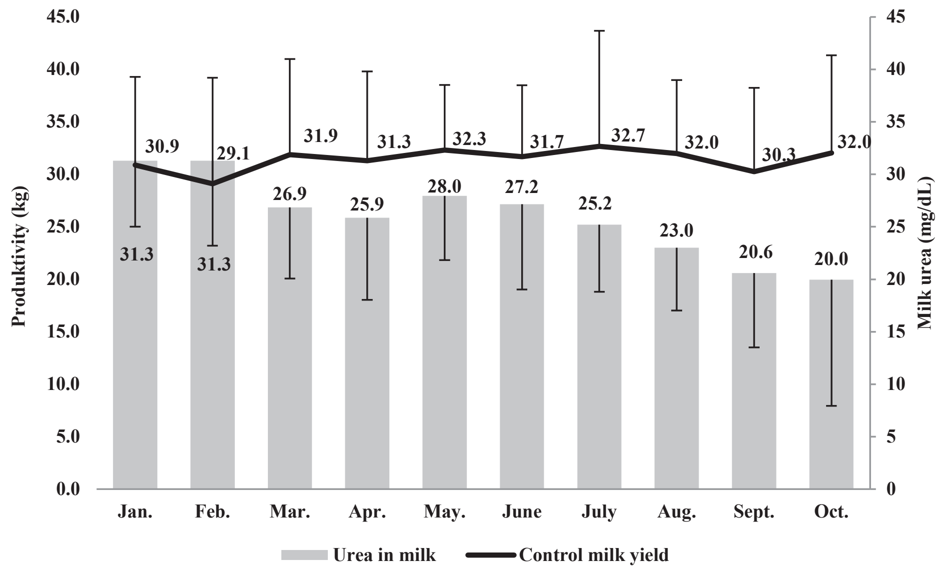


Figure 2. Dynamics of MU and milk yield on Farm Y. (n = 250), (r = -0.34, p>0.05).

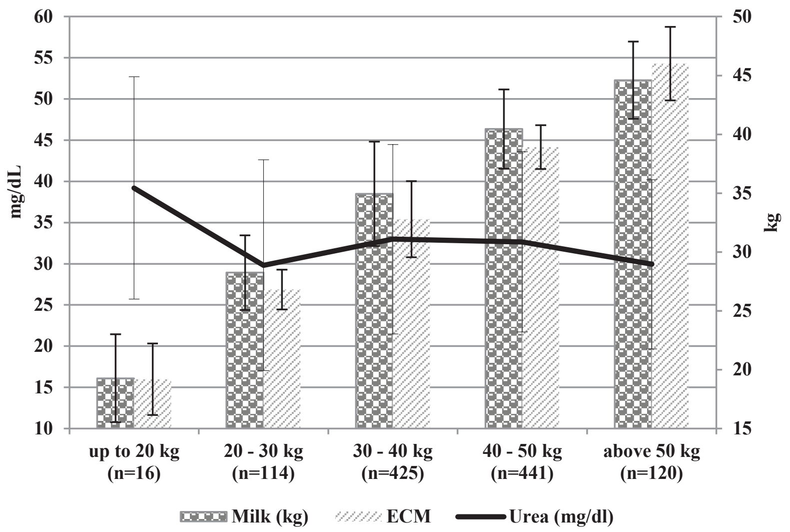


Figure 3. Milk yield and MU in relation to productivity of cows in the early lactation group over one year period on the farm X.

their fat content in milk was also lower: 3.8 ± 6.7% versus 4.1 ± 4.1% ($p<0.001$), milk protein was found to be 3.2 ± 0.3% versus 3.3 ± 0.4% ($p<0.05$) and they had a trend towards higher MU: 31.4 ± 7.6 mg $dL^{-1}$ and 30.8 ± 7.7 mg $dL^{-1}$ respectively ($p = 0.06$). Recalculating the daily milk yield to ECM, the differences in productivity are even more evident, the daily average ECM for first calf heifers was 32.2 ± 5.7 kg, while for mature cows it was 39.4 ± 8.0 kg per cow per day ($p<0.001$).

In the early lactation group of farm X the monthly average number of cows were 123 ± 4, while the feeding table allowed access to only 70 animals at one time. In the herd hierarchy, if kept in one and the same group, the first half heifers usually find themselves lower than mature cows. Consequently, the first calf heifers gain access to the feed table only after the stronger cows have already eaten. In one of the herd X health check visits it was established that TMR had been excessively dry. This gives an opportunity for cows to sort feed eating up the tastier bits, i.e. concentrates, first. Possibly, the first calf heifers mostly get just silage. It means that the feed ration for the first lactation cows is richer in nitrous substances and poorer in less highly digestible carbohydrates than for older cows. The conclusion to be drawn is that cows consuming more concentrates produce a higher milk yield with the higher milk protein level due to less ammonia found in their liver which has to be transformed into urea. Consequently, the high producing cows use up nitrogen substances more completely and the latter are less excreted into environment.

On Farm X, a statistically significant negative weak correlation was established between MU and the freezing point of milk ($r = -0.33$; $p<0.01$) as well as between MU and milk protein level ($r = -0.22$; $p<0.05$). The results of our study differ from findings published by other authors (Kedzierska-Matysek *et al*., 2011; Hanuš *et al*., 2011) who had found that cows with higher MU would demonstrate also a higher freezing point of milk, explained by higher milk protein concentration. Distinctive conclusions have been drawn also by other Latvian scientists (Jonkus *et al*., 2008): MU and the milk yield have no relation to freezing point of milk and these factors do not exert influence on one another.

Within the research period, on farm X, a weak positive correlation between MU and the number of artificial insemination was established for all cows ($r = 0.12$; $p<0.001$) despite the earlier findings in research literature which assert a significant negative impact of high urea in the cow's body system on their reproductive performance especially among the first calf heifers (Nourozi *et al*., 2010). Another veterinary medical science publication points out that reproductive problems in cows are observed only if at increased MU, the milk protein remains in norm or below it (Noordhuizen, 2012). In farm X, cows with MU concentration of up to 35 mg $dL^{-1}$ have had 1.63 ± 0.99 artificial inseminations (AI) per pregnancy on average, while cows with MU level above 40 mg $dL^{-1}$, have had 1.71 ± 1.10 AI per pregnancy ($p>0.05$). The impact of other factors on reproductive performance of animals in research herds cannot be excluded either, e.g. the subacute rumen acidosis or ketosis which appears due to irrelevant grouping of animals or the heat stimulation with hormones practiced by veterinarians on cows with reproductive problems. As the result, within the present research study, an insignificantly shorter service period was established for the cows with higher MU than ones with lower MU: for cows with MU above 40 mg $dL^{-1}$ the service period was 96 ± 36.8 days on average, for cows with MU 35 – 40 mg $dL^{-1}$ it was 98 ± 38.4, while for cows with MU below 30 mg $dL^{-1}$, the service period established was 108 ± 54.4 days. High urea level in milk correlates with its higher concentration in follicular liquid and intrauterine environment. High urea content in cows' body system hinders their fertility (Butler, 2005; Melendez *et al*., 2000). It should be noted that on farm X, the average productive life of cows is just 2.2 ± 1.20 lactations. In 2015, the first and second lactation cows made up 67.4% of the herd, while there were only 26.9% of third lactation cows and 5.7% cows of later lactations in the herd. These are economically alarming results calling for more in-depth future analysis of cow culling and involuntary slaughtering reasons with an aim of increasing the productive life of dairy animals.

## Conclusions

In both herds**,** a weak negative correlation was established between the MU concentration and the milk yield, and MU and milk protein level on farm X. MU is a good indicator to control the optimum use of rumen degradable protein by the cow's body system and decrease the nitrogen excretion into environment. Deviations of MU from the norm may testify not only to the need to correct the rumen degradable protein (nitrogen substances) amount in the feed ration or the adjustment thereof with highly digestible carbohydrates but also point to substantial mistakes in the grouping of cows or preparing of feed. Essential changes in reproductive indicators of cows (number of AI per pregnancy, the length of service period) for cows with increased MU concentration influenced by hormones induced heat practiced on the farm X has not been established by the present research. The statistical analysis of data obtained on research farms is continued in order to establish the relation between biochemical components of milk, including MU with metabolic diseases of cows.

## Acknowledgements

This publication has been prepared thanks to funding of the State Research Project (AgroBioRes) No. 2014.10-4/VPP-7/5 subproject No.3 (VP29).

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