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THE EFFECT OF SOME NON-NUTRITIONAL FACTORS ON UREA LEVEL IN MILK OF POLISH HOLSTEIN-FRIESIAN COWS

Summary. The aim of the study was to investigate the effect of selected non-nutritional factors on urea content in milk of Polish holstein-friesian black-and-white cows. It was shown that the lactation group, the stage of lactation and actual daily milk yield do not have a significant effect on urea content in milk of analysed cows. In contrast, a statistically significant dependence was found between urea content in milk and both somatic cell count (at $p \leq 0.01$) and the genetic group of animals (at $p \leq 0.05$). The highest urea content was recorded in milk containing the lowest number of somatic elements and that coming from cows with the highest share (> 87.5%) of HF genes in their genotype.

Key words: cattle, Polish holstein-friesian, milk, urea

Introduction

Urea content in milk is a good indicator of protein-energy balance in the feed ration (NAGEL 1994). When feeding cows it needs to be remembered that factors limiting blood urea level include the uptake of ruminally digestible protein by the cow and the available portion of energy required for the synthesis of protein by ruminal microorganisms. The correlation between urea level in milk and its content in the blood plasma falls within the 0.88-0.98 range (BRODERICK and CLAYTON 1997, ŘEHÁK et AL. 2009). The appropriate urea level in milk is assumed to be 150-250 mg/l and all deviations indicate a lack of balance in the feed ration. Excess urea in blood causes disturbances in the reproduction of cows. GODDEN et AL. (2001) indicated that a high urea level is the main obstacle in reproduction and embryogenesis, as well as changes occurring in the uterus. This is so because urea affects changes in pH of the uterine mucosa, which as a consequence hinders the embryo implantation in the mucosa or leads to the systematic poisoning of the embryo, which results in early fetus atrophy. High urea level may cause problems with the detachment of the placenta and it may also occur in cows after calving. If urea level drops below 150 mg/l of milk it means that there is a deficit of protein in the feed ration in relation to the supplied energy. This condition may occur in the period of winter feeding, when high energy feeds are available on the farm (maize silage, fodder beets, dried sugar beet pulp, crushed cereal meals) and there is a deficit of feeds rich in protein, i.e. haylages from meadow grasses and legumes. A low level of urea in milk is less harmful than its elevated content, but still it results in economic losses due to reduced milk yields of cows and deterioration of their health.

According to ZIEMIŃSKI and JUSZCZAK (1997), apart from feeding, factors affecting the amount of urea in milk include e.g. yield of milk, season of the year and herd. MIGLIOR et AL. (2007) were of an opinion that also genetic factors have a considerable effect on the level of urea in milk, since the coefficient of heritability for this parameter is 0.44.

The aim of the study was to investigate the effect of selected non-nutritional factors on the amount of urea in milk of Polish holstein-friesian cows of the black-and-white variety.

Material and methods

Experimental material for the study comprised milk obtained in the years 2003-2008 from 386 Polish holstein-friesian black-and-white cows kept on the farm owned by Niwapol Sp. z o.o. located in Wielka Wieś near Buk. A detailed structure and population size of the experimental material are presented in the table below.

Lactation rank reached by cows	Number of lactation in which data collection was initiated								
	1	2	3	4	5	6	7	8	9
	Number of cows								
1	**229**	×	×	×	×	×	×	×	×
2	171	**61**	×	×	×	×	×	×	×
3	94	57	**38**	×	×	×	×	×	×
4	44	40	36	**28**	×	×	×	×	
5	8	29	25	25	**12**	×	×	×	×
6	2	7	13	18	11	**13**	×	×	×
7	0	0	6	5	4	6	**2**	×	×
8	0	0	0	0	0	2	2	**3**	×
9	0	0	0	0	0	0	0	2	**0**

Information was gathered on 8657 milk samples collected in the course of milk recording with the AT4 method. Animals were kept in the free stall system. Milking was performed twice a day in a herringbone 8 × 2 milking parlour.

The Partly Mixed Ration (PMR) system was applied in the feeding regime. Animals were fed mostly feeds produced on the farm. Feed was administered twice a day. Pelleted concentrate was applied at doses adjusted individually for each cow (depending on daily milk yield) using a feeding station.

The following data were collected on each animal: date of birth, percentage of HF genes in their genotype, lactation number, days in milk, daily yields of milk, fat, protein, lactose, milk solids as well as milk contents of urea, fat, protein, lactose, solids and somatic cell count.

Actual daily yield was converted into 4%-FCM (milk with a 4% fat content) according to the formula:

$$FCM = 0.4M + 15F$$

where:

FCM – milk corrected to a 4% fat content (kg),
M – actual daily milk yield (kg),
F – actual fat yield (kg).

In order to obtain the normal distribution for the somatic cell count in milk a logarithmic transformation was applied according to ALI and SHOOK (1980).

In the study relationships were analysed between selected factors, other than feeding, and urea level in milk as well as daily yield and composition of milk. The effect of the following factors was investigated:

- the share of original holstein-friesian cattle genes in the genotype (%) – the experimental animals were divided into the following groups: ≤ 75, 75.01-87.5, and > 87.5,
- lactation number – the cows were divided into those being in their 1st, 2nd, 3rd, 4th, or ≥ 5th lactation,
- stage of lactation – lactations were divided into the following periods (days): ≤ 40, 41-100, 101-200 and > 200,
- daily milk yield – milk production was divided into the following classes (kg): < 20, 20.1-25.0, 25.1-30.0, 30.1-35.0 and > 35,
- all milk samples in terms of the number of somatic elements were divided into the following classes (thousand per 1 ml): ≤ 200, 201-400, 401-500, 501-1000 and > 1000.

Statistical analysis was conducted using the GLM procedure of the SAS® statistical package (SAS®... 2006). Data was analyzed according to the following model:

$$Y_{ijklmno} = \mu + l_i + \beta_1 g_{ijko} + \beta_2 f_{ijlo} + \beta_3 w_{ijmo} + \beta_4 s_{ijno} + e_{ijklmno}$$

where:

$Y_{ijklmno}$ – phenotypic value of a trait,
μ – population mean
l_i – fixed effect of lactation rank (i = 1, 2, 3, 4, 5),
$\beta_1, \beta_2, \beta_3, \beta_4$ – partial regression coefficients,
g_{ijko} – fixed effect of genetic group (i = 1, 2, 3),

f_{ijlo} – fixed effect of stage of lactation (i = 1, 2, 3, 4),
w_{ijmo} – fixed effect of production group (i = 1, 2, 3, 4, 5),
s_{ijno} – fixed effect of somatic cell count in milk (i = 1, 2, 3, 4, 5),
$e_{ijklmno}$ – random error.

During the statistical analysis the significance of the effect of model components on quantitative and qualitative characteristics of milk was examined. Statistically non-significant effects were eliminated from the linear model.

Results and discussion

Table 1 presents results concerning the significance of the effect of model components on the analysed trait. It was shown that the lactation rank, the stage of lactation as well as the actual daily milk yield does not have a statistically significant effect on urea content in milk of analysed cows. In turn, a statistically significant dependence was found between urea content in milk and the number of somatic elements (at $p \leq 0.01$)

Table 1. Significance of effect of model components on the analysed trait
Tabela 1. Istotność wpływu składowych modelu na analizowaną cechę

Trait	l_j	β_1		β_2		β_3		β_4		R^2	Radical MSE
Urea (mg/l)	NS	*	0.2223	NS	0.0129	NS	–0.2031	**	–0.0104	0.007	81.907
Milk (kg)	**	**	0.0384	**	–0.0479	×	×	**	–0.0018	0.351	7.971
Fat (kg)	**	**	0.0010	NS	–0.0001	**	0.0527	**	–0.0001	0.789	0.263
Fat (%)	**	**	0.0033	NS	0.0001	**	0.0162	**	–0.0001	0.039	0.923
Protein (kg)	**	**	–0.0006	**	0.0003	**	0.0306	**	–0.0001	0.925	0.082
Protein (%)	**	**	–0.0030	**	0.0015	**	–0.0124	**	–0.0001	0.392	0.334
Lactose (kg)	**	NS	0.0001	**	–0.0001	**	0.0469	**	–0.0001	0.986	0.055
Lactose (%)	**	NS	–0.0001	**	–0.0003	**	0.0018	**	–0.0001	0.211	0.245
Milk solids (kg)	**	NS	–0.0002	**	0.0001	**	0.1384	**	–0.0001	0.958	0.288
Milk solids (%)	**	NS	–0.0013	**	0.0008	**	0.0099	**	–0.0001	0.024	1.083
Protein / Fat	**	**	–0.0011	**	0.0003	**	–0.0046	**	–0.0001	0.224	0.131
SCC (thous. per 1 ml)	**	**	2.0800	**	–0.2078	**	–10.858	×	×	0.098	625.053
Ln (SCC per 1 ml)	**	**	0.0030	**	0.0002	**	–0.0255	×	×	0.160	1.118
FCM (kg)	**	**	0.0158	NS	–0.0004	**	1.1873	**	–0.0002	0.899	3.946

** $p \leq 0.01$, * $p \leq 0.05$, NS – non-significant.

and the genetic group of animals (at $p \leq 0.05$). No statistically significant dependencies were established between the genetic group of animals and the yield and content of milk solids, or between the stage of lactation in cows and the yield and percentage of fat in milk as well as FCM yield.

Table 2 presents results concerning urea level in milk and other milking performance traits depending on the genetic group of cows. The performed statistical analysis showed the following dependence between the share of holstein-friesian black-and-white cows in the genotype of animals and urea level in milk. The highest value for this parameter (173 mg/l) differing at $p \leq 0.05$ from the other populations was found for cows with the highest share of holstein-friesian genes (> 87.5) in their genotype. The genetic group of cows was also observed to have a highly significant effect on the recorded values of milking performance of cows, except for the yields and percentages of lactose and milk solids. The somatic cell count in milk decreased with an increasing share of HF genes in the genotype of cows. CARLSSON et AL. (1995) did not find any effect of the holstein and red swedish breeds on urea content in milk.

Table 2. Urea level in milk and other milk performance traits of cows depending on genetic group
Tabela 2. Poziom mocznika w mleku oraz inne cechy użytkowości mlecznej krów w zależności od grupy genetycznej

Trait	Genetic groups		
	≤ 75% HF (N = 2043)	75.1-87.5% HF (N = 4295)	> 87.5% HF (N = 2319)
Urea (mg/l)	162 a	168 b	173 ab
Milk (kg)	23.46	23.02 a	23.65 a
Fat (kg)	1.13 A	1.13 B	1.18 AB
Fat (%)	4.74 AB	4.82 AC	4.90 BC
Protein (kg)	0.79	0.78	0.78
Protein (%)	3.48 A	3.46 B	3.39 Ab
Lactose (kg)	1.09	1.08	1.11
Lactose (%)	4.60	4.67	4.71
Milk solids (kg)	3.20	3.14	3.23
Milk solids (%)	13.56	13.68	13.66
Protein / Fat	0.76 A	0.74 AC	0.71 BC
SCC (thous. per 1 ml)	656 AB	572 AC	444 BC
Ln (SCC per 1 ml)	12.77 ab	12.60 ac	12.28 bc
FCM (kg)	26.25 a	25.99 A	27.09 Aa

** $p \leq 0.01$, * $p \leq 0.05$, NS – non-significant.
Means marked in rows with identical letters differ significantly: ABC – $p \leq 0.01$, abc – $p \leq 0.05$.

Table 3 contains results concerning dependencies between successive lactation and urea level in milk as well as milking performance of cows. It was shown that lactation

Table 3. Urea level in milk and other milk performance traits of cows in successive lactations
Tabela 3. Poziom mocznika w mleku oraz inne cechy użytkowości mlecznej krów w kolejnych laktacjach

Trait	Lactations				
	1 (N = 2215)	2 (N = 1963)	3 (N = 1679)	4 (N = 1285)	≥ 5 (N = 1515)
Urea (mg/l)	171	171	169	164	161
Milk (kg)	21.19 ABCD	24.11 AE	24.31 BF	24.37 CG	23.20 DEFG
Fat (kg)	1.03 ABC	1.18 AD	1.22 BE	1.21 CF	1.11 DEF
Fat (%)	4.80 AB	4.84 CD	4.93 CEa	4.86 Fa	4.69 BDEI
Protein (kg)	0.70 ABCD	0.82 AE	0.82 BF	0.82 CG	0.77 DEFG
Protein (%)	3.40 ABC	3.48 AD	3.49 BE	3.47 CF	3.41 DEF
Lactose (kg)	1.02 ABCa	1.13 AD	1.14 BE	1.12 CF	1.06 DEFa
Lactose (%)	4.80 ABCD	4.69 AEFG	4.64 BEHI	4.58 CFHJ	4.52 DGIJ
Milk solids (kg)	2.90 ABCD	3.28 AE	3.36 BF	3.36 CG	3.12 DEFG
Milk solids (%)	13.64 ABa	13.74 Ca	13.78 AD	13.70 E	13.34 BCDE
Protein / Fat	0.73 ABC	0.74 Aa	0.73 D	0.74 BE	0.76 CDEa
SCC (thous. per 1 ml)	333 ABCD	490 AEFG	586 BEHI	699 CFHJ	874 DGIJ
Ln (SCC per 1 ml)	11.97 ABCD	12.57 AEFG	12.71 BEHI	12.89 CFHJ	13.15 DGIJ
FCM (kg)	23.83 ABCD	27.23 AEFG	27.93 BF	27.80 CG	25.84 DEFG

** $p \le 0.01$, * $p \le 0.05$, NS – non-significant.
Means marked in rows with identical letters differ significantly: ABC – $p \le 0.01$, abc – $p \le 0.05$.

rank did not affect statistically the amount of urea in milk of cows. In this study it was found that milk coming from animals being in their first and second lactations contained an identical amount of urea (171 mg/l), while that milked from animals in their further lactations had lower contents of this metabolite. CARLSSON et AL. (1995) and OSTEN-SACKEN (1999) found that milk of primiparous cows contained lower amounts of urea than that from older animals. In turn, in studies by JUSZCZAK et AL. (1997), JONKER et AL. (1998) and NAŁĘCZ-TARWACKA et AL. (2004) higher concentrations of this compound were found in milk of primiparous cows in comparison to older cows. A significant relationship ($p \le 0.01$) was shown between lactation number and average values of milk performance traits. The highest yields of milk, FCM, fat, protein and milk solids were found for animals being in the third and fourth lactation. An increase was shown for somatic cell count in milk with an increasing lactation number.

Table 4 presents results concerning the effect of the stage of lactation in cows on urea level in milk and selected milking performance of cows. The conducted statistical analysis did not show a significant dependence between the stage of lactation in cows and the following parameters: urea level, the yield and content of fat as well as FCM

Table 4. Urea level in milk and other milk performance traits of cows depending on lactation stage
Tabela 4. Poziom mocznika w mleku oraz inne cechy użytkowości mlecznej krów w zależności od fazy laktacji

Trait	Stages of lactation			
	≤ 40 days (N = 941)	41-100 days (N = 1606)	101-200 days (N = 2580)	> 200 days (N = 3530)
Urea (mg/l)	156	166	182	166
Milk (kg)	29.38 ABa	30.03 CDa	25.03 ACE	17.26 BDE
Fat (kg)	1.56	1.47	1.20	0.83
Fat (%)	5.26	4.83	4.75	4.75
Protein (kg)	0.93 AB	0.94 CD	0.84 ACE	0.63 BDE
Protein (%)	3.21 ABC	3.14 ADE	3.39 BDF	3.70 CEF
Lactose (kg)	1.37 ABC	1.43 ADE	1.18 BDF	0.81 CEF
Lactose (%)	4.65 ABC	4.75 ADE	4.69 BDF	4.61 CEF
Milk solids (kg)	4.13 ab	4.07 cd	3.41 ace	2.38 bde
Milk solids (%)	13.97 ABC	13.50 AD	13.54 BE	13.70 CDE
Protein / Fat	0.64 ABC	0.68 ADE	0.73 BDF	0.80 CEF
SCC (thous. per 1 ml)	554	526	542	580
Ln (SCC per 1 ml)	12.43	12.37	12.52	12.69
FCM (kg)	35.03 ABC	33.95 ADE	28.02 BDF	19.25 CEF

** $p \leq 0.01$, * $p \leq 0.05$, NS – non-significant.
Means marked in rows with identical letters differ significantly: ABC – $p \leq 0.01$, abc – $p \leq 0.05$.

yield. Osten-Sacken (2000) was of the opinion that urea level in milk during lactation fluctuates to a certain degree, i.e. it is lower at the beginning of lactation, to grow next and then decrease towards the end of lactation. In a study by Nałęcz-Tarwacka and Grodzki (2004) it was shown that the highest amount of urea in milk is found most frequently in cows being in the final stage of lactation (from the eighth month). In turn, Antkowiak et al. (2007) found a systematic increase in the concentration of urea in milk in successive stages of lactation.

The highest daily yields of milk, protein, lactose and the lowest somatic cell count were recorded for cows being between day 41 and 100 after calving.

Table 5 presents the effect of daily milk yield in cows on urea level and milking performance traits. No statistically significant dependence was shown between daily milk production and urea content in milk. In contrast, highly significant dependencies were observed between daily milk productivity and the other analysed parameters of milking performance. In studies by Carlsson and Pehrson (1993), Ziemiński and Juszczak (1997), Arunvipas et al. (2003), Litwińczuk et al. (2003), Rajala-Schultz and Saville (2003), Jankowska et al. (2004), Bogucki et al. (2005) and Guliński

Table 5. Urea level in milk and other milk performance traits of cows depending on daily milk yield
Tabela 5. Poziom mocznika w mleku oraz inne cechy użytkowości mlecznej krów w zależności od wydajności dobowej mleka

Trait	Daily milk yields				
	≤ 20 kg (N = 3502)	20.1-25.0 kg (N = 1682)	25.1-30.0 kg (N = 1507)	30.1-35.0 kg (N = 937)	> 35 kg (N = 1029)
Urea (mg/l)	167	173	172	163	159
Fat (kg)	0.65 ABCD	1.09 AEFG	1.37 BEHI	1.63 CFHJ	2.11 DGIJ
Fat (%)	4.64 ABCD	4.81 AEFG	4.95 BEHa	5.02 CFIa	5.14 DGHI
Protein (kg)	0.51 ABCD	0.78 AEFG	0.92 BEHI	1.05 CFHJ	1.28 DGIJ
Protein (%)	3.67 ABCD	3.43 AEFG	3.32 BEHI	3.23 CFHJ	3.11 DGIJ
Lactose (kg)	0.65 ABCD	1.07 AEFG	1.30 BEHI	1.53 CFHJ	1.93 DGIJ
Lactose (%)	4.60 ABCD	4.71 AE	4.70 BEHI	4.70 Ca	4.68 DE
Milk solids (kg)	1.90 ABCD	3.09 AEFG	3.79 BEHI	4.47 CFHJ	5.67 DGIJ
Milk solids (%)	13.55 ABCa	13.65 Ab	13.73 A	13.73 B	13.76 CB
Protein / Fat	0.81 ABCD	0.73 AEFG	0.69 BEHI	0.67 CFHJ	0.64 DGIJ
SCC (thous. per 1 ml)	627 ABCD	505 Aa	527 BE	530 Cb	477 DEab
LN (SCC per 1 ml)	12.76 ABCD	12.44 AE	12.43 BE	12.47 CG	12.29 DEFG

** $p \leq 0.01$, * $p \leq 0.05$, NS – non-significant.
Means marked in rows with identical letters differ significantly: ABC – $p \leq 0.01$, abc – $p \leq 0.05$.

et AL. (2008) it was shown that the concentration of urea in milk increases with an increase in milk yield of cows.

Table 6 contains results concerning the effect of somatic cell count on urea level and milk performance traits in cows. A significant effect ($p \leq 0.01$) on all analysed traits was shown for the number of somatic cells. It was found that urea level in milk decreases with an increase in somatic cell count. Similar results were recorded in the studies by BORKOWSKA et AL. (2002), HOJMAN et AL. (2004), NAŁĘCZ-TARWACKA and GRODZKI (2004) and BOGUCKI et AL. (2005). ANTKOWIAK et AL. (2007) were of the opinion that such a result is a consequence of the increasing utilization of protein provided in feed in the metabolism of cows with mastitis. In turn, BORKOWSKA and JANUŚ (2004) suggested that an increase in the number of somatic elements in milk at a low urea level may be caused by a protein deficit in the feed ration, which could have reduced immunity of animals. In this study, taking into consideration daily yields of milk, FCM, fat, protein, lactose and milk solids, a similar relationship was shown, i.e. values for the above mentioned milk performance traits decreased with an increase in somatic cell count in milk. Only the percentage of protein increased in milk from mastitic animals, which was probably caused by an increase in the proportion of whey proteins in milk.

Table 6. Urea level in milk and other milk performance traits of cows depending on somatic cell count in milk
Tabela 6. Poziom mocznika w mleku oraz inne cechy użytkowości mlecznej krów w zależności od liczby komórek somatycznych w mleku

Trait	Somatic cell count in 1 ml of milk				
	≤ 200 thous. (N = 3304)	201-400 thous. (N = 1447)	401-500 thous. (N = 433)	501-1000 thous. (N = 1166)	> 1000 thous. (N = 2307)
Urea (mg/l)	178 ABCD	166 Aa	167 Bb	163 C	156 Dab
Milk (kg)	25.50 ABCD	22.85 AEF	21.54 B	22.07 CE	21.46 DF
Fat (kg)	1.27 ABCD	1.12 AEFG	1.05 BE	1.05 CF	1.04 DG
Fat (%)	4.93 ABCa	4.83 Da	4.80 AE	4.70 BDE	4.75 C
Protein (kg)	0.84 ABCD	0.78 AEFa	0.74 BE	0.75 Ca	0.73 DF
Protein (%)	3.35 ABCD	3.49 Aa	3.53 Ba	3.50 C	3.52 D
Lactose (kg)	1.22 ABCD	1.07 AEFa	1.01 BEb	1.03 CGab	0.97 DFG
Lactose (%)	4.80 ABCD	4.70 AEFG	4.66 BEH	4.63 CFI	4.46 DGHI
Milk solids (kg)	3.49 ABCD	3.11 Aab	2.96 Ba	2.98 Cb	2.91 DE
Milk solids (%)	13.76 AB	13.71 CD	13.70 EF	13.52 ACE	13.48 BDF
Protein / Fat	0.70 ABCD	0.74 AEFa	0.76 Ba	0.77 CF	0.77 DF
FCM (kg)	29.29 ABCD	25.87 AEFG	24.36 BE	24.53 CF	24.16 DG

** $p \leq 0.01$, * $p \leq 0.05$, NS – non-significant.
Means marked in rows with identical letters differ significantly: ABC – $p \leq 0.01$, abc – $p \leq 0.05$.

Conclusions

1. It was shown that the lactation group, the stage of lactation and the actual daily milk yield have no significant statistical effect on urea content in milk of analysed cows. In contrast, a statistically significant dependence was found between urea content in milk and somatic cell count (at $p \leq 0.01$) and the genetic group of animals (at $p \leq 0.05$).

2. The highest urea content was recorded for milk containing the lowest number of somatic elements and that coming from cows with the highest share (> 87.5%) HF genes in the genotype.

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WPŁYW WYBRANYCH CZYNNIKÓW POZAŻYWIENIOWYCH NA POZIOM MOCZNIKA W MLEKU KRÓW RASY POLSKIEJ HOLSZTYŃSKO-FRYZYJSKIEJ

Streszczenie. Celem pracy było zbadanie wpływu wybranych czynników pozażywieniowych na zawartość mocznika w mleku krów rasy polskiej holsztyńsko-fryzyjskiej odmiany czarno-białej. Wykazano, że grupa laktacyjna, faza laktacji oraz rzeczywista dobowa wydajność mleka nie wpływają istotnie pod względem statystycznym na zawartość mocznika w mleku badanych krów. Stwierdzono istotną pod względem statystycznym zależność między zawartością mocznika w mleku a liczbą elementów komórkowych (przy $p \leq 0,01$) i grupą genetyczną zwierząt (przy $p \leq 0,05$). Największą zawartością mocznika charakteryzowało się mleko zawierające najmniejszą liczbę komórek somatycznych oraz pochodzące od krów o największym udziale (> 87,5%) genów bydła hf w genotypie.

Słowa kluczowe: bydło, rasa polska holsztyńsko-fryzyjska, mleko, mocznik

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