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RELATIONSHIPS BETWEEN SOMATIC CELLS COUNTS AND UREA LEVEL IN THE MILK OF POLISH HOLSTEIN--FRIESIAN COWS OF BLACK-AND-WHITE AND RED-WHITE VARIETIES

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Abstract. The aim of the study was to investigate the effect of somatic cell counts on urea content in the milk of Holstein-Friesian cows of Black-and-White (N = 390) and Red-White (N = 86) varieties kept on a farm in the Wielkopolska region. It was found that urea level in milk of the evaluated genotypes of cows was within the accepted standard, with higher values of this parameter in Red-and-White cows. In Polish Holstein-Friesian of Black-and-White variety a decrease in urea level was shown with an increase in somatic cell count in milk. Taking into consideration the daily yield of milk and fat corrected milk (4%-FCM) the most advantageous results were recorded for animals with the lowest somatic cell count in milk.

Key words: milk, somatic cell count, urea

INTRODUCTION

Hygienic quality and processing ability of milk are considerably affected by its somatic cell count. Somatic elements are dead and desquamated cells of epithelium lining the alveoli, milk ducts and cisterns as well as white blood cells transferred to milk from blood [Borkowska and Januś 2004]. Information on somatic cell count in milk and insight into factors affecting them make it possible for breeders and producers to improve the quality of sold milk and they facilitate monitoring of the health state of the udder in cows. It is assumed that the physiological state characteristic of cows' health is when the content of cell elements is up to 100 thousand per 1 ml [Skrzypek 2002]. When this threshold is exceeded financial losses are incurred, resulting from a reduction of milk production, and unfavorable changes in milk composition, having a decreasing effect on its processing ability and nutrition value.

Urea content in milk is a good indicator of appropriate balancing of the feed ration for dairy cows in terms of protein and energy. Excess ammonia produced in the rumen is

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transferred to blood and in the liver in the urea cycle it is transformed into urea, which through kidneys is partly excreted with urine. In turn, unexcreted urea and excess ammonia circulate with blood throughout the body and reach the mammary gland, getting to milk. From the point of view of animal nutrition it was determined that the optimal concentration of urea in milk for cows of large breeds should range from 150 to 300 mg · l^{-1} [Bogucki et al. 2005]. However, some authors reported that the appropriate level of urea in cow's milk should fall within the range from 140 to 250 mg · l^{-1}. In the opinion of Skrzypek et al. [2005], a reduced amount of urea in milk indicates a deficit of protein in feed or a lack of energy available to ruminal microorganisms, while an elevated level of this parameter is characteristic in case of excess protein or deficit of energy in the feed ration or both. According to many authors an excessive concentration of ammonia and urea in the rumen and blood promotes the incidence of metabolic disorders, causing liver dysfunction and reproduction disorders [Butler et al. 1996; Melendez et al. 2000; Markiewicz 2003].

According to Osten-Sacken [2000], apart from feeding the content of urea in milk is also determined by other factors such as milk yield, lactation number and stage, season of the year and body weight. That author also reported that urea level in milk is positively correlated with somatic cell count, which is caused by the irritating action of urea molecules, transferred from blood to milk, on cell walls of milk alveoli in the udder.

The fact that very few studies concerned an association between somatic c ell count and urea level in milk was an incentive for the authors of this study to undertake research on this subject. Therefore, the aim of this study was to determine the effect of somatic cell count on urea content in milk of cows of Polish Holstein-Friesian, Black-and-White and Red-and-White varieties, managed in identical conditions.

MATERIAL AND METHODS

The investigations were conducted on cows of the Polish Holstein-Friesian breed, being of the Black-and-White (390 head) and Red-and-White (86 head) varieties. Animals were kept on a farm in Chaławy, belonging to the Mróz S.A. consortium. Data on cows were collected in the years 2006–2008.

Mean annual yield from a cow in the last year of the study was 8 833 kg milk with fat content of 3.74% and protein content of 3.54%. Animals were kept in a free stall system on shallow litter. Cows used a roofed shelter being an extension of the barn, where they had access to an adequate bedding area and free access to a run and a feeding bunk, on which feed was available at all times.

Milking was performed twice a day, however in case of high-producing cows (daily milk production of over 42 kg) milking was performed three times a day in a carrousel type milking parlor with 26 stalls.

The Total Mixed Ration system (TMR) was applied in feeding. Animals were fed mostly the feed produced on the farm. Feed was administered twice a day and was available at all times.

Cows were subjected to milk recording with the A4 method. A total of 4253 test-day records were collected and each contained the following information: milk yield, milk urea content, somatic cell count, milk fat and protein contents. Additionally, actual daily milk yield was calculated in terms of fat corrected milk standardized to 4% (4%-FCM):

$$FCM = 0.4\ M + 15\ F$$

where:

M – actual daily milk yield, kg,

F – actual fat yield, kg.

In terms of the number of cell elements all milk samples were divided into the following classes (in thousand per ml):

- ≤ 200,
- 201–400,
- 401–500,
- 501–1000,
- >1000.

In order to determine the effect of somatic cell count in milk on the level of urea and daily yield and composition of milk the cows were divided according to their genotype:

- HO-1 – cows of the Polish Holstein-Friesian, Black-and-White variety, with a 100% share of HF genes in their genotype,
- HO-2 – cows of the Polish Holstein-Friesian, Black-and-White variety, with a less than 100% share of HF genes in their genotype (on average 88%),
- RW – cows of the Polish Holstein-Friesian, Red-and-White variety, with a varying share of HF genes in their genotype (on average 70%).

The effect of somatic cell count in milk on urea level as well as daily yield and composition of milk was investigated for the entire analyzed population of cows and taking into consideration individual genotypes of animals mentioned above.

Statistical analyses were performed using procedures of the SAS statistical software package [2007]. Means and standard deviations for selected traits were calculated using the MEANS procedure, while in the analysis of variance the GLM procedure was applied. Detailed comparisons between object means were performed using the LSD test. In the computations the effect of the following fixed effects was included: genotype, age at first calving, production group, lactation rank, stage of lactation, year and season of calving. In order to obtain the normal distribution of somatic cell count in milk a logarithmic transformation according to Ali and Shook [1980] was conducted.

RESULTS AND DISCUSSION

Table 1 presents results concerning the effect of the number of somatic cells contained in milk on urea level and milk performance traits in the analyzed population of cows. The statistical analysis of data showed a downward trend for urea content with an increase in the number of somatic elements in milk. Milk with the highest somatic cell count (>1000 thousand per ml) in terms of the amount of urea differed ($P \leq 0.01$) from the other groups

of milk samples with a varying number of somatic elements. Similar results were reported in the studies by Borkowska et al. [2002], Nałęcz-Tarwacka and Grodzki [2004] and Bogucki et al. [2005], who also observed a reduction of urea content in milk with an increase in the somatic cell count. In the opinion of those authors the health status of the mammary gland had the largest effect on milk urea concentration. Antkowiak et al. [2007] recorded similar results in the investigations on Polish Holstein-Friesian, Black-and-White, and the Jersey breeds. Those authors were of an opinion that such a result is an effect of an increasing conversion of feed protein in metabolism (which may be evidenced by a lower urea level in milk) in cows with a progressing infection and inflammation of the mammary gland. In the opinion of Borkowska and Januś [2003] an increase in the number of somatic elements in milk at a low urea level may be caused by a deficit of protein in the feed rations, which as a consequence could have reduced immunity of animals. In view of the collected results recorded in this study it may be suggested that such a relationship was most probably the effect of an increasing requirement for nitrogen compounds in the metabolism of animals with progressing mastitis.

Taking onto consideration the daily yield of milk and a 4%-FCM, the most advantageous results were found in this study for animals with the lowest somatic cell counts and at the same time the highest urea level in milk. Similar results were reported by Litwińczuk et al. [2003] and Bogucki et al. [2005]. Carlsson and Pehrson [1993], who compared milk from herds of different productivity, showed that a low urea level was associated with a low milk yield. In turn, in the opinion by Osten-Sacken [2000] urea content in milk increases with an increase in the daily yield, since feed rations for low producing cows contain less protein than it is recommended. Godden et al. [2001] showed that urea content in milk is positively correlated with the content of crude protein, both digestible and indigestible in the rumen. In contrast, a negative relationship was observed in relation to nonstructural carbohydrates.

In this study the lowest contents of fat (3.79 %), protein (3.50 %) and milk solids (12.83 %) were recorded for milk of cows with the highest urea level (on average 237 mg $\cdot$ l^{-1}). This milk differed from the milk from the other groups ($P \leq 0.01$) in terms of the above mentioned traits. Nałęcz-Tarwacka and Grodzki [2004] observed a similar relationship between protein and urea concentration in milk.

Table 1. The effect of somatic cell count in milk on urea level and yield and composition of milk in the analyzed cows
Tabela 1. Wpływ liczby komórek somatycznych w mleku na poziom mocznika oraz wydajność mleka i jego skład u badanych krów

Traits – Cechy	Somatic cell count, thous. · ml^{-1} – Liczba komórek somatycznych, tys. · ml^{-1}				
	± 200 (N = 4253)	201–400 (N = 1771)	401–500 (N = 391)	501–1000 (N = 881)	>1000 (N = 853)
Urea – Mocznik, mg · l^{-1}	237A	235Ba	233C	227D	218ABCDa
Milk – Mleko kg · d^{-1}	30.5ABCD	25.92A	25.48B	25.37C	26.68D
FCM kg · d^{-1}	28.54ABCD	25.44A	24.89B	24.81C	26.33D
Fat – Tłuszcz %	3.79ABCD	4.03A	4.03B	4.01C	4.00D
Protein – Białko %	3.50ABCD	3.70A	3.69B	3.66C	3.64D
Dry matter – Sucha masa %	12.83ABCD	13.19A	13.12B	13.08C	13.02D

Means marked with identical letters differ significantly; large letters – $P \leq 0.01$, small letters – $P \leq 0.05$.
Średnie oznaczone takimi samymi literami różnią się istotnie; duże litery – $P \leq 0,01$, małe litery – $P \leq 0,05$.

Table 2 presents relationships between somatic cell counts in milk and urea levels as well as milking performance traits in cows taking into consideration their genotype. The average urea content in milk of the above mentioned genotypes of cows fell within the adopted standard. Milk from animals of the Polish Holstein-Friesian, Red-and-White variety, in comparison to the two other genotypes in each of the classes of the division in terms of the somatic cell count was characterized by a significantly ($P \leq 0.01$) higher level of urea. The statistical analysis showed significant ($P \leq 0.01$) differences only within the HO-2 genotype between urea content in milk of cows with different amounts of somatic elements. Carlsson et al. [1995] did not find any effect of the Holstein and the Red Swedish breeds on urea content in milk. In this study it was shown that in milk of Polish Holstein--Friesian of Black-and-White variety with a varied share of HF genes in their genotype the level of urea decreased with an increase in the somatic cell count. In turn, in the other genotypes of cows such a trend was observed, although not confirmed statistically, at somatic element contents in milk over 500 thousand per ml. A similar relationship was observed in the studies by Johnson and Young [2003] and Meyer et al. [2006], Guliński et al. [2008]. The former authors found also a negative relationship between the level of urea in milk and the contents of fat, protein and lactose in Holstein cows. Arunvipas et al. [2003] analyzed milk from six cattle breeds and showed a positive relationship between the level of urea and milk yield as well as a negative relationship between milk urea and fat contents. Rajala-Schultz and Saville [2003] showed that milk of cows from high producing herds was characterized by a higher level of urea and a lower somatic cell count and a lower fat percentage. Hojman et al. [2004] found a negative association between the level of urea and the number of somatic elements and protein percentage in milk of Holsteins. In this study, taking into consideration the productivity of cows expressed in actual and standardized (%-FCM) kilograms of milk, irrespective of the genotype of cows, the most advantageous results were recorded for animals, which milk contained the lowest number of somatic elements ($\leq$ 200 thousand per ml). Milk yield in this group of animals differed significantly ($P \leq 0.01$) from the productivity of cows coming from the groups, which milk contained more somatic elements. Results of this study concerning a reduction of daily milk yield with an increase in the somatic cell count are confirmed by Dorynek et al. [1998] and Pytlewski and Dorynek [2000].

Table 2. The effect of somatic cell count in milk on urea level as well as milk yield and composition in the analyzed cows depending on their genotype

Tabela 2. Wpływ liczby komórek somatycznych w mleku na poziom mocznika oraz wydajność mleka i jego skład u badanych krów w zależności od ich genotypu

Traits – Cechy	Genotype Genotyp	Somatic cell count, thous. · ml^{-1} – Liczba komórek somatycznych, tys. · ml^{-1}									
		± 200		201–400		401–500		501–1000		>1000	
		N	$\bar{x}$	N	$\bar{x}$	N	$\bar{x}$	N	$\bar{x}$	N	$\bar{x}$
Urea – Mocznik, mg · l^{-1}	HO-1	858	225AC	287	226B	61	232A	135	220B	150	213B
	HO-2	3063	238AB*AE*	1327	234A*B*	301	230B*C*	654	226A*DE*	610	213A*ABCD*
	RW	332	257BC	157	258AB	29	258AB	92	243AB	93	225AB
Milk – Mleko, kg · d^{-1}	HO-1	858	30.25B *ABCD*	287	26.93B *Aa*	61	24.15 *Bab*	135	26.58a *Cb*	150	25.74 *D*
	HO-2	3063	30.20A *ABCD*	1327	25.97A*A*	301	25.59*BE*	654	25.34*CF*	610	27.20a*DEF*
	RW	332	28.18AB*Aac*	157	23.61AB*Ab*	29	27.08*b*	92	23.79a*a*	93	24.74a*c*
FCM kg · d^{-1}	HO-1	858	28.28*ABCD*	287	25.60b*A*	61	23.68*B*	135	25.25*C*	150	24.88a*D*
	HO-2	3063	28.64*ABCD*	1327	25.58a*AE*	301	25.07*BF*	654	24.89*CG*	610	26.94ab*DEFG*
	RW	332	28.19*ABCD*	157	23.96ab*A*	29	25.57*B*	92	23.63*C*	93	24.61b*D*
Fat – Tłuszcz, %	HO-1	858	3.68Ba*Abcd*	287	3.82AC*b*	61	4.01*A*	135	3.81A*ac*	150	3.87A*d*
	HO-2	3063	3.78Aa*ABCD*	1327	4.04AB*A*	301	4.05*B*	654	4.04a*C*	610	4.02*D*
	RW	332	4.13AB	157	4.30BC	29	3.99	92	4.12A	93	4.07A
Protein – Białko, %	HO-1	858	3.53B*ABa*	287	3.65B*A*	61	3.68*B*	135	3.60	150	3.62A*a*
	HO-2	3063	3.49A*ABCD*	1327	3.70A*A*	301	3.69*B*	654	3.68*C*	610	3.66B*D*
	RW	332	3.59AB*ABCD*	157	3.80AB*A*	29	3.67*B*	92	3.66*C*	93	4.07AB*D*
Dry matter – Sucha masa %	HO-1	858	12.74B*A*	287	12.92AC	61	13.10*A*	135	12.85ab	150	12.90
	HO-2	3063	12.82A*ABCD*	1327	13.21AB*Aa*	301	13.15*B*	654	13.12a*C*	610	13.05*Da*
	RW	332	13.21AB	157	13.50BC*Aa*	29	12.92*A*	92	13.16b	93	13.03*a*

Means within columns marked with identical letters differ significantly; large letters (A, B, C…) – $P \leq 0.01$, small letters (a, b, c…) $P \leq 0.05$.
Średnie w obrębie kolumn oznaczone takimi samymi literami różnią się istotnie; duże litery (A, B, C…) – $P \leq 0.01$, małe litery (a, b, c…) – $P \leq 0.05$.
Means within rows marked with identical letters differ significantly; large letters (*A*, *B*, *C*…) – $P \leq 0.01$, small letters (*a*, *b*, *c*…) $P \leq 0.05$.
Średnie w obrębie wierszy oznaczone takimi samymi literami różnią się istotnie; duże litery (*A*, *B*, *C*…) – $P \leq 0.01$, małe litery (*a*, *b*, *c*…) – $P \leq 0.05$.

When analyzing milk fat content it was found that the lowest amounts of this component were contained in milk with the lowest somatic cell count (≤ 200 thousand per ml). In animals with the HO-2 genotype the content of this component in milk of cows with the lowest number of somatic elements was lower ($P \leq 0.01$) in comparison to the other groups of animals, whose milk contained more somatic elements. In turn, in case of HO-1 genotype only one significant association at $P \leq 0.01$ was found for this trait between the group of animals with the lowest somatic cell count in milk, while the animals, whose milk contained from 401 to 500 thousand of cells per ml differed from the other groups at $P \leq 0.05$. Dorynek et al. [1998] did not find changes in the percentage of fat in milk depending on the number of somatic elements. Kisza [1990] reported that the content of fat in milk decreases and the percentage of protein increases along with an increase in somatic cell count. Brzozowski et al. [1999] and Sawa and Oler [1999] showed that with a deteriorating health state of the mammary gland the contents of fat and protein increases. According to Dorynek et al. [1998] and Dorynek and Kliks [1998] a decreasing daily yield of fat and protein in milk occurs when the somatic cell count increases and this results from losses in milk yield, and not from a decrease in the percentage of fat and protein in milk, which can even increase.

In this study, the lowest milk protein content was found in the milk of cows with the lowest number of somatic cells. In the HO-2 and Red-and-White animals the value of this trait recorded for cows, which milk contained the lowest amounts of somatic elements, differed ($P \leq 0.01$) in comparison to the percentage of protein found in milk of the other groups of cows. A similar correlation for dry matter content in milk was found for the group of HO-2 cows. The population of Black-and-White cows with a 100% share of Holstein-Friesian genes in their genotype (HO-1), which was characterized by the lowest number of somatic elements, differed in terms of protein content in milk from animals, which milk contained from 201 to 400 thousand of cells per ml and from 401 to 500 thousand of cells per ml at $P \leq 0.01$, and from cows, which milk contained the highest amount of somatic elements (>1000 thousand/ml) at $P \leq 0.05$.

CONCLUSION

It was found that the level of urea in milk of the analyzed genotypes of cows was within the limits of the accepted standard, with higher values of this parameter being reported for cows of the Polish Holstein-Friesian, Red-and-White, as compared to Black-and White variety. In the milk of the latter strain of cows with an incomplete share of Holstein-Friesian genes in their genotype a decrease in urea content was recorded with an increase in somatic cell count in milk. Taking into consideration daily yield of milk and fat corrected milk (4%-FCM) the most advantageous results were found for animals with the lowest somatic cell count in milk.

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ZALEŻNOŚCI MIĘDZY LICZBĄ KOMÓREK SOMATYCZNYCH A POZIOMEM MOCZNIKA W MLEKU KRÓW RASY POLSKIEJ HOLSZTYŃSKO-FRYZYJSKIEJ ODMIANY CZARNO-BIAŁEJ I CZERWONO-BIAŁEJ

Streszczenie. Celem pracy było zbadanie wpływu liczby komórek somatycznych na zawartość mocznika w mleku krów rasy polskiej holsztyńsko-fryzyjskiej odmiany czarno-białej (N = 390) i czerwono-białej (N = 86) utrzymywanych w jednym z gospodarstw Wielkopolski. Stwierdzono, że poziom mocznika w mleku krów ocenianych genotypów mieścił się w przyjętej normie, przy czym wyższymi wartościami tego parametru charakteryzowały się krowy rasy polskiej holsztyńsko-fryzyjskiej odmiany czerwono-białej. W mleku krów rasy polskiej holsztyńsko-fryzyjskiej odmiany czarno-białej, o zróżnicowanym udziale genów rasy holsztyńsko-fryzyjskiej, wykazano spadek zawartości mocznika w miarę wzrostu liczby komórek somatycznych. Biorąc pod uwagę wydajność dobową mleka oraz mleka standaryzowanego (4%-FCM), najkorzystniejszymi wynikami charakteryzowały się zwierzęta o najniższej zawartości komórek somatycznych w mleku.

Słowa kluczowe: komórki somatyczne, mleko, mocznik

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