EFFECT OF MILK UREA AND PROTEIN LEVELS ON FERTILITY INDICES IN COWS
WPŁYW POZIOMU MOCZNIKA I BIAŁKA W MLEKU NA WSKAŹNIKI PŁODNOŚCI KRÓW

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ABSTRACT

An analysis of the effect of milk urea and protein levels in four consecutive lactations on fertility indices of Black-and-White Polish Holstein-Friesian cows, milk recorded in the Kujawsko-Pomorskie province has been made. Poorer fertility indices were found in first-calf heifers and second lactation cows receiving energy-deficient diets and in older (third and fourth lactation) cows receiving excess dietary protein and energy. Best fertility was found in young cows fed excess protein (>3.60%) regardless of milk urea levels, and in older cows having lower and optimum levels regardless of protein levels. Cow fertility is differentiated more by milk protein levels than by urea content. Fertility parameters were poorer in first and second lactation cows than in older cows. The coefficients of correlation between milk urea and protein levels and fertility indices were very low, with the only significant differences between protein content vs. calving interval and reproductive rest period.

Key words: cows, urea, protein, fertility

STRESZCZENIE

Analizowano wpływ poziomu mocznika i białka w mleku w czterech kolejnych laktacjach na wskaźniki płodności krów rasy polskiej holsztyńsko-fryzyjskiej odmiany czarno-białej, będących pod oceną użytkowości mlecznej w województwie kujawsko-pomorskim. Gorsze wskaźniki płodności występowały u krów pierwiastek i w II laktacji przy niedoborze energii w dawce pokarmowej, natomiast u krów starszych w III i IV laktacji zarówno przy nadmiarze białka jak i energii. Krowy młode wykazywały najlepszą płodność niezależnie od poziomu mocznika w mleku, przy nadmiarze białka >3,60%, natomiast krowy starsze niezależnie od poziomu białka przy niższej i optymalnej zawartości mocznika. Poziom białka w mleku bardziej różnicuje płodność krów niż zawartość mocznika. Parametry płodności były gorsze u krów w I i II laktacji niż u krów starszych. Współczynniki korelacji pomiędzy poziomem mocznika i białka w mleku a wskaźnikami płodności były bardzo niskie i tylko w przypadku zawartości białka a OMW i OSR istotne statystycznie

Słowa kluczowe: krowy / mocznik / białko / płodność

STRESZCZENIE SZCZEGÓŁOWE

Badania zostały przeprowadzone na krowach rasy polskiej holsztyńsko-fryzyjskiej odmiany czarno-białej, będących pod oceną użytkowości mlecznej w województwie kujawsko-pomorskim. Informacje dotyczące poziomu mocznika i białka w mleku krów uzyskano z bazy danych systemu SYMLEK Analizą objęto zawartość mocznika i białka w mleku z próbnych udojów do 150. dnia laktacji. Uwzględniono 2173 próbnych udojów w pierwszej laktacji, 15817 próbnych udojów w drugiej laktacji, 10917 próbnych udojów w trzeciej laktacji i 6654 próbnych udojów w czwartej laktacji. Oszacowano wpływ poziomu mocznika mg·l $^{-1}$ i białka % (1 - <150 i <3,2, 2 – 150-300 i <3,2, 3 - >300 i <3,2, 4 - <150 i 3,20-3,60, 5 – 150-300 i 3,20-3,60, 6 - >300 i 3,20-3,60, 7 - <150 i >3,60, 8 – 150-300 i >3,60, 9 - >300 i >3,60) w mleku z próbnych udojów na wskaźniki płodności (okres międzywycieleniowy, okres usługi, okres spoczynku rozrodczego, indeks inseminacji) w kolejnych wycieleniach (1-4). Stwierdzono, niezależnie od laktacji, największy udział próbek mleka o zawartości <3,20% białka, wskazujący na niedobór energii w dawce. Płodność krów, których zawartość białka w mleku świadczyła o niedożywieniu energetycznym okazała się słabsza, zwłaszcza w przypadku krów po pierwszym i drugim wycieleniu. Natomiast krowy po trzecim i czwartym wycieleniu najgorszą płodność miały przy nadmiarze białka i energii w dawce (w mleku >300 mg·l $^{-1}$ mocznika i białka >3,60%). Świadczy to, że zarówno niedobór jak i nadmiar białka i energii w paszy wpływa negatywnie na płodność. Różnice dotyczące wskaźników płodności krów w I i IV laktacji były nieistotne. Istotne różnice stwierdzono w zakresie OMW i OSR u krów w II i III laktacji.

INTRODUCTION

The normal course of lactation and health of animals are conditional on whether the ration is well balanced for protein and energy, especially with regard to high-yielding cows. The feeding of unbalanced rations often leads to a decline in productivity and reproductive disorders. Information on protein and urea percentage may be useful for assessing the proper composition of the diet. According [12], who developed a model for evaluating protein and energy balance in the diets of dairy cows, the normal level of urea is 150-300 mg·l $^{-1}$ with a protein content of 3.2-3.6%. Based on a synthesis of relevant research findings of recent years, Krzyżewski et al. [9] hold that the current state of knowledge is inadequate to determine recommended, physiological or safe concentrations of milk urea.

Because of the inconsistent views of different authors regarding the optimum milk urea levels in cows, the objective of this study was to determine the effect of milk urea and protein levels in four consecutive lactations on some fertility indices in cows.

MATERIALS AND METHODS

The study was carried out with Black-and-White Polish Holstein-Friesian cows, milked recorded in the Kujawsko-Pomorskie province. Information concerning milk urea and protein levels was obtained from the SYMLEK database. Urea and protein content in test-day milk obtained to 150 days of lactation was analysed.

A total of 2173 test-day yields in the first lactation, 15817 test-day yields in the second lactation, 10917 test-day yields in the third lactation and 6654 test-day yields in the fourth lactation were analysed and grouped according to model of the evaluation of balancing the protein end energy at cows [13].

The effect of urea and protein content on fertility indices (calving interval, CI; service period, SP; reproductive rest period, RRP; insemination index, II) was estimated in successive calvings (1 to 4). In addition, simple correlation coefficients were calculated between urea (mg·l $^{-1}$) and protein (%) levels and the above fertility indices of the cows. The calculations were made using SAS/STAT software [15]. The significance of differences among average values were estimated using the Scheffe's test.

Group	Protein, %	Urea, mg l^{-1}	In alimentary dose
1	<3,2	<150	Protein and energy deficiency
2	<3,2	150-300	Energy deficiency
3	<3,2	>300	Excess of protein and energy deficiency
4	3,2-3,6	<150	Protein deficiency and small overage surplus of energy
5	3,2-3,6	150-300	Ballance level of protein and energy
6	3,2-3,6	>300	Excess of protein and small energy deficiency
7	>3,6	<150	Protein deficiency and excess of energy
8	>3,6	150-300	Excess of energy
9	>3,6	>300	Excess of protein and energy

Table 1. Cow fertility according to milk urea and protein levels
Tabela 1. Płodność krów w zależności od poziomu mocznika i białka w mleku

Urea content Zawartość mocznika ($mg \cdot l^{-1}$)	Milk protein Białko w mleku (%)	No. of milk samples Liczba próbek mleka	Calving interval (days) Okres między-wycieleniowy (dni)	Service period (days) Okres usługi (dni)	Reproductive rest period (days) Okres spo-czynku roz-rodczego (dni)	Insemination index Indeks inseminacji
First lactation	Pierwsza laktacja					
<150	<3.20	575	422	53.6	84.9	2.12
150-300		924	427	54.1	90.1	2.16
>300		242	431	49.6	97.2	2.15
<150	3.20-3.60	87	421	56.4	83.6	2.31
150-300		215	416	43.2	87.6	2.07
>300		70	406	39.0	86.2	1.94
<150	>3.60	14	410	22.5	96.5	1.75
150-300		37	405	36.6	84.7	1.96
>300		9	406	43.3	79.8	1.87
Second lactation	Druga laktacja					
<150	<3.20	3574	420 ABaCD	47.8	90.9 ABCD	2.00
150-300		4663	419 bc	47.5	89.4 EFdG	2.00
>300		2067	416	48.1	88.0	2.03
<150	3.20-3.60	1673	409 Ab	44.5	81.1 AE	1.94
150-300		1884	408 BD	43.5	81.7 BF	2.00
>300		546	413	44.0	87.9	2.02
<150	>3.60	579	405 a	42.1	81.4 Cd	1.94
150-300		663	404 Cc	43.2	79.5 DG	1.95
>300		168	413	50.2	81.2	2.20
Third lactation	Trzecia laktacja					
<150	<3.20	3538	417 ab	44.5	92.8 Aa	1.93
150-300		3246	419 AB	46.0	92.7 b	1.98
>300		852	416	42.5	91.7	1.93
<150	3.20-3.60	1169	407 aAC	41.8	86.0 Ab	1.90
150-300		1083	407 bBD	41.4	86.6 a	1.94
>300		195	408	38.0	90.1	1.82
<150	>3.60	404	409	39.4	89.5	1.88
150-300		363	407	41.1	86.5	2.02
>300		67	424CD	46.8	90.0	2.30
Fourth lactation	Czwarta laktacja					
<150	<3.20	2076	407	37.1	89.9	1.81
150-300		1968	409	39.3	89.6	1.91
>300		548	404	35.1	89.3	1.80
<150	3.20-3.60	717	403	37.5	84.9	1.86
150-300		696	405	40.2	85.2	1.93
>300		146	402	34.2	87.7	1.83
<150	>3.60	234	407	43.3	83.2	1.89
150-300		229	398	33.4	83.7	1.76
>300		40	425	63.0	91.0	2.24

Mean values in within examined factors followed by the same letters differ significantly: capital letters – at P≤0.01; small letters – at P≤0.05
Wartości średnie cech oznaczone tymi samymi literami różnią się istotnie: duże litery przy P≤0,01; małe litery przy P≤0,`05

RESULTS AND DISCUSSION

Based on the results given in Table 1, it was found that regardless of lactation, the highest proportion of milk samples had <3.20% protein, which is indicative of dietary energy deficiency. The fertility of cows whose milk protein content was indicative of energy undernutrition proved inferior, especially in animals with 1-3 calvings. This agrees with the opinion of many authors that energy nutrition is generally considered the most important nutritional factor affecting fertility and that energy underfed cows often have reproductive problems. However, excess protein in the diet, especially when paralleled by energy deficiency, increases blood urea and leads to a number of disorders [8]. In our study, this was especially true for young cows. Cows after their third and fourth calvings had poorest fertility with excess protein and energy supply (>300 mg·l $^{-1}$ urea and >3.60% protein in milk). This in turn supports the fact that fertility is negatively influenced by both deficiency and excess of protein and energy in the diet. Elrod and Butler [3] and Elrod et al. [4] provided evidence that increased protein in feed decreases uterine pH, which could be responsible for reduced fertility. In our study, cow fertility is differentiated more by milk protein content than by milk urea content. In first-calf heifers and second lactation cows, better fertility indices were found for excess dietary energy (>3.60% protein in milk), whereas best fertility was shown by cows whose milk contained 150-300 mg·l $^{-1}$ urea, indicating that dietary protein was well balanced. In older (third and fourth lactation) cows, better fertility was noted, regardless of milk protein levels, for lower and optimum urea content (<150 and 150-300 mg·l $^{-1}$ milk). The results obtained are evidence that young cows utilize excess protein and energy more efficiently that older cows. The differences in fertility indices of first and fourth lactation cows were not significant. Significant differences were found for calving interval and reproductive rest period in second and third lactation cows. According to Melandez et al. [11], Butler et al. [2] and Fergusson et al. [5], there is a

Table 2. Coefficients of correlation between milk urea and protein levels and cow fertility
Tabela 2. Współczynniki korelacji pomiędzy poziomem mocznika i białka w mleku a płodnością krów

Item Wyszczególnienie	Calving interval (days) Okres międzywycieleniowy (dni)	Service period (days) Okres usługi (dni)	Reproductive rest period (days) Okres spoczynku rozrodczego (dni)	Insemination index Indeks inseminacji
First lactation Laktacja 1				
urea (mg·l $^{-1}$)	0.01	-0.02	0.08^{xx}	-0.01
mocznik protein (%) białko	-0.04^{xx}	-0.02^{xx}	-0.03^{xx}	-0.01
Second lactation Laktacja 2				
urea (mg·l $^{-1}$)	-0.004	0.004	-0.006	0.01
mocznik protein (%) białko	-0.03^{xx}	-0.009	-0.06^{xx}	0.01
Third lactation Laktacja 3				
urea (mg·l $^{-1}$)	0.002	-0.004	0.001	0.01
mocznik protein (%) białko	-0.03^{xx}	-0.01	-0.03^{xx}	-0.008
Fourth lactation Laktacja 3				
urea (mg·l $^{-1}$)	0.006	-0.005	0.004	0.009
mocznik protein (%) białko	-0.02^{xx}	-0.006	-0.03^{xx}	-0.007

xx - P≤0,01

relationship between milk urea levels and reproductive indices. Melandez et al. [11] demonstrated that with urea levels of 170-250 mg·l $^{-1}$ milk, cows were characterized by poorer calving rates compared to the cows whose milk urea content was 60-160 mg·l $^{-1}$. Likewise, Butler et al. [2] and Fergusson et al. [5] reported that calving rate deteriorated in cows whose milk urea levels exceeded 190 and 200 mg·l $^{-1}$. Our findings support the results of other authors concerning older (third and fourth lactation) cows. Some authors showed that fertility deteriorated for even lower milk urea: <154 mg·l $^{-1}$ [14] and <117.5 mg·l $^{-1}$ [6]. Larson et al. [10] suggest that a high concentration of milk urea may result in early embryo loss even before pregnancy has been diagnosed. It is concluded from the data in Table 1 that regardless of milk urea and protein levels, fertility parameters were poorer in first and second lactation cows than in older cows. Other studies by Jankowska and Sawa [7] and Bogucki et al. [1] also found more favourable fertility indices in older cows compared to first-calf heifers.

The coefficients of correlation between milk urea and protein levels and fertility indices were presented in Table 2. In both cases, the correlation coefficients were very low. For urea they were both positive and negative and non-significant, and for protein they were mostly negative and highly significant for calving interval and reproductive rest period. Such low correlation values are indicative of a weak relationship between the analysed traits. Also Skrzypek et al. [16] found low and non-significant correlations between milk urea level and reproductive indices.

CONCLUSIONS

In summing up the results obtained, it is concluded that first-calf heifers and second lactation cows have poorer fertility indices with dietary energy deficiency, and older (third and fourth lactation) cows with both protein and energy excess. Young cows showed best fertility with excess protein (>3.60%) regardless of milk urea levels, and older cows with lower and optimum urea levels regardless of the protein level. Cow fertility was differentiated more by milk protein levels than by milk urea levels. Fertility parameters were poorer in first and second lactation cows than in older cows. The coefficients of correlation between milk urea and protein levels and fertility indices were very low and statistically significant only between protein content vs. calving interval and reproductive rest period.

REFERENCES

[1] Bogucki M., Jankowska M., Oler A., Krężel S., Neja W., Wpływ wydajności na płodność krów mlecznych. Prace Komisji Nauk Rolniczych i Biologicznych BTN, seria B, (2006) 60, 15-20

[2] Butler W. R., Calaman J. J., Beam W., Plasma and Milk Urea Nitrogen in Relation to Pregnancy Rate in Lactating Dairy Cattle. Journal Animal Science (1996) 74, 858-865

[3] Elrod C. C., Butler W. R., Reduction of fertility and alteration of uterine pH in heifers fed excess ruminally degradable protein. Journal Animal Science (1993) 71, 694 – 701

[4] Elrod C. C., M. Van Amburgh, Butler W. R., Alterations of pH in response to increased dietary protein in cattle and unique to the uterus. Journal Animal Science (1993) 71, 702-706

[5] Ferguson J. D., Galigan D. T., Blanchard T., Reeves M., Serum urea nitrogen and conception rate: the usefulness of test information. Journal of Dairy Science (1993) 76, 3742-3753

[6] Hojman D., Kroll O., Adin G., Gips M., Hanochi B., Ezra E., Relationships Between Milk Urea and Production, Nutrition and Fertility Traits in Israeli Dairy Herds. Journal of Dairy Science (2004) 87, 4, 1001 - 1011

[7] Jankowska M., Sawa A., Zależność między jakością cytologiczną mleka a wskaźnikami płodności krów. Roczniki Naukowe Polskiego Towarzystwa Zootechnicznego, (2008) t. 4, nr 1, 103-107

[8] Kowalski Z. M., Żywienie krów a problemy z ich rozrodem. II Międzynarodowe Targi Ferma Bydła, (2002) 75-80

[9] Krzyżewski J., Słoniewski K., Strzałkowska N., Zawartość mocznika w mleku krów oraz perspektywy wykorzystania tego wskaźnika w zarządzaniu stadem krów mlecznych. Zeszyty Naukowe Przeglądu Hodowlanego (2001) 55, 53-65

[10] Larson S. F., Butler W. R., Currie W. B., Reduced fertility associated with low progesterone postbreeding and increased milk urea nitrogen in lactating cows. Journal of Dairy Science (1997) 80, 1288-1295

[11] Melandez P., Donovan A., Hernandez J., Journal of Dairy Science (2000) 83, 459-463

[12] Nagel S., Harnst offbericht: Neus fur grosse Herden. Tirzuchter (1994) 46 (9), 28-31

[13] Osten-Sacken A., Zawartość mocznika w mleku – nowy parametr diagnostyczny. Chów Bydła (2000) 1, 6-8

[14] Rajala-Schultz P. J., Saville W. J. A., Frazer G. S., Assotiaton Between Milk Urea Nitrogen and Fertility in Ohio Dairy Cows. Journal of Dairy Science (2001) 84, 2, 482-489

[15] SAS Institute Inc. 2008. SAS/STAT 9,2 User's Guide. Cary, NG: SAS Institute Inc.

[16] Skrzypek R., Chraplewski H., Białoń K., Zależność między koncetracją mocznika w mleku a płodnością krów. Medycyna Weterynaryjna (2005) 61 (5), 536-53