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**Evaluation of the relationship between body condition
of high-yield Black-and-White Polish Holstein-Friesian
cows and their productivity**

Ocena zależności pomiędzy kondycją wysokowydajnych krów rasy phf cb
a ich produktywnością

Summary. The aim of the study was to evaluate the relationship between the body condition of cows and their daily milk yield and composition of the milk. Body condition was assessed once a month (according to the 5-point BCS system) in a herd of 52 Black-and-White Polish Holstein-Friesian cows with annual milk yield of over 10,000 kg. The analysis covered 607 body condition assessments and test-day milking results. The data were analysed using the SAS package. Daily milk yield decreased significantly as BCS scores increased. Cows with the lowest BCS (≤ 2.25) produced 35.3 kg of milk, when for the highest scores (BCS > 3.75 pts) the amount of milk obtained amounted to 25.1 kg. Increasing body condition scores were accompanied by a significant increase in the content of protein, lactose and dry matter in the milk. Somatic cell count was not affected by body condition scores. At the beginning of lactation, multiparous cows used their energy reserves more intensively than primiparous cows, and from the sixth month replenished them to a greater degree. Lactations in primiparous cows were more persistent.

Key words: cows, body condition, primiparous cows, multiparous cows, milk yield, milk composition

INTRODUCTION

The extent to which feed rations for dairy cows are properly balanced can be evaluated with various relatively simple tools, e.g. the level of urea in the milk and its total protein content, test strips for the presence of various metabolites in the milk or urine, etc. Another method for evaluating nourishment of cows and depletion or replenishment

of their energy reserves, particularly fatty tissue, is the use of BCS body condition scores. This is a subjective, non-invasive method for determining the level of energy accumulated in fat and muscle tissue [Ferguson *et al.* 1994]. Body condition score can be used not only in managing dairy herds, but also in mixed populations of meat and dairy cattle [Bouška *et al.* 2008]. In a study by Walsh *et al.* [2008], among cows representing different genotypes (4 breeds and 2 groups of hybrids) the lowest BCS scores were observed in Holstein-Friesian cows. Nevertheless, they produced the most milk, fat, and protein.

Assessment of the body condition of cows has measurable results, provided that it is carried out systematically. According to Guliński [1996], cows should be evaluated during their dry period, after calving, and on days 45, 90, 180, and 270 of lactation. The relationship between body condition at different stages of the production and reproduction cycle and milk yield and composition has been analysed many times [Borkowska and Januś 2002, Januś 2003, Januś and Borkowska 2005, Bouška *et al.* 2008]. Jilek *et al.* [2008] determined that cows whose BCS score was < 4 in the first month after calving produced significantly more milk than cows with higher scores; this was true of milk converted to FPCM (fat and protein corrected milk) as well.

The aim of the study was to evaluate the relationship between body condition of Black-and-White Polish Holstein-Friesian cows and their daily yield and milk composition.

MATERIAL AND METHODS

The study was carried out on a family farm on which 52 Black-and-White Polish Holstein-Friesian cows with average milk yield of about 11,000 kg per cow were kept in 2011 [PFCBDF 2012]. The cows were housed in a tie-stall barn. During the entire year their feed rations included fed hay, grass silage, and silage from maize and alfalfa. In winter the cows were also fed sugar beet pulp silage. Concentrate feed (in amounts determined individually) consisted of grain meal, bran, sunflower meal, and rapeseed meal. The cows also received vitamin and mineral supplements.

On test-day milking days in 2011 the body condition of the cows in the herd was evaluated according to the 5-point BCS system [Wildman *et al.* 1982], accurate to within 0.25 points. A total of 607 body condition scores and test-day milking results were analysed (322 in primiparous and 285 in multiparous). Data pertaining to milk yield, chemical composition of the milk, and somatic cell count (converted to a natural logarithm in Microsoft Excel) were obtained from breeding documentation.

Changes in the body condition of the cows and their daily yield in successive months after calving (month 1, 2, 3,..., 10, > 10) were evaluated, taking into account whether the cows were primiparous or multiparous. In analysing the effect of different body condition scores on daily yield, milk composition, and somatic cell count, the cows were divided into 4 groups: BCS up to 2.25; 2.50-3.00; 3.25-3.75 and > 3.75. The data were analysed using the SAS package [SAS[®] User's Guide 2006], and Duncan's test was used to determine the significance of the factors (PROC GLM). Correlation coefficients (PROC CORR) were calculated in order to estimate the interdependence between body condition and milk yield and composition.

RESULTS AND DISCUSSION

During the study the average daily yield of the cows was 31.0 kg of milk, containing on average 13.43% dry matter, including 4.39% fat, 3.58% protein, and 4.78% lactose (Table 1). Somatic cell count in the milk, expressed as a natural log, was 12.33. Most of the characteristics analysed in the milk were significantly influenced by body condition. Daily milk yield decreased as body condition increased (35.3, 33.4, 30.9, and 25.1 kg). The difference between the extreme values for milk yield was as high as 10.2 kg ($P \leq 0.01$). Increasing body condition scores were accompanied by a significant increase ($P \leq 0.01$ and $P \leq 0.05$) in the content of fat (from 3.95 to 4.51%), protein (from 3.15 to 3.73%), and dry matter (12.58 to 13.65%) in the milk. In the case of protein, the highest percentage was noted for the highest body condition scores, while the maximum content of fat and dry matter was associated with body condition scores between 3.25 and 3.75. No direct dependence was noted between lactose content in the milk and the level of energy reserves, as the lowest lactose level (4.75%) was observed for body condition scores of 2.50–3.00, while the highest level (4.84%) was noted in the case of BCS 3.25–3.75. These values differed significantly at $P \leq 0.01$. Also significant (at $P \leq 0.05$) was the difference between lactose level averages calculated for BCS 3.25–3.75 and those over 3.75. Body condition did not significantly influence somatic cell count in the milk expressed in $1,000 \times \text{ml}^{-1}$. However, a significant difference ($P \leq 0.05$) was noted with respect to the natural log of SCC. The difference was 0.31 between values calculated for BCS 2.50–3.00 and over 3.75.

The association between body condition and some of the productivity characteristics analysed was confirmed by correlation coefficients (Table 2). A negative, statistically significant ($P \leq 0.01$) correlation was calculated between body condition scores and milk yield ($r = -0.334$). The coefficients between body condition score and content of protein, lactose, and dry matter in the milk were $r = 0.215$, $r = 0.112$, and $r = 0.131$, respectively ($P \leq 0.01$). The correlations did not confirm a significant association between body condition score and fat content in the milk. A significant association between body condition of cows and milk yield and composition was also noted by Walsh *et al.* [2008]. Borkowska [2000] analysed body condition of cows from individual farms and calculated positive correlation coefficients, but they were statistically insignificant. This study, however, included cows, whose average annual milk yield was up to 5,000 kg per cow.

Borkowska *et al.* [2001] reported that the level of energy reserves might influence the state of health of the udder, as higher body condition scores were accompanied by a lower percentage of negative results for the Mastirapid test, and a higher percentage of positive and strongly positive results. The results of the present study do not confirm this, as the correlation coefficients calculated between the level of energy reserves in cows and SCC (in $1,000 \times \text{ml}^{-1}$ and \ln) in milk were positive ($r = 0.018$ and $r = 0.060$, respectively), but statistically insignificant.

The changes in body condition over the course of lactation were somewhat different in primiparous and multiparous cows (Fig. 1). Primiparous cows began lactation with lower fat reserves (BCS 3.14) than other cows (3.43). In the second month, their average body condition score decreased by 0.05, attaining its lowest value (3.09). From this point on (with the exception of month 6) fat reserves increased. However, the increase in body condition scores in primiparous cows was small, as their average score in the 10th month

Table 1. Daily yield, chemical composition, and somatic cell count in milk of cows with different body condition
 Tabela 1. Dobowa wydajność, skład chemiczny i liczba komórek somatycznych w mleku krów o różnej kondycji

Body condition (BCS score) Ocena kondycji (pkt BCS)	Number of milk samples Liczba prób mleka	Daily milk yield (kg) Dobowa wydajność mleka (kg)	Content in milk (%) Zawartość w mleku (%)				Somatic cell count Liczba komórek somatycznych	
			fat tłuszczu	protein białka	lactose laktozy	dry matter suchej masy	in 1,000 · ml ⁻¹ w tys. · ml ⁻¹	natural log logarytm naturalny
≤ 2.25	14	35.3 ^{AB}	3.95 ^a	3.15 ^A	4.80	12.58 ^{Aa}	321	12.26
2.50–3.00	281	33.4 ^A	4.33 ^a	3.50 ^B	4.75 ^A	13.27 ^{Ab}	622	12.24 ^a
3.25–3.75	188	30.9 ^B	4.51 ^b	3.62 ^{Ca}	4.84 ^{Ba}	13.65 ^B	429	12.32
> 3.75	124	25.1 ^C	4.38 ^{ab}	3.73 ^{Cb}	4.78 ^b	13.56 ^B	700	12.55 ^b
Σ; x̄	607	31	4.39	3.58	4.78	13.43	572	12.33

Averages designated with different letters differ significantly: capital letters – at P ≤ 0.01; lowercase letters – at P ≤ 0.05

Średnie oznaczone różnymi literami różnią się istotnie: wielkie litery – przy P ≤ 0,01; małe litery – przy P ≤ 0,05

Table 2. Correlation coefficients between body condition of cows and milk yield, milk composition, and somatic cell count
 Tabela 2. Współczynniki korelacji pomiędzy kondycją krów a wydajnością i składem mleka oraz liczbą komórek somatycznych

Characteristics Cechy	Daily milk yield (kg) Dobowa wydajność mleka (kg)	Content in milk (%) Zawartość w mleku (%)				Somatic cell count Liczba komórek somatycznych	
		fat tłuszcz	protein białko	lactose laktoza	dry matter sucha masa	in 1,000 · ml ⁻¹ w tys. · ml ⁻¹	natural log logarytm naturalny
Body condition (BCS score) Kondycja (pkt BCS)	-0.334*	0.03	0.215*	0.112*	0.131*	0.02	0.06

*Correlation coefficients significant at P ≤ 0.01 / Współczynniki korelacji istotne przy P ≤ 0,01

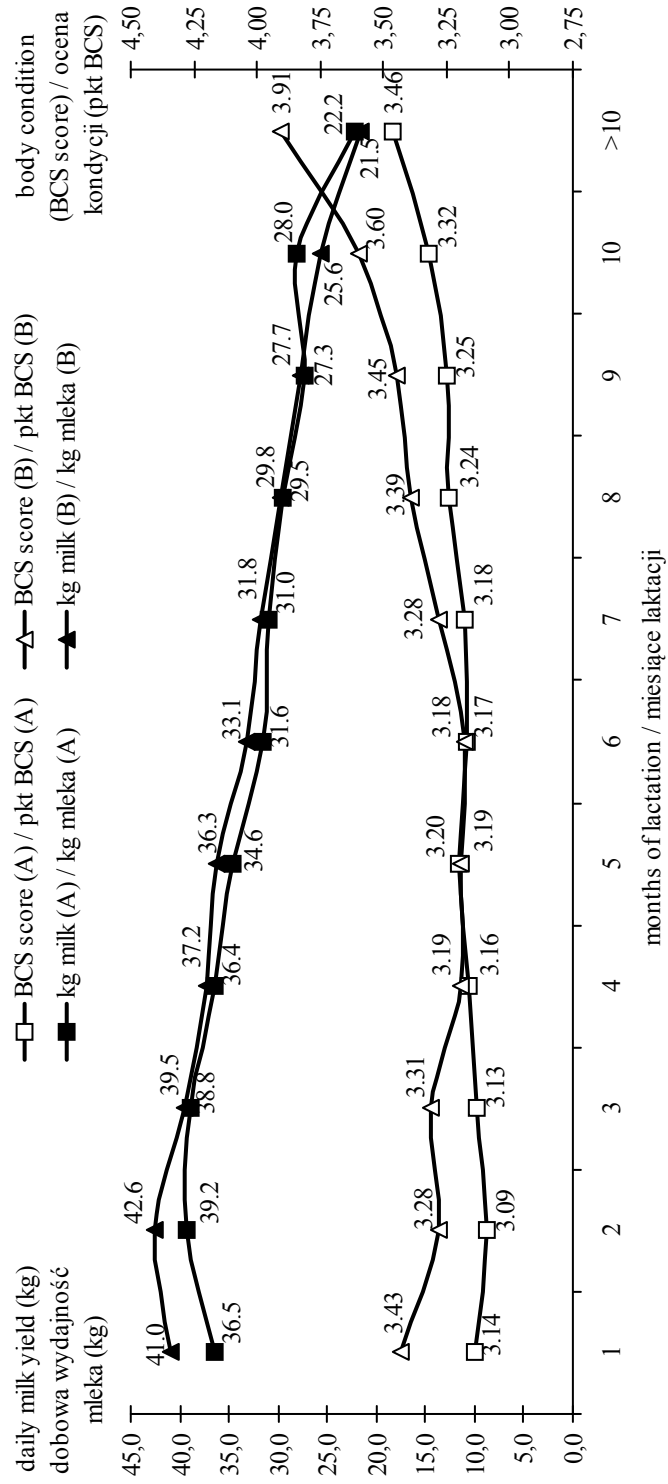


Fig. 1. Changes in body condition and daily milk yield in primiparous cows (A) and multiparous cows (B) in successive months of lactation
 Rys. 1. Kształtowanie się kondycji i dziennej wydajności mleka pierwsiastek (A) i wieloródek (B) w kolejnych miesiącach laktacji

after calving was only 3.32, and 3.46 in lactation extended beyond the 305-day standard. Older cows relied substantially on energy reserves, as their body condition in the 2nd month after calving was 0.15 lower than in the first, and continued to decrease until month 6, which indicates a prolonged negative energy balance. The body condition of multiparous cows improved substantially from month 7 of lactation, and in the 10th and subsequent months it was 3.60 and 3.91, respectively. Januś and Borkowska [2005] demonstrated that cows with milk yield of 6,000 kg per cow began replenishing their fat reserves as early as the 4th month of lactation. Walsh *et al.* [2008] reported that body condition score in cows began to increase, depending on the feeding system, in weeks 25–28 or 29–32 after calving.

It is also noteworthy that energy reserves in older cows were greater than in primiparous cows during the first three months after calving and in the 7th month of lactation. Other research has also found differences in body condition curves between primiparous and multiparous cows in successive months after calving [Januś and Borkowska 2005]. As in the present study, this study found less reduction in body condition in primiparous cows at the beginning of lactation and slower replenishment of reserves as lactation progressed.

The data in Fig. 1 show that lactations in primiparous cows were more persistent than in multiparous cows. Their daily milk yield in the 10th month of lactation decreased by only 28.6% in comparison to their peak yield, while in multiparous cows the difference was as high as 39.9%. Moreover, the increase in milk yield between the first month after calving and peak yield in the 2nd month was greater than in multiparous cows – 2.7 kg compared to 1.6 kg. Multiparous cows produced more milk than primiparous cows up to the 9th month of lactation; the difference was 4.5 kg in the first month after calving, 3.4 kg in the second, and from 0.3 to 1.7 kg in subsequent months. The difference in daily yield was lowest (0.3 and 0.4 kg) in months 8 and 9 of lactation. In the 10th and subsequent months of lactation, higher yield was noted in primiparous cows (by 2.4 and 0.7 kg, respectively).

CONCLUSIONS

The body condition of the cows during lactation was associated with milk yield. Cows with the lowest BCS (≤ 2.25) produced 35.3 kg of milk, when for the highest scores (BCS > 3.75 pts) the amount of milk obtained amounted to 25.1 kg.

An increase in body condition was accompanied by a significant increase in content of fat, protein, lactose, and dry matter in the milk. No association between body condition and fat content in the milk was confirmed by the correlation coefficient ($r = 0.028$).

The level of energy reserves in the cows did not significantly affect somatic cell count in the milk.

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Streszczenie. Celem pracy była ocena zależności między kondycją krów a ich wydajnością dobową i składem mleka. Kondycję oceniano raz w miesiącu (w 5-punktowej skali BCS) w stadzie liczącym 52 krowy rasy polskiej holsztyńsko-fryzyjskiej odmiany czarno-białej o wydajności powyżej 10 tys. kg mleka rocznie. Analizą objęto 607 ocen kondycji i wyników próbných udojów. Dane opracowano, wykorzystując pakiet SAS. Dobowa wydajność mleka istotnie zmniejszyła się (od 35,3 do 25,1 kg) wraz ze wzrostem ocen BCS. Zwiększaniu się ocen kondycji krów towarzyszyło istotne zwiększenie zawartości białka, laktozy i suchej masy w mleku. Na liczbę komórek somatycznych nie wpływała wielkość ocen kondycji. Wieloródki, w porównaniu z pierwiastkami, na początku laktacji intensywniej uruchamiały rezerwy energetyczne, a od 6. miesiąca w większym stopniu je odbudowywały. Laktacje pierwiastek były bardziej wytrwałe.

Słowa kluczowe: krowy, kondycja, pierwiastki, wieloródki, wydajność, skład mleka