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CORRELATION OF BODY CONDITION SCORE OF COWS AND MILK PRODUCTION IN STANDARD LACTATION

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Abstract: The aim of the study was, within the tested samples of high yielding Holstein-Friesian cows ($n = 363$), to analyze the significance of the actual level of correlation between the average BCS of cows according to body regions and results in the production of milk indifferent stages and the standard duration of lactation. Differences in average realized BCS in regard to the recommended values in stages of production cycle were highly significant ($p \leq 0.01$). In general, realized correlation coefficients, whose significance was tested, were at very low level. The average value of the BCS at dry off period in the first, second and third body region was statistically significantly ($p < 0.05$) and highly significantly ($p < 0.01$) positively associated with milk production during the first 100 days of lactation. The mean value of BCS at dry off period in the second body region was in a statistically significant positive correlation ($p < 0.05$) with the production of milk in the second 100 days and standard lactation. The average value of BCS at dry off period for all three body regions was highly significantly ($p < 0.05$) positively associated with milk production in the first 100 days. The mean value of BCS at calving in the first body region was highly significantly ($p < 0.01$) positively associated with milk production during the first and the second 100 days of lactation and standard lactation. Average BCS value at calving for the second body region was highly significantly ($p < 0.01$) positively correlated with milk production in the first and second 100 days of lactation and significantly positively correlated ($p < 0.05$) with the production of milk in the standard lactation. The mean value of BCS at calving in the third body region was highly significantly ($p < 0.01$) positively correlated with milk production during the first 100 days of lactation and significantly positively correlated ($p < 0.05$) with the production of milk in the second 100 days and standard lactation. Average BCS value for all three body regions at calving was in a highly significant ($p < 0.01$) positive correlation with milk production in the first hundred days of lactation. A significant positive correlation ($p < 0.05$) with the production of milk in the second 100 days and a standard lactation was achieved. The average value of BCS at the peak of

lactation for the first, second and third body region was significantly ($p < 0.05$) and highly significantly ($p < 0.01$) negatively correlated with the production of milk in a standard lactation. The mean value of BCS at the peak of lactation for all three body regions was very significantly ($p < 0.01$) negatively correlated with the production of milk in the standard lactation. The mean value of BCS in the mid-lactation for the first, second and third body region was highly significantly ($p < 0.01$) negatively correlated with the production of milk in the standard lactation. BCS average value for all three body regions in the mid-lactation was very significantly ($p < 0.01$) negatively correlated with the production of milk in the standard lactation.

Key words: body condition score, correlation, yield of milk, Holstein-Friesian breed

Introduction

A number of problems in the production of milk occurs due to lack of knowledge and monitoring of energy reserves in the body of cows (*Šamanc et al., 2005; Grubić et al., 2009*). Cows in optimal body condition after calving have sufficient appetite and produce more milk of good quality. Milk is a complex product of the mammary gland, which contains more than 100 different substances (*Wattiaux, 1996*).

Preparing cows for lactation cycle should begin during late lactation and the dry off period. The body condition of cows at calving has a significant impact on milk production in the current lactation. Body condition score (BCS) is a qualitative method for determining the body's energy reserves in the form of subcutaneous fat that is deposited in the region of the hips, flanks and tail root (*Wildman et al., 1982; Edmonson et al., 1989, Ferguson et al. 1994*).

Ability to consume large amounts of food is very important to meet the growing energy needs during the early lactation period which support the efficient production of milk (*Morow 1976, Pedron et al., 1993; Heuer, 2004*). Energy is the main determinant of milk production. The greatest number of animals has a negative energy balance (NEB) in early lactation. In this regard, the young animals that are still in the period of growth and development are particularly sensitive. Due to poor appetite, the intake of nutrients is insufficient for all bodily needs and body reserves are used as an energy source (*Moe, 1981*).

If energy requirements are not met at the required level from diet, then the body is necessarily directed towards its own body reserves. There was a significant correlation between body condition and milk production of cows (*Domecq, 1997*).

The cows in fattening condition have longer period of NEB (*Garnsworthy and Topps, 1982*). The body condition of dairy cows is associated with a number of environmental factors that affect consumption of dry matter intake of the diet (*Pryce 2002; Hutjens, 2005; Drackley, 2006*).

Cows that calved in poor physical shape, have a reduced ability to consume their daily ration of dry matter at the end of the dry offperiod and early lactation. Consumption of dry matter in the food reaches its maximum in the period between 9 to 13 weeks of lactation. Until then, to cover the energy needs cows use their own body reserves as a source (*Kertz et al., 1991; Bertics et al., 1992; Grant and Albright, 1995; Grummer, 1995*).

The aim of the study was, within a sample of high yielding Holstein-Friesian cows, to examine the significance of the achieved level of correlation between the average BCS of cows by body regions and results in the production of milk in stages and the standard duration of the production cycle.

Material and Methods

The subject of this paper was to assess the significance of the achieved level of correlation between the average values of the cows' BCS realized within all body regions with total milk production in stages and total duration of a standard lactation. The study was conducted on cattle farm that has 363 Holstein-Friesian cows. Feeding of cows was defined in terms of total requirements of each phase of the production cycle. Depending on the time of year and availability of adequate nutrients, two types of daily diets were used (summer and winter). Completely mixed diets were prepared using modern mixer trailer.

According to the research plan and program, the visual BCS and control of milk production of cows were carried out. The applied method of BCS (*Edmonson et al., 1989*) includes standards defined for each stage of the production cycle. Scoring of each cow was done at the beginning of the dry offperiod (P1), two days after calving (P2), at the peak of lactation (40 days) (P3) and in the mid-lactation (150 days) (P4).

BCS system for dairy cows has been created in the form of map. Map includes all body regions (BR) and body fields (BF), which are important for the allocation of the total BCS cows. Precisely defined three major body regions (BR₁₋₃): loins (BR₁), pelvis (BR₂) and tail root (BR₃). Within all three regions of the body, a cow has a total of eight body fields. The first body region has 4 fields, 3 fields in the second and in the third one field. Heads were evaluated individually. Each body field was assessed separately. Scoring of body fields represented the basis for calculating the average score for each body region.

Application of BCS provides continuous monitoring of individual body condition of cows per lactation phases. The method is the basis for selection of

quality criteria for the establishment of technological groups of cows and the whole farm management.

Control of milk performance all tested cows milk was carried out in accordance with the principles of milk testing/recording (ICAR method A4). Milk traits that were included in the analysis have the following abbreviations:

ML₀₋₁₀₀ - milk production during the first 100 days of lactation

ML₁₀₁₋₂₀₀- milk production during the second 100 days of lactation

ML₂₀₁₋₃₀₀- milk production during the third 100 days of lactation

ML₃₀₅ - milk production in the standard lactation of 305 days

The choice of methods for the statistical analysis was determined by the hypothesis and the characteristics of the data collected. The conclusion on the significance of the established correlation between the average BCS by body regions and the production of milk in stages and the duration of standard lactation was based on the results of testing of the corresponding correlation coefficient. The Pearson's correlation coefficient was used to investigate the correlation between two variables whose data were homogeneous ($C_v < 30\%$). Statistical analysis of experimental data was performed using the software STATISTICA v. 6th StatSoft, Inc. (2003).

Results and discussion

The research results of the significance of achieved level of correlation between the average BCS of cows by body regions and realized milk production per stages and a standard lactation period are shown in the following tables. Evaluating body condition of cows is an integral part of the overall strategy for managing the farm. Ideal body condition is a rank in the function of flow and lactation stage (*Ferguson et al., 1994*).

Realized average milk production and milk fat content in the standard lactation period of 305 days is shown in the following table:

Table 1. Average milk production and milk fat content in the standard lactation period (305 days)

Indicators	Milk (kg)	Milk fat (kg)	Milk fat (%))MF
\bar{X}	6560	245.00	3.75
n	315	315	315
Max	9390	373.00	4.18
Min	3871	120.00	3.49
Sd	1156.72	45.71	0.13
Cv	17.63	18.63	3.59

Milk production in standard lactation was at the average level of 6560 kg of milk with 245.00 kg and 3.75% fat. Coefficient of variation achieved for the amount of milk was 17.63% and 18.63% for milk fat (Table 1).

Table 2. Average BCS of cows for all body regions (BR₁₋₃) according production cycle stages

Indicators	BCS			
	P1	P2	P3	P4
\bar{X}	3.39	3.56	2.30	2.50
n	363	360	340	322
Max	4.41	4.63	3.16	3.43
Min	2.37	2.55	1.35	1.35
Sd	0.37	0.38	0.27	0.35
SX	0.022	0.022	0.017	0.021
Cv	11.01	10.77	11.82	14.10
p	0.000	0.000	0.000	0.000

N.S.- $p > 0.05$ *- $p \leq 0.05$ **- $p \leq 0.01$

Statistical indicators in the second table show the variability of achieved average value for the BCS of cows all body regions (BR₁₋₃) per production cycle phases (P₁₋₄). The average value of the BCS at dry off period was 3.39 (2.37 to 4.41), 3.56 at calving (2.55-4.63), at the peak of lactation 2.30 (1.35 to 3.16) and in the mid-lactation 2.50 (1.35 to 3.43). Differences in average realized BCS compared to the recommended optimal values per production cycle phases were highly significant ($p \leq 0.01$).

In general realized correlation coefficients, whose significance was tested, between the average values of the cows' BCS within each body region and production of milk in various phases and the duration of a standard lactation were low.

Correlation between cows' BCS and production of milk in the production cycle is shown in the following tables:

Table 3. Correlation between BCS by body regions at dry off period (P₁) and realized production of milk per production phases and total duration of standard lactation

Phase	Body region	Milk production (kg)	Correlation coefficient (r)	Level of significance (p)
P ₁	BR ₁	ML ₀₋₁₀₀	0.151	0.008
		ML ₁₀₁₋₂₀₀	0.098	0.085
		ML ₂₀₁₋₃₀₀	0.000	1.000
		ML ₃₀₅	0.108	0.058
	BR ₂	ML ₀₋₁₀₀	0.131	0.021
		ML ₁₀₁₋₂₀₀	0.125	0.028
		ML ₂₀₁₋₃₀₀	0.015	0.791
		ML ₃₀₅	0.114	0.045
	BR ₃	ML ₀₋₁₀₀	0.139	0.014
		ML ₁₀₁₋₂₀₀	0.090	0.113
		ML ₂₀₁₋₃₀₀	0.012	0.839
		ML ₃₀₅	0.103	0.069
	BR ₁₋₃	ML ₀₋₁₀₀	0.138	0.015
		ML ₁₀₁₋₂₀₀	0.092	0.106
		ML ₂₀₁₋₃₀₀	-0.006	0.918
		ML ₃₀₅	0.097	0.088

N.S.- p>0.05

*-p<0.05

**-p<0.01

The average value of the BCS in the dry period (P₁) in the first, second and third body region was statistically significantly (p <0.05) and highly significantly (p <0.01) positively correlated with milk production during the first 100 days of lactation. The mean value of BCS in the dry period in the second body region was in a statistically significant positive correlation (p <0.05) with the production of milk in the second 100 days and standard lactation. The average value of BCS in the dry period for all three body regions was in a statistically significant positive correlation (p <0.05) with milk production during the first 100 days of lactation (Table 3).

Cows which reach optimal body condition before drying off have fewer problems after calving (*Ferguson et al., 1994*). Obtained results indicate a significant and highly significant positive correlation between BCS at dry off (P₁) with the values of milk production realized in the first hundred days of lactation. Body reserves, established beforehand are an important basis for the level of milk production that will be reached in early lactation (*Domecq et al., 1997; Doepel et al., 2002*).

Table 4. Correlation between BCS by body regions at calving (P_2) and realized production of milk per production phases and total duration of standard lactation

Phase	Body region	Milk production (kg)	Correlation coefficient (r)	Level of significance (p)
P_2	BR ₁	ML ₀₋₁₀₀	0.190	0.001
		ML ₁₀₁₋₂₀₀	0.152	0.007
		ML ₂₀₁₋₃₀₀	0.026	0.653
		ML ₃₀₅	0.156	0.006
	BR ₂	ML ₀₋₁₀₀	0.159	0.005
		ML ₁₀₁₋₂₀₀	0.148	0.009
		ML ₂₀₁₋₃₀₀	-0.002	0.974
		ML ₃₀₅	0.130	0.022
	BR ₃	ML ₀₋₁₀₀	0.176	0.002
		ML ₁₀₁₋₂₀₀	0.120	0.034
		ML ₂₀₁₋₃₀₀	0.026	0.649
		ML ₃₀₅	0.138	0.015
	BR ₁₋₃	ML ₀₋₁₀₀	0.180	0.001
		ML ₁₀₁₋₂₀₀	0.145	0.011
		ML ₂₀₁₋₃₀₀	0.014	0.809
		ML ₃₀₅	0.144	0.011

N.S.- $p > 0.05$ *- $p \leq 0.05$ **- $p \leq 0.01$

The mean value of BCS at calving (P_2) in the first body region was highly significantly ($p < 0.01$) positively correlated with milk production in the first and second 100 days and standard lactation. The average value of BCS at calving in the second body region was highly significantly ($p < 0.01$) positively correlated with milk production in the first and second 100 days, and a significantly positively correlated ($p < 0.05$) with the production of milk in a standard lactation. The mean value of BCS at calving in the third body region was highly significantly ($p < 0.01$) positively correlated with milk production during the first 100 days of lactation and in a significant positive correlation ($p < 0.05$) with the production of milk in the second 100 days and standard lactation. Average BCS value for all three body regions at calving was in a highly significant ($p < 0.01$) positive correlation with milk production in the first hundred days of lactation. A significant positive correlation ($p < 0.05$) with the production of milk in the second 100 days and a standard lactation was realized (Table 4).

The transition from the dry period into early lactation stage is the most critical for the metabolism of high yielding cows (*Šamanc et al., 2005*). Prepared

body reserves in the previous period are used for the synthesis of milk. Adequate nutrition is of great importance in early lactation in terms of reduction of the NEB. At the same time it is important to produce the expected quality and quantity of milk. This indicates that the dietary management of the herd is at the appropriate level (*Ruegg and Milton, 1995*). The achieved results demonstrate the importance of the correlation between BCS, at calving (P_2) with the values of the actual production of milk in the first and second 100 days and standard lactation.

Table 5. Correlation between BCS by body regions at lactation peak (P_3) and realized production of milk per production phases and total duration of standard lactation

Phase	Body region	Milk production (kg)	Correlation coefficient (r)	Level of significance (p)
P3	BR ₁	ML ₁₀₁₋₂₀₀	- 0.093	0.103
		ML ₂₀₁₋₃₀₀	-0.014	0.805
		ML ₃₀₅	-0.162	0.004
	BR ₂	ML ₁₀₁₋₂₀₀	-0.088	0.123
		ML ₂₀₁₋₃₀₀	-0.020	0.722
		ML ₃₀₅	-0.151	0.008
	BR ₃	ML ₁₀₁₋₂₀₀	-0.071	0.213
		ML ₂₀₁₋₃₀₀	-0.077	0.173
		ML ₃₀₅	-0.139	0.014
	BR ₁₋₃	ML ₁₀₁₋₂₀₀	-0.084	0.140
		ML ₂₀₁₋₃₀₀	-0.013	0.817
		ML ₃₀₅	-0.153	0.007

N.S.- $p > 0.05$

*- $p \leq 0.05$

**- $p \leq 0.01$

The average value of the BCS at the peak of lactation (P_3) in the first, second and third body region was significantly ($p < 0.05$) and highly significantly ($p < 0.01$) negatively correlated with the production of milk in a standard lactation. The mean value of the BCS at the peak of lactation for all three body regions was in a highly significant ($p < 0.01$) negative correlation with the production of milk in a standard lactation (Table 5).

Obtained results indicate the presence of negative correlation of average BCS at the peak of lactation (P_3) in all three regions with the production of milk in the standard lactation. The reason is the increasing use of body reserves in cows with high milk production. This is an important capability of high yielding cows to overcome NEB, which is a consequence of limited appetite at this stage of the production cycle (*Grummer, 1995; Prodanović et al., 2012*). Present energy deficit

is compensated by high yielding cows by their body depots (*Grant and Albright, 1995; Rastan et al., 2001*).

Table 6. Correlation between BCS by body regions at mid-lactation (P4) and realized production of milk per production phases and total duration of standard lactation

Phase	Body region	Milk production (kg)	Correlation coefficient (r)	Level of significance (p)
P4	BR ₁	ML ₂₀₁₋₃₀₀	-0.070	0.221
		ML ₃₀₅	-0.180	0.001
	BR ₂	ML ₂₀₁₋₃₀₀	-0,087	0.126
		ML ₃₀₅	-0.188	0.001
	BR ₃	ML ₂₀₁₋₃₀₀	-0.078	0.171
		ML ₃₀₅	-0.162	0.004
	BR ₁₋₃	ML ₂₀₁₋₃₀₀	-0.069	0.223
		ML ₃₀₅	-0.173	0.002

N.S.- $p > 0.05$

*- $p \leq 0.05$

**- $p \leq 0.01$

The mean value of the BCS in the mid-lactation (P4) in the first, second and third body region was highly significantly ($p < 0.01$) negatively correlated with the production of milk in a standard lactation. Average BCS value for all three body regions in the mid-lactation was very significantly ($p < 0.01$) negatively correlated with the production of milk in the standard lactation (Table 6).

The presented results indicate a highly statistically significant negative correlation of the average BCS value in the mid-lactation (P4) in all three body regions with the production of milk in the standard lactation. The reason is the current utilization of body reserves for lactation in cows with high milk production (*Buckley et al., 2003*). This process represents an important ability of cows to compensate a negative energy balance in a adequate extent from their own body reserves (*Šamanc et al., 2005*). The consequence is the loss of body condition, which thus allows the normal course of lactation (*Ferguson et al., 1994*).

Conclusion

The results indicate that the procedure of BCS is used to control nutrition and other necessary requirements that are aimed at improving production, fertility, health, longevity and well-being of high yielding cows. The subject of this paper was to assess the significance of the achieved level of correlation between the average values of the cows' BCS that occurred within all body regions with total milk production in production stages and duration of a standard lactation. In

general, realized correlation coefficients were low. The obtained results indicate a significant ($p \leq 0.05$) and highly significant ($p \leq 0.01$) positive correlation between BCS at drying off with milk production performance recorded in the first 100 days of lactation. Excessive body condition before and/or during the dry period, causes fat cow syndrome. The transition from the dry period into early lactation stage is the most critical for the metabolism of high yielding cows. The achieved results demonstrate the importance of the positive correlation between average BCS at calving with the values of milk production achieved in the first and second 100 days and standard lactation ($p \leq 0.05$, $p \leq 0.01$). There was a significant ($p \leq 0.05$) and highly significant ($p \leq 0.01$) negative correlation between average BCS score at the peak of the lactation in all three regions with the production of milk in the standard lactation. The presented results indicate a statistically significant ($p \leq 0.01$) negative correlation between average BCS in the mid-lactation in all three body regions with the production of milk in a standard lactation. The reason is the current utilisation of body reserves for lactation in cows with high milk production. This process represents an important capability of high yielding cows to compensate to certain extent the NEB by own body reserves. The consequence is the loss of body condition, which thus allows the normal course of lactation.

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Povezanost ocene telesne kondicije krava sa proizvodnjom mleka u standardnoj laktaciji

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Rezime

Cilj istraživanja bio je da se u okviru ispitivanog uzorka visokomlečnih krava holštajn-frizijske rase ($n=363$) analizira značajnost ostvarenog nivoa povezanosti između prosečnih vrednosti BCS krava po telesnim regijama i postignutih rezultata u proizvodnji mleka po fazama i standardnom trajanju laktacije. Razlike ostvarenih prosečnih BCS u odnosu na preporučene optimalne vrednosti po fazama proizvodnog ciklusa su visoko značajne ($p \leq 0.01$). U celini

posmatrano realizovani koeficijenti korelacije, čija je značajnost ispitana, bili su na niskom nivou. Prosečna vrednost BCS na zasušenju u prvoj, drugoj i trećoj telesnoj regiji bila je statistički značajno ($p < 0.05$) i vrlo značajno ($p < 0.01$) pozitivno povezana sa proizvodnjom mleka u prvih 100 dana laktacije. Srednja vrednost BCS na zasušenju u drugoj telesnoj regiji bila je u statistički značajnoj pozitivnoj vezi ($p < 0.05$) sa proizvodnjom mleka u drugih 100 dana i standardnoj laktaciji. Prosečna vrednost BCS na zasušenju za sve tri telesne regije bila je u statistički značajnoj pozitivnoj vezi ($p < 0.05$) sa proizvodnjom mleka u prvih 100 dana laktacije. Srednja vrednost BCS kod teljenja u prvoj telesnoj regiji bila je vrlo značajno ($p < 0.01$) pozitivno povezana sa proizvodnjom mleka u prvih i drugih 100 dana i standardnoj laktaciji. Prosečna vrednost BCS kod teljenja u drugoj telesnoj regiji bila je vrlo značajno ($p < 0.01$) pozitivno povezana sa proizvodnjom mleka u prvih i drugih 100 dana i u značajnoj pozitivnoj vezi ($p < 0.05$) sa proizvodnjom mleka u standardnoj laktaciji. Srednja vrednost BCS kod teljenja u trećoj telesnoj regiji bila je vrlo značajno ($p < 0.01$) pozitivno povezana sa proizvodnjom mleka u prvih 100 dana laktacije i u značajnoj pozitivnoj vezi ($p < 0.05$) sa proizvodnjom mleka u drugih 100 dana i standardnoj laktaciji. Prosečna vrednost BCS za sve tri telesne regije kod teljenja bila je u vrlo značajnoj ($p < 0.01$) pozitivnoj vezi sa proizvodnjom mleka u prvih sto dana laktacije. Ostvarena je značajna pozitivna veza ($p < 0.05$) sa proizvodnjom mleka u drugih 100 dana i standardnom laktacijom. Prosečna vrednost BCS na vrhu laktacije u prvoj, drugoj i trećoj telesnoj regiji bila je u značajnoj ($p < 0.05$) i vrlo značajnoj ($p < 0.01$) negativnoj vezi sa proizvodnjom mleka u standardnoj laktaciji. Srednja vrednost BCS na vrhu laktacije za sve tri telesne regije bila je u vrlo značajnoj ($p < 0.01$) negativnoj vezi sa proizvodnjom mleka u standardnoj laktaciji. Srednja vrednost BCS na sredini laktacije u prvoj, drugoj i trećoj telesnoj regiji bila je u vrlo značajnoj ($p < 0.01$) negativnoj vezi sa proizvodnjom mleka u standardnoj laktaciji. Prosečna vrednost BCS za sve tri telesne regije na sredini laktacije bila je u vrlo značajnoj ($p < 0.01$) negativnoj vezi sa proizvodnjom mleka u standardnoj laktaciji.

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