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Research Article

Effect of Body Condition Score at Calving on 305-day and Test-day Milk Yield in Holstein-Friesian and Brown Swiss Cows

*Zhivka GERGOVSKA[1], Jurii MITEV[1], Teodora ANGELOVA[2], Daniela YORDANOVA[2], Zhivko KRASTANOV[2], Krassimira UZUNOVA[3]**

[1]Trakia University, Faculty of Agriculture, Student's Campus 6000, Stara Zagora, Bulgaria
[2]Agricultural Institute, Stara Zagora 6000, Bulgaria
[3]Trakia University, Faculty of Veterinary Medicine, Department of Animal Husbandry, Student's Campus 6000, Stara Zagora, Bulgaria

**Corresponding Author: Krassimira UZUNOVA Trakia University, Faculty of Veterinary Medicine, Department of Animal Husbandry, Student's Campus 6000, Stara Zagora, Bulgaria*
e-mail: mira60bg@yahoo.com

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ABSTRACT

The study included 37 cows, 20 of which were of the Holstein-Friesian and 17 of which were of the Brown Swiss breed at the Agricultural Institute's farm in Stara Zagora. The cows from both breeds were kept together under similar rearing and feeding conditions. A free-range production system with individual boxes for rest was applied. The cows were divided into three technological groups depending on their physiological condition, respectively: dry period, first lactation period (up to the 120th day of lactation) and second lactation period. Feeding was based on a complete ration including maize silage, alfalfa haylage, concentrated feed, and vitamin mineral premix. The concentrated feed during lactation was in accordance with the group's mean milk yield. The cows' body condition score (BCS) was measured monthly per a 5-grade evaluation system with accuracy of up to 0.5 points. The body condition score of the cows at calving was measured 7 to 10 days before calving. The BCS at calving had a significant influence on the 305-day lactation milk yield, test-day milk yield and peak lactation production. The cows that reached a BCS of 3.5 – 4 points at calving had sufficient body reserves for the lactation's beginning, which allowed them to reach higher milk yield during the peak of lactation, and higher yield for 305 days compared to cows with grades of 3 or lower at calving. The Holstein-Friesian cows had better mobilisation potential than Brown Swiss cows. At BCS of 2 to 2.5 points at calving, Holstein-Friesian cows reached a milk yield that was only 876 kg less than those of cows with high BCS (3.5 – 4 points), whereas in Brown Swiss cows the difference was 1,400 kg. The cows of the Brown Swiss breed had preserved to a greater extent the defence reaction to reduce milk production when body reserves were diminished.

Key Words: Body condition score evaluation, 305-day lactation, peak lactation, test-day milk yield, Holstein-Friesian, Brown Swiss cattle

ÖZET

SİYAH ALACA VE ESMER IRK İNEKLERDE BUZAĞILAMA ÖNCESİ VÜCUT KONDİSYON SKORUNUN 305 GÜN VE TEST-GÜNÜ SÜT VERİMİ ÜZERİNE ETKİLERİ

Araştırma, Stara Zagora Ziraat Enstitüsü Çiftliğindeki 20 baş Siyah Alaca ve 17 baş Esmer olmak üzere toplam 37 baş inek ile yürütülmüştür. Her iki ırktan inekler benzer yetiştirme ve besleme koşullarında bakılmışlardır. İneklere serbest gezinmeli sistemde dinlenme için bireysel bokslar sağlanmıştır. İnekler fizyolojik durumlarına göre üç gruba ayrılmışlardır: a) Kuru dönem, b) I. laktasyon periodu (laktasyonun 120. gününe kadar) ve c) II. laktasyon periyodu. Mısır silajı, kuru yonca, konsantre yem ve vitamin - mineral premiksi içeren rasyona dayalı bir besleme programı uygulanmıştır. Laktasyon süresince verilen konsantre yem, grubun ortalama süt verimine göre düzenlenmiştir. İneklerin vücut kondisyon skoru (VKS), 5 dereceli değerlendirme sistemi ile 0,5 puanlık kesinlik ile aylık olarak ölçülmüştür. Buzağılama öncesi VKS, buzağılamadan 7-10 gün önce ölçülmüştür. Buzağılama öncesi VKS'nun 305-gün laktasyon süt verimi, test günü süt verimi ve pik süt verimi üzerine etkisi önemli bulunmuştur. Buzağılama öncesi VKS 3,5-4 puan olan ineklerin laktasyon başlangıcında yeterli vücut rezervlerine sahip oldukları ve böylece VKS 3 ve daha az olan ineklerle karşılaştırıldığında laktasyon pikinde daha yüksek süt verimine ulaştıkları ve daha yüksek 305-gün laktasyon süt verimine sahip oldukları sonucuna ulaşılmıştır. Siyah Alaca ineklerin Esmer ineklerle karşılaştırıldığında daha iyi mobilizasyon potansiyeline sahip oldukları gözlenmiştir. Siyah Alaca ırkında buzağılama öncesi VKS 2-2,5 olan inekler, 3,5-4 VKS olanlara kıyasla sadece 876 kg daha az süt verimine sahip iken, Esmer ineklerde aradaki fark 1400 kg olarak belirlenmiştir. Vücut rezervleri azaldığında Esmer ırk inekler süt verimini azaltma savunma reaksiyonunu daha fazla ortaya koymuşlardır.

Anahtar Kelimeler: Vücut kondisyon skoru değerlendirmesi, 305 gün laktasyon, laktasyon piki, test-günü, süt verimi, Siyah Alaca, Esmer

Introduction

Data on the systemic energy balance in cows is practically not available, mostly due to the lack of information on feed consumption. An indicator currently used to measure the accumulated reserve energy for milk production in dairy cows is body condition score (BCS) (Broster and Broster, 1998). BCS is a quick, non-invasive, cheap and slightly subjective estimation of the fat reserves in dairy cows, regardless of their size and live body weight (Waltner et al., 1993). In most cases, this information is used in the taking of managerial decisions. In many countries, this information is already used in selection programmes and there is much knowledge in terms of data, selection results and various solutions.

What focuses interest towards changes in cows' BCS is the intense transgenerational genetic selection aimed at higher milk yield for the entire lactation period and at the start of lactation during the past 50 years (Dillon, 2006). This selection pressure has led to a number of physiological changes favouring enhanced mobilisation of energetically important tissues in dairy cows more than what is exhibited in other mammals (Chagas et al., 2009; Lucy et al., 2009). In addition to the effects of genetic selection, BCS is influenced by a number of factors, such as the parity (Coffey et al., 2004; Pryce et al., 2001), the age at calving (Koenen et al., 2001; Pryce and Harris, 2004), and the season of calving (Pryce et al., 2001). A number of management factors also have an influence, such as herd size (Macdonald et al., 2008; McCarthy et al., 2007; Roche et al., 2007), feeding level, diet type, etc. (Coffey et al., 2004; Roche, 2007; Roche et al., 2007). Differences in the extent of genetic improvement and managerial strategies in different countries and cattle populations lead to different results in this relation, as seen from numerous studies.

The aim of the current research is to establish the influence of the different body condition scores at calving on the milk yield for 305-days lactation, per test-day, during the peak of lactation, as well as the shape of the lactation curve in Holstein-Friesian and Brown Swiss dairy cows.

Materials and Methods

The study included 37 cows, 20 of which were of the Holstein-Friesian and 17 of which were of the Brown Swiss breed at the Agricultural Institute's farm in Stara Zagora. The cows from both breeds were kept together under similar rearing and feeding conditions. The free-range production system with individual boxes for rest was used. Every day, lactating cows were released in a yard, allowing them more freedom of movement. Milking was performed twice daily at a milking parlour. The cows were divided into three technological groups depending on their physiological condition: dry period, first lactation period (up to the 120th day of lactation) and second lactation period, respectively.

Feeding was based on a complete ration including maize silage, alfalfa haylage, concentrated feed, and vitamin mineral premix. The concentrated feed during lactation was in accordance with the group's mean milk yield. Data on the milk yield and milk contents were taken from the official test-day records of the farm. The cows' age was taken into account as number of the lactation, divided into the following classes – first, second, third or higher lactation.

For the purposes of the experiment, the BCS of cows was assessed using a 5-grade system (Edmonson et al., 1989). The body condition scores (BCS) were measured with an accuracy of up to 0.5 points. The experiment included all dry cows for the period from December 2008 to April 2009 and the pregnant heifers for two months before calving. The cows' calvings occurred during the spring and a part of the summer in 2009, respectively. Thus, the factors year and season of calving were the same and were not included in the models.

The body condition score of the cows before calving was assessed 7 to 10 days before calving. The minimum score was 2 and the highest was 4, with only single cows with these scores were seen in both breeds. The predominant number of cows received 2.5 – 3.5 points. To achieve a greater approximation, the cows were divided into the following classes depending on the BCS at calving: 1st class: 2–2.5 points, 2nd class: 3 points, and 3rd class: 3.5–4 points. During lactation, the BCS was measured every month, as close as possible to the test-day milk yield.

The following model was used to evaluate the effect of factors:

$$\mathbf{Y_{ijkl}} = \boldsymbol{\mu} + \mathbf{P_i} + L_j + BCS_k + \mathbf{e_{ijkl}}$$

where:

$\mathbf{Y_{ijkl}}$ is the dependent variable (the studied trait); $\boldsymbol{\mu}$ is the population mean; $\mathbf{P_i}$ is the breed effect; L_j is the effect of the lactation's number, BCS_k is the effect of BCS at calving, and $\mathbf{e_{ijkl}}$ is the effect of the non-included random factors.

The data were analysed using the LSMMW software application by Harvey (1987). Through analysis of variance (ANOVA) the least square means (LSM) and the least square estimates (LSE) that are sums of the squares of deviations from means derived by the model are calculated.

Results and Discussion

Of the total number of cows, the relative share of cows with a high BCS at calving (3.5 – 4 points) was predominant – 40.5% (Figure 1). The next group, in accordance with BCS at calving was the one with BCS of 3 points – 37.8% and the lowest was the share of cows with BCS of 2 and 2.5 points – 21.7%. Viewed in terms of breeds, the share of cows with low BCS at calving was the lowest for both breeds. In the Holstein-Friesian breed, the relative share of cows with mean BCS at calving was the highest – 45% (BCS of 3 points), whereas in the cows of the Brown Swiss breed the predominant share was the one of BCS at calving of 3.5–4 points (47.1%).

There was a fairly large share of cows with BCS at calving of 3 or less for both breeds. This share was higher in the Holstein-Friesian cows – 65% total, compared to 52.9% in Brown Swiss. This could be partly explained by the differences in the cattle types – the Holstein-Friesian is an exclusively dairy breed with lower capacity for reserve energy accumulation compared to the Brown Swiss breed. Because

the cows from both breeds were fed uniformly during the dry period, the cause for the lower BCS of some of the cows could be the duration of the dry period or the previous lactation, which were outside the scope of this research.

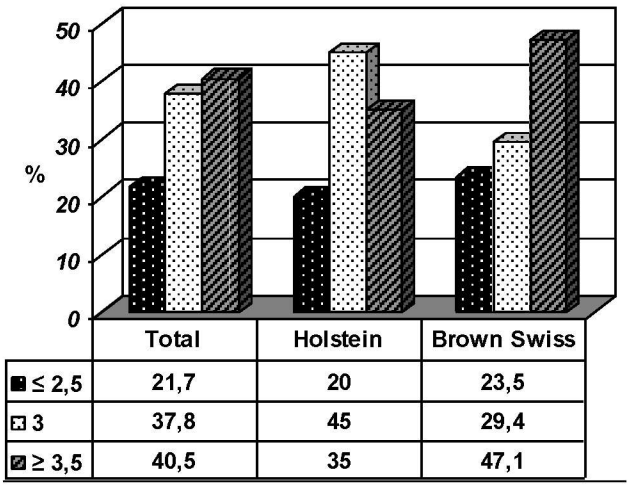

Figure 1. Distribution of the cows (%) depending on the body condition score (BCS) at calving.
Şekil 1. Buzağılama öncesi vücut kondisyon skoruna göre ineklerin dağılımı (%).

The influences of the controlled factors upon milk yield for 305-day lactation, per test-day and during peak lactation were presented in Table 1. Of the controlled factors included in the study, significant influence on all traits was exhibited by the breed ($P<0.001$ for test-day milk yield, $P<0.05$ for 305-day milk yield, and $P<0.01$ for peak lactation milk yield). The cows' BCS at calving also had a significant influence upon the studied traits at the same degrees of significance for the first two traits and on milk yield during peak lactation at $P<0.05$.

Table 1. Analysis of variance of controlled factors on the studied traits.
Tablo 1. İncelenen özelliklere ilişkin varyans analizi sonucu.

Sources of variation	Degrees of freedom	Test day milk yield		305 day milk yield		Peak lactation milk yield	
	(n – 1)	F	P	F	P	F	P
Total of the model	363	6.46	***	2.85	*	4.38	**
μ - y μ	1	1.30	NS	0.46	NS	0.42	NS
Breed	1	14.56	***	7.23	*	7.63	**
Number of lactation	2	0.24	NS	0.15	NS	1.01	NS
BCS at calving	2	8.66	***	3.86	*	4.19	*

NS: P>0.05; *: P<0.05; **: P<0.01; ***: P<0.001.

The number of lactation did not exhibit a significant influence on the studied traits. The observed difference between the milk yields of cows per lactations was anticipated, yet it was insignificant between breeds.

Table 2. Influence of body condition score (BCS) at calving on 305-day milk yield in Holstein and Brown Swiss cows.
Tablo 2. Siyah Alaca ve Esmer ırk ineklerde buzağılama öncesi vücut kondisyon skorunun (VKS) 305 gün süt verimi üzerine etkisi.

BCS at calving	Total for the two breeds			Holstein cows			Brown Swiss cows		
	n	LS estimation	LS mean ± SE	n	LS estimation	LS mean ± SE	n	LS estimation	LS mean ± SE
Mean of the model	37	-	5685.6± 192.9	20	-	6240.7± 280.5	17	-	5255.8 ± 346.2
≤ 2.5	8	-679.3	5006.3 ±362.3	4	-416.2	5824.4± 575.9	4	-868.4	4387.3 ± 552.6
3	14	+147.5	5833.1± 293.3	9	-43.6	6197.0± 403.2	5	+337.2	5592.9 ± 437.9
≥ 3.5	15	+531.8	6217.5± 302.8	7	+459.9	6700.5± 512.9	8	+531.3	5787.0 ± 424.8

Table 3. Influence of body condition score (BCS) at calving on peak lactation milk yield in Holstein and Brown Swiss cows.
Tablo 3. Siyah Alaca ve Esmer ırk ineklerde buzağılama öncesi vücut kondisyon skorunun (VKS) pik süt verimi üzerine etkisi.

BCS at calving	Total for the two breeds			Holstein cows			Brown Swiss cows		
	n	LS estimation	LS mean ± SE	n	LS estimation	LS mean ± SE	n	LS estimation	LS mean ± SE
Mean of the model	37	-	25.04± 0.69	20	-	26.92 ± 0.94	17	-	22.68 ± 0.76
≤ 2.5	8	-2.51	22.53 ±1.29	4	-2.67	24.25 ± 1.98	4	-2.43	20.25 ± 1.51
3	14	+0.51	25.55 ± 1.05	9	+0.30	27.22 ±1.32	5	-0.28	22.40 ±1.35
≥ 3.5	15	+2.00	27.05 ± 1.08	7	+2.37	29.29 ± 1.49	8	+2.70	25.37 ±1.07

Table 4. Influence of body condition score (BCS) at calving on test-day milk yield in Holstein and Brown Swiss cows.
Tablo 4. Siyah Alaca ve Esmer ırk ineklerde buzağılama öncesi vücut kondisyon skorunun (VKS) test-günü süt verimi üzerine etkisi.

BCS at calving	Total for the two breeds			Holstein cows			Brown Swiss cows		
	n	LS estimation	LS mean ± SE	n	LS estimation	LS mean ± SE	n	LS estimation	LS mean ± SE
Mean of the model	338	-	19.41± 0.33	186	-	20.63± 0.45	152	-	18.82±0.56
≤ 2.5	71	-1.67	17.73 ±0.62	38	-1.74	18.89± 0.92	33	-1.29	17.54±0.91
3	129	+0.25	19.66± 0.49	84	-0.05	20.59± 0.65	45	+0.45	19.27±0.71
≥ 3.5	138	+1.43	20.84± 0.51	64	+1.78	22.43± 0.83	74	+0.84	19.66±0.68

Table 2 presents the influence of BCS at calving on the 305-day milk yield. Cows from both breeds, with low BCS at calving of 2 and 2.5 exhibited the lowest 305-day milk yield after calving. This difference was more expressed in Brown Swiss cows. Their milk yield at low BCS was about 1400 kg lower than the yield of cows with BCS of 3.5 – 4 points. In Holstein-Friesian cows, this difference was lower – only 876 kg, even though their milk yield was higher in general. This demonstrates the greater mobilisation potential of Holstein-Friesian cows as well as their ability to utilize body reserves to produce milk, which often causes exhaustion and secondary reproductive and health problems (Harrison et al., 1990; Waltner et al., 1993). With lower reserves, Brown Swiss cows react by reducing milk yield in order to preserve their bodies. Mitev et al. (1998) also pointed out that the highest milk yield for 305-day lactation (4926 kg) was reached by cows with BCS of 3.5 – 4 at calving. Renno et al. (2006) reported that in Holstein-Friesian cows at their second or higher lactation, those with BCS above 3.25 had higher milk yields, higher lactation peaks and more effective mobilisation of body reserves at the onset of lactation compared to those with BCS at calving of less than 3.25.

BCS at calving had a significant influence on the reached peak lactation milk yield. Cows with high BCS at calving of 3.5 – 4 points, reached the highest peak lactation milk yield in both breeds (Table 3). Cows with BCS of 2 – 2.5, had about 5 kg lower milk yield during peak lactation, compared to those in better body condition, and by nearly 2 and 3 kg in Brown Swiss and Holstein-Friesian cows, respectively, of mean BCS of 3 at calving.

The provided optimal body reserves before calving allowed the cows to reach a higher milk yield at the onset of lactation, when they experience a negative energy balance as they consume these reserves to achieve higher milk yield. Cows that did not manage to accumulate sufficient body reserves before calving cannot reach high milk yield during lactation.

BCS at calving had a significant influence on the test-day milk yield for both breeds, with the same tendency being observed as for the other two traits (Table 4). In Holstein-Friesian cows there was a clearly expressed difference in the mean test-day milk yield in the three groups depending on BCS at calving, with the ones exhibiting low BCS $\leq$ 2.5 points having the lowest mean daily milk yield by 1.7 and 3.54 kg compared to BCS of 3 or $\geq$ 3.5 points, respectively. In Brown Swiss cows, these differences were lower or almost absent. The mean test-day milk yield in cows with BCS at calving of 3 or $\geq$ 3.5 points was almost equal.

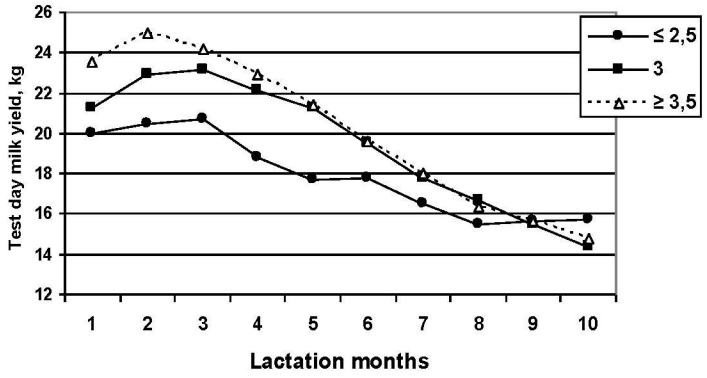

Figure 2. Effect of body condition score (BCS) at calving on lactation curve.
Şekil 2. Buzağılama öncesi vücut kondisyon skorunun (VKS) laktasyon eğrisi üzerine etkisi.

BCS at calving had an influence on the cows' lactation curve as well. In average for both breeds, the lactation curve in cows with BCS of 3 and 3.5–4 at calving differed only during the first 4 months of lactation (Figure 2). Cows with higher BCS at calving begin and achieve higher milk yield at the onset of lactation, compared to those with average BCS. After the fourth month, there were no differences in milk yield. Cows with lower BCS at calving had, as a whole, unstable lactation curves with faintly expressed peaks.

The studies of Samarutel et al. (2006) included only first calf heifers from the same herd during a period of 5 years. The cows' mean milk yield was 8821 kg. BCS was measured every month before and after calving per a 5-grade scale. The cows were divided into three groups depending on their BCS at calving, respectively: thin cows ≤ 3.0, average from 3.25 to 3.75, and heavy ≥ 3.75. During the first two months of lactation, the heavy cows had the highest milk yield (corrected 4% milk) with the best ratio of fat and protein in milk.

In both cow breeds, the tendency in the lactation curve of cows with mean and high BCS at calving was similar. In Holstein-Friesian cows, the difference in the milk yield of both groups at the onset of lactation was lower, yet the ones with higher BCS maintained higher milk yields up to the 10th lactation month (Figure 3). In Brown Swiss cows, the milk yield of the ones with better BCS was higher during the first 3 months, after which it declined nearly to the level of the ones with mean BCS (Figure 4).

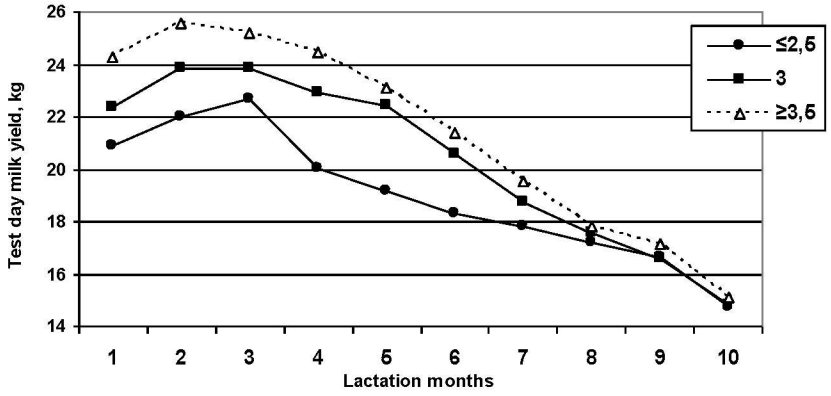

Figure 3. Effect of body condition score (BCS) at calving on lactation curve in Holstein cows.
Şekil 3. Siyah Alaca ineklerde buzağılama öncesi vücut kondisyon skorunun (VKS) laktasyon eğrisi üzerine etkisi.

The greatest difference was observed in the lactation curve of cows with low BCS at calving for both breeds. The Holstein-Friesian cows increased, although at a lower rate than cows with high BCS (3 and 3.5 – 4 points), their milk yield up to the third month of lactation, after which a sharp fall in milk production occurred. Apparently, the rise in milk yield led to significant depletion of the body's reserve energy, which was followed by the impossibility for maintaining the previously achieved milk yield.

Brown Swiss cows with low BCS at calving exhibited low milk yields at the onset of lactation, with almost no increase after the first month. Milk yield remained low with a gradual decrease towards the end of lactation. It can be said that Brown Swiss cows have preserved to a larger extent their self-protective response by reducing milk yield when body reserves decline.

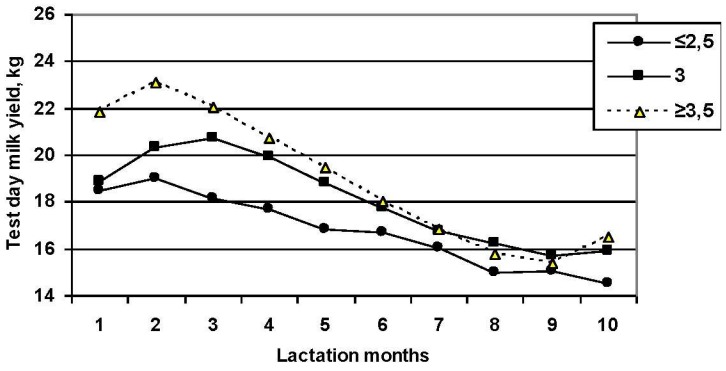

Figure 4. Effect of body condition score (BCS) at calving on lactation curve in Brown Swiss cows.
Şekil 4. Esmer ırk ineklerde buzağılama öncesi vücut kondisyon skorunun (VKS) laktasyon eğrisi üzerine etkisi.

Conclusion

The body condition score of cows at calving had a significant influence on their 305-day milk yield, test-day milk yield and peak lactation milk yield. Cows that had reached BCS of 3.5 – 4 points at calving had sufficient body reserves at the onset of lactation, allowing them to achieve higher 305-day milk yields compared to the cows with BCS of 3 or lower at calving.

The Holstein-Friesian cows had better mobilisation potential than Brown Swiss. At low BCS at calving, of 2 and 2.5 points, Holstein-Friesian cows achieved a milk yield that was only by 876 kg lower than the yield of cows with high BCS (3.5 – 4 points), whereas in Brown Swiss cows that difference was 1400 kg.

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