

How body condition score affects milk production and the metabolic parameters in postpartum crossbred dairy cows raised in Amazon biome?

Como o escore de condição corporal afeta a produção de leite e os parâmetros metabólicos pós-parto em vacas leiteiras mestiças criadas no bioma Amazônia?

¿Cómo afecta la condición corporal la producción de leche y los parámetros metabólicos posparto en vacas lecheras mestizas criadas en el bioma amazónico?

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Abstract

Body condition score (BCS) is a categorical variable that is widely accepted as an important tool for subjectively quantifying energy reserves in dairy cows. The aims of this study was to compare milk production and some metabolic parameters of crossbred dairy cows with low, adequate and high BCS in the recent postpartum period (PPP). This study included lactation data from 35 crossbred Girolando (Holstein × Gir) cows from calving to 90 days in milk. Cows were evaluated every 15 days for BCS, milk production, live weight, internal angle of the rump (IAR) and serum concentration of β -hydroxybutyrate (β Hb). BCS loss and nadir of the BCS in PPP were also evaluated. Cows were divided into 3 groups, as follows: High, Adequate and Low BCS, according to the BCS recommendation for cows with less than 100 days in lactation. Cows with Adequate BCS had higher milk production than cows with High BCS ($P = 0.01$). Cows with High BCS had the highest ($P < 0.001$) live weight, BCS and IAR among the groups. In addition, these cows had a higher serum β Hb concentration than cows with Adequate BCS ($P = 0.001$) and had the greatest loss of BCS ($P < 0.001$) in the PPP. The results of this study showed that Girolando dairy cows with Adequate BCS at calving had higher milk production and better metabolic condition than cows with High BCS at calving.

Keywords: BCS; Energy balance; Milk production; Metabolism; Girolando.

Resumo

O escore de condição corporal (ECC) é uma variável categórica amplamente aceita como uma importante ferramenta para quantificar subjetivamente as reservas energéticas em vacas leiteiras. O objetivo deste estudo foi comparar a produção de leite e alguns parâmetros metabólicos de vacas leiteiras mestiças com baixo, adequado e alto ECC no período pós-parto (PPP) recente. Este estudo incluiu dados de lactação de 35 vacas mestiças Girolando (Holandês × Gir) do parto aos 90 dias de lactação. As vacas foram avaliadas a cada 15 dias quanto ao ECC, a produção de leite, o peso vivo, o ângulo interno da garupa (AIG) e a concentração sérica de β -hidroxibutirato (β Hb). Também foram

avaliados a perda de ECC e o nadir do ECC no PPP. As vacas foram divididas em 3 grupos, Alto, Adequado e Baixo ECC, de acordo com a recomendação de ECC para vacas com menos de 100 dias em lactação. Vacas com ECC adequado apresentaram maior produção de leite que vacas com ECC alto ($P = 0,01$). Vacas com alto ECC apresentaram o maior ($P < 0,001$) peso vivo, ECC e o AIG entre os grupos. Além disso, essas vacas apresentaram maior concentração sérica de β HGB do que vacas com ECC Adequado ($P = 0,001$) e apresentaram a maior perda de ECC ($P < 0,001$). Os resultados deste estudo demonstraram que vacas Girolando com ECC adequado ao parto apresentaram maior produção de leite e melhor condição metabólica em relação às vacas com alto ECC ao parto.

Palavras-chave: ECC; Balanço energético; Produção de leite; Metabolismo; Girolando.

Resumen

La condición corporal (CC) es una variable categórica ampliamente aceptada como una herramienta importante para cuantificar subjetivamente las reservas de energía en las vacas lecheras. El objetivo de este estudio fue comparar la producción de leche y algunos parámetros metabólicos de vacas lecheras mestizas con CC baja, adecuada y alta en el posparto reciente (PP). Este estudio incluyó datos de lactancia de 35 vacas Girolando (Holstein \times Gir) desde el parto hasta los 90 días de lactancia. Las vacas fueron evaluadas cada 15 días para CC, producción de leche, peso vivo, ángulo interno de la grupa (AIG) y concentración sérica de β -hidroxibutirato (β HGB). También se evaluaron la pérdida de CC y el nadir de CC en PP. Las vacas se dividieron en 3 grupos, CC Alta, Adecuada y Baja, de acuerdo con la recomendación de CC para vacas con menos de 100 días de lactancia. Las vacas con CC adecuado tuvieron mayor producción de leche que las vacas con CC alto ($P = 0,01$). Las vacas con alto CC tuvieron el peso vivo, CC y AGA más altos ($P < 0,001$) entre los grupos. Además, estas vacas tenían una concentración sérica de β HGB más alta que las vacas con CC Adecuado ($P = 0,001$) y tenían la mayor pérdida de CC ($P < 0,001$). Los resultados de este estudio mostraron que las vacas Girolando con CC adecuado al parto tuvieron una mayor producción de leche y una mejor condición metabólica en comparación con las vacas con CC alto al parto.

Palabras clave: CC; Balance energético; Producción de leche; Metabolismo; Girolando.

1. Introduction

Dairy cows commonly lose body condition (BC) in the postpartum period due to physiological changes at the beginning of lactation that impact their metabolism. Several studies on dairy cows have quantified the effect of BC score (BCS) on health (Markusfeld et al., 1997; Berry et al., 2007) fertility (Gillund et al., 2001; Roche et al., 2007a), and milk yield (Waltner et al., 1993; Ruegg and Milton, 1995; Domecq et al., 1997). Associations between BCS and health are less consistent with overfat cows, which are more prone to metabolic diseases (Gillund et al., 2001). Studies linking BCS to dairy production have shown inconsistent findings. Some have reported no effect of BCS at calving on subsequent lactation (Pedron et al., 1993; Ruegg and Milton, 1995; Domecq et al., 1997), whereas others have found the opposite result (Waltner et al., 1993; Markusfeld et al., 1997; Roche et al., 2007b). A more consistent finding reported across studies is an association between greater loss of BCS and higher milk production (Ruegg and Milton, 1995; Domecq et al., 1997; Roche et al., 2007b). However, cows that lose less or maintain BCS during the first weeks of lactation have lower serum concentrations of β -hydroxy-butyrate (β HGB) and non-esterified fatty acids (NEFA) (Carvalho et al., 2014; Barleta et al., 2017), a decrease in the incidence of clinical and subclinical metabolic diseases and a reduction in calving interval, which enables these females to reach high fertility cycles (HFC) and, consequently, to exhibit calving intervals of up to 13 months (Middleton et al., 2019).

The intrinsic ability of a dairy cow to address the energy requirements demanded by lactation will determine its health and, consequently, its performance during the early postpartum period (PPP) (Ribeiro et al., 2013). In this regard, BCS is an important marker of cow health and a useful tool for monitoring the nutritional status of dairy herds (Heuer et al., 1999). Although the BCS has been used as a tool for managing dairy herds since the 1970s (Lowman et al., 1976) and there is an extensive body of literature that endorses its importance (Edmonson et al., 1989; Waltner et al., 1993; Domecq et al., 1997; Moreira et al., 2000; Pryce et al., 2000), BCS assessment is still not performed routinely in most of the dairy farms in the Amazon biome. The low adoption of the BCS evaluations may rely on the difficulty in interpreting and transforming the BCS values into information capable of guiding nutritional and reproductive management. Given the importance of managing the BCS of cows in all stages of production (from the beginning of lactation to the dry season), methods for the systematic

implementation of BCS assessments are needed so that dairy producers can use these records to make appropriate decisions about the nutritional and reproductive management of their herds. A new method for dealing with BCS data was proposed by Pfeifer e Silva (2021), the BCSi, which considers the lactation phase and the BCS recommendation for each of these phases may help producers to improve management practices enabling dairy herds to reach HFC and, consequently, to increase the productivity of their farms.

Based on these considerations, the objective of this study was to compare the milk production and metabolic parameters of crossbred dairy cows raised in the Amazon Biome with low, adequate, and high BCS according to the recommended BCS during the PPP. The hypotheses of this study is that cows with adequate BCS have lower serum concentrations of β HGB and higher milk production than cows with low and high BCS in the postpartum period.

2. Methodology

The Committee for Ethics in Animal Experimentation of the Brazilian Agricultural Research Corporation (Embrapa - Rondônia) approved all procedures performed in this experiment (Number F.02 / 2014).

2.1 Animals and location

This experiment was conducted at the Embrapa Rondônia experimental farm, Porto Velho, RO, Brazil. The study included the lactation of 35 Girolando cows (Holstein \times Gir) with a daily average milk production of 22.6 ± 3 kg, grazing marandu grass, supplemented with corn and soybean concentrate (22% PB and 80% NDT). The cows were milked twice a day.

2.2 Experimental groups, metabolic assessments, and milk production

From calving to 90 days in milk (DIM), cows were evaluated every two weeks for BCS, live weight (LW), internal angle of the rump (IAR), and milk production. In addition, blood samples were collected to analyse the serum concentration of β -hydroxy-butyrate (β HGB) with a hand meter device (TD - 4235®; Ketovet, MG, Brazil). For all cows, the greatest loss of BCS (Δ BCS) between calving and 90 DIM was calculated, the calculation was based on the difference between the lower BCS observed and the BCS at calving.

All cows were evaluated for BCS using a scale from 1 to 5 (1 - Severe underconditioning, to 5 - Severe overconditioning) with 0.25 increment units (Edmonson et al., 1989). Cows were divided into three groups according to recommended BCS for lactating dairy cows with less than 100 days in milk (Table 1). Cows with the BCS above the recommended was considered as having High BCS (n = 12), cows with the BCS within the recommended was considered as having Adequate BCS (n = 17), and with the BCS bellow the recommended was considered as having Low BCS (n = 6).

For the evaluation of the internal angle of the rump (IAR), a goniometer was used to measure the angle between the two sides of the croup. The goniometer device was placed on the rump, a rod on each side of the rump, between the sacral bone and the first coccygeal vertebrae.

Table 1. Recommended BCS for each lactation phase

Lactation phase	Recommended BCS	References*
≤ 100 DIM	2.75 – 3.25	Ferguson (1996); Defra (2011); Klopčič et al., (2011); Middleton et al., (2019).

* All references were adapted to meet the BCS scale used in the present study (1 – 5). Source: Authors.

2.3 Statistical analysis

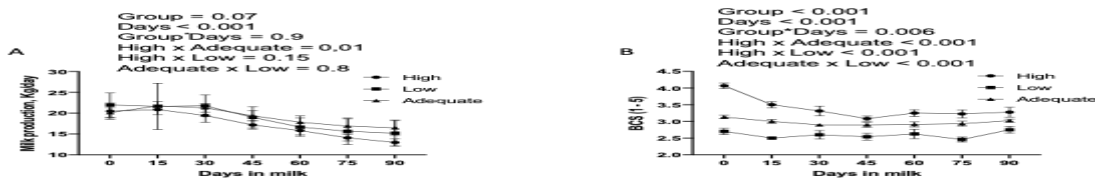
Statistical analyses were performed using the SAS program (SAS Institute Inc., Cary, NC, USA). All data obtained from the repeat measurements (BCS, milk production, β Hb, IAR, and LW) were compared between groups by ANOVA using the Mixed procedure to evaluate the main effects of group, time, and their interactions. Difference of BCS and DIM of the nadir of BCS data were analyzed by ANOVA and the means were compared between groups using tukey's test.

3. Results

The results of milk production, BCS, LW, IAR, and β Hb throughout the experimental period are shown in the Figure 1. Cows with adequate BCS showed higher milk production than cows with High BCS ($P = 0.01$). In contrast, no difference ($P = 0.15$) in milk production was observed between cows with High BCS and Low BCS and between cows with Adequate and Low BCS ($P = 0.08$; Fig. 1 A). The LW differed among groups (Fig. 2 A; $P < 0.001$), as well as the BCS (Fig. 1 B; $P < 0.001$).

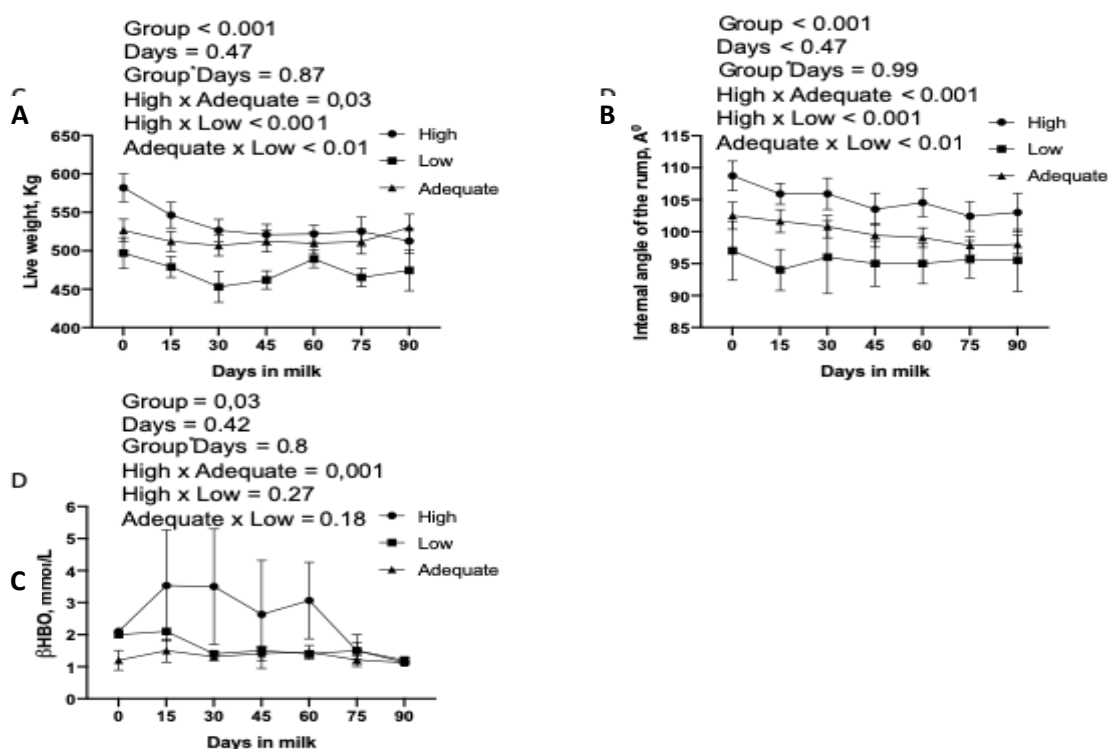
A difference in the IAR was also observed among groups (Fig. 2 B; $P < 0.001$). Cows with Low BCS had the lowest IAR and the cows with High BCS had the highest IAR. Similarly, cows with High BCS had the highest live weight (Fig. 2 A; $P = 0.01$) and the highest BCS values (Fig. 1 B; $P = 0.01$) throughout the evaluation period. Moreover, these cows had a higher serum β Hb concentration than cows with Adequate BCS (Fig. 2 C; $P = 0.001$), reaching the peak concentration at 15 DIM, and showed the highest loss of BCS in the period (Table 2; $P < 0.001$). No differences were observed among groups for DIM of the nadir of BCS (Table 2; $P = 0.73$).

Figure 1. Daily milk production (A), body condition score (B) in Girolando cows with Low, Adequate and High BCS.



Source: Authors.

Figure 2. Live weight (A), internal angle of the rump (B), and plasma β -hydroxybutyrate concentration (β Hb; C) in Girolando cows with Low, Adequate and High BCS.



Source: Authors.

Table 2. BCS loss and DIM of the nadir of BCS after calving in crossbred dairy cows with Low, Adequate and High BCS.

	Group			P-Value
	Low BCS	Adequate BCS	High BCS	
BCS loss (BCS points \pm se)	0.3 \pm 0.14 ^A	0.4 \pm 0.06 ^A	1.1 \pm 0.11 ^B	< 0.001
DIM of the nadir of BCS	30	35.29	38.75	0.73

^{a/c} Values within a row with different superscript letters differ at P < 0.05. Source: Authors.

4. Discussion

The hypotheses of this study was study was partially confirmed; cows with Adequate BCS had higher milk production and better metabolic condition compared to cows with High BCS. However, no differences were observed in milk production and serum concentration of BHB between Adequate and Low BCS.

Adequate management of energy body reserves in dairy cows reflects their productive potential, especially for high yielding cows. When cows are too fat or too thin at calving, they are at an increased risk of developing metabolic disorders. Thus, unlike the BCS average of the herd, considering each cows as having Low, Adequate or High BCS provides a more reliable information and demonstrate whether an animal has already reached an excellent BCS.

The BCS technique is a tool that has been widely used to quickly and cheaply estimate the energy reserves of dairy cows at regular intervals (Klopčič et al., 2011). While many may consider the BCS as a nutritional practice, the use of this tool

to manage the BC of cows in dairy farms has direct implications for milk yield, herd health, reproductive performance, animal welfare, and farm profitability (Bewley and Schutz, 2008). The benefits of using the BCS as a tool to assist the nutritional and reproductive management of dairy cows have been widely described in the literature (Domecq et al., 1997; Moreira et al., 2000; Pryce et al., 2000; Carvalho et al., 2014). However, despite these benefits, the systematic assessment of dairy cow BCS is not routine in most of dairy farms, especially in those with extensive pasture based management.

Cows with high BCS had higher β HBA serum concentration, higher LW and higher AIR, this group showed more severe BCS reduction during PPP than cows that with adequate BCS. These results indicate that cows with high BCS have more severe BEN during the PPP. The metabolism of dairy cows during the PPP is directly affected by their BCS at calving (Rennó et al., 2006; Pires et al., 2013). Studies have reported a relationship between high BCS at calving and severe losses of BCS with high serum concentrations of NEFA and β HBA (Pires et al., 2013; Adrien et al., 2012), and reduced postpartum health (Roche et al., 2015). Accordingly, the results observed in the present study showed that cows with high BCS had the highest BCS losses in the PPP. Although these cows were not followed for the entire lactation, we believe that this group is more likely to have metabolic disorders. According to Garnsworthy (2006), cows that show larger BCS reduction are more likely to have problems such as ketosis and liver fat. In that regard, Gillund et al., (2001) reported that cows that have a BCS > 3.5 units at the time of calving are 2.3 to 2.8 times more likely to have ketosis compared to cows that have given birth with BCSs ≤ 3.25 . Blood metabolites can be used as indicators to estimate disease risk. Similarly with what we observed in the present study, Ward (1995) observed that, at calving, β HBA concentrations were higher in cows with a BCS > 3 than cows with a BCS < 3 . Even moderate levels of fat tissue mobilisation are known to be associated with BEN and reduced fertility in postpartum cows. Several studies indicate that excessive loss of BCS units during the PPP are associated with increased serum concentrations of non-esterified fatty acids, and reduced insulin, as well as with delayed first postpartum ovulation, and reduced pregnancy in the first postpartum AI (Butler et al., 2003; Carvalho et al., 2014; Middleton et al., 2019). Butler (2005) concluded that there is a 10% reduction in conception rate at first postpartum insemination for each BCS unit lost during the PPP. These studies indicate that loss of BCS units is directly related to reduced fertility during the PPP. In this way, reducing BC losses during the PPP helps the herd reach HFC. These cycles, which should be the goal for milk production systems, are productive cycles where cows have reduced loss of BC during the PPP and, consequently, are more likely to conceive at the beginning of the service period. In the present study the cows with Low and Adequate BCS loss less BCS in the PPP than cows with High BCS. Unfortunately, in the present study, the reproductive performance during the early PPP was not evaluated. This is because the cows belongs to a herd of the experimental research farm and they could not be inseminated soon after the voluntary waiting period. Therefore, reproductive data were not recorded.

Cows that have suboptimal BCS during productive period may produce less milk and have poor reproductive performance (Waltner et al., 1993). Studies performed with the objective of evaluating the effect of BCS on milk production in dairy cows have shown contradictory results. Grainger et al., (1982) reported an increase in milk production at the beginning of lactation associated with an increase in the BCS at calving. Similarly, Berry et al., (2007) evaluated Holstein cows in a grazing system and observed that the total milk production during 305 DIM was higher in cows with higher BCS at calving (4.25 units), although the increase in BCS units was also associated with less lactation persistence. In contrast, the present study demonstrated that there was no difference in the milk production during the experimental period between cows with low and high BCS. However, cows with adequate BCS have higher milk production than cows with high BCS. One may concern that this study was performed with girolando crossbred cows and, therefore, this genetic group may have had a strong influence on the postpartum BCS and milk production relationship. Although more studies are needed to confirm the optimal BCS at calving for girolando dairy cows, the results of the present study showed that High (> 3.5) BCS at calving is the most

detrimental BCS for milk production and energy balance in Girolando cows. In that regard, to evaluate how BCS can be used to detect nutritional management issues, there is already an available excel worksheet that can help producers to evaluate the effect the BCS in different lactation phase (available at: <http://jaci.cpafrro.embrapa.br/iECCleite.php>). Termed as BCS index, it was developed to assist producers to optimize the milk production and reproductive efficiency of the herd.

5. Conclusion

BCS is an important marker to estimate body reserves, as well as the nutritional condition of dairy herds, with direct impacts on the productive efficiency of the system. Girolando cows with adequate BCS at calving had higher milk production and better metabolic condition compared to cows with high BCS which, in general, did not differ from cows with low BCS. We believe that by performing more studies, increasing the number of animals in different stages of lactation, it will be possible to detect what would be the best recommended BCS according to the lactation phase which is associated with productive characteristics.

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