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Effects of body condition score at calving on indicators of fat and protein mobilization of periparturient Holstein-Friesian cows

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ABSTRACT

The objective was to study the effects of body condition score (BCS) at calving on dairy performance, indicators of fat and protein mobilization, and metabolic and hormonal profiles during the periparturient period of Holstein-Friesian cows. Twenty-eight multiparous cows were classed according to their BCS (0 to 5 scale) before calving as low (BCS $\leq$2.5; n = 9), medium (2.75 $\leq$ BCS $\leq$ 3.5; n = 10), and high (BCS $\geq$3.75; n = 9), corresponding to a mean of 2.33, 3.13, and 4.17 points of BCS, and preceding calving intervals of 362, 433, and 640 d, respectively. Cows received the same diets based on preserved grass to allow ad libitum feed intake throughout the study, and lactation diet contained 30% of concentrate (dry-matter basis). Measurements and sampling were performed between wk −4 and 7 relative to calving. No significant effects were observed of BCS group on dry matter intake (kg/d), milk yield, BCS loss, plasma glucose, and insulin concentrations. The high-BCS group had the lowest postpartum energy balance and the greatest plasma concentrations of leptin prepartum, nonesterified fatty acids and β-hydroxybutyrate postpartum, insulin-like growth factor 1, and milk fat content. Milk fat yield was greater for the high- than the low-BCS group (1,681 vs. 1,417 g/d). Low-BCS cows had the greatest concentration of medium-chain fatty acids (e.g., sum of 10:0 to 15:0, and 16:0), and the lowest concentration and secretion of preformed fatty acids (e.g., *cis*-9 18:1) in milk fat. Milk protein secretion was lowest in the low-BCS group, averaging 924, 1,051, and 1,009 g/d for low-, medium-, and high-BCS groups, respectively. Plasma 3-methylhistidine was greater in wk 1 and 2 postpartum compared with other time points, indicating mobilization of muscle protein. Plasma creatinine tended to be lower and the 3-methylhistidine: creatinine ratio was greater in low- compared with medium- and high-BCS cows, suggesting less muscle mass but more intense mobilization of muscle protein in lean cows. High-BCS cows were metabolically challenged during early lactation due to intense mobilization of body fat. Conversely, limited availability of body fat in low-BCS cows was associated with increased plasma indicators of body protein mobilization during the first weeks of lactation, and lower milk protein secretion. These results should be confirmed using an experimental approach where calving BCS variation would be controlled by design.
Key words: bovine, lactation, body reserve, mobilization

INTRODUCTION

The periparturient dairy cow experiences profound physiological and metabolic adaptations to support lactation, simultaneous with environmental challenges due to transitions of diet, housing, and social interactions. Physiological adjustments include short-term (homeostasis) and long-term (homeorhesis/teleophoresis) hormonal changes and altered tissue response to key hormones that lead to increased net lipolysis, enhanced utilization of mobilized FA by peripheral tissues and the mammary gland, and mobilization of the limited glucose and amino acid reserves (e.g., liver glycogen and muscle protein; Bell and Bauman, 1997; Chilliard, 1999). Furthermore, ruminants depend on gluconeogenesis as the major source of glucose, but the increase in hepatic glucose output during early lactation is insufficient to meet requirements, and other adjustments of nutrient partitioning must take place to cope with this shortfall (Doepel et al., 2009), namely by the establishment of insulin resistance in peripheral tissues (Bell and Bauman, 1997).

Fat and labile protein reserves are mobilized during early lactation, but the ability to use body protein is limited in quantity and duration. For instance, estimates have ranged from 10 to 90 kg of fat, and up to 24 kg of protein (Komaragiri and Erdman, 1997; Chilliard, 1999; Chibisa et al., 2008). No further protein mobilization occurred after 5 wk of lactation, whereas utilization of body fat continued until at least 12 wk postpartum (Komaragiri and Erdman, 1997). Continuous genetic selection with emphasis on milk yield has

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led to chronic low BCS in modern dairy cows, especially in grass-based systems, and to a decline in reproductive performance, probably due to prioritization of nutrient partition toward milk secretion (Chagas et al., 2007; Roche et al., 2009). Limited information exists on the mobilization of body reserves in cows with extreme BCS because most studies focus on animals in the medium range, and receiving conventional high-energy lactation diets ad libitum (Broster and Broster, 1998; Roche et al., 2009). Furthermore, correlation between BCS and body fat may be weaker at the lower end of the BCS scale, and it has been speculated that BCS loss in lean cows may correspond to muscle mobilization (Chagas et al., 2007). Additionally, cows may undergo extended lactations when insemination is voluntarily delayed to avoid periods of extreme negative energy balance (**EBAL**), as a result of reproductive failure, or to group calvings in a defined season (Kolver et al., 2007; Kay et al., 2009). Animals that experience extended lactations may increase their BCS over time (Kolver et al., 2007), especially if rations are not solely composed of pasture. Semi-mountain dairy production systems in central France are mostly grass based, and include a fall/winter indoor period and a spring/summer grazing season. Despite year-round milking, calvings are generally concentrated in the fall and winter seasons. Cows that are not inseminated or do not become pregnant during the breeding period may be maintained in extended lactations. Therefore, the diversity of intercalving intervals within a herd is likely to lead to BCS heterogeneity. The objective of this study was to assess the effects of BCS at calving on the adaptability of dairy cows to a moderate-energy diet based on preserved grass. Namely, to study how different calving BCS that resulted at least in part from variable calving intervals relate to dairy performance, changes in BW and BCS, plasma indicators of fat and protein mobilization, and overall metabolic and hormonal profile during the periparturient period. We expected that cows calving with high BCS would be metabolically challenged during early lactation due to mobilization of body fat. Conversely, we hypothesized that utilization of body reserves would be altered in low-BCS cows due to the limited availability of body fat, and that mobilization of body protein during the first weeks of lactation would be more intense in these animals.

MATERIALS AND METHODS

Animals, Diets, and Housing

The experiment was conducted in the Orcival farm of the Institut National de la Recherche Agronomique (**INRA**), located in a semi-mountain grassland area (1,000 m of altitude) in the Auvergne region (Puy-de-Dôme, France). Twenty-eight multiparous Holstein-Friesian cows were studied from 4 wk before expected calving until 7 wk postpartum. Cows were classed according to their BCS before calving as low (BCS $\leq$2.5; n = 9), medium (2.75 $\leq$ BCS $\leq$3.5; n = 10), and high (BCS $\geq$3.75; n = 9) using the French notation scale of 0 to 5 (Table 1; Bazin et al., 1984). Different BCS were due to differences in previous intercalving intervals (Table 1). In the North-American 1 to 5 scale (Edmonson et al., 1989), low-, medium-, and high-BCS groups would correspond to BCS $\leq$3.0, 3.2 $\leq$ BCS $\leq$3.8, and BCS $\geq$4.0, respectively, assuming a linear relationship between scoring systems. Cows received identical diets to allow ad libitum feed intake throughout the study (10% refusals). Diet ingredient, nutrient, and FA composition are presented in Table 2. The far-off dry period diet was mixed forage composed of 75% grass silage and 25% hay (DM basis) from permanent semi-mountain grasslands rich in *Dactylis glomerata* (orchardgrass). Starting 3 wk before the expected calving date, the forage mixture was top-dressed with 2 kg of the lactation concentrate. Lactation TMR was (DM basis) 46.5% grass silage, 22% hay, 30% concentrate, and 1.5% of a mineral and a vitamin premix. The lactation diet was initially formulated to meet 85% of energy and 100% of protein requirements to produce 32 kg/d of milk based on table values (INRA, 2007). Cows were housed in a freestall barn with individual feed bunks equipped with automatic gates, were milked at 0630 and 1600 h, and had free access to water throughout the study.

Sampling and Analyses

Blood samples were collected from the jugular vein after morning milking and before feeding at wk −4, −2, 1, 2, 3, 5, and 7 relative to calving date, corresponding to −28, −14, 4, 11, 18, 32, and 46 DIM, respectively (SD = 7 DIM prepartum and 1 DIM postpartum). Blood samples were drawn into evacuated tubes containing either EDTA (1.95 mg/mL) or Li-heparin (10 IU/mL; Terumo Europe NV, Leuven, Belgium). Plasma was separated by centrifugation at 1,400 × *g* for 15 min at 4°C and frozen at −20°C. Plasma (EDTA) was analyzed for glucose, NEFA, BHBA using enzymatic methods, and for insulin and leptin using RIA, as previously described (Delavaud et al., 2002; Lerch et al., 2012a). Plasma IGF1 concentration was determined by RIA (IGF-I RIA-CT; Mediagnost GmbH, Reutlingen, Germany) validated for the bovine. Heparinized plasma was analyzed for 3-methylhistidine (**3-MH**) by HPLC (Adechian et al., 2012), and creatinine was quantified in selected samples (wk −4, 1, 2, and 7) using an auto-