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Effect of dietary energy supply to dry Holstein cows with high or low body condition score at dry off on production and metabolism in early lactation

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ABSTRACT

The aim of the experiment was to investigate the effects of manipulating body condition score (BCS) during the dry period of over-conditioned and under-conditioned cows using two dry period diets with high and low energy content, respectively. The cows' ability to cope with the transition from pregnancy to lactation was evaluated by production parameters and several plasma and liver variables. Furthermore, the outcome of the experiment was used to see the potential of using BCS at dry off as a guiding principle in dry cow feeding management.

A complete randomized design was used with a two by two factorial arrangement of treatments. Fifty-one Holstein dairy cows participated in the trial from 20 weeks before expected calving to eight weeks postpartum. With the aim to obtain two groups of cows with high or low BCS at dry off, the cows were divided into two groups in late lactation and assigned to one of two different late lactation diets: High-energy diet (HiLate, net energy for lactation (NE_L)=6.76 MJ) or low-energy diet (LoLate, NE_L=5.73 MJ). At dry off, each group was divided and assigned to one of two dry period diets: High-energy diet (HiDry, NE_L=6.86 MJ) or low-energy diet (LoDry, NE_L=4.96 MJ). Thus, from dry off the cows were divided into four groups (HiHi, HiLo, LoHi and LoLo). After parturition, all cows received the same lactation diet (NE_L=6.73 MJ).

Irrespective of BCS at dry off, it was demonstrated that cows fed the LoDry diet were physiologically healthier and in less risk of developing metabolic diseases in early lactation, compared to cows with the same late lactation background fed the HiDry diet. This result was established despite the fact that energy intake and milk production in early lactation was not different between the groups with the same BCS at dry off.

In early lactation, there was a lower concentration of plasma non-esterified fatty acids and plasma β-hydroxybutyrate and a numeric higher concentration of plasma glucose in the HiLo group compared with the HiHi group. The difference between the LoHi group and the LoLo group showed the same trends. The milk productions in early lactation were related to the treatments in late lactation, irrespective of the dry period feeding treatments hence, implying the importance of acknowledging carry-over effects from the energy intake in the previous lactation.

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1. Introduction

In the period around parturition, dramatic adaptive regulations in metabolism occur in dairy cows, and the immune system and hormone profiles undergo changes in order to prepare the cow for parturition and lactation. The function of adipose tissue pools to represent energy storage, for times of insufficient energy supply, is a key factor in this period. Just after parturition, the cows' digestive capacity and motivation (energy intake) are not sufficient to support the level of milk production (energy output). Thus, mobilization of adipose tissue makes a substantial contribution to the energetic requirement in early lactation (Roche et al., 2009). Mobilization of adipose tissue in early lactation is a disputed subject. In the last couple of decades, the objective of many experiments was to limit the mobilization of adipose tissue postpartum using a "steaming up" feeding strategy in the dry period. In general, Friggens et al. (2004) concluded that this strategy did not have the intended decreasing effect on adipose tissue mobilization. Others see the mobilization of adipose tissue as a natural phenomenon among mammals around parturition and to a large extent as genetically driven (Vernon and Pond, 1997; Friggens, 2003; Friggens et al., 2007). Garnsworthy and Topps (1982), who found that cows have a drive to reach a certain target body condition score (BCS) 12–15 weeks after parturition, support this view.

Body condition score is a way to evaluate the subcutaneous adipose tissue depot of the cow (e.g. Edmonson et al., 1989) and is used as a management tool around the world. There has been a lot of focus on BCS at parturition and loss of BCS after parturition and how this influences the lactation performance, reproduction, and health of the cow. A review of Broster and Broster (1998) reported that high BCS at parturition led to decreased feed intake, increased loss of BCS after parturition, and increased milk fat concentration. Furthermore, Roche et al. (2009) estimated the optimal BCS at parturition for milk production to be 3–3.5. In addition, they explained how the association between the BCS at parturition and the nadir BCS after parturition influenced the reproductive outcome, and they demonstrated that a high BCS at parturition leads to a higher risk of mastitis and metabolic disorders.

How BCS at dry off and changes of BCS during the dry period affects health, production and metabolism in the following very early lactation has been given minor attention. Domecq et al. (1997) found that increasing BCS during the dry period resulted in higher milk yield in high yielding dairy cows. Gearhart et al. (1990) showed that high yielding dairy cows with BCS ≥ 4 at dry off had a higher risk of reproductive disorders and hoof problems after parturition compared with cows in lower BCS. In an observational study, Hoedemaker et al. (2009) suggested that loss of BCS in the dry period would negatively affect the BCS in the lactation leading to increased reproductive disorders, lameness and culling rate.

Body condition score and changes in BCS are reflected in metabolic parameters in blood and liver tissue (e.g. Holtenius et al., 2003; Janovick et al., 2011; Weber et al., 2013). The concentrations of non-esterified fatty acids (NEFA), β-hydroxybutyrate (BHBA), and glucose in plasma and the concentrations of triacylglycerides (TAG), NEFA, glucose, and glycogen in liver tissues provide information on the metabolic status of the cow (Ingvartsen, 2006; Leblanc, 2010). In addition, dietary composition and energy content in the dry period diet influence the above mentioned parameters (e.g. Damgaard et al., 2013; Douglas et al., 2006; Janovick et al., 2011).

In order to achieve the largest milk production in the first eight weeks of lactation and to minimize negative metabolic effects, it was hypothesized, that cows with BCS at dry off greater than desired at parturition would improve, if BCS was reduced during the dry period compared with unchanged BCS; and that cows with BCS at dry off lower than desired at parturition would improve, if BCS was increased during the dry period compared with unchanged BCS. The aim of the experiment was to investigate the effects of manipulating BCS during the dry period of over-conditioned and under-conditioned cows using two dry period diets with high and low energy content, respectively. Cows were evaluated by production parameters (dry matter intake, BCS, body weight, milk yield and milk composition) and several plasma and liver parameters. Furthermore, the outcome of the experiment would be used to evaluate the possibility of manipulating BCS in the dry period by diets with different energy levels, and to see the potential of using BCS at dry off as a guiding principle in dry cow feeding management.

2. Materials and methods

All procedures involving animals were evaluated and approved by the Danish Animal Experiments Inspectorate and complied with the Danish laws concerning animal experimentation and care of experimental animals.

2.1. Description of the experiment

2.1.1. Animals and experimental design

This experiment was carried out from April 2009 to April 2010. Fifty-one Holstein dairy cows participated in the trial from 20 weeks before expected calving to 8 weeks postpartum. Originally seventy-two cows were allocated to the experiment. One cow died after cesarean section, one cow became severe ill 4 weeks after parturition, one cow had only a 4 weeks dry period, and due to technical problems, the automatic feed intake registrations were insufficiently recorded for 18 cows. These cows were omitted from the experiment. The experimental design was a two by two factorial design with randomized allocation of cows to treatments, and included repeated measurements. The cows were grouped according to parity and expected parturition date. BCS was evaluated once a week through the whole experiment. The cows were scored at a 5 point scale with 0.25 point intervals according to Ferguson et al. (1994). After each milking, the cows were weighed automatically by an electronic scale (Insentec BV, Marknesse, Holland) outside the milking barn.

2.1.2. Diets

The period from 20 to 9 weeks before expected parturition (the late lactation period) was a conditioning period. The cows were randomly assigned to one of two