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Effects of dry period length on milk production, body condition, metabolites, and hepatic glucose metabolism in dairy cows

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ABSTRACT

Dry period (DP) length affects energy metabolism around calving in dairy cows as well as milk production in the subsequent lactation. The aim of the study was to investigate milk production, body condition, metabolic adaptation, and hepatic gene expression of gluconeogenic enzymes in Holstein cows (>10,000 kg milk/305 d) with 28- (n = 18), 56- (n = 18), and 90-d DP (n = 22) length (treatment groups) in a commercial farm. Cows were fed total mixed rations ad libitum adjusted for far-off (not for 28-d DP) and close-up DP and lactation. Milk yield was recorded daily and body condition score (BCS), back fat thickness (BFT), and body weight (BW) were determined at dry off, 1 wk before expected and after calving, and on wk 2, 4, and 8 postpartum (pp). Blood samples were taken on d −56, −28, −7, 1, 7, 14, 28, and 56 relative to calving to measure plasma concentrations of metabolites and hormones. Liver biopsies (n = 11 per treatment) were taken on d −10 and 10 relative to calving to determine glycogen and total liver fat concentration (LFC) and to quantify mRNA levels of pyruvate carboxylase (*PC*), cytosolic phosphoenolpyruvate carboxykinase, and glucose-6-phosphatase. Time course of milk yield during first 8 wk in lactation differed among treatment. Milk protein content was higher in 28-d than in 90-d DP cows. Milk fat to protein ratio was highest and milk urea was lowest in 90-d DP cows. Differences in BW, BFT, and BCS were predominantly seen before calving with greatest BW, BFT, and BCS in 90-d DP cows. Plasma concentrations of NEFA and BHBA were elevated during the transition period in all cows, and the greatest increase pp was seen in 90-d DP cows. Plasma glucose concentration decreased around calving and was greater in 28-d than in 90-d DP cows. Dry period length also affected plasma concentrations of urea, cholesterol, aspartate transaminase, and glutamate dehydrogenase. Plasma insulin concentration decreased around calving in all cows, but insulin concentration pp was greater in 28-d than in 56-d DP cows. Hepatic glycogen concentration decreased and LFC increased after calving in all cows, and LFC was greater pp in 90-d DP than in 28-d DP cows. Hepatic PC mRNA abundance pp tended to increase most in 90-d DP cows. Changes on glucose metabolism were more balanced in cows with a reduced DP, whereas cows with extended DP and elevated body condition indicated greatest metabolic changes according to lipid and glucose metabolism during the transition period.

Key words: dairy cow, dry period length, glucose metabolism

INTRODUCTION

Dry period (**DP**) management by farmers is generally arranged by a 6- to 8-wk period to give the cow a resting time after lactation and in preparation for the next calving and lactation. It is well known that DP length influences milk production and composition, energy balance, and health in the consecutive lactation (Grummer and Rastani, 2004; Watters et al., 2008; van Knegsel et al., 2013). The dramatic increase of energy required after calving for milk production in high-yielding dairy cows and insufficient DMI at the same time lead to the well-described negative energy balance in early lactation (Ingvartsen and Andersen, 2000; Drackley et al., 2001). Shortening the DP length in dairy cows often results in decreased milk production, which is partly compensated by a greater milk yield during prolonged previous lactation, but reduces metabolic load at beginning of the subsequent lactation, as reviewed by Bachman and Schairer (2003) and van Knegsel et al. (2013). Besides milk production, effects of shortening DP length on glucose metabolism during the transition period are of interest. Providing

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sufficient glucose for milk production is a prerequisite for maximal milk performance (Linzell, 1972; Rigout et al., 2002). Recent studies in dairy cows revealed marked changes in adaptation of hepatic glucose production during the transition period to comply with the huge glucose demand after onset of lactation (Greenfield et al., 2000; Hammon et al., 2009; Weber et al., 2013a). Whether a shortened DP length affects hepatic glucose metabolism during the transition period in dairy cows is not yet known.

In addition, an extended DP length often occurs on farms due to a prolonged calving interval or other reasons. Insufficient milk production at the end of lactation prevents achievement of intended lactation cut off and foreseen DP length. Due to inadequate management, these cows often gain weight, fill up their fat depots, and their body condition increases. However, metabolic adaptation to consecutive lactation largely depends on body condition during previous lactation (Grummer, 1993; Drackley et al., 2001; Weber et al., 2013b). Elevated body condition before calving often leads to enhanced lipolysis around calving that results in moderate to severe metabolic load in dairy cows with increased plasma concentrations of NEFA and BHBA as well as enhanced fat storage in the liver (Grummer, 1993; Hammon et al., 2009; Weber et al., 2013b). Therefore, an extended DP might result in imbalances with respect to glucose and lipid metabolism during the transition period that impair consecutive lactation by developing disorders such as ketosis and fatty liver, but studies investigating this topic are rare.

The aim of the present study was to investigate the metabolic consequences of either an extended or a shortened DP length on metabolic changes during the transition and early lactation period with emphasis on glucose metabolism. The hypothesis was tested that an extended as well as a shortened DP length affects systemic and hepatic glucose metabolism in dairy cows when preparing for consecutive lactation. Besides measurements on milk performance, body condition, and metabolic changes in blood plasma, gene expression of key enzymes on hepatic gluconeogenesis that contribute to the metabolic adaptation around calving in dairy cows were investigated (Hammon et al., 2009; Weber et al., 2013a) and tested for their responses to different DP length.

MATERIALS AND METHODS

Animals, Housing, Feeding, and Classification of Cows

The experimental procedures were carried out according to the animal care guidelines and were approved by the relevant authorities of the State Mecklenburg-Vorpommern, Germany (LALLF M-V/TSD/7221.3–2.1–021/06). Multiparous (lactation number 2 to 8) German Holstein cows (n = 58) with comparable milk production (>10,000 kg/305 d during preceding lactation) on a conventional farm (Gut Dummerstorf GmbH, Dummerstorf, Germany) were selected for this experiment. Cows were kept in a free-stall barn with deep lying boxes filled with chaffed straw. One week before expected calving cows were moved in calving boxes with straw, immediately after calving cows were moved into the fresh cow group for 6 consecutive days, and after this period relocated to the lactational transition group. Cows were studied from dry off to 56 DIM in the consecutive lactation. Cows were grouped into shortened (28-d DP; n = 18) and conventional (56-d DP; n = 18) DP before expected calving. A third treatment group was created by cows with an extended (90-d; n = 22) DP before expected calving. Actual DP lengths were (mean ± SE) 26 ± 3.3, 56 ± 4.5, and 98 ± 22.7 d for 28-, 56-, and 90-d DP treatment, respectively. Cows with 28- and 56-d DP were selected randomly and were blocked on milk yield and DIM of previous lactation and on lactation number. Cows with 90-d DP were selected due to the decline in milk yield (<15 kg /d) during late lactation. The dry-off protocol included treatment of all cows with intramammary applied antibiotics (Cloxacillin, Pfizer Corporation, Wien, Austria) after last milking.

The experimental groups were fed with TMR ad libitum during the DP (far-off and close-up ration), and lactation. Cows with 56- and 90-d DP were first fed with the far-off diet from dry off until wk 4 before the expected calving date, and afterward were fed the close-up diet from wk 3 before expected calving to parturition. Cows with the 28-d DP were moved after dry off to the close-up pen and fed only the close-up ration during DP. After calving all groups received the same lactation diet until 56 DIM. Diets were fed 2 times a day at 0700 and 1300 h, and TMR was shoveled closer to the feedlot in a time interval of 4 h. Ingredients and chemical composition of the different diets are shown in Table 1. Dry matter, utilizable protein, crude fat, NE_L, ADF, and NDF were determined according to Naumann and Bassler (2004). Cows always had free access to water troughs.

Measurement of Milk Yield, Milk Composition, and Body Condition

Cows were milked thrice per day at 0600, 1400, and 2200 h. Milk yield was electronically recorded at each milking. Milk samples were taken monthly from 3 milkings during the day and were pooled for the determina-