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Effects of dry period length and dietary energy source on inflammatory biomarkers and oxidative stress in dairy cows

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ABSTRACT

Negative energy balance in dairy cows in early lactation has been associated with increased inflammation and oxidative stress in these cows. The objective of this study was to evaluate the effects of dry period (DP) length and dietary energy source on inflammatory biomarkers and oxidative stress in dairy cows. Holstein-Friesian dairy cows (60 primiparous and 107 multiparous) were assigned randomly to a 3×2 factorial design with 3 DP length (0, 30, or 60 d) and 2 early lactation rations (glucogenic or lipogenic). Cows were fed a glucogenic or lipogenic ration from 10 d before the expected calving date. Blood was collected in wk −3, −2, −1, 1, 2, and 4 relative to calving. Dry period length affected inflammatory biomarkers and oxidative stress, especially in wk 1 and 2 after calving. Cows with a 0-d DP had higher levels of ceruloplasmin, cholesterol, and reactive oxygen metabolites, and they tended to have higher haptoglobin levels compared with cows with a 30- or 60-d DP. Cows with a 0-d DP had a lower plasma paraoxonase and bilirubin in the first 2 wk after calving and a lower liver functionality index compared with cows with a 60-d DP. Cows of parity >3 fed a glucogenic ration had higher cholesterol levels compared with cows of parity >3 fed a lipogenic ration. No interaction between DP length and ration was present for inflammatory biomarkers or oxidative stress variables. Plasma bilirubin levels for cows with a 0-d DP were negatively related to energy balance and metabolic status in these cows. Moreover, occurrence of clinical health problems (fever, mastitis, metritis, and retained placenta) was 41, 27, and 30% for cows with 0-, 30-, and 60-d DP, respectively. High levels of ceruloplasmin, cholesterol, and reactive oxygen metabolites in cows with 0-d DP were related to the occurrence of health problems in these cows. In conclusion, omitting the DP increased levels of ceruloplasmin, cholesterol, and reactive oxygen metabolites, and decreased levels of bilirubin and paraoxonase in plasma, independent of ration, compared with cows with a 60-d DP. These contrasting effects of DP length on inflammatory status could be explained in part by the improved energy balance and occurrence of health problems in these cows, but was not related to increased somatic cell count in cows with a 0-d DP. Cows with a 0-d DP had better energy balance, but also had higher levels of oxidative stress compared with cows with a 60-d DP. Moreover, occurrence of health problems did not differ between cows with different DP lengths.
Key words: continuous milking, acute phase protein, oxidative stress, energy balance

INTRODUCTION

During the transition period, which lasts from 3 wk before to 3 wk after calving (Drackley, 1999), dairy cows experience negative energy balance (**NEB**), which is accompanied by metabolic disorders and by increased inflammation (Bionaz et al., 2007; Trevisi et al., 2012a), immunosuppression (Mallard et al., 1998), and oxidative stress (Sordillo et al., 2009). Proinflammatory cytokines are related to increased inflammation during NEB (Grimble, 1990; Ametaj et al., 2005) by stimulating hepatic synthesis of positive acute phase proteins (**APP**), such as haptoglobin and ceruloplasmin, and impairing hepatic synthesis of negative APP, such as albumin and cholesterol (Bionaz et al., 2007; LeBlanc, 2012). Cows with NEB and inflammation have higher bilirubin in plasma due to impairment of hepatic function (Bertoni et al., 2008). Paraoxonase is part of an extensive antioxidative system (Turk et al.,

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2004) and is considered a negative APP (James and Deakin, 2004). In the early postpartum period, a lower plasma paraoxonase activity is positively associated with lipid metabolic disorders. Negative energy balance and high plasma free fatty acid (**FFA**) levels contribute to the development of fatty liver, which is in turn a contributing factor to other health concerns (e.g., metritis and retained placenta; Kaneene et al., 1997) and periparturient immunosuppression in the postpartum period (Lacetera et al., 2005; Kehrli et al., 2006).

Shortening or omitting the dry period (**DP**) during early lactation in dairy cows has been shown to improve energy balance (**EB**) (van Knegsel et al., 2014) and metabolic status (Rastani et al., 2005; Chen et al., 2015) of dairy cows in the subsequent lactation. However, earlier studies showed variable effects of dry period length (**DPL**) on mammary health (Pezeshki et al., 2007; Watters et al., 2008; Mayasari et al., 2016). A shortened DP (34–40 d) compared with a conventional DP (55–65 d) did not result in differences in SCC (Gulay et al., 2003; Watters et al., 2008; Shoshani et al., 2014) or clinical mastitis (**CM**; Enevoldsen and Sørensen, 1992; Watters et al., 2008; Shoshani et al., 2014). Other studies have shown that a shortened DP was associated with a tendency for higher SCC (Rémond et al., 1997; Annen et al., 2004) or tendency for lower SCC (Rastani et al., 2005) compared with a conventional DP. Some studies (Klusmeyer et al., 2009; Mayasari et al., 2016) concluded that omitting the DP resulted in higher SCC values compared with cows with a 56-d DP, but some studies showed no differences on SCC between cows with 0- and 56-d DP (Rastani et al., 2005; Köpf et al., 2014). Another study showed that omitting DP had a tendency for higher SCC (Rémond et al., 1997) compared with a conventional DP. To our knowledge, omitting the DP did not affect occurrence of CM (Rémond et al., 1997; Mayasari et al., 2016). The effects of shortening or omitting the DP in dairy cows on inflammatory biomarkers, liver functionality (paraoxonase and bilirubin levels), oxidative stress [reactive oxygen metabolites (**ROM**) and ferric-reducing antioxidant power (**FRAP**) levels], and creatinine as markers for mobilization of body muscle have not been reported.

We can hypothesize that when EB is improved by shortening or omitting the DP, the beneficial effects of other management strategies, such as feeding a more glucogenic ration to improve EB and metabolic health, are reduced. Earlier, we reported that cows used in the current experiment fed a glucogenic ration compared with a lipogenic ration had improved EB (van Knegsel et al., 2014) and decreased plasma BHB concentration (Chen et al., 2015), independent of DPL. In other studies, reduced FFA and BHB concentrations were associated with increased cholesterol and reduced haptoglobin levels in plasma (Bionaz et al., 2007; Trevisi et al., 2009) and reduced plasma ROM levels (Bernabucci et al., 2005; Trevisi et al., 2009). Thus, we could expect that feeding a glucogenic ration would reduce inflammation and oxidative stress of cows with different DPL.

Our hypothesis was that improving EB and metabolic status by omitting or shortening the DP would reduce the inflammatory response (i.e., higher levels of negative APP, lower levels of positive APP, and higher liver functionality) and oxidative stress (lower ROM and higher FRAP levels in plasma) during the transition period. Moreover, if omitting the DP resulted in increased SCC but no occurrence of CM, inflammatory biomarkers and oxidative stress may not be affected. The objective of this study was to evaluate effects of DPL and dietary energy source on inflammatory biomarkers and oxidative stress in plasma from dairy cows.

MATERIALS AND METHODS

Animals and Experimental Design

The Institutional Animal Care and Use Committee of Wageningen University (Wageningen, the Netherlands) approved the experimental protocol (registration number 2010026). The experimental design, DPL, and dietary contrasts were described by van Knegsel et al. (2014). In summary, 167 Holstein-Friesian dairy (60 primiparous and 107 multiparous) were selected from the Dairy Campus research herd (WUR Livestock Research, Lelystad, the Netherlands), blocked according to parity, calving date, milk yield in previous lactation, and BCS, and randomly assigned to treatments within blocks. In total, 28 blocks were used and each block consisted of 6 cows and 1 cow/treatment (28 blocks × 6 cows = 168 cows; 1 cow was excluded because she received the wrong ration at drying off). Before the experiment began, all cows had SCC <250,000 cells/mL at the last and second last monthly test-day recordings. Treatments consisted of 3 DPL (0, 30, or 60 d) and 2 early lactation rations (glucogenic or lipogenic) resulting in a 3 × 2 factorial design. Cows used in this study were clinically healthy at start of the experiment. Cows were housed in a freestall with slatted floor and cubicles, and milked twice daily (0500 and 1630 h). The drying-off protocol was as follows: cows with a 30-d or a 60-d DP received a far-off ration 7 d before drying-off and were milked once daily 4 d before drying-off. All cows were treated with an intramammary antibiotic at drying off (Supermastidol; Virbac Animal Health, Barneveld, the Netherlands).