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Concentrate supplementation of a diet based on medium-quality grass silage for 4 weeks prepartum: Effects on cow performance, health, metabolic status, and immune function

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ABSTRACT

Because negative energy balance (EB) contributes to transition-period immune dysfunction in dairy cows, dietary management strategies should aim to minimize negative EB during this time. Prepartum diets that oversupply energy may exacerbate negative EB in early lactation, with detrimental effects on immune function. However, with lower body condition score (BCS) cows, it has been shown that offering concentrates in addition to a grass silage-based diet when confined during an 8-wk dry period resulted in increased neutrophil function in early lactation. The aim of this study was to examine if similar benefits occur when concentrate feeding was restricted to a 4-wk period prepartum. Twenty-six multiparous and 22 primiparous Holstein-Friesian cows were offered ad libitum access to medium-quality grass silage until 28 d before their predicted calving dates (actual mean of 32 d prepartum; standard deviation = 6.4). At this time multiparous cows had a mean BCS of 2.9 (standard deviation = 0.12) and primiparous cows a mean BCS of 3.0 (standard deviation = 0.14) on a 1 to 5 scale. Cows were then allocated in a balanced manner to 1 of 2 treatments (13 multiparous cows and 11 primiparous cows on each treatment): silage only (SO) or silage plus concentrates (S+C) until calving. Cows on SO were offered the same grass silage ad libitum. Cows on S+C were offered an ad libitum mixed ration of the same grass silage and additional concentrates in a 60:40 dry matter (DM) ratio, which provided a mean concentrate DM intake (DMI) of 4.5 kg/cow per d. After calving, all cows were offered a common mixed ration (grass silage and concentrates, 40:60 DM ratio) for 70 d postpartum. Offering concentrates in addition to grass silage during the 4 wk prepartum increased prepartum DMI (12.0 versus 10.1 kg/cow per d), EB (+40.0 versus +10.6 MJ/cow per d), and body weight (BW; 640 versus 628 kg), and tended to increase BCS (3.02 versus 2.97). However, postpartum DMI, milk yield, milk composition, BW change, BCS change, serum nonesterified fatty acid, and β-hydroxybutryrate concentrations, health, and corpus luteum measures were unaffected by treatment. The in vitro assays of neutrophil phagocytosis, neutrophil oxidative burst, and interferon gamma production, conducted on blood samples obtained at d 14 prepartum and d 3, 7, 14, and 21 postpartum, were unaffected by treatment. Primiparous cows had higher phagocytic fluorescence intensity at d 14 prepartum and d 3 and 7 postpartum; a higher percentage of neutrophils undergoing oxidative burst at d 3, 7, and 21 postpartum; and a higher oxidative burst fluorescence intensity at d 14 prepartum and d 7, 14, and 21 postpartum compared with multiparous cows. This suggests that neutrophil function of primiparous cows was less sensitive to the changes occurring during the transition period than that of multiparous cows. In conclusion, offering concentrates during the 4-wk period prepartum had no effect on postpartum DMI, milk yield, body tissue mobilization, EB, measures of neutrophil or lymphocyte function, health, or corpus luteum activity.
Key words: dairy cow, transition period, immunity, metabolic status

INTRODUCTION

The transition period is commonly defined as the last 3 wk of gestation and the first 3 wk of lactation (Grummer, 1995; Drackley, 1999). During this time the dairy cow experiences an immune dysfunction, which is an important contributing factor toward health problems, which peak in incidence immediately postpartum (Ingvartsen, 2006; Mulligan and Doherty, 2008).

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Both prepartum and postpartum negative energy balance (**EB**) have been shown to impair aspects of peripartum neutrophil activity and increase the risk of postpartum uterine disease (Hammon et al., 2006; Galvão et al., 2010), with this due in part to the individual metabolites associated with negative EB. Low serum glucose concentrations has been shown to have detrimental effects on neutrophil function (Galvão et al., 2010), high nonesterified fatty acid (**NEFA**) concentrations decreased peripheral blood mononuclear cell proliferation and neutrophil respiratory burst activity (Ster et al., 2012), and high BHB concentrations impaired neutrophil chemotaxis (Suriyasathaporn et al., 2000) and respiratory burst (Hoeben et al., 1997). Indeed, elevated NEFA and BHB concentrations have been shown to be predictive of infectious diseases, such as clinical mastitis (Moyes et al., 2009) and metritis (Ospina et al., 2010). Thus, it is suggested that prepartum nutritional strategies should seek to minimize negative EB and provide for good metabolic status during the transition period.

Increasing the energy density of the prepartum diet is one approach by which prepartum EB can be improved, and indeed the NRC (2001) advocates a higher energy density in the close-up dry cow diet. However, the suitability of this approach is likely to be influenced by cow BCS at drying off. Offering higher energy TMR diets for the entire prepartum period (in cows with a BCS >3.2 at study commencement; scale 1 to 5) resulted in greater body tissue mobilization postpartum (Janovick and Drackley, 2010), and decreased prepartum neutrophil phagocytosis (Graugnard et al., 2012), compared with those offered lower energy rations. Similarly, increasing energy allowance during the last few weeks prepartum (in cows with a mean BCS of 3.2 to 3.5 at study commencement; scale 1 to 5) resulted in a greater degree of negative EB postpartum (Hayirli et al., 2011), higher incidence of subclinical ketosis postpartum (Vickers et al., 2013), and higher serum NEFA concentrations postpartum (Zhang et al., 2015). Thus, when an increased energy allowance is offered to prepartum cows that already are in high BCS, or when this increased energy allowance results in a high BCS, detrimental consequences may ensue.

When exposed to the typical grassland-based dairy production systems of Western Europe, higher yielding cows may complete the lactation with a BCS of 3.0 or less (scale 1 to 5). For example, in an on-farm study by Law et al. (2016) involving over 1,200 cows, 88% of cows had a BCS ≤2.5 (scale 1 to 5) at drying off. In these scenarios it is possible that concentrate feeding during the dry period will have beneficial effects on subsequent health and performance, but without the risk of cows becoming overconditioned. A recent study involving low BCS cows (2.4 at study commencement; scale 1 to 5), found that offering 3 kg concentrates for 8 wk prepartum in addition to a grass silage-based diet improved EB prepartum and led to improved neutrophil phagocytic index at wk 1 postpartum, compared with unsupplemented cows (Little et al., 2016). However, as concentrates are considerably more expensive than conserved forages (Finneran et al., 2012), it is important to identify if similar benefits can be achieved with a shorter period of concentrate feeding.

It was hypothesized that offering additional concentrates to low BCS cows during the prepartum period would have a beneficial effect on immunity during the transition period, and on postpartum performance. Therefore, the objectives of the current study were to examine the effects of offering lower BCS cows a concentrate supplement, in addition to grass silage, during the 4 wk prepartum on cow performance, health, fertility, metabolites, and neutrophil and lymphocyte functions.

MATERIALS AND METHODS

Animals and Housing

This study involved 28 multiparous (mean parity, 3.3; SD = 1.7) and 22 primiparous (first-calving heifers) Holstein-Friesian dairy cows. Cows had a mean predicted transmitting ability for milk yield and fat plus protein yield of 99 (SD = 190.4) and 16.2 (SD = 10.61) kg, respectively, and a mean profitable lifetime index of £186 (SD = 83.7). These cows were within the top 1% of UK genetics in terms of profitable lifetime index. All procedures described in this paper were approved by the animal research ethics committee at the Agri-Food and Biosciences Institute, Hillsborough, and conducted under an experimental license granted by the Department of Health, Social Services and Personal Safety for Northern Ireland in compliance with the United Kingdom Animals (Scientific Procedures) Act (1986).

Throughout the experiment (except at calving) cows were housed in a free stall cubicle house with concrete flooring, which was scraped every 3 h by an automated system. The cubicle to cow ratio was ≥1:1 at all times, thus meeting the recommendations of the Farm Animal Welfare Council (1997). Cubicles were fitted with rubber mats and were bedded 3 times each week with sawdust.

Experimental Design, Diets, and Feeding

Multiparous cows were dried off 8 wk before the predicted calving date (mean dry-off date, January 20, 2015; SD = 11 d), with primiparous cows joining