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Prepartum concentrate supplementation of a diet based on medium-quality grass silage: Effects on performance, health, fertility, metabolic function, and immune function of low body condition score cows

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ABSTRACT

When cows with a "higher" body condition score (BCS) are oversupplied with energy during the dry period, postpartum energy balance is normally reduced, which can have a detrimental effect on immune competence and increase the infectious disease risk. However, within grassland-based systems higher yielding cows frequently have a low BCS at drying off. The effects on performance, health, and metabolic and immune functions of providing additional energy to cows with low BCS during the dry period is less certain. To address this uncertainty, 53 multiparous Holstein-Friesian cows (mean BCS of 2.5; 1–5 scale) were allocated to 1 of 2 treatments at dry-off: silage only or silage plus concentrates. Cows on the silage-only treatment were offered ad libitum access to medium-quality grass silage. Cows on the silage-plus-concentrate treatment were offered ad libitum access to a mixed ration comprising the same grass silage plus concentrates [in a 75:25 dry matter (DM) ratio], which provided a mean concentrate DM intake of 3.0 kg/cow per day. Postpartum, cows were offered a common mixed ration comprising grass silage and concentrates (in a 40:60 DM ratio) for a 70-d period. Offering concentrates during the dry period increased DM intake, tended to increase energy balance, and increased body weight (BW) and BCS gain prepartum. Offering concentrates during the dry period increased BW and BCS loss postpartum and tended to increase milk fat percentage and serum nonesterified fatty acid concentration, but it did not affect postpartum DM intake, energy balance, and milk yield. Although the percentage of phagocytosis-positive neutrophils did not differ, neutrophils from cows on the silage-plus-concentrate treatment had higher phagocytic fluorescence intensity at 1 and 2 wk postpartum and higher phagocytic index at 1 wk postpartum. Serum haptoglobin concentrations and IFN-γ production by pokeweed mitogen stimulated whole blood culture were unaffected by treatment, although haptoglobin concentrations increased and IFN-γ production decreased peripartum. Offering concentrates during the dry period increased the incidence of lameness postpartum, although other health and fertility parameters were unaffected. In conclusion, supplementing low BCS cows with concentrates during the dry period had no effect on performance and fertility and resulted in a higher neutrophil phagocytic index at 1 wk postpartum and an increased incidence of lameness compared with offering cows a grass silage–only diet prepartum.
Key words: dairy cow, transition period, concentrate supplementation, immunity

INTRODUCTION

The transition period is defined as the last 3 wk of gestation and the first 3 wk of lactation (Grummer, 1995; Drackley, 1999). During this time the cow must adapt to number of changes that occur in quick succession, including moving from a pregnant to a lactating state (with associated hormonal and metabolic changes and challenges), changes in social grouping and daily routine, and diet changes (which can often be dramatic). Of these transition period changes, the challenge of increasing metabolic demands are of particular importance (Grummer, 1995; Goff and Horst, 1997; Drackley, 1999). Prepartum, energy demands increase due to fetal growth and colostrogenesis (Bell, 1995), while DMI (and therefore energy supply) declines (Hernandez-Urdaneta et al., 1976; Johnson and Otterby, 1981). Postpartum, the rapid increase in energy requirements for milk production outpaces what can be supplied by DMI (Bell,

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1995; Drackley, 1999). This imbalance between energy supply and demand means that negative energy balance (**EB**) frequently occurs, contributing to the high incidence of metabolic disease at this time (Goff and Horst, 1997; Friggens et al., 2004).

The change in blood metabolites due to negative EB have been shown to impair immune function. For example, low blood glucose results in less energy being available for neutrophil phagocytosis (Newsholme et al., 1986; Roche et al., 2013), higher ketone levels impair neutrophil phagocytic and bactericidal capacity (Suriyasathaporn et al., 2000), and higher nonesterified fatty acids (**NEFA**) levels decrease neutrophil viability (Scalia et al., 2006). These findings are in keeping with comparisons between intact and mastectomized cows, which demonstrated that the metabolic stress associated with early lactation slowed the recovery of the normal peripartum decrease in neutrophil activity and adhesion molecule expression (Kimura et al., 1999). This periparturient immune suppression occurs at a time of increased challenge from bacteria, including those responsible for mastitis (Bradley and Green, 2004) and metritis (Sheldon et al., 2008), resulting in an increased risk of infectious diseases.

Therefore, failure to adapt to the physiological challenges arising during the transition period can increase the risk of both metabolic and infectious diseases (Goff and Horst, 1997; Ingvartsen, 2006). Any diseases that occur at this time can lead to reductions in DMI and milk production during the subsequent lactation (Roche et al., 2013) and can have detrimental effects on reproductive performance (Staples et al., 1990; Bobe et al., 2004; Roche et al., 2013). In recognition of the importance of the transition period, research has sought to develop nutritional and management strategies that aid the cow in adapting to the physiological challenges that occur at this time. Nutritional strategies designed to ensure a successful transition often focus on the dry period, with strategies designed to "regulate" energy intake (both restricting and increasing) often advocated. Strategies to increase energy intake during the dry period are designed to reduce the extent of prepartum negative EB and thus reduce the serum concentrations of the associated metabolites and their detrimental effects. Indeed, evidence exists that increasing energy intake (Dann et al., 1999; Vandehaar et al., 1999; Rabelo et al., 2005) and maximizing DMI (Grummer, 1995) in cows during the close-up period is beneficial to transition success and can result in improvements in immune function, such as enhanced immunoglobulin production (Stabel et al., 2003). However, other studies have shown that overconsumption of energy prepartum can have a deleterious effect on postpartum DMI, serum NEFA, and BHB concentrations (Dann et al., 2006; Douglas et al., 2006; Janovick and Drackley, 2010) and on hepatic adipose accumulation (Rukkwamsuk et al., 1998).

However, the response to energy intake during the dry period must be considered within the context of the cow's BCS. For example, it is generally accepted that dry cow nutritional management should prevent cows becoming overconditioned because cows with excessive body tissue reserves have poorer appetites pre- and postpartum, mobilize more lipid around calving (Ingvartsen et al., 2003; Friggens et al., 2004), and have a more severe periparturient immune depression, for example, depression in lymphocyte function (Lacetera et al., 2005). Indeed, studies that have observed benefits with restricted energy intakes during the dry period have involved cows with mean BCS 2.9 to 3.3 (1–5 scale) during the dry period (Dann et al., 2006; Douglas et al., 2006; Janovick and Drackley, 2010). In addition, diet and management systems clearly have an important effect on dry period BCS, with a recent review by Drackley and Cardoso (2014) highlighting that the problem of excessive prepartum BCS and subsequent excessive postpartum mobilization of lipid to particularly be an issue in herds where corn (maize) silage is the primary forage. In contrast, when higher yielding cows are managed within grassland-based systems, in which diets are based on grazed grass and grass silage, the problem is often one of "underconditioned" cows during the dry period. For example, in a study involving more than 1,200 dairy cows on 10 Northern Ireland dairy farms, 88% of the cows had a BCS or 2.5 or less at dry-off [R. A. Law (Agri-Food and Biosciences Institute, Hillsborough, Northern Ireland) and C. P. Ferris, unpublished data]. Thus, in these thinner cows the response to receiving additional energy during the dry period may be very different compared with that observed in higher BCS cows. This expectation is supported by the findings of a recent study that demonstrated the need to consider tailoring the dry cow diet to cow BCS (Roche et al., 2015). In this study, when measuring indictors of immune competence, optimally conditioned cows benefited from a short-term feed restriction during the dry period, but lower BCS cows benefited from a diet that met requirements.

Increasing energy intakes during the dry period is also often advocated as a strategy that may improve BCS, although the extent of the associated changes is often small (Agenäs et al., 2003; Dann et al., 2006; Law et al., 2011). In addition, the decline in DMI that regularly precedes calving can be abated by increasing dry period energy intakes (Keady et al., 2001; McNamara et al., 2003b; Rabelo et al., 2003). In practice, one of the easiest ways to increase energy intakes during the dry period is to offer additional concentrates, and although this practice is common on many dairy farms,