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Lactation and body composition responses to fat and protein supplies during the dry period in under-conditioned dairy cows

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ABSTRACT

An experiment was designed to study the effect of precalving supplementation with protein (Pr) and rumen-inert fat (F) on body composition and subsequent milk production and composition. Forty Holstein-Friesian dairy cows were allocated to 1 of 4 dietary treatments in the dry period (DP) based on a first-cut ryegrass silage, with 6 mature (in their third or greater pregnancy) and 4 young (in their second pregnancy) cows per treatment. These were low Pr, low F (silage alone); low Pr, high F (silage with 10% rumen-inert fat, mixed on a dry matter basis); high Pr, low F [silage with 5% high-protein corn gluten meal (CGM)]; and high Pr, high F (silage with 5% CGM and 10% rumen-inert fat). All the diets were individually offered ad libitum and dry matter intake (DMI) was recorded daily during the DP. After calving, all cows received ryegrass silage plus 8 kg/d of a commercial dairy concentrate. During the DP, DMI was higher for mature than for young cows. All animals recovered body condition score (0.13 units/wk, 1–5 scale), reaching a maximum score of 2.4 some days before calving. Precalving maximum muscle longissimus dorsi (LD) depth was greater for mature (47.5 mm) than for young cows (45.7 mm), and milk fat concentration was also higher for mature than for young cows (40.2 and 39.0 g/kg, respectively). Supplementation with CGM increased maximum LD depth (from 45.9 to 47.6 mm), calf birth weight (low Pr = 43.2, high Pr = 46.3 kg), and milk crude protein concentration (from 30.8 to 31.6 g/kg). Fat supplementation in the DP of the mature cows increased maximum back fat depth (from 3.6 to 4.5 mm), milk yield (low F = 26.3, high F = 28.7 kg/d), and Pr yields (low F = 837, high F = 899 g/d). Inclusion of F in the DP diets reduced casein concentration in milk at wk 3 of lactation from 26.3 to 24.5 g/kg. Milk CP yield was also increased by CGM supplementation when compared within cows receiving F-supplemented silages (low Pr, high F = 832 g/d; high Pr, high F= 877 g/d). It can be concluded that CGM supplementation in the DP increased subsequent milk Pr concentration, but milk Pr yield increased only in those animals also receiving F supplementation. Dry period diet supplementation with F increased maximum back fat depth and milk and CP yields in the mature cows, and led to more LD muscle mobilization during early lactation. Second-calving cows had a lower DMI and milk fat concentration than mature cows.
Key words: dry cow, milk production, milk quality, body composition

INTRODUCTION

The dry period (**DP**) of the dairy cow occurs during late gestation, when the highest nutrient demands from the conceptus and mammary tissue development occur (Prior and Laster, 1979; Bell et al., 1995). Many authors have suggested the importance of the DP on the subsequent lactation performance of dairy cows (Grummer, 1998; Drackley, 1999), but many dairy producers still tend to think of the dry cow as having relatively low energy and protein requirements. The metabolic, physiological, and behavioral changes associated with this relatively short period of the lactation cycle suggest a phase of high metabolic activity, and producers should consider the DP as a linking phase between successive lactations, when management aims to prepare the cow to cope with the next lactation. The aim of DP management should be to avoid subsequent metabolic disorders, to support fetal calf growth and mammary gland development, and optimize subsequent milk production and composition without compromising reproductive performance.

Many cows start the dry period under-conditioned, leading to cows calving below the optimum BCS and thereby becoming more susceptible to a variety of health problems (NRC, 2001). Although the need to

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improve the body condition of under-conditioned cows at drying off has been noted by some authors (van Saun and Sniffen, 1996), achievement of a moderate amount of body reserves throughout the late pregnancy period is acknowledged as a key factor to maximize dairy cow productive performance in the subsequent lactation (van Saun and Sniffen, 1996; Studer, 1998; NRC, 2001). Cows that begin lactation with a BCS of less than 2.8 (on a 0–5 scale) may not be capable of mobilizing enough energy to support maximal milk production (Otto et al., 1991) and may have suboptimal reproductive capabilities (Crowe, 2008). Previous experiments have highlighted the effects of BW gain during the DP, focusing particularly on the consequences of over-conditioning (Fronk et al., 1980), but little attention has been paid to recovery of body reserves by thin cows. Grum et al. (1996) indicated that replenishment of the energy reserves of under-conditioned cows during the DP could increase milk production and decrease the incidence of metabolic disorders during early lactation, but further research of the same group suggested that recovering BW during the entire DP could bring about peripartum health problems and impaired postpartum performance, even when animals did not become over-conditioned (Douglas et al., 2006).

Nutrition of dairy cows during the final stages of gestation is further complicated because any nutritional imbalance is exacerbated by a typical DMI reduction (Ingvartsen and Andersen, 2000; NRC, 2001) and the fact that overfeeding can promote fetal overgrowth, which can lead to dystocia and other health problems in the cow (Mee, 2008). At the same time, increasing fetal nutrient demands can bring about important maternal body tissue remobilization with undesirable consequences on the cow's postpartum performance (Beever, 2006; Crowe, 2008).

In under-conditioned cows (BCS typically <2), supplying large quantities of dietary energy as carbohydrate (grain) during the DP to improve BCS can lead to risk problems such as fatty liver (Grum et al., 1996). However, supplying energy in the form of fat reduces this risk because the liver is not a lipid depot during positive energy balance (NRC, 2001). In addition, feeds with a high concentrations of fat constrain energy supply to the fetus due to low conceptus access to fatty acids and keto acids (Bell, 1993), and it has been speculated that feeding fat to dry cows could lead to increased fatty acid oxidation and reduced fatty acid esterification in liver metabolism (Grum et al., 1996). According to Grummer (1993), dietary fat could minimize the risk of fatty liver, ketosis, or both by (a) reducing fatty acid mobilization from adipose tissue, (b) alleviating the shortage of fatty acid precursors for mammary triglyceride synthesis, and (c) by sparing glucose oxidation by reducing the requirement of NADPH for mammary fatty acid synthesis. In other dietary considerations, supplementation with bypass protein during the DP has shown improvements in milk production and composition (van Saun et al., 1993; Moorby et al., 1996; Moorby et al., 2002a,b), apparently mediated by replenishment of the labile body protein pool.

Our hypothesis was that increasing the fat and protein supply to the dairy cow during the late DP would improve body fat reserves and labile body protein, hence supporting milk production and composition during the early phase of the subsequent lactation. The objective of our study was to examine the effect of precalving dietary protein and rumen-inert fat supply on body composition and subsequent milk production and composition of under-conditioned dry dairy cows.

MATERIALS AND METHODS

General Design and Management

To investigate the interactive effects of fat and protein in precalving diets, diets based on first-cut ryegrass silage supplemented with a rumen-inert fat source and a rumen bypass protein source were fed. The fat source was Megalac (Volac International Ltd., Royston UK), a calcium soap of long-chain fatty acids from palm oil, containing 772 g/kg of acid hydrolysis ether extract and, according to manufacturer label specifications, supplied 48% C16:0, 5% C18:0, 36% C18:1, and 9% C18:2. The rumen bypass protein source was corn gluten meal.

Forty Holstein-Friesian dairy cows at the Institute of Grassland and Environmental Research Trawsgoed Research Farm (Aberystwyth, UK) were allocated to 1 of 4 diets in a factorial treatment arrangement of rumen-inert fat (**F**) and protein (**Pr**). The experimental diets were all based on first-cut ryegrass silage and were low-Pr, low-F (**Ll**), the ryegrass silage only; low-Pr, high-F (**Lh**), the same silage with 10% rumen-inert fat (mixed on a DM basis); high-Pr, low-F (**Hl**), the same silage with 5% high-protein corn gluten meal (**CGM**); high-Pr, high-F (**Hh**), the same silage with 5% CGM and 10% rumen-inert fat. Animals were balanced for parity across treatments, with 6 mature (in their third or greater pregnancy) and 4 young (in their second pregnancy) cows per treatment. The average age of the 16 young cows at the start of the experiment was 36 (±3.6) mo. In the mature group, 11 cows were in their third pregnancy (46 ± 0.7 mo old), 8 cows in their fourth pregnancy (58 ± 0.8 mo old), and 5 cows in their fifth pregnancy (71 ± 1.5 mo old).

Animals were adapted to the housing and were trained to use Calan gates (American Calan, Northwood, NH) over a 2-wk period before the start of the