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Short communication: Effect of dietary manipulation of crude protein content and nonfibrous-to-fibrous-carbohydrate ratio on energy balance in early-lactation dairy cows[1]

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ABSTRACT

Disparities between nutrient intake and demand often result in a state of negative energy balance (EB) in the early-lactation dairy cow. Reducing dietary crude protein (CP) content and providing glucogenic nutrients may overcome this issue. This study evaluates whether or not offering a diet lower in CP and higher in nonfiber carbohydrates (LP-NFC) can improve EB and the metabolic status of the early-lactation dairy cow compared with a diet higher in CP and fibrous carbohydrates (HP-FC). Twenty Holstein-Friesian dairy cows were assigned to 1 of 2 dietary treatments in a randomized block design. Diets were isoenergetic (6.57 MJ of net energy for lactation) and formulated to contain 15% CP and 6% starch (HP-FC), or 12% CP and 28% starch (LP-NFC) and were offered for the first 63 d of lactation. Intake and milk yield were determined daily, whereas milk and blood samples, weights, and body condition scores were collected weekly. Intakes (mean ± standard errors of the mean, SEM) of dry matter (17.4 ± 0.6 kg/d) and energy (113.0 ± 4.6 MJ of net energy for lactation) were not different between treatments. However, the HP-FC group had a higher milk yield (31.8 vs. 28.9 ± 1.4 kg/d) and a lower EB compared with the LP-NFC group. Blood urea N concentration (3.5 vs. 1.8 ± 0.2 mmol/L) was higher, whereas bilirubin (6.0 vs. 6.7 ± 0.2 mmol/L) and β-hydroxybutyrate concentrations (0.7 vs. 0.8 ± 0.05 mmol/L) were lower in the HP-FC group compared with the LP-NFC group. These data suggest that EB can be improved during early lactation through the manipulation of milk output by offering a lower CP, higher NFC diet.

Key words: early lactation, energy balance, dairy cow, carbohydrate

Short Communication

Increases in the genetic potential for milk production have created technical challenges for nutritionists and metabolic challenges for the early-lactation dairy cow. In particular, disparities between energy intake and that required for production can result in a state of negative energy balance (**EB**) and a metabolic status that predisposes the cow to reduced reproductive performance and clinical and subclinical production diseases cumulating in reduced profitability at the farm level (McArt et al., 2013). Restricting milk production through reducing dietary CP supply may be an effective method of improving EB in early-lactation dairy cows (McCormick et al., 2001; Law et al., 2009). However, these effects are inconsistent in the literature, with some reports showing improved EB (Ørskov et al., 1987) and others showing no effect (Chapa et al., 2001; Law et al., 2009). Improvements in EB and metabolic status of the dairy cow are also possible through altering the ratio of fibrous carbohydrates (**FC**) to NFC, creating diets that are either lipogenic or glucogenic. Previously, van Knegsel et al. (2007) reported a lower milk fat yield (0.24 kg/d) and improved daily EB by 56 $kJ/kg^{0.75}$ for the glucogenic-type diets.

In the literature, the effect of manipulating dietary CP concentration on EB has been well documented (Chapa et al., 2001; Law et al., 2009). Similarly, the balance of FC and NFC has been studied for effects on EB (van Knegsel et al., 2007). However, with the exception of Broderick (2003), who evaluated the effect of dietary CP and energy content in mid-lactation cows (126 DIM), limited information exists on the simultaneous application of energy type and CP content to improve EB in the early-lactation cow. This experiment aimed to evaluate the effects of offering diets lower in CP and higher in NFC on milk production, EB, and metabolic profile in the early-lactation dairy cow.

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Communities (Amendment of the Cruelty to Animals Act 1876) Regulations 2002 and 2005 (Department of Health and Children, 2005). Twenty multiparous dairy cows (*Bos taurus* strain Holstein-Friesian) were selected from the dairy herd at University College Dublin Lyons Research Farm (Newcastle, Dublin, Ireland; 53°17′56″ N, 6°32′18″ W). The cows were blocked by parity and calving date and randomly assigned to one of the following isoenergetic diets: high-CP, low-NFC (**HP-FC**) diet or a low-CP, high-NFC (**LP-NFC**) diet (Table 1). Blocks were balanced for previous 305-d lactation milk yield (6,734 ± 700 kg), milk protein yield (230 ± 21 kg), and BCS at calving (3.0 ± 0.11; means ± SE). Dietary treatments were offered once daily from d 1 to 63 postpartum as a TMR. Individual feed intake was facilitated using preprogrammed feed boxes (RIC System; Insentec B.V., Marknesse, the Netherlands). Feed samples were taken daily, pooled on a weekly basis, and analyzed for chemical composition as previously described in Whelan et al. (2011). These data were then entered into the Nutrient Requirements for Dairy Cattle software package (version 1.1.9; NRC, 2012) to calculate NE and MP.

Cows were milked twice daily for the duration of the experiment at 0700 and 1600 h to determine milk yield (**MY**) with weekly sampling for milk constituents (Dairymaster, Kerry, Ireland). Milk samples were analyzed in a commercial milk laboratory (Progressive Genetics, Bluebell, Dublin, Ireland) using infrared analysis (CombiFoss 6000; Foss Analytical A/S, Hillerød, Denmark). These data were used to calculate milk energy output according to Tyrrell and Reid (1965). Blood samples were harvested by jugular venipuncture on d 0, 7, 14, 21, 28, 35, and 63 postpartum for determination of glucose, urea, NEFA, BHBA, bilirubin, γ-glutamyl transferase, and glutamate dehydrogenase concentrations. Blood samples were prepared and analyzed as described in Whelan et al. (2012) using Randox reagents and equipment (Randox Laboratories Ltd., Antrim, UK). Rumen fluid was harvested by stomach tubing (Flora Rumen Scoop; Prof-Products, Guelph, ON, Canada) approximately 6 h postfeeding on d 58 to 62 postpartum to determine rumen VFA and NH_3-N concentrations. Sample preparation (Whelan et al., 2013) and analyses for VFA (Hart et al., 2009) and NH_3-N (Weatherburn, 1967) were as previously described.

Data were checked for adherence to the normal distribution and homogeneity of variance using histograms and formal statistical tests as part of PROC UNIVARIATE of SAS (SAS Institute, 2004). Analysis of data was conducted using PROC MIXED of SAS (SAS Institute, 2004). The model included tests for the fixed effects of treatment, week, parity, and their interactions. Cow within treatment was modeled as a random effect. Statistically significant differences between least squares means were tested using the PDIFF command, incorporating the Tukey test for pairwise comparison of treatment means. Where interactions were not significant, these terms were excluded from the model. Statistical significance was assumed at $P < 0.05$ and a

Table 1. Ingredient inclusion rate and chemical composition of TMR used during the experiment

Item	HP-FC TMR[1]	LP-NFC TMR[1]
Inclusion (%)		
Grass silage	46	14
Corn silage	3	41
Barley straw	1	2
NFC-Pellet[2]	0	43
FC-Pellet[3]	49	0
Composition (% of DM, unless otherwise stated)		
DM (%)	29.3	37.3
NE_L (MJ/kg of DM)	6.57	6.57
CP	14.6	11.9
MP	12.7	8.1
NDF	54.5	39.5
ADF	35.1	22.3
ADL	4.1	2.9
Ash	7.5	5.7
Ether extract	3.0	3.0
NFC	20.4	39.9
Starch	5.7	27.5

[1]HP-FC = high-CP, low-starch TMR; LP-NFC = low-CP, high-starch TMR.

[2]NFC-Pellet = low-CP, high-NFC pellet (48% ground corn, 29% citrus pulp, 19% soybean meal, 1% molasses, and 3% mineral-vitamin premix, on a DM basis).

[3]FC-Pellet = high-CP, low-NFC pellet [8% ground corn, 14% beet pulp, 16% soybean meal, 55% soy hulls, 2% Megalac (Church & Dwight Co. Inc., Ewing, NJ), 1% molasses, and 4% mineral-vitamin premix, on a DM basis].