Short-term feeding of a rumen-protected carbohydrate increases plasma insulin concentrations in early postpartum dairy cows

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Summary

Low blood glucose concentrations early postpartum are associated with low blood insulin concentrations, postpartum metabolic disorders, and infertility. The hypothesis was that short-term feeding of a rumen protected carbohydrate (RPC) would increase blood insulin concentrations by increasing glucose supply from the gastrointestinal tract. Lactating dairy cows were jugular catheterized. During the first 24 h (day 1), cows were fed a nutritionally balanced TMR. After 24 h (d 2, 3, and 4), cows were fed the TMR with the RPC added at 10% of diet DM. On d 5 cows were switched to control TMR. There was an effect of day ($P<0.001$) on plasma insulin concentrations. The increase in blood insulin was associated with a decrease in plasma glucose and an increase ($P<0.001$) in plasma BHB. There was no effect of day on plasma NEFA but there was an effect of time ($P<0.001$). Milk produced and DMI were similar ($P>0.10$) for days 1 to 5. In conclusion, short-term feeding of the RPC increased blood insulin concentrations. The increase in blood insulin was associated with a decrease in blood glucose and an increase in BHB. Feeding RPC effectively alleviated depressed insulin and shifted associated metabolite concentrations.

Introduction and rational

Glucose is a critical nutrient in the postpartum dairy cow because glucose is used by the mammary gland for the synthesis of milk (Bell, 1995). Glucose is also required by a variety of other tissue types including those involved in reproduction (Nishimoto et al., 2006; Clark et al., 2011; Berlinguer et al., 2012) (Figure 1). Low blood glucose in early lactation may be a causative mechanism for infertility in dairy cows. The hypothesis was that short-term feeding of a rumen protected carbohydrate (RPC; 56% soybean meal, 40% soluble carbohydrates, 3.2% urea, and 0.8% minerals) would increase blood insulin concentrations by increasing glucose supply from the gastrointestinal tract.

Methods

Lactating dairy cows (4 Holstein and 1 Guernsey; 17±2 DIM; 30.9±4.6 kg milk and 13.7±2.6 kg DMI per day; Figure 2) were jugular catheterized, barn housed, and milked 2X. During the first 24 h (day 1; Table 1), cows were fed a nutritionally balanced TMR (corn silage, haylage, wet brewer grains, dry corn, alfalfa hay, rumen protected and unprotected soybean meal, soyhulls, and premix). After 24 h (d 2, 3, and 4), cows were fed the TMR with the RPC added at 10% of diet DM. On d 5 cows were switched to control TMR. Blood was sampled every 2 h for days 1 to 5 through a jugular catheter. Plasma was isolated and analyzed for insulin, glucose, beta-hydroxybutyrate (BHB) and nonesterified fatty acids (NEFA). Data were analyzed for the effects of day, time, and day by time with cow as a random effect (Proc GLM of SAS).

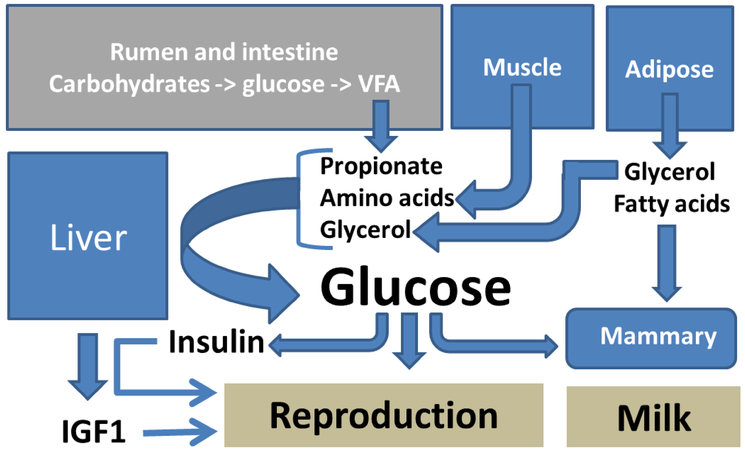

Figure 1. Metabolic processes in the early postpartum cow with potential to link glucose to the reproductive system. Low circulating glucose may impair reproductive processes that are needed to re-establish pregnancy.

Table 1. Trial timeline. RPC = rumen protected carbohydrate.

Day 1	Day 2	Day 3	Day 4	Day 5
TMR	TMR + 10% RPC	TMR + 10% PRC	TMR + 10% PRC	TMR

Figure 2. Cows with jugular cannula being individually fed TMR + 10% rumen protected carbohydrate.

Table 2. Plasma concentrations of insulin, glucose and BHB[1]

Day 1	Day 2	Day 3	Day 4	Day 5
Insulin (ng/mL; SEM = 0.03)				
0.23^{a}	0.24^{a}	0.31^{ab}	0.40^{c}	0.36^{bc}
Glucose (mg/dL; SEM = 0.7)				
54.4^{a}	55.7^{a}	51.0^{b}	50.9^{b}	51.3^{b}
BHB (mmol/L; SEM = 0.06)				
1.64^{a}	1.78^{a}	2.01^{b}	2.19^{c}	1.97^{b}

[1]Data are lsmean and SEM for the entire day. Means with different superscript differ at $P < 0.05$.

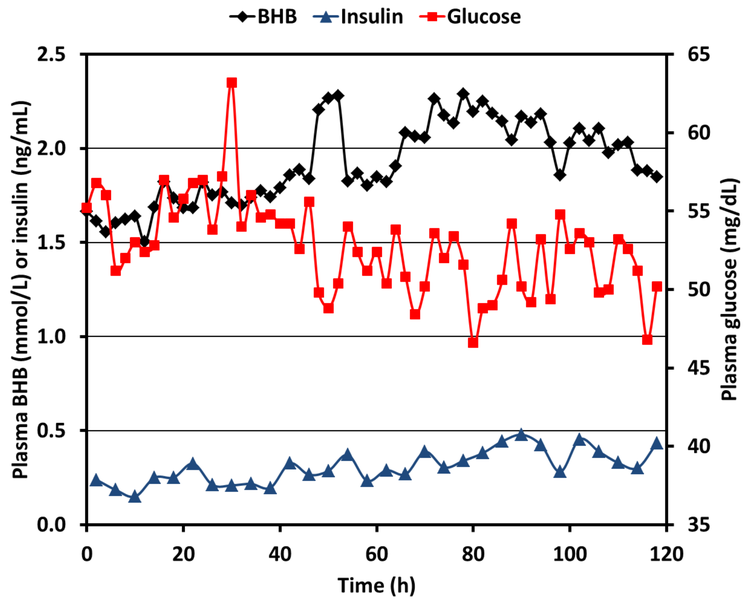

Figure 3. Concentrations of β-hydroxybutyrate (BHB; SEM = 0.2; black line), glucose (SEM = 2.2; red line) and insulin (SEM = 0.07; blue line) in blood samples collected once every 2 h from early postpartum Holstein (n = 4) or Guernsey (n=1) dairy cows that were fed either a control TMR (0 to 24 h and 96 to 120 h) or a TMR + 10% rumen protected carbohydrate (RPC; 24 to 96 h).

Key finding:

- Feeding a rumen-protected carbohydrate effectively alleviated depressed insulin and shifted associated metabolite concentrations.