PREPARTUM NUTRIENT INTAKE ALTERS METABOLISM OF PALMITATE BY LIVER SLICES FROM PERIPARTAL DAIRY COWS

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TAKE HOME MESSAGES

- Excessive energy intake during the far-off dry period decreased liver oxidation and increased esterification of palmitate.

- These changes are likely to increase liver triglyceride accumulation postpartum.

INTRODUCTION

Optimal nutritional management of dry cows is not yet clearly defined. Some dairy nutrition research has indicated that dry cows should be fed an energy dense diet during the dry period to “steam-up” the rumen and metabolic pathways in preparation for high dry matter intake (DMI) during early lactation. University of Illinois dairy nutrition research, however, has focused on feeding an energy restricted diet to minimize the depression in DMI that occurs around the time of calving and thus avoid large shifts in metabolism. There also is little information in the literature concerning which phase of the dry period, either the far-off or the close-up, is the most important time to focus on nutritional strategies to minimize metabolic problems in the transition period. Fatty liver is a metabolic disorder that often occurs in early lactation and is associated with decreased health status and reproductive performance.

Fatty liver develops when hepatic uptake of NEFA (mobilized body fat) exceeds the oxidation and secretion of lipids by the liver. Previous research at the University of Illinois showed that cows with restricted energy intake prepartum had higher hepatic β-oxidation capacity, lower esterification capacity and lower liver triglyceride one day after calving (Grum et al., 1996). Additionally, cows feed-restricted during the dry period had lower liver triglyceride concentration one day after calving and had higher DMI postpartum (Douglas et al., 1998). Despite the positive benefits observed by feeding energy restricted diets in the dry period experimentally, it remains to be seen whether benefits of restricted feeding during the dry period can be captured in practical management systems. Our hypothesis was that cows fed a low energy diet formulated to meet NRC recommendations in the far-off period, followed by increased energy density of the diet three week prepartum will offer the best chance to increase oxidation of NEFA (non-esterified fatty acids) by liver and to decrease accumulation of triglyceride in liver. Our objective for this experiment was to determine the effect of far-off and close-up diets, varying in energy density and amount fed, on hepatic capacity for palmitate oxidation and esterification using an in vivo dietary treatment with an in vitro test of liver metabolism.
METHODS

Dietary treatments during the far-off period (d –60 to –24) before calving include; 1) control diet fed ad libitum and formulated to meet approximately 100% of NE\textsubscript{L} requirements (FOCA), 2) extra energy diet fed ad libitum (165% of NE\textsubscript{L}) (FOEA), and 3) extra energy diet fed in restricted amount (80% of NE\textsubscript{L}). Wheat straw was used to dilute the energy density to meet requirements for FOCA. Dietary treatments during the close-up period (d -23 to calving) were; 1) close-up diet fed ad libitum to meet approximately 140% of NE\textsubscript{L} requirements (CUA) or close-up diet fed in restricted amounts to meet approximately 80% of NE\textsubscript{L} requirements (CUR). Seventy-one multiparous Holstein cows were randomly assigned to dietary treatments and biopsies of liver were taken on d –30, -14, 1, 14, and 28 relative to calving. Slices of the liver tissue were prepared and were incubated in a shaking water bath. Liver palmitate metabolism was determined by measuring production of carbon dioxide (CO\textsubscript{2}), ketone bodies or acid soluble products (ASP), total esterified products (EP) (a measure of liver lipid accumulation), and total palmitate metabolism defined as the sum of CO\textsubscript{2}, ASP, EP).

RESULTS AND DISCUSSION

Palmitate metabolism was not affected by either of the close-up treatments. Total palmitate metabolism by liver slices increased for all treatments on d 1 postpartum. Palmitate conversion by liver slices to CO\textsubscript{2} was greater on d 1 for cows fed FOER than cows fed FOEA, indicating that cows fed a restricted energy diet in the far-off period had greater ability to completely oxidize palmitate than cows fed a diet containing extra energy and fed ad libitum during the far-off period. Ketone body production (ASP) was greater on d 1 for cows fed FOCA and FOER than for cows fed FOEA. Ketones are produced from the incomplete oxidation of body fat stores. Although ketone body production is often associated with ketosis, controlled ketone production by the liver contributes energy for maintenance and milk production, especially during early lactation. Palmitate conversion to esterified product was greater on d –30 for cows fed FOCA than for cows fed FOER. Palmitate conversion to esterified product increased for all treatments on d 1 postpartum with no difference among far-off treatments. The combination of treatments in the far off and the close up period for cows fed FOEA and CUA (high energy diets fed ad libitum) compared with cows fed FOER and CUA (restricted energy fed in restricted amounts) showed that esterified product as a percent of total palmitate metabolism was lower and fluctuated less for cows fed FOER plus CUR than for cows fed FOEA plus CUA (Figure 1). Liver triglyceride accumulation measured separately from the in vitro system described in this report showed that liver triglyceride accumulation was greatest for cows fed FOEA and was lowest for cows fed FOER (Figure 2). Results from this study suggest that overfeeding of energy during the far-off dry period may negatively impact liver lipid metabolism, by suppressing the oxidation of NEFA and increasing the conversion of NEFA to triglyceride.
**Figure 1.** Liver slice esterified product expressed as a percent of total palmitate metabolism.

- FOEA = Far-off extra energy diet fed ad libitum (~165% of NE\textsubscript{L} requirement)
- FOER = Far-off extra energy fed restricted (~80% of NE\textsubscript{L} requirement)
- CUA = Close-up diet fed ad libitum (~140% of NE\textsubscript{L} requirement)
- CUR = Close-up diet fed restricted (~80% of NE\textsubscript{L} requirement)

**Figure 2.** Liver triglyceride concentration as a percent of wet tissue.

- FOCA = Far-off control diet fed ad libitum (~100% of NE\textsubscript{L} requirement)
- FOEA = Far-off extra energy diet fed ad libitum (~165% of NE\textsubscript{L} requirement)
- FOER = Far-off extra energy fed restricted (~80% of NE\textsubscript{L} requirement)