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Metabolism in periparturient dairy cows fed rumen-protected choline*

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ABSTRACT

We evaluated daily supplementation with rumen-protected choline (RPC) for 45 days on the metabolism of transition dairy cows, assigning 15 cows to either control (no RPC but 1000 IU vitamin E) or treatment (50 g RPC plus 1000 IU vitamin E). On day 20 of lactation, treatment significantly increased plasma cholesterol, folate and α-tocopherol and lowered NEFA, with a tendency for increased glucose and choline phospholipids, and reduced β-hydroxybutyrate. These differences indicate improved lipid and methyl group metabolisms. Milk production tended to be increased. RPC supplementation seems useful for optimizing the metabolic profile of transition dairy cows.

KEY WORDS: dairy cows, choline, folate, α-tocopherol

INTRODUCTION

In our previous study (Pinotti et al., 2003) supplementation of 45 g/d rumen-protected choline (RPC) providing 20 g choline chloride to transition cows increased milk yield during the first month of lactation, and reduced plasma non-esterified fatty acid (NEFA) and the NEFA:cholesterol ratio around parturition. RPC also increased plasma α-tocopherol, suggesting improved vitamin E status. Although it has been reported that phosphatidylcholine hydrolysis may be important for promoting intestinal absorption of α-tocopherol in rats (Koo and Noh, 2001), our study suggested a novel choline-vitamin E interaction in dairy cows. The aims

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of the present study were to determine whether RPC supplementation influenced plasma variables including folate and α-tocopherol at 20 days in milk, as well as milk production and milk composition, in periparturient dairy cows.

MATERIAL AND METHODS

Thirty Italian Holstein multiparous cows were assigned randomly to control receiving no RPC plus 1000 IU vitamin E (Vitamin E 40% by-pass-microencapsulated, ASCOR Chimici, Forlì, Italy) or 50 g RPC (Overcholine 40% Coated, Ascor Chimici, Forlì, Italy) plus 1000 IU vitamin E. Both supplementations were added to the concentrate (Zenit Mangimi, Vaiano Cremasco, CR, Italy). Treatment started 14 days before calving and continued for 30 days after parturition. Both groups were provided with total mixed ration (TMR), once daily during prepartum and twice daily subsequently. Prepartum and lactation diets were formulated to provide respectively, net energy for lactation (NE_L) 1.45 Mcal/kg dry matter (DM), 1.70 Mcal/kg DM, CP 14.6% kg DM, 16.5% kg DM, NDF 48.93% kg DM, and 32.86% kg DM. Dry matter intake (DMI) for each group was calculated weekly as the difference between DM feed offered and feed DM refused. Milk yield and milk composition for fat, protein (Milkoscan, Foss Technology, Denmark) and SCC (Fossmatic Somatic Cell Counter, Foss Technology, Denmark) were determined on days 10, 20 and 30 in milk. Blood was sampled 1 week before expected calving, and on day 20 post-partum. The plasma was analysed for glucose (Sigma Chemical Co., St. Luis, MO), NEFA (Enzycolor), cholesterol (DCL Cholesterol-SL, Oxford, CT), β-hydroxybutyrate (Sigma Chemical Co., St. Luis, MO), folate (VetMedLab, Ludwigsburg, Germany) and α-tocopherol (VetMedLab, Ludwigsburg, Germany). Plasma phospholipids containing choline (PlCho) were determined (Takayama et al., 1977) on day 20 of lactation.

Milk yield, milk composition and blood measurements were analysed using the PROC MIXED procedure of SAS (1999). The statistical model included the fixed effects of treatment, sampling time (day relative to calving) and their interactions, random effect of cows nested within treatment, and residual error. Differences were considered significance for $P<0.05$, and indicating a tendency for $P<0.15$.

RESULTS

Mean prepartum and postpartum DMI were 9.10 vs 9.24 kg/d, and 18.57 vs 18.82 kg/d, for control and RPC animals, respectively. Based on DMI, daily intake of supplemented vitamin E was 918 and 923 IU/d, respectively, in control and RPC cows during the prepartum period, and 828 and 840 IU/d, respectively, during lactation. In the RPC group, mean choline intake was 18.49 g/d before parturition and 16.81 g/d during the first month of lactation.

RPC supplementation tended (P=0.06) to increase milk yield (25.10 kg/d in control vs 27.05 kg/d in RPC) during the first mount of lactation, while milk composition (mean of 10, 20, 30 d in milk) did not differ between groups (fat 3.38 and 3.45%, protein 3.08 and 3.13%).

Significant effects of RPC on plasma NEFA, cholesterol, folate and α-tocopherol were observed on day 20 of lactation (Table 1). Also at this time glucose (P=0.06), PlCho (127 vs 171 mg/dl (P=0.08) in control and RPC supplemented cows, respectively) tended to be higher and β-hydroxybutyrate (P=0.11) lower in the RPC group.

Table 1. Effect of rumen-protected choline on plasma metabolites in control and RPC supplemented cows.

		Prepartum (-1wk)[1]		Post-partum (20 DIM)[2]		SEM
		control	RPC	control	RPC	
Total proteins	G/l	69.0	67.1	74.8	78.2	2.90
Glucose	mmol/l	3.20	3.66	3.03	3.26	0.15
β-hydroxybutyrate	mmol/l	0.42	0.38	0.71	0.48	0.11
NEFA	mmol/l	0.60	0.54	0.70[a]	0.58[b]	0.22
Cholesterol	mmol/l	2.09	2.21	2.23[a]	2.89[b]	0.28
Folate	ng/ml	9.00	9.92	6.74[a]	9.68[b]	0.67
α-Tocopherol	µg/ml	2.66	2.86	1.68[a]	2.81[b]	0.24

[1] 1 week before calving, [2] 20 days in milk, [a,b] means in a row with different letters differ, P<0.05

DISCUSSION

We found that RPC supplementation tended to increase milk yield, as also found by other studies that gave 12-15 g/d choline (see Pinotti et al., 2002 for references). This effect may be due to increased choline availability, since choline is a limiting nutrient at lactation onset in dairy cows (Erdman and Sharma, 1991). In our previous study (Pinotti et al., 2003) which also supplemented RPC at 20 g/d, the increase in milk yield was significant, probably due to the fact that it was fed individually, to ensure complete consumption; in the present study RPC was added directly to feed.

RPC supplementation had beneficial effects on several plasma variables at the end of the transition period. Thus increased cholesterol (+30%) and reduced NEFA (-18%) and ß-hydroxybutyrate (-30%), suggest improved balance between fat retained in and metabolized by the liver (Holtenius, 1989), and hence improved lipid metabolism generally, after parturition in RPC-supplemented cows. Indeed, not only choline serves as methyl donor in the synthesis of carnitine, which is essential for fatty acid oxidation, but it is also required in the esterification of NEFA to triglycerides, and their export into VLDL. PlCho (+34%) and folate (+43%) were increased, enhancing the availability of both. The folate increase may

be due to a sparing effect of choline on methyl group metabolism. Choline is an important source of methyl groups for the biosynthesis of methylated compounds. When in short supply, methyl groups are derived from the tetrahydrofolate system. Enhanced choline availability seems therefore to spare de novo methyl group synthesis required by extra demand for methyl groups during lactation (see Pinotti et al., 2002 for references). We note also that plasma α-tocopherol was increased suggesting, as did our previous study (Pinotti et al., 2003), that choline can improve vitamin E status in the dairy cow.

CONCLUSIONS

Overall these results suggest that greater choline availability can improve milk production, and also lipid and methyl group metabolism in transition dairy cows. However, the mechanisms of these findings are not known with certainty, and further feeding experiments to assess the effects of choline on lipid and methyl group metabolism, and fat-soluble nutrient absorption are required.

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