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EFFECTS OF SUPPLEMENTAL CARNITINE ON NITROGEN BALANCE AND BLOOD METABOLITES OF GROWING BEEF STEERS FED A HIGH-PROTEIN, CORN-BASED DIET

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Summary

Seven Angus-cross steers (475 lbs initial body weight) were used in a 7 × 4 incomplete Latin square experiment to evaluate the effects of supplemental L-carnitine on nitrogen balance and blood metabolites. Steers were fed the same high-protein, corn-based diet near ad libitum intake. Treatments were control and .25, .5, 1.0, 1.5, 2.0, and 3.0 grams/day of supplemental carnitine. Experimental periods were 18 days with 13 days for adaptation and 5 days for collection of feces and urine. Blood was collected at feeding and 3 and 6 hours after feeding on day 18 of each period. Supplementing steers with carnitine increased urinary carnitine excretion and plasma carnitine concentration. Nitrogen retention (a measure of protein deposition) was not affected by carnitine supplementation and averaged 29.3 g/d. Plasma insulin and glucagon, indicative of energy status, and cholesterol and triglyceride, representative of energy storage metabolites, were not affected by carnitine supplementation. Plasma glycerol and beta-hydroxybutyrate, reflective of fat catabolism, increased with intermediate levels of supplemental carnitine. In conclusion, carnitine supplementation did not alter N balance in our experiment, but it did alter some of the plasma metabolites of steers fed high-protein, corn-based diets.

(Key Words: Growing Steers, Carnitine, Nitrogen Balance, Plasma Metabolites.)

Introduction

Newly weaned calves generally are limit-fed high-energy (corn-based) diets or fed low-energy (forage-based) diets ad libitum to restrict growth before they enter the finishing phase. These dietary regimens are implemented to increase the proportion of gain that is lean and decrease the proportion that is fat. Although this restricted growth optimizes finishing performance, it lengthens the time cattle must be fed to achieve market weight.

Carnitine is a vitamin-like compound required to metabolize fat for energy. It can either be produced by the body (de novo) or absorbed from the diet. However, negligible amounts of carnitine are found in common feedstuffs. Supplemental carnitine potentially could serve as a repartitioning agent by increasing fat utilization for energy, thereby increasing lean gain at the expense of fat deposition. This would allow growing cattle to be given ad libitum access to high-energy diets without causing excessive fat deposition, which would reduce the days required for cattle to achieve market weights. Our objectives were to evaluate the effects of supplemental L-carnitine on nitrogen balance and key blood metabolites.

Experimental Procedures

Seven Angus-cross steers (475 lbs initial body weight) were used in a 7 × 4 incomplete Latin square design with seven treatments and four periods. Experimental periods were 18 days with 13 days for adaptation and 5 days for collection of feces and urine. Steers were housed in metabolism crates and fed a high-protein, corn-based diet at 2.5% of BW daily (Table 1).

Treatments were control and .25, .5, 1.0, 1.5, 2.0, and 3.0 grams/ day of supplemental carnitine provided as Carniking® (Lonza). Blood was collected at feeding and 3 and 6

hours after feeding on day 18 of each period. Only three observations were obtained for .25 grams carnitine/ day.

Table 1. Composition of the Basal Diet[ab]

Ingredient	% of Dry Matter
Rolled corn	71.9
Alfalfa	10.0
Blood meal	4.0
Corn gluten meal	4.0
Molasses	4.0
Soybean meal	2.1
Tallow	1.6
Urea	.4
Minerals/vitamins	2.0

[a]Diet contained (dry matter basis): Ca .75%, P .35%, Mg .20%, K .70%, Na .17%, S .20%, Cl .45%, vitamin A 1.16 KIU/lb, monensin 29 g/ton, tylosin 9.7 g/ton.

[b]Added to diet (dry matter basis): Co .03 ppm, Cu 8.1 ppm, I .41 ppm, Fe 132 ppm, Mn 40 ppm, Se .23 ppm,
Zn 41 ppm.

Results and Discussion

Supplementing steers with carnitine increased (P<.01) urinary carnitine excretions (Table 2) and tended to increase (P<.07) plasma carnitine concentrations (Table 3), illustrating that at least a portion of the dietary carnitine was absorbed. Urinary carnitine excretion was increased notably when 2.0 and 3.0 grams/day of carnitine were fed.

Nitrogen retention, a measure of protein deposition, averaged 29.3 grams/day and was not affected by carnitine supplementation. This indicates that de novo and basal dietary carnitine supplies were adequate to meet the animals' requirements for maximal protein gain. Additionally, plasma urea nitrogen, reflective of protein catabolism, and alpha-amino nitrogen, reflective of circulating amino acids, were not affected by carnitine supplementation (Table 3).

Concentrations of plasma metabolites representative of energy status generally were not affected by carnitine supplementation. Insulin averaged 1.72 ng/ml; glucagon, 199.9 pg/ml; insulin-like growth factor-1, 264.3 ng/ml; cholesterol, 141.9 mg/dl; and triglycerides, 16.0 mg/dl. A significant cubic increase (P<.02) in glucose concentrations occurred, but this did not correspond to changes in insulin, which generally responds to glucose levels. Metabolites reflective of lipid metabolism increased with intermediate levels of carnitine. Plasma glycerol (P<.04) and beta-hydroxybutyrate (P<.14) increased when 1.0 to 2.0 grams/day of carnitine were fed. Plasma nonesterified fatty acids measured before feeding decreased linearly (108.7 to 92.7 μeq/L) with increasing carnitine supplementation, but they increased linearly (95.4 to 109.3 μeq/L) at 6 hours postfeeding (data not shown). This may indicate that as steers were provided more carnitine, less adipose was catabolized prefeeding, whereas more circulating lipids were metabolized postfeeding.

In conclusion, carnitine supplementation did not increase nitrogen retention but did alter some blood and plasma metabolites. Although supplementation might affect lipid metabolism, the inability of carnitine to alter hormone concentrations or protein deposition raises questions about the importance of alterations in these factors.

Table 2. Effects of Carnitine Supplementation on Nitrogen Balance and Urinary Carnitine Excretion

	Carnitine (grams/day)								Contrast (P=)[a]		
Item	0	.25	.50	1.0	1.5	2.0	3.0	SEM[b]	L	Q	C
n[c]	4	3	4	4	4	4	4				
Nitrogen											
Intake, g/day	165.4	167.3	153.7	167.9	174.3	170.2	158.0	5.5	.96	.12	.14
Feces, g/day	36.4	34.3	33.4	35.7	37.7	36.9	35.5	1.1	.32	.31	.07
Urine, g/day	96.5	108.8	94.6	99.9	103.2	102.4	96.5	5.1	.78	.47	.70
Retention, g/day	32.4	24.1	25.7	32.3	33.5	31.0	26.1	3.4	.99	.21	.22
Digestibility, %	77.9	79.5	78.4	79.0	78.4	78.1	77.6	.76	.31	.47	.49
Urine carnitine, mg/d	46	62	30	90	119	180	428	31.8	.001	.003	.66

[a]L= linear, Q= quadratic, C= cubic.

[b]For n= 4.

[c]n= number of observations per treatment.

Table 3. Effects of Carnitine Supplementation on Plasma and Blood Metabolites

	Carnitine (grams/day)								Contrast (P=)[a]		
Item	0	.25	.50	1.0	1.5	2.0	3.0	SEM[b]	L	Q	C
n[c]	4	3	4	4	4	4	4				
Plasma											
Carnitine, nmol/ml	58	54	75	65	74	82	79	9.8	.07	.46	.92
Insulin, ng/ml	1.59	1.94	1.49	1.70	1.83	1.70	1.77	.26	.75	.97	.98
Glucagon, pg/ml	195	204	184	198	192	217	209	17	.38	.86	.50
IGF-1[d], ng/ml	271	252	251	243	267	274	292	34	.42	.57	.61
Glucose, m*M*	5.06	5.21	5.28	5.22	5.26	5.06	5.34	.08	.28	.83	.02
Cholesterol, mg/dl	141	127	130	151	157	145	142	10	.31	.22	.58
Triglyceride, mg/dl	15.1	16.5	15.5	17.1	14.9	17.1	16.1	.88	.56	.56	.82
Glycerol, mg/dl	.97	.31	1.24	1.01	1.57	1.73	.48	.40	.74	.04	.19
NEFA[d], μeq/L	101.9	97.3	105.1	107.6	103.2	97.4	101.4	3.7	.76	.53	.19
Urea, m*M*	5.20	5.34	5.07	5.51	5.48	5.40	5.07	.20	.90	.12	.66
∝-amino N, m*M*	2.84	2.67	2.66	2.84	2.85	2.95	2.81	.15	.43	.63	.30
Blood											
BHBA[d], m*M*	.181	.192	.161	.196	.237	.210	.182	.023	.48	.14	.33

These values represent the means across the three sampling times (at feeding and 3 and 6 hours after feeding). Except for NEFA, no significant treatment × time interactions were observed.

[a]L= linear, Q= quadratic, C= cubic.

[b]For n= 4.

[c]n= number of observations per treatment.

[d]IGF-1= insulin-like growth factor-1; NEFA= non-esterified fatty acid; BHBA= beta-hydroxbutyrate.