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KANSAS STATE UNIVERSITY CATTLEMEN'S DAY

GreatO+ Supplementation Leads to Greater Proportions of Omega-3 Fatty Acids in the Small Intestines of Holstein Steers

R.L. Thorn and J.S. Drouillard

Abstract

Omega-3 fatty acids are essential to produce various signaling hormones and cellular structures. NBO3 technologies in Manhattan, KS, has developed an extruded blend of flaxseed and microalgae known as GreatO+, which is utilized in various livestock diets. Flaxseed and microalgae contain high levels of omega-3 fatty acids, which are essential nutrients. We hypothesized that supplementation of GreatO+ would lead to greater proportions of omega-3 fatty acids reaching the small intestines of cattle and allow greater absorption. Dry matter intake (DMI) increased for cattle supplemented with GreatO+ ($P < 0.01$), while water intake was not affected ($P = 0.89$). Cattle fed GreatO+ had a lower ruminal acetate:propionate ratio ($P = 0.02$) and tended to have higher concentrations of propionate ($P = 0.09$) and butyrate ($P = 0.08$) within the rumen compared to cattle fed the control diet. Higher amounts of fatty acids, including α-linolenic acid ($P < 0.01$), were present in the duodenum of cattle supplemented with GreatO+ compared to the control group. This allows steers supplemented with GreatO+ to absorb greater amounts of these fats.

Introduction

Omega-3 fatty acids are essential nutrients in cattle and are used as components of cellular membranes and signaling molecules involved in growth, reproduction, and immunity. Diets commonly fed to cattle in confinement often lack sufficient omega-3 fats due to the more significant usage of cereal grains, which have higher proportions of omega-6 fats. This diet creates an imbalance in the omega-6 to omega-3 fatty acid ratio which can lead to exaggerated inflammation and lower reproductive performance in cattle. Challenges with supplementation of omega-3 fats include the costs of producing omega-3 fats as well as transformation of the omega-3 fatty acids to saturated fatty acids through ruminal biohydrogenation. GreatO+ (NBO3, Manhattan, KS) is a microalgae and flaxseed extruded product containing approximately nine percent omega-3 fat and has been used to supplement essential fats in livestock diets. This study aimed to determine if supplementation of GreatO+ affected apparent ruminal and total tract flow of fatty acids, volatile fatty acid concentrations, dry matter intake (DMI), and water intake.

Experimental Procedures

This study utilized 12 ruminal and duodenal fistulated steers in a cross-over design. Each steer was blocked by weight and assigned to one of two treatments, resulting in six replications per treatment in each of the two periods. These treatments included a control diet without supplemental omega-3 fatty acids and a treatment diet consisting of GreatO$^+$ inclusion at 10% of the diet DM. Two consecutive feeding periods were utilized, which included a 15-day adaptation interval and a 4-day sampling interval. Feed was dispensed in each bunk at 10:00 a.m. each day. Titanium dioxide was used as an internal marker to calculate the apparent flow of fatty acids to the small intestines and feces. Titanium dioxide (15 g) was placed in the rumen of each steer 15 minutes before feeding, starting on day 10 of the feeding period. Feed and water intake data were collected each time the animal consumed feed or water using the Insentec Roughage Intake Control system (Hokofarm Group, Emmeloord, Netherlands). Ruminal, duodenal, and fecal contents were collected over the 4-day sampling interval, with collection times being advanced every eight hours each day to obtain digest or fecal samples every two hours during a 24-hour period. Ruminal contents were strained through four layers of cheesecloth, and ruminal fluid pH was measured. After pH was measured, a 4-mL ruminal fluid sample was collected and vortexed with 25% w/v meta-phosphoric acid before the sample was frozen. Volatile fatty acid (VFA) and long-chain fatty acid concentrations were analyzed using gas chromatography, and titanium concentrations were analyzed using light spectroscopy.

Results were analyzed using the Mixed procedure of SAS version 9.6 (SAS Inst. Inc., Cary, NC). Dry matter intake and water intake data were analyzed with DMI, and water intake was used as fixed effect with repeated measurements by day. Steer was used as the random effect. Volatile fatty acid concentrations and pH data were analyzed as fixed effects with hour as the repeated measurement and steer as the random effect. Ruminal flow and total tract flow were analyzed using the Proc Mixed procedure of SAS, with treatment and period interaction used as fixed effects and steer as the random effect. A significant effect was declared when $P \leq 0.05$ and a tendency of an effect if $0.05 < P < 0.10$.

Results and Discussion

GreatO$^+$ supplementation effects on DMI, water intake, VFA concentrations, and apparent amounts of fatty acids consumed and appearing in the duodenum and feces are presented in Figures 1 and 2, and Tables 2 and 3, respectively. Compared to cattle fed the control diet, those fed GreatO$^+$ had greater DMI ($P < 0.01$), but not water intake ($P = 0.48$). Ruminal acetate concentrations were not affected by treatment ($P = 0.19$); however, there were greater concentrations of propionate ($P = 0.03$) in ruminal fluid from cattle supplemented with GreatO$^+$ compared to animals fed the control diet. Cattle fed GreatO$^+$ had lower acetate:propionate ratios ($P < 0.01$) compared to steers fed the control diet. Greater amounts of omega-3 fatty acids were present in the duodenum of cattle fed GreatO$^+$ compared to cattle consuming the control diet. Higher amounts of omega-3 in the small intestines leads to the possibility that more omega-3 fat could be absorbed in the intestine of cattle fed GreatO$^+$ compared to cattle fed the control diet.

Implications

Cattle supplemented with GreatO+ had greater amounts of fatty acid presented to the small intestines. Increased absorption of omega-3 fat in the small intestines could lead to greater incorporation of these essential fats in tissue and milk.

Acknowledgments

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Table 1. Diet composition [% dry matter basis (DM)]

Item	Control	GreatO+
Steam-flaked corn	31.30	23.87
Alfalfa hay	15.00	15.00
Corn silage	50.00	50.00
GreatO+	-	10.00
Soybean meal, dehulled	2.57	-
Supplement[1]	1.13	1.13
Nutrient composition, calculated, %		
Crude protein, % of DM	11.51	11.51
Net energy for maintenance, Mcal/lb	0.84	0.86
Net energy for gain, Mcal/lb	0.55	0.57
Omega-3 fatty acid, % of diet	0.18	1.12
Ether extract, % of DM	2.58	4.24
Major fatty acid composition of diet, %		
C16:0	0.43	0.51
C18:0	0.07	0.14
C18:1n9c	0.56	0.89
C18:1n7c	0.02	0.03
C18:2n6c	1.21	1.42
C18:3n3	0.18	1.12
C20:5n3	0.00	0.00

[1] Supplement was formulated to provide 1,000 IU/lb of vitamin A; 10 ppm of copper; 30 ppm of zinc; 20 ppm of manganese; 0.5 ppm of iodine; 0.1 ppm of selenium; and 0.15 ppm of cobalt in the total diet DM.

Table 2. Volatile fatty acid (VFA) concentrations

	Treatment			*P*-value[2]		
Item	Control	GreatO+	SEM[1]	Treatment	Hour	Treatment × hour
VFA, mM						
Acetate	95.7	95.6	5.95	0.995	<0.01	0.19
Propionate	29.6	31.9	2.60	0.33	<0.01	0.03
Butyrate	14.4	14.0	1.62	0.76	<0.01	0.04
Total VFA	142.3	144.0	9.90	0.86	<0.01	0.12
Acetate: propionate ratio	3.4	3.0	0.20	0.10	<0.01	<0.01

[1] Standard error of the mean.
[2] $P \leq 0.05$ is considered statistically different.

Table 3. Apparent amounts of fatty acid present in the duodenum and feces

	Nutrient intake			Nutrient to duodenum			Nutrient in feces		
Item	Control	GreatO+	SEM[1]	Control	GreatO+	SEM	Control	GreatO+	SEM
Fatty acid, g									
C16:0	47.4[a]	61.6[b]	2.3	33.7[a]	47.4[b]	2.1	8.5[a]	12.9[b]	0.53
C18:0	7.7[a]	16.9[b]	0.5	108.9[a]	203.2[b]	11.4	24.3[a]	63.6[b]	3.48
C18:1n9c	61.8[a]	107.4[b]	3.6	9.3[a]	17.5[b]	1.0	2.8[a]	6.1[b]	0.32
C18:1n7c	2.2[a]	3.6[b]	0.1	1.7[a]	2.0[b]	0.1	0.3[a]	0.4[b]	0.02
C18:2n6c	133.4[a]	171.5[b]	6.4	9.3[a]	11.3[a]	0.9	3.4[a]	5.0[b]	0.41
C18:3n3	19.9[a]	135.3[b]	3.9	1.6[a]	6.3[b]	0.5	0.6[a]	3.5[b]	0.27
C20:5n3[‡]	ND	ND	ND	ND	ND	ND	ND	ND	ND

[1] Standard error of the mean.
[a,b] Values with common superscript letters within a row and nutrient site are not statistically different $P > 0.05$.
[‡] ND: Not detected.

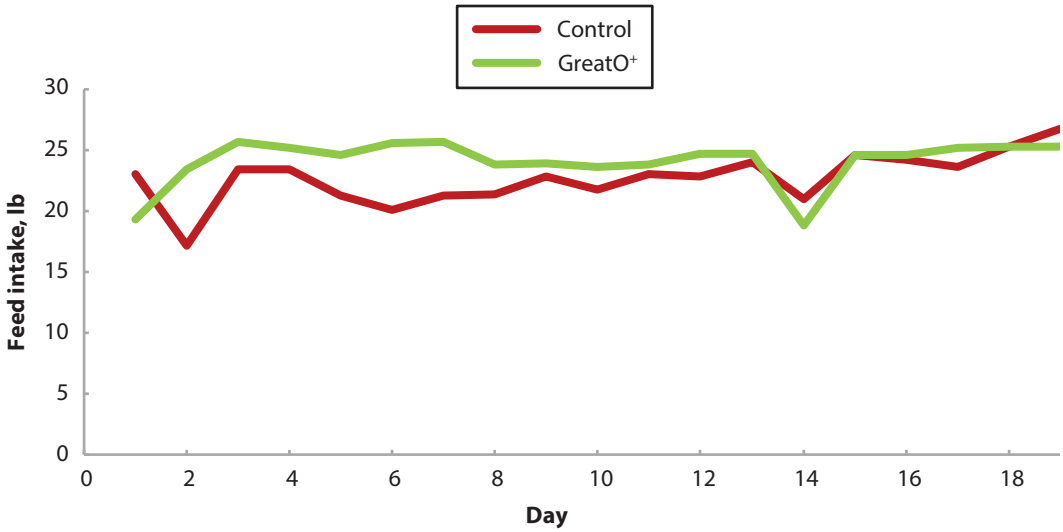

Figure 1. Dry matter intake.
Treatment P = 0.40
Day *P* < 0.01
Treatment × hour P < 0.01
Standard error of the mean = 1.68

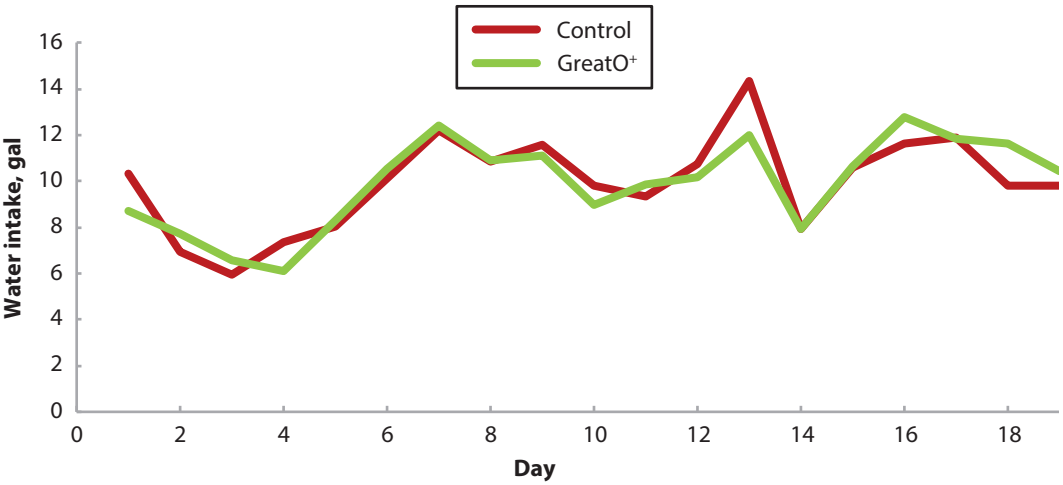

Figure 2. Water intake.
Treatment P = 0.97
Day *P* < 0.01
Treatment × hour P = 0.48
Standard error of the mean = 1.09