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Summary with Implications

Six ruminally and duodenally cannulated steers were utilized in a 3 × 3 replicated Latin square experiment to test 0, 15, and 30% dietary inclusion of Green Grass (Sunseo Omega 3; Chungcheong Duk-Do, South Korea), a feed comprised of sesame meal, giant kelp, cassava, and sorghum (not currently approved to be fed in the US). Dry matter and fiber intake increased linearly with increased Green Grass inclusion. Dry matter and organic matter digestibility were not affected by Green Grass inclusion. Concentration of saturated fatty acids at the duodenum were similar for Green Grass 0 and Green Grass 15 with a decrease for Green Grass 30; however, amount of saturated fatty acids increased with increasing Green Grass in the diet. The concentration and flow of unsaturated, mono-unsaturated, poly-unsaturated, and trans fatty acids responded quadratically with the largest increase for Green Grass 30. Omega-3 fatty acid concentration and flow increased linearly from 0 to 30% Green Grass inclusion (1.1 and 11.8 g/d, respectively). Feeding Green Grass increases unsaturated and omega-3 fatty acids flowing to the duodenum, which would be expected to impact fatty acid composition of the beef and may have human nutrition implications.

Introduction

There has been recent interest in the amount of omega-3 fatty acids in food products due to perceived health benefits (cardiovascular health, cognitive function, reduced cancer risk) in the human diet. The effects of supplementing cattle with dietary ingredients that contain large amounts of omega-3 fatty acids have been evaluated using fish oil, linseed oil, and flaxseed. Increasing the inclusion of the omega-3 fatty acids that are consumed by the animal can increase omega-3 fatty acids flowing to the duodenum. There is also evidence that increasing the amount of omega-3 fatty acids in the diet increases the amount of

Table 1. Dietary composition (DM basis) of feeding Green Grass in finishing cattle diets

	Green Grass Inclusion, %		
Ingredient, %	0	15	30
Dry rolled corn	60	45	30
Modified distillers grains plus solubles	15	15	15
Green Grass[1]	-	15	30
Corn silage	20	20	20
Supplement	5	5	5
Fine ground corn	2.38	2.88	2.88
Limestone	1.61	1.61	1.61
Tallow	0.12	0.12	0.12
Urea	0.5	-	-
Salt	0.3	0.3	0.3
Trace minerals[2]	0.05	0.05	0.05
Vitamin A-D-E[3]	0.02	0.02	0.02
Monensin[4]	0.02	0.02	0.02
Nutrient Composition, %[5]			
Organic matter	94.9	93.4	92.2
Crude protein	12.4	14.6	18.1
Neutral detergent fiber	21.6	26.5	31.4
Acid detergent fiber	11.1	13.5	15.9
Ether Extract	4.80	5.28	5.68

[1]Green Grass (Sunseo Omega 3; Chungcheong Duk-Do, South Korea) is a mixture of sesame meal, giant kelp, cassava and sorghum.
[2]Premix contained 10% Mg, 6% Zn, 4.5% Mn, 0.5% Cu, 0.3% I, and 0.05% Co.
[3]Premix contained 1,500 IU of vitamin A, 3,000 IU of vitamin D, and 3.7 IU of vitamin E per g.
[4]Supplements contained 30 g/ton monensin (Rumensin-90; Elanco Animal Health, Indianapolis, IN).
[5]Diet nutrient compositions calculated using analyzed individual ingredient nutrient profile

Table 2. Analyzed nutrient composition (% DM basis) of Green Grass[1]

Nutrient	Green Grass
Dry matter	90.8
Organic matter	90.7
Crude protein	30.9
Neutral detergent fiber	46.7
Ether extract	7.03

[1]Green Grass (Sunseo Omega 3; Chungcheong Duk-Do, South Korea) is a mixture of sesame meal, giant kelp, cassava and sorghum.

omega-3 fatty acids found in the meat and adipose tissue.

The objective of this study was to evaluate the effect of a new product, Green Grass (GG; Sunseo Omega 3; Chungcheong Duk-Do, South Korea) on nutrient digestibility in cattle finishing diets and determine fatty acid flow to the duodenum. A companion experiment feeding GG to cattle and evaluating fatty acid profile of the beef has also been completed (*2020 Nebraska Beef Cattle Report*, pp. 78–82). Cattle fed GG at 10, 20, or 30% of diet DM had poorer feed conversion than cattle not fed GG. The hypothesis for this experiment was that increasing the inclusion of GG would result in increased unsaturated fatty acid (UFA) flow and omega-3 fatty acid flow, but would decrease dry matter and organic matter digestibility.

Procedure

Six ruminally and duodenally cannulated beef steers were utilized in a 3 × 3 replicated Latin square design. Steers were assigned randomly to each dietary treatment for six, 21 d periods allowing for 16 d of adaptation and 5 d of collection. Diets consisted of increasing inclusion of Green Grass from 0 to 30% inclusion [dry matter (DM) basis] and are presented in Table 1. Nutrient composition of GG is presented in Table 2. Green Grass is not currently FDA approved to be fed to cattle entering the U.S. food chain and cattle were composted at completion of the experiment.

Cattle were fed once daily at 0700 h. Feed refusals were collected on d 16 to 20, subsampled and analyzed to determine nutrient refusals. From d 7 to 20, 5 grams of titanium dioxide were dosed twice daily (10 g/d) at 0700 and 1600 h via the rumen cannula to determine fecal output. Fecal and duodenal samples were collected at 0700, 1100, 1500, and 1900 h on d 17 to 20 of each period. Determination of fat content and fatty acid concentration was conducted on all ingredient and duodenal samples using gas chromatography. Orts were collected daily and dried for 48 h in a 60° C forced-air oven to determine DM intake (DMI). Ruminal pH was determined utilizing wireless pH probes inserted on d 15 to 21 and rumen pH was recorded every minute. Gross energy (GE) of the diets was measured using a bomb calorimeter and used to calculate digestible energy (DE) and total digestible nutrients (TDN).

Nutrient digestibility and intake data were analyzed using the MIXED procedure of SAS (SAS Inst., Inc., Cary, NC). The model included treatment and period as fixed effects with animal as a random effect. Ruminal pH data were analyzed as a repeated measure, with day repeated, using the MIXED procedure of SAS. Orthogonal contrasts were utilized to determine the effect of GG inclusion and to compare the slopes of the linear and quadratic lines for nutrient digestibility and intake data. Significance was declared at $P \leq 0.10$.

Results

Dry matter intake increased as GG inclusion increased from 0 to 30 % of diet DM (Table 3). There was no effect ($P \geq 0.31$) on DM or OM digestibility with increasing inclusion of GG. Intake, excretion, and digestibility of neutral detergent fiber (NDF) linearly ($P \leq 0.03$) increased with increasing inclusion of GG.

Gross energy and DE intake (Mcal/d) increased linearly ($P \leq 0.02$) with increased GG inclusion. Digestible energy expressed as Mcal/lb or calculated TDN value were not different ($P \geq 0.49$) between treatments and there were no linear or quadratic ($P \geq 0.24$) trends observed with increased GG inclusion. There were no differences ($P \geq 0.51$) reported for DE as a % of gross energy. This is not in alignment with the companion cattle performance experiment where cattle increased feed intake with similar daily gain as GG inclusion increased in the diet.

There was not a difference in minimum ruminal pH. A quadratic ($P < 0.02$) response for maximum rumen pH was observed with maximum pH decreasing from GG0 to GG15 then increasing from GG15 to GG30. A similar quadratic ($P < 0.03$) response was observed for average rumen pH. Time and area under either pH of 5.6 or 5.3 increased from GG0 to GG15 and then decreased from GG15 to GG30.

Fatty acid concentration and fatty acid duodenal flow data are represented in Table 4. Fat flow increased linearly ($P < 0.01$) as inclusion of GG increased from 0 to 30% of diet DM. A quadratic trend ($P \leq 0.02$) was observed for saturated fatty acid (SFA) concentration and the ratio of SFA concentration to unsaturated fatty acid (UFA) concentration with a slight decrease from GG0 to GG15 and a more dramatic decrease from GG15 to GG30. Unsaturated fatty acid, monounsaturated fatty acid (MUFA), polyunsaturated fatty acid (PUFA) and trans fatty acid concentrations responded quadratically ($P \leq 0.01$), with little difference between GG0 and GG15 and a large increase from GG15 to GG30. Omega-6 fatty acid (ω6) concentration decreased linearly ($P < 0.01$) with increased GG inclusion while the opposite was true of omega-3 fatty acid concentration (ω3). Omega-3 FA concentrations increased quadratically ($P < 0.04$) with ω3 concentration being almost 3.5 times and 8 times greater than the concentration of GG0 for GG15 and GG30, respectively.

While concentration of SFA decreased with increasing inclusion of GG, the duodenal flow of SFA on a g/d basis increased quadratically ($P < 0.07$) with a large increase from GG0 to GG15 and an increase at a decreased rate from GG15 to GG30. This is due to the increased fat flow through the duodenum in the GG diets compared to the control. Fatty acid flow on g/d basis increased quadratically ($P \leq 0.05$) for UFA, MUFA, PUFA, and trans FA, with increases from GG0 to GG15 and increasing at a greater rate from GG15 to GG30. Omega-6 FA flow was not altered by increased inclusion of GG resulting in no linear or quadratic ($P \geq 0.19$) trends between treatments. Omega-3 concentrations increased quadratically ($P < 0.03$), increasing from GG0 to GG15 and increasing at an increasing rate from GG15 to GG30.

Table 3. Effect of Green Grass inclusion on apparent total tract nutrient digestibility and rumen pH in finishing diets

Measure	GG inclusion, %[1]			SEM	*P*-Value[2]	
	0	15	30		Lin.	Quad
Dry matter						
Intake, lb/d	21.1	22.7	23.1	0.59	0.04	0.40
Digestibility, %	74.1	74.4	72.8	0.90	0.31	0.39
Organic matter						
Intake, lb/d	20.2	21.1	21.3	0.55	0.16	0.46
Digestibility, %	76.0	76.1	74.9	0.91	0.39	0.53
Neutral detergent fiber						
Intake, lb/d	4.4	5.9	7.0	0.24	< 0.01	0.28
Digestibility, %	50.9	55.9	56.6	2.84	0.03	0.31
Energy						
Digestible energy, Mcal/lb	1.35	1.39	1.43	0.045	0.24	0.93
Digestible energy, % of Gross Energy	73.1	72.1	73.0	1.21	0.97	0.51
TDN[3]	67.3	69.6	71.3	2.30	0.34	0.93
Rumen pH						
Minimum pH	5.25	5.14	5.15	0.050	0.16	0.31
Maximum pH	6.60	6.53	6.72	0.072	0.04	0.02
Average pH	5.89	5.74	5.85	0.069	0.55	0.03
Time < 5.6, min/d	369	595	489	85	0.19	0.03
Area < 5.6	69	156	109	28	0.27	0.03
Time < 5.3, min/d	86	256	156	50	0.31	0.03
Area < 5.3	8	45	18	12	0.55	0.04

[abc] Means within a row with different superscripts differ ($P < 0.10$).

[1]GG = Green Grass; Treatments were 0, 15, and 30% inclusion of Green Grass in the diet.

[2]F-test = *P*-value for treatment differences. Lin and Quad = *P*-Value for orthogonal contrasts determining linear or quadratic trends.

[3]Total digestible nutrients (TDN) values calculated from digestible energy (DE) of the diet; TDN, % = DE intake, Mcal/kg ÷ 4.4.

Conclusion

Feeding GG up to 30% of diet DM resulted in increased intakes with no change in digestibility. The amount of fat reaching the duodenum was increased with increased GG inclusion along with the amount of SFA, UFA, MUFA, PUFA, Trans FA, and ω3. Increased duodenal flow of desirable fatty acids suggests GG could be a viable feed option in finishing diets. Due to the correlation between FA absorption and FA abundance in the meat profile, increasing GG inclusion in the diet is expected to result in greater ω3 concentrations in beef.

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Table 4. Fatty acid concentration and abundance in cattle finishing diets with increasing inclusion of Green Grass

	Green Grass inclusion, %[1]				*P*—Values[2]	
Measure	0	15	30	SEM	Lin.	Quad
Duodenal Fat Flow, g/d[3]	443	563	629	24.8	< 0.01	0.31
Fatty Acid (FA) Concentration, % of total fat						
Saturated FA	79.03	78.18	70.23	0.94	< 0.01	< 0.01
Unsaturated FA	20.55	21.32	29.14	0.96	< 0.01	< 0.01
SFA:UFA	4.00	3.76	2.47	0.18	< 0.01	0.02
Monounsaturated FA	12.52	13.68	18.93	0.65	< 0.01	0.01
Polyunsaturated FA	8.03	7.62	10.15	0.52	< 0.01	0.01
Trans FA	4.85	5.08	8.99	0.52	< 0.01	< 0.01
Omega-6	1.10	0.91	0.71	0.09	< 0.01	0.96
Omega-3	0.24	0.86	1.89	0.09	< 0.01	0.04
Fatty Acid Flow, g/d[4]						
Saturated FA	351	440	442	20.9	< 0.01	0.07
Unsaturated FA	91	120	184	7.1	< 0.01	0.03
Monounsaturated FA	55	77	120	4.5	< 0.01	0.05
Polyunsaturated FA	36	43	64	3.7	< 0.01	0.05
Trans FA	21	30	57	3.5	< 0.01	0.04
Omega-6	5.0	5.0	4.3	0.54	0.19	0.38
Omega-3	1.1	5.0	11.8	0.71	< 0.01	0.03

[abc] Means within a row with different superscripts differ ($P < 0.10$)

[1]GG = Green Grass; Treatments were 0, 15, and 30% inclusion of Green Grass in the diet.

[2]F-test = *P*-value for treatment differences. Lin and Quad = *P*-Value for orthogonal contrasts determining linear or quadratic trends

[3]Duodeanl fat flow measured as ether extract g/d

[4]Fatty acid flow = duodenal fat flow, g/d × fatty acid concentration, %