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Effects of Increased Inclusion of Algae Meal on Finishing Steer Performance and Carcass Characteristics

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Summary and Implications

Algae meal is a novel feedstuff comprised of partially deoiled microalgae (43% DM basis) and soyhulls (57% DM basis). It appears algae meal may have a lesser energy value than corn. However, algae meal is readily consumed by steers and has minimal effects on carcass performance. This suggests that algae meal could potentially serve as a replacement for corn and a valuable component of feedlot diets.

Introduction

Recently, a novel feedstuff has become available from the large-scale commercial production of heterotrophic microalgae utilized for bioenergy and oil. Heterotrophic microalgae, grown in dark fermenters, results in an algae meal (ALG) which may offer a more consistent nutrient profile than other sources of naturally produced marine algae. The ruminant diet can directly influence subsequent carcass characteristics. Improving the quality and consistency of beef carcasses can provide positive economic implications and ultimately impact consumer demand. The ruminant animal, with their unique ability to convert what may otherwise be waste products into nutritious animal protein via fermentation, is an ideal target for consumption of this novel feedstuff. Feedlot cattle represent a ready market for large quantities of ALG. Algae meal may serve as a potential substitute for corn, which is the basis for many feedlot diets worldwide; consequently contributing to global nutritional security for both humans and animals. Therefore, the objective of this study was to determine the impact of replacing corn with increasing inclusions of ALG on steer performance, carcass characteristics, and steak fatty acid composition.

Materials and Methods

Experimental design. One hundred and sixty eight steers (952 ± 51.3 lbs) were blocked by weight into pens and randomly assigned to 1 of 4 dietary treatments (Table 1): a corn-based control (CON), 14% ALG (ALG14), 28% ALG (ALG28), and 42% ALG (ALG42). Steers were implanted on day -20 with Component TE-IS with Tylan and on day 56 with Component TE-S with Tylan (Elanco Animal Health, Greenfield, IN). Steers were weighed every 28 days and consecutive body weights were taken at the beginning (day -1 and 0) and the end (day 101 and 102) of the trial.

Sample collection and analysis. Samples of total mixed rations were taken weekly to determine DMI. Dietary energy values were calculated based on the shrunk live body weights and mean pen performance. Steers were harvested on d 102 when greater than 60% of the steers were visually appraised to have at least 0.5 inches of backfat. Following slaughter and a 24 hour chill carcasses were ribbed between the 12th and 13th rib and graded according to USDA standards. Additionally, a rib facing at the 12th rib was removed from the right side of each carcass for fatty acid analysis

Statistical Analysis. Data were analyzed using the MIXED procedure of SAS (SAS Institute, Inc., Cary, NC). Pen served as the experimental unit for all analysis (n = 7/treatment) and date was the repeated effect. Three single degree of freedom contrast statements were designed prior to the analysis of data: 1) CON vs ALG, 2) linear effect of ALG, and 3) quadratic effect of ALG.

Results

Steer dry matter intake, carcass adjusted performance, energy values, and carcass characteristics are presented in Table 2. Dry matter intake linearly increased as ALG increased in the diet ($P < 0.01$). However, there was no difference in final body weight or ADG ($P \geq 0.20$). Feed to Gain linearly increased as ALG increased in the diet ($P < 0.01$). Energy values were greater for the CON diet compared to the ALG diets ($P <0.01$) and linearly increased as ALG increased in the diet ($P < 0.01$). Hot carcass weight, REA, marbling score, and quality grade were not affected ($P \geq 0.14$) by ALG inclusion. There was a tendency for a linear decrease ($P = 0.10$) in dressing percent. There was also a tendency for a linear decrease ($P = 0.08$) in 12th rib back fat. Percentage of KPH fat was greater ($P < 0.02$) for control than ALG steers and linearly decreased ($P < 0.02$) as ALG increased in the diet. Yield grade also linearly decreased ($P < 0.02$) as ALG inclusion increased in the diet.

The steak fatty acid percentages are presented in Table 3. The concentration of saturated fatty acids (SFA), monounsaturated fatty acids (MUFA), polyunsaturated fatty acids (PUFA), and the ratio of PUFA-to-SFA was not different ($P \geq 0.13$) between CON and ALG-fed cattle. There was a tendency for omega 3 fatty acids to be lesser ($P = 0.06$) for ALG- fed steers than CON-fed steers. There was no difference ($P = 0.57$) between CON and ALG-fed cattle on omega 6 fatty acids. The addition of ALG to the diet led to a tendency for a quadratic effect ($P = 0.10$) on the ratio of omega 6-to-omega 3 fatty acids. Control cattle had a greater

($P = 0.02$) atherogenic index (AI) than ALG-fed cattle and adding ALG to the diet favorably decreased ($P = 0.005$) the AI in a linear fashion.

Discussion

Overall ALG did not affect final BW, ADG, or HCW which allows us to conclude that ALG can replace corn without affecting steers ability to gain body weight. However, those steers fed ALG had increased DMI across the entire trial. While this proves that palatability is not a challenge with this feedstuff, steers fed ALG ultimately had to consume more to gain the same as their corn fed counterparts. This was most notable in the 42% ALG diet, suggesting that this rate of corn replacement is likely too great for feedlot diets. Ultimately this was further supported by the decrease calculated in both ME and NEg as ALG replaced corn. However, increasing inclusion of ALG at up to 42% of the diet did not impact ribeye area, marbling scores or quality grade of the cattle, which is important to producers choosing to sell cattle on a value base grid that rewards better marbling scores and discounts cattle with poorer quality grades. Interestingly, both backfat and yield grade were decreased in the 42% ALG cattle, meaning these steers were able to achieve better marbling scores while having a lesser amount of undesirable backfat. The lower the yield grade the greater the premium for cattle producers, as a high yield grade is indicative of less lean meat yield and more fat. Overall it appears that feeding ALG will have limited impacts on carcass characteristics when compared to corn-fed cattle.

Due to the controlled growing environment of microalgae for specialized oil production, ALG offers a unique fatty acid profile. However, various properties such as degree of saturation and the physical association of fat with feed particles and microbes can alter microbial effects in the rumen. Altering the absorption of select fatty acids via the regulation of microbial biohydrogenation may positively alter or decrease the saturation of fatty acids in meat. Concentrations of SFA, MUFA, PUFA, and the ratio of PUFA-to-SFA from steaks were similar between traditional corn-fed steers and the ALG-fed steers suggesting that ruminal fat availability for digestion and saturation by microbes is similar between corn and ALG. It is important to note that the ALG used in this study is not a marine algae and thus does not offer increased concentrations of omega 3 fatty acids. In fact, in the present study concentrations of omega 3 found in the steaks was actually lesser in ALG fed steers than the concentrations from their traditional corn-fed counterparts. Despite the fact that ALG-fed steers tend to have lesser concentrations of omega 3 fatty acids in steaks, these samples may still offer some health benefits. In the present study cattle fed ALG had a lesser AI and this index decreased as more ALG was added to the diet. The AI is a significant marker for the potential risk of atherosclerosis. Atherosclerosis is a form of chronic inflammation that results when lipoproteins interact with macrophages, T cells, and the arterial wall and in Western societies is the most common cause of death. This suggests that ALG may offer producers a viable way to improve the health benefits of meat by altering the fatty acid profile.

In conclusion, the results of this study suggest that ALG can serve as a replacement for corn in feedlot diets with minimal effect on live and carcass based performance. However, because DMI is clearly increased by ALG, feed efficiency is decreased suggesting that ALG may have a lesser feeding value than that of corn. Interestingly, the 14% ALG treatment was not largely different from the CON-fed cattle thus more work is needed to refine the optimal inclusion level for ALG in feedlot diets. Still, its unique combination of protein, fiber, and fat allows this to be a viable feedstuff in feedlot diets. Algae meal may also offer the unique opportunity for producers to alter the fatty acid profile of meat, thus offering a product with increased health benefits. Additional research will be required to determine how this feedstuff will best be utilized by the livestock industry, including synergies with other feedstuffs and commonly utilized technologies, and supplementation of high forage diets.

Table 1. Ingredient composition of finishing steer diets (% DM basis).

		Algae meal		
	Control	14%	28%	42%
Ingredient				
Dry-rolled corn	59.5	45.5	31.5	17.5
MDGS[1]	25.5	25.5	25.5	25.5
Hay	10	10	10	10
Algae meal[2]	-	14	28	42
Soyhulls	-	-	-	-
DDGS[3]	2.96	2.96	2.96	2.96
Limestone	1.58	1.58	1.58	1.58
Salt	0.31	0.31	0.31	0.31
Rumensin[4]	0.014	0.014	0.014	0.014
Vitamin A premix[5]	0.11	0.11	0.11	0.11
Trace mineral premix[6]	0.024	0.024	0.024	0.024
Calculated composition[7]				
Crude protein	13.0	13.2	13.5	13.7
NDF	19.7	24.4	29.2	33.9
Ether extract	4.8	5.6	6.4	7.2
Analyzed composition[8]				
Cu, ppm	7.4	6.5	7.7	5.2
Fe, ppm	100.7	163.4	208.4	256.2
Mn, ppm	27.3	35.2	40.4	42.8
Zn, ppm	54.3	62.7	62.1	64.8
S, %	0.26	0.31	0.33	0.38

[1] Modified corn distillers grains with solubles, analyzed to contain 6.72% fat and 0.84% S.

[2] Contains 43% partially deoiled microalgae and 57% soyhulls.

[3] Dried distillers grains with solubles; carrier for micro-ingredients.

[4] Provided 200 mg monensin$\cdot$steer$^{-1}\cdot$d^{-1} (Elanco Animal Health, Greenfield, IN).

[5] Contained 4,400,000 IU/kg Vitamin A premix.

[6] 10 ppm of Cu (copper sulfate), 30 ppm of Zn (zinc sulfate), 20 ppm of Mn (manganese sulfate), 0.5 ppm of I (calcium iodate), 0.1 ppm of Se (sodium selenite), and 0.1 ppm of Co (cobalt carbonate).

[7] Based on ingredient analysis from Dairyland, Inc., Arcadia, WI.

[8] Monthly composites for each treatment were analyzed at Iowa State University, Ames.

Table 2. Effect of increased inclusions of algae meal on BW, gain, efficiency, and carcass characteristics of finishing steers.

		Algae meal				*P*-value		
	Control	14%	28%	42%	SEM	Control vs Algae	Linear	Quadratic
Carcass adjusted performance[1]								
Final BW, lbs	1360	1357	1357	1348	7.3	0.50	0.30	0.70
ADG, lbs/d	4.00	3.96	3.96	3.83	0.080	0.41	0.20	0.60
DMI, lbs/d	27.9	29.6	30.5	31.7	0.32	<0.001	<0.001	0.39
F:G	7.00	7.43	7.82	8.27	0.147	<0.001	<0.001	0.91
Dietary energy values[2]								
ME, Mcal/lb	0.92	0.86	0.85	0.82	0.011	<0.001	<0.001	0.29
NEg, Mcal/lb	0.62	0.57	0.56	0.54	0.010	<0.001	<0.001	0.30
Carcass characteristic								
HCW, lbs	873	871	871	866	4.7	0.50	0.30	0.70
Dressing percent	64.3	64.4	64.2	63.9	0.19	0.45	0.10	0.32
12th-rib back fat, in	0.61	0.59	0.61	0.54	0.021	0.29	0.08	0.24
KPH, %	2.60	2.49	2.50	2.42	0.043	0.02	0.02	0.81
Ribeye area, in^2	13.5	13.4	13.5	13.5	0.17	0.79	0.94	0.65
Yield grade	3.25	3.19	3.19	2.88	0.100	0.17	0.02	0.23
Marbling score[3]	448	460	469	451	10.3	0.32	0.70	0.17
Quality grade[4]	2.95	3.07	3.17	2.95	0.108	0.38	0.85	0.14

[1] Carcass adjusted performance values are based on final BW calculated from HCW divided by the average dressing percent of 64%; a 4% shrink was applied to initial live weights.

[2] Energy values calculated based on cattle performance.

[3] Marbling scores: slight: 300, small: 400, modest: 500.

[4] Quality grade: 2: Select^{+}, 3: Choice^{-}, 4: Choice.

Table 3. Effect of algae meal on fatty acid percentages and ratios of the steaks collected from steers after 102 d on diets.

		Algae meal				*P*-value		
Fatty acid composition	Control	14%	28%	42%	SEM	Control vs Algae	Linear	Quadratic
SFA, %[1]	44.22	42.72	43.74	42.00	0.759	0.13	0.11	0.88
MUFA, %[2]	43.64	43.78	44.73	44.82	1.072	0.52	0.36	0.98
PUFA, %[3]	7.77	7.87	7.23	8.20	0.758	1.00	0.85	0.57
PUFA:SFA	0.18	0.19	0.17	0.20	0.022	0.75	0.62	0.62
n3, %[4]	1.15	0.55	0.63	0.74	0.223	0.06	0.27	0.13
n6, %[5]	6.28	6.99	6.24	7.15	0.762	0.57	0.59	0.89
n6:n3	15.31	25.97	17.09	15.01	3.615	0.35	0.55	0.10
AI[6]	0.71	0.66	0.66	0.61	0.021	0.02	0.005	0.92
Other, %[7]	4.42	5.59	4.30	4.98	0.713	0.52	0.91	0.73
Lipid, %[8]	4.13	4.54	4.51	3.95	0.588	0.77	0.83	0.42

[1] Saturated fatty acid calculation, sum of C10:0, C12:0, C13:0, C14:0, C15:0, C16:0, C17:0, C18:0, C20:0, C22:0, C23:0, C24:0.

[2] Monounsaturated fatty acid calculation, sum of: C14:1n5, C16:1n7, C17:1n9, C18:1t6 & t9, C18:1t10, C18:1t11, C18:1t12, C18:1t15, C18:1c9, C18:1c11, C18:1c12, C18:1c13, C20:1n11.

[3] Polyunsaturated fatty acid calculation, sum of: C18:2n6, C18:3n3, C18:3n6, C20:2n6, C20:3n6, C20:3n3, C20:4n6, C20:5n3, C22:5n3, C22:6n3, c9–t11 CLA.

[4] Omega 3 fatty acid calculation, sum of: C18:3n3, C20:3n3, C20:5n3, C22:5n3, and C22:6n3.

[5] Omega 6 fatty acid calculation, sum of: C18:2n6, C18:3n6, C20:2n6, C20:3n6, and C20:4n6.

[6] Atherogenic index is calculated: ((C12:0 + (4 ∗ C14:0) + C16:0)/(% MUFA + % PUFA)).

[7] Indicates the percent of unidentified peaks.

[8] Percent lipid of steaks based on fatty acid extraction.