Effect of Feeding CARS on Digestibility and Fatty Acid Flow in Finishing Cattle Diets

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Summary with Implications

An experiment was conducted to evaluate the impact of a liquid feed, Condensed Algal Residue Solubles (CARS) on diet digestibility and fatty acid flow to the small intestine. Three treatments included CARS at 0, 2.5, and 5% of the diet dry matter, replacing steam-flaked corn. The base diet included 73, 70.5, or 68% steam flaked corn, 15% dried distillers grains plus solubles, 8% alfalfa haylage, and 4% supplement. Inclusion of CARS in the diet did not affect dry matter or organic matter intake or digestibility of dry matter, organic matter or neutral detergent fiber. Amount of fatty acid flowing to the duodenum was not affected by treatment; however, the fatty acid profile changed, with a lesser portion of saturated fatty acids and a greater portion of unsaturated and poly-unsaturated fatty acids available for post rumen absorption as CARS increased in the diet. Concentration of both omega-3 and omega-6 fatty acids at the duodenum increased linearly. The CARS product can be included up to 5% of finishing diets without affecting diet digestibility which complements the performance data from a companion experiment. It also increased unsaturated fatty acid flow to the small intestine, which might alter concentration of these fatty acids in the beef.

Introduction

With improved methods of cultivating and harvesting algae for omega-3 supplementation in aquaculture and pet diets, the residue known as Condensed Algal Residue Solubles (CARS; Veramaris, The Netherlands; Table 1) has also become available as a byproduct feed for cattle (Blair, NE). The CARS product contains de-oiled algae cells plus biomass residual fermentation substrates and has expert-affirmed generally recognized as safe (GRAS) status. The CARS feed has relatively high levels of protein as well as omega-3 fatty acids. Docosahexaenoic acid (DHA) is an omega-3 fatty acid important in human nutrition and is commonly supplemented in human diets with fish or algae products. Feeding CARS to cattle may increase the omega-3 fatty acid content of beef. Previous research has shown a 4.3% improvement in feed:gain with 2.5% CARS inclusion in finishing cattle diets (*2021 Nebraska Beef Cattle Report*, pp. 56–58). Thus, the objective of this study was to evaluate diet digestibility and fatty acid flow at the duodenum of cattle fed increasing amounts of CARS.

Table 1. Nutrient composition of Condensed Algal Residue Solubles (CARS) as an ingredient in cattle finishing diets[1]

Dry Matter (DM), %	22.7
	Dry Basis
Organic Matter	63.0
Crude Protein	21.7
Neutral Detergent Fiber	1.59
Fat[2]	6.10
Calcium	0.44
Phosphorus	0.53
Potassium	0.80
Sulfur	3.05
Sodium	9.96

[1]Nutrient composition of CARS analyzed by Ward Laboratories, Inc. (Kearney, NE) with DM, OM, CP, and NDF analyzed at the University of Nebraska–Lincoln (Lincoln, NE).

[2]Total fat was analyzed using an acid hydrolysis method.

Procedure

This study utilized 6 ruminally and duodenally cannulated steers in a 3 × 3 replicated Latin Square design. Treatments differed by increasing inclusion of CARS at 0, 2.5, and 5% of diet DM (0%, 2.5%, 5%), replacing steam flaked corn. All diets contained 15% dry distillers grains, 8% alfalfa haylage, and 4% supplement. Supplement contained Rumensin-90 (fed to target 30 g/ton of diet DM), Tylan-40 (fed to target 90 mg/hd/d), along with trace minerals, vitamins A-D-E, tallow, limestone, salt (not included in the 5% CARS diet) and urea to meet rumen degradable protein requirements with fine ground corn as a carrier.

The steers were fed *ad libitum*, with feed delivered once each day in the morning. Periods lasted 21 d, with 16 d for adaption and 5 d of collections. Rumen pH probes were placed directly into the rumen on d 14. Orts were collected on days 16 to 21 and feed ingredient samples were collected on day 18. Steers were dosed twice daily with 5 g of titanium dioxide (TiO_2) for a total of 10 g/d on days 7 to 20. Duodenal and fecal grab samples were collected four times/d on days 17 to 20 and composited into 4 samples (1 per day) per period. Whole rumen samples were collected on day 21 to correct for microbial contamination in the duodenal samples, and pH probes were removed. Feed, fecal, orts and duodenal samples were freeze dried, ground through a 1-mm screen, composited and analyzed for dry matter (DM), organic matter (OM), and neutral detergent fiber (NDF). Fecal and duodenal samples were also ground again through a ½ mm screen to measure TiO_2 concentration to determine both fecal output and diet digestibility. Total fat and fatty acid profile analysis was conducted on both the feed ingredient and duodenal samples. The data were analyzed using the MIXED procedure in SAS (SAS Inst., Cary,

Table 2. Fatty acid profile of diets including Condensed Algal Residue Solubles (CARS)

	Treatment Diets[1]		
	0%	2.5%	5%
Total Fat, % of diet DM	3.38	3.46	3.54
Fatty Acid, % of Fat			
Saturated FA	18.7	19.0	19.4
Unsaturated FA	81.0	80.6	80.1
Mono-unsaturated FA	26.3	25.6	24.9
Poly-unsaturated FA	54.7	54.9	55.2
Omega-3	4.15	5.73	7.30
Omega-6	0.003	0.007	0.011
C16:0	0.358	0.361	0.354
C18:0	0.240	0.241	0.232
C18:1T	24.7	24.1	23.4
C18:1 Oleic	0.488	0.473	0.467
C18:1 Vaccenic	50.3	48.9	47.5
C18:2 Linoleic	3.96	3.93	3.89
C18:3ω3 α-Linolenic	0.427	0.427	0.427
C20:5ω3 (EPA)	0.153	1.38	2.59
C22:6ω3 (DHA)	14.8	15.0	15.3

[1]Treatments varied in CARS inclusion, 0%, 2.5%, and 5% of the diet DM replacing steam flaked corn.

NC) with CARS inclusion and period as fixed effects and animal as a random effect. Orthogonal contrasts were used to test linear and quadratic effects of CARS inclusion.

Results

Total fatty acid content of the diets numerically increased with the addition of CARS (Table 2), with omega-3 fatty acids increasing from 0.13 to 0.33% of diet DM for 0% and 5% diets, respectively. Intake of both DM and OM were not affected by CARS inclusion ($P \geq 0.17$; Table 3), though there was a linear decrease ($P = 0.07$) in NDF intake as CARS was included in the diet. Inclusion of CARS had no effect on total tract DM, OM, or NDF digestibility ($P \geq 0.52$). Gross energy (GE), DM intake, and digestible energy (DE) intake were not different ($P \geq 0.32$). Apparent ruminal DM, OM and NDF digestibility were not affected by treatment ($P \geq 0.20$). True ruminal DM and OM digestibility were not affected by treatment ($P \geq 0.38$).

Total fatty acid flow at the duodenum was unaffected ($P = 0.18$; Table 4) as CARS increased in the diet, though the fatty acid profile was impacted, with a linear decrease ($P = 0.06$) in saturated fatty acids (SFA), correlated with a linear increase ($P \leq 0.07$) in unsaturated (UFA), mono-unsaturated (MUFA), and poly-unsaturated fatty acids (PUFA) as CARS increased in the diet. There was a linear increase ($P < 0.01$) of C16:0, C18:0, C18:1T, and C18:1 Vaccenic acid in the fatty acid flow to the small intestine. There was also a quadratic response for C18:3ω3 α-Linolenic acid concentrations ($P = 0.01$) with CARS included at 2.5% having the greatest g/d flow of α-Linolenic acid, increasing from 1.54 g/d with 0% CARS to 2.07 g/d with 2.5% CARS, and decreasing to 1.87 g/d flow to the small intestine for the 5% CARS treatment.

Both omega-3 and omega-6 fatty acid content of total flow to the small intestine increased linearly ($P \leq 0.02$) as CARS increased in the diet, with 5% having the greatest omega-3 and omega-6 content and 0% having the least omega-3 and omega-6 fatty acids. The DHA content of fat available for post rumen absorption was significantly different ($P < 0.01$) with 5% CARS treatment having the greatest DHA content at 7.75 g/d flow to the small intestine compared to 2.5% CARS having 5.12 g/d and 0% CARS having the least at 4.57 g/d. Concentrations of these fatty acids deposited in the beef were not measured but are expected to be similar to flow at the duodenum.

Average ruminal pH linearly increased from 5.76 to 6.06 ($P < 0.01$) as CARS was included in the diet. There was a linear decrease ($P \leq 0.01$) in both time (661 to 324 min/d) and area under pH 5.6 (156 to 68.9) as CARS was included.

Conclusion

Replacing up to 5% steam-flaked corn with CARS did not impact DM and OM intake, or DM, OM, and NDF total tract digestibility. With a small numerical increase in fatty acid content of the diet and small numerical decrease in DMI, there was no effect on total fatty acid flow to the small intestine. However, concentration of PUFA, including omega-3 in the duodenal flow, increased with CARS inclusion in the diet. Both metabolism and performance data demonstrate that CARS can be effectively included in feedlot finishing diets up to 5% of the diet DM and inclusion will be primarily dictated by availability and price of CARS.

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Table 3. Effect of CARS inclusion on diet digestibility

	Treatment[1]				P-Value[2]	
Item	0%	2.5%	5%	SEM	Linear	Quadratic
DM						
Intake, lb/d	17.4	17.2	16.3	0.69	0.27	0.67
Apparent Rumen digestibility, %	26.2	22.2	25.6	2.18	0.86	0.20
True Rumen digestibility, %	53.6	51.8	55.1	2.405	0.66	0.38
Total Tract digestibility, %	81.2	81.3	82.2	1.45	0.58	0.80
OM						
Intake, lb/d	16.6	16.3	15.3	0.65	0.17	0.67
Apparent Rumen digestibility, %	34.3	31.4	33.3	2.318	0.77	0.42
True Rumen digestibility, %	62.3	61.2	64.1	2.51	0.62	0.53
Total Tract digestibility, %	83.6	83.7	84.3	1.349	0.68	0.87
NDF						
Intake, lb/d	2.80	2.69	2.49	0.108	0.07	0.75
Apparent Rumen digestibility, %	14.2	14.7	13.3	4.98	0.87	0.85
Total Tract digestibility, %	53.4	51.1	54.4	4.885	0.83	0.52
Energy						
Gross Energy Intake, Mcal/d	31.1	30.9	29.4	1.25	0.32	0.66
Digestible Energy Intake, Mcal/d	24.9	25.0	24.3	1.34	0.71	0.78
Digestible Energy, Mcal/lb of DM	1.42	1.50	1.49	0.029	0.15	0.94

[1]Treatments varied in CARS inclusion, 0%, 2.5%, and 5% of the diet DM replacing steam flaked corn; CARS = condensed algae residue solubles.

[2] Linear and quadratic orthogonal contrasts are shown for CARS inclusion.

[abc] Means in a row with different superscripts differ ($P < 0.05$).

Table 4 Effect of CARS inclusion on fatty acid profile of duodenal flow

	Treatment[1]				*P*-Value[2]	
Fatty Acid, g/d[3]	0%	2.5%	5%	SEM	Linear	Quadratic
Total Duodenal Fat Flow	438.4	493.2	458.2	25.817	0.60	0.18
Saturated FA	315 [ab]	332 [a]	238 [b]	25.449	0.06	0.10
Unsaturated FA	123 [b]	158 [b]	212 [a]	11.469	< 0.01	0.52
Mono-unsaturated FA	73.6 [c]	107.0 [b]	154.2 [a]	10.375	< 0.01	0.60
Poly-unsaturated FA	49.2 [b]	51.2 [ab]	58.0 [a]	3.095	0.07	0.54
Omega-3	11.0 [b]	12.1[b]	15.4[a]	4.22	< 0.01	0.09
Omega-6	3.92 [b]	4.02 [b]	4.59 [a]	1.32	0.02	0.28
C16:0	63.6[c]	93.7[b]	111.2[a]	5.49	< 0.01	0.36
C18:0	236.9[a]	218.5[a]	108.1[b]	23.16	< 0.01	0.13
C18:1T	31.5[c]	59.5[b]	108.5[a]	9.66	< 0.01	0.39
C18:1 Oleic	34.8	37.0	33.1	2.05	0.59	0.24
C18:1 Vaccenic	4.26[b]	5.92[a]	7.36[a]	0.60	< 0.01	0.88
C18:2 Linoleic	40.5	40.3	39.3	2.72	0.77	0.90
C18:3ω3 α-Linolenic	1.54[b]	2.07[a]	1.87[a]	0.101	0.04	0.01
C22:6ω3 (DHA)	4.57[a]	5.12[a]	7.75[b]	3.99	< 0.01	0.19

[1]Treatments varied in CARS inclusion, 0%, 2.5%, and 5% of the diet DM replacing steam flaked corn; CARS = condensed algae residue solubles.

[2] Linear and quadratic orthogonal contrasts are shown for CARS inclusion.

[3] Fatty acids reported as g/d of fat flowing to the duodenum.

[abc] Means in a row with different superscripts differ ($P < 0.05$).