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Summary

A metabolism trial was conducted to evaluate the effects of dietary fat source on the metabolism characteristics of feedlot steers fed 8.5% fat (7% fatty acids) diets. Steers fed condensed corn distillers solubles (CCDS) had lower average pH and greater DM digestibility than those fed corn oil, tallow, or WDGS. Steers fed CCDS also had greater fat and fatty acid digestibility than corn and corn oil fed steers and greater NDF digestibility than corn oil or tallow fed steers. Although CCDS fat is similar to corn oil, the two feeds are digested differently. The omasal fatty acid profile of steers fed WDGS is less saturated than cattle fed corn diets with or without corn oil, CCDS, or beef tallow. In addition, the efficiency of fat and fatty acid absorption was not decreased with high fat feedlot diets.

Introduction

Previous research (*2008 Nebraska Beef Report*, pp. 35-36) indicates part of the increased feeding value of WDGS is due to fat content of the feed. The fatty acid composition of the WDGS fat may influence individual fatty acid digestibility in the small intestine, a potential mechanism of increased feeding value of WDGS (*2007 Nebraska Beef Report*, pp. 39-42).

Rumen microorganisms have the ability to biohydrogenate fatty acids prior to intestinal absorption. Research has shown that when added directly to the diet, WDGS fat is less susceptible to rumen biohydrogenation than fat in dry rolled corn or corn oil (*2007 Nebraska Beef Report*, pp. 39-42). UNL research also has shown increases in the amount of polyunsaturated fatty acids in carcass fat in steers fed WDGS compared to steers fed a corn control diet (*2009 Nebraska Beef Report*, pp. 107-109). It is unknown if there are differences in rumen biohydrogenation protection, digestion, and absorption of the fat in distillers solubles compared to wet distillers grains that comprise WDGS when fed to finishing steers.

The current study was conducted to determine the effect of dietary fat source on metabolism characteristics of steers fed feedlot finishing diets.

Procedure

Five ruminally cannulated steers were used in a completely randomized, five-period Latin square designed study. Each steer was assigned randomly to one of five balanced treatment sequences. Treatments were five diets with different dietary fat sources (Table 1). The CORN diet contained no added fat. The OIL and TAL diets contained 4.8% of diet DM as corn oil or beef tallow, respectively. The CCDS diet contained added fat in the form of condensed corn distillers solubles (CCDS). The WDGS diet contained added fat from WDGS. The four diets with added fat were formulated to be isofat with total diet fat at 8.5% of diet DM. Post-trial analysis indicated the four diets consisted of 8.2% to 8.6% dietary fat. All diets contained Rumensin, thiamine, and Tylan at the rates of 309, 112, and 77 mg per steer daily, respectively.

Steers were fed 6 times daily with Ankom automatic feeders at *ad libitum* intake and *ad libitum* access to fresh water. The CCDS and WDGS were from a single load of each commodity for the entire trial from the same ethanol plant (Abengoa Bioenergy, York, Neb.).

Period duration was 21 days, including a 12-day adaptation period. Corn bran *in situ* bags were ruminally incubated for 0, 12, 24, or 48 hours on days 13 to 15. Quadruplicate bags were incubated in each steer per time point. Bags were inserted at staggered times. All bags were removed the morning of day 15, rinsed, refluxed in NDF solution, and dried for corn bran NDF digestibility calculation. Chromic oxide (7.5 g/dose) was dosed intraruminally at 0800 hr and 1600 hr daily on days 13 to 20. Omasal and fecal samples were collected at 0800 hr and 1600 hr on days 16 to 20. Omasal samples were collected via

Table 1. Diets fed to steers in the digestibility experiment evaluating dietary fat sources (% of diet DM).

Diet[1]	CORN	OIL	TAL	CCDS	WDGS
Dry rolled corn	80.0	82.7	82.7	62.0	31.5
Grass hay	7.5				
Supplement	5.0				
Molasses	7.5	—	—	—	—
Corn oil	—	4.8	—	—	—
Tallow	—	—	4.8	—	—
CCDS	—	—	—	25.5	—
WDGS	—	—	—	—	56
Diet					
CP, %	11.9	11.4	11.4	12.7	22.4
Fat, %	3.6	8.5	8.5	8.2	8.6
Fatty acid, %	3.1	7.3	6.9	6.6	7.2
Sulfur, %	0.15	0.11	0.11	0.45	0.58
NDF, %	14.0	14.0	14.0	12.6	28.5

[1]CORN = corn control diet; OIL = corn diet with added corn oil;TAL = corn diet with added beef tallow; CCDS = corn diet with added fat from condensed corn distillers soluble; WDGS = corn diet with added fat from corn wet distillers grains plus solubles.

Table 2. Effects of dietary fat source on nutrient intake and total tract DM, fat, fatty acids, and NDF digestibility.

Diet[1]	CORN	OIL	CCDS	TAL	WDGS	SE	*P*-value
DM							
Intake, lb/day	24.6	21.2	21.9	22.7	23.4	1.5	0.43
Total tract digestibility, %	81.3[cd]	77.3[ab]	83.8[d]	80.3[bc]	75.8[a]	2.5	< 0.01
Total fat							
Intake, lb/day	0.9[a]	1.8[b]	1.8[b]	1.9[b]	2.0[b]	0.1	< 0.01
Total tract digestibility, %	89.2[a]	90.9[ab]	94.2[c]	92.9[bc]	90.3[a]	1.2	< 0.01
Fatty Acids							
Intake, lb/day	0.8[a]	1.6[b]	1.5[b]	1.6[b]	1.7[b]	0.1	< 0.01
Omasal fatty acid profile, % of total omasal fatty acids							
Palmitic acid (C16:0)	12.5[a]	12.4[a]	14.3[b]	19.8[c]	14.2[b]	0.6	< 0.01
Stearic acid (C18:0)	51.5[b]	57.4[c]	49.4[b]	47.3[b]	39.1[a]	2.3	< 0.01
C18:1 (all isomers)	16.0[a]	17.5[ab]	19.8[b]	17.9[ab]	25.0[c]	1.4	< 0.01
C18:2 (all isomers)	13.1[b]	7.6[a]	11.4[b]	7.5[a]	17.0[c]	1.3	< 0.01
C18:3 (all isomers)	1.0[bc]	0.9[ab]	1.1[bc]	0.8[a]	1.1[c]	0.06	0.02
Unsaturated FA:Saturated FA	0.49[a]	0.39[a]	0.52[a]	0.40[a]	0.83[b]	0.06	< 0.01
Digestibility, % of fatty acid reaching omasum[2]							
Palmitic acid (C16:0)	93.7	95.0	97.2	96.6	96.0		
Stearic acid (C18:0)	95.6	94.9	97.4	95.5	94.9		
C18:1 (all isomers)	92.6	94.6	96.9	96.2	96.1		
C18:2 (all isomers)	88.8	84.2	92.6	91.0	92.9		
C18:3 (all isomers)	88.7	90.9	100.0	93.0	92.9		
Total	94.1[a]	93.9[a]	96.7[b]	95.4[ab]	95.2[ab]	0.9	0.06
NDF							
Intake, lb/day	3.5[b]	3.0[ab]	2.7[a]	3.2[b]	6.7[c]	0.3	< 0.01
Total tract digestibility, %	63.2[bc]	49.1[a]	68.8[c]	60.2[b]	65.0[bc]	4.9	0.01

[1]CORN = corn control diet; OIL = corn diet with added corn oil; CCDS = corn diet with added fat from condensed corn distillers solubles; TAL = corn diet with added beef tallow; WDGS = corn diet with added fat from corn wet distillers grains plus solubles.
[2]Calculated from the disappearance of omasal fatty acids (amount of fatty acid intake x individual fatty acid proportion of omasal profile with an assumed net zero addition of rumen biosynthesized fat) relative to actual quantity of individual fecal fatty acids.
[a,b,c,d]Means within a row with unlike superscripts differ ($P < 0.10$).

Table 3. Effects of dietary fat source on *in situ* corn bran NDF digestibility.

Diet[1]	CORN	OIL	CCDS	TAL	WDGS
12h NDF digestibility, %	15.6[b]	9.2[a]	11.5[ab]	13.5[ab]	13.9[ab]
24h NDF digestibility, %	22.6[b]	17.1[a]	21.4[ab]	18.4[ab]	19.1[ab]
48h NDF digestibility, %	31.6[c]	29.1[bc]	22.1[a]	26.2[ab]	24.7[ab]

[1]CORN = corn control diet; OIL = corn diet with added corn oil; CCDS = corn diet with added fat from condensed corn distillers soluble; TAL = corn diet with added beef tallow; WDGS = corn diet with added fat from corn wet distillers grains plus solubles.
[a,b,c]Means within a row with unlike superscripts differ ($P < 0.10$).

Table 4. Effects of dietary fat source on ruminal pH parameters.

Diet[1]	CORN	OIL	CCDS	TAL	WDGS	SE	*P*-value
Ruminal pH							
Average	5.41[ab]	5.75[c]	5.31[a]	5.60[bc]	5.56[bc]	0.09	0.01
Variance	0.07[d]	0.06[c]	0.04[a]	0.05[b]	0.04[a]	0.01	< 0.01
Time < 5.6, min/day	1091[bc]	564[a]	1289[c]	618[a]	843[ab]	147	< 0.01

[1]CORN = corn control diet; OIL = corn diet with added corn oil; CCDS = corn diet with added fat from condensed corn distillers soluble; TAL = corn diet with added beef tallow; WDGS = corn diet with added fat from corn wet distillers grains plus solubles.
[a,b,c]Means within a row with unlike superscripts differ ($P < 0.10$).

Table 5. Effects of dietary fat source on rumen fluid volatile fatty acid parameters.

Diet	CORN	OIL	CCDS	TAL	WDGS	SE	*P*-value
Total, mM	140.3	125.5	131.7	142	129.2	8.4	0.54
Acetate, mol/100 mol	50.5[bc]	50.9[c]	45.3[a]	46.4[ab]	52.0[c]	1.9	0.07
Propionate, mol/100 mol	34	32.4	40.6	38	32.8	2.6	0.15
Butyrate, mol/100 mol	11.8	11.1	9.8	9.4	9.7	1	0.21
Acetate:Propionate	1.55	1.63	1.16	1.26	1.62	1.2	0.25

[1]CORN = corn control diet; OIL = corn diet with added corn oil; CCDS = corn diet with added fat from condensed corn distillers soluble; TAL = corn diet with added beef tallow; WDGS = corn diet with added fat from corn wet distillers grains plus solubles.
[a,b,c]Means within a row with unlike superscripts differ ($P < 0.10$).

tube inserted in the omasal orifice from the rumen canula. Omasal and fecal samples were composited by day, freeze dried, ground, and composited by animal within period for chromic oxide, fat, and NDF analysis. Individual feed ingredients and omasal and fecal composites were analyzed via gas chromatography for fatty acid profile and quantification. Continuous pH data were collected with intraruminal pH probes on days 15 to 20. Rumen fluid samples were collected at 0800 hr and 1600 hr on days 19 and 20 for volatile fatty acid analysis.

Data were analyzed as a crossover design using the MIXED procedure of SAS (SAS Inst. Inc.) Period was included in the model as a fixed effect and the random effect was steer. A Cholesky covariance structure was utilized for pH repeated measures analysis. Treatment differences were evaluated when overall significance was less than $P = 0.10$.

Results

Dry matter intake was numerically least for OIL and numerically greatest for CORN fed steers (Table 2). Fat intake was similar for all fat-supplemented diets, but roughly 2 times greater for fat-supplemented diets than for CORN. Diet NDF intake was roughly 2 times greater for WDGS than for the other diets due to the increased NDF content of WDGS relative to the other feed ingredients.

Total tract DM digestibility was greatest for CCDS and lowest for WDGS. Total tract fat digestibility was greatest for CCDS and lowest for CORN and WDGS. All fat digestibilities were greater than 89%, indicating that fat absorption efficiency at the small intestine was not decreased with the high fat diets. Diet NDF digestibility was greatest with CCDS and least for OIL. This result is interesting considering the fatty acid profile and rumen biohydrogenation potential of corn oil and solubles are expected to be similar.

Rumen *in situ* corn bran NDF digestibility was generally poorer than

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expected for all treatments (Table 3). Total tract NDF digestibilities were roughly 2 to 3 times greater than *in situ* corn bran digestibilities, indicating that either the *in situ* values are artificially low or significant lower-gut NDF digestion occurred. The NDF digestibilities may be artificially low due to dietary fat clogging pores on the *in situ* Dacron bag and preventing microbial contact with corn bran samples. This argument is supported by the CORN diet (lowest fat diet) having the greatest NDF digestibility at all three time points. The bran incubated in steers fed CCDS had the greatest rate of fiber digestion between 12 and 24 hours of incubation. However, the CCDS treatment had the lowest extent of digestion at 48 hours and lowest rate of digestion from 24 to 48 hours. This may indicate a different rumen fermentation pattern of corn bran when steers are fed solubles relative to other fat sources.

Ruminal average pH was lowest for CCDS and highest for OIL (Table 4). Time of ruminal pH below 5.6 was greatest for CCDS and least for OIL and TAL. These differences were interesting considering the DMI, fat profiles, and fat forms were similar for CCDS and OIL. In addition, CCDS contained less starch. Dry matter digestibility was similar between CCDS and OIL, while NDF digestibility was significantly lower for OIL. Anecdotal observations suggested rumens of steers fed CCDS were fuller, frothier, and more likely to spill rumen contents when the cannula plugs were removed than when the same steers were fed the remaining four diets.

The omasal fatty acid profile of WDGS was less saturated than other treatments due to proportionately greater C18:1 and C18:2 and less C18:0 synthesis. This is due to WDGS fatty acid protection from rumen biohydrogenation of fatty acids. The degree of fatty acid saturation at the omasum did not change the digestibility of the WDGS fatty acids relative to the more saturated omasal fatty acids of other treatments. Total fatty acid digestibility was 93.9% or greater for all treatments.

Rumen VFA proportion of acetate was greatest for OIL and WDGS and least for CCDS (Table 5). Although not significantly different, the acetate to propionate ratio was lowest for CCDS.

These findings indicate an interesting difference in CCDS digestion relative to other fat sources. Although CCDS fat is similar to corn oil, the two feeds were digested differently. Steers fed CCDS had lower average pH and greater DM digestibility than steers fed corn oil, tallow, or WDGS. Steers fed CCDS also had greater fat and fatty acid digestibility than corn and corn oil fed steers, and greater NDF digestibility than corn oil or tallow fed steers. The omasal fatty acid profile of steers fed WDGS was less saturated than that of cattle fed corn diets with or without corn oil, CCDS, or beef tallow. In addition, the efficiency of fat absorption was not decreased with high fat feedlot diets.

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