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Nutrient Digestibility and Ruminal pH of Finishing Diets Containing Dry Milling Byproducts With and Without Oil Extraction

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Summary

A metabolism trial was conducted to determine the effects of corn oil removal in condensed distillers solubles (CDS) and modified distillers grains plus solubles (MDGS) on nutrient digestibility and ruminal pH. Oil removal had no impact on DM, OM, or NDF digestibility in steers fed CDS or MDGS. However, steers fed de-oiled CDS had a lower fat digestibility than steers fed normal CDS. Average ruminal pH was lower for steers fed de-oiled MDGS than for steers fed normal MDGS, however no difference within CDS was observed.

Introduction

For the last two years, ethanol plants have been removing a portion of corn oil via centrifugation to produce de-oiled distillers byproducts. Previous research has concluded that removal of corn oil by this centrifugation process had limited impact on ADG and F:G when 27% inclusion of CDS or 40% inclusion of MDGS were fed in finishing diets (*2013 Nebraska Beef Cattle Report*, pp. 64-65). No data have been reported on the nutrient digestibility of diets containing de-oiled byproducts. The hypothesis of this trial was that oil removal would improve NDF digestibility. Therefore, the objective of this study was to determine the effects of feeding de-oiled CDS and MDGS on nutrient digestibility and ruminal pH of finishing steers.

Procedure

A 112-day metabolism experiment utilized six ruminally fistulated steers in a 5 x 5 Latin Square design. Treatments were designed as a 2 x 2 + 1 factorial arrangement with steers assigned randomly to one of five treatments (Table 1). Factors consisted of oil concentration (de-oiled or normal) and byproduct type (27% CDS or 40% MDGS) plus a corn-based control. All diets contained (DM basis) a 1:1 blend of dry-rolled and high-moisture corn which was replaced by either CDS or MDGS, 12% corn silage, and a 5% supplement. All supplements contained Rumensin® and tylosin at 345 and 90 mg per steer daily, respectively. The byproducts utilized in this trial were procured from Green Plains, LLC (Central City, Neb).

Steers were housed in individual concrete slatted pens with *ad libitum* access to feed and water. Ingredient samples were taken during the collection period at time of mixing, composited by period, ground through a 1-mm screen, and analyzed for DM, fat, CP, S, and NDF. Fat concentration

Table 1. Diet composition on a DM basis fed to finishing steers.

		27% CDS[1]		40% MDGS[1]	
Ingredient, % of DM	Control	De-Oiled	Normal Fat	De-Oiled	Normal Fat
DRC[1]	41.5	28	28	21.5	21.5
HMC[1]	41.5	28	28	21.5	21.5
MDGS: De-oiled[1]	—	—	—	40	—
MDGS: Normal fat[1]	—	—	—	—	40
CDS: De-oiled[1]	—	27	—	—	—
CDS: Normal fat[1]	—	—	27	—	—
Corn silage	12	12	12	12	12
Supplement [2,3]	5	5	5	5	5
Analyzed Composition, %					
Fat	4.01	5.17	6.99	5.93	7.16
CP	12.4	14.8	13.8	19.0	18.5
NDF	13.1	10.2	11.9	19.9	22.6
S	0.14	0.30	0.25	0.28	0.27

[1]CDS = Condensed distillers solubles; MDGS = Modified distillers grains plus solubles; DRC = Dry-rolled corn; HMC = High-moisture corn.
[2]Formulated to contain 345 mg/steer daily of Rumensin® and 90 mg/steer daily of Tylan®.
[3]Control supplement contained 1.516% urea.

Table 2. Nutrient Composition of MDGS and CDS[1].

	De-Oiled CDS[2]	Normal CDS[2]	De-Oiled MDGS[2]	Normal MDGS[2]
Fat, %	8.7	15.4	9.2	12.3
CP, %	29.9	25.5	33.9	32.4
S, %	0.73	0.56	0.51	0.48
NDF, %	1.9	8.2	29.7	36.4

[1]All values expressed on a DM basis.
[2]CDS = Condensed distillers solubles; MDGS = Modified distillers grains plus solubles.

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Table 3. Effects of dietary treatment on intake and total tract digestibility of DM, organic matter, fat, and NDF.

		27% CDS[1]		40% MDGS[1]			*P*-value			
Item	Control	De-Oiled	Normal	De-Oiled	Normal	SEM	Int.[2]	CDS[3]	MDGS[4]	F-Test[5]
DM										
Intake, lb/day	22.2[bc]	19.9[a]	21.0[ab]	24.2[c]	22.8[bc]	1.3	0.33	0.34	0.29	0.05
Total tract digestibility, %	81.6	81.4	83.6	82.1	80.0	1.9	0.14	0.17	0.26	0.27
OM										
Intake, lb/day	21.3[bc]	18.7[a]	19.9[ab]	23.1[c]	21.8[c]	1.2	0.33	0.29	0.32	0.03
Total tract digestibility, %	82.9[ab]	84.6[bc]	86.0[c]	83.6[abc]	81.9[a]	1.8	0.21	0.30	0.30	0.08
NDF										
Intake, lb/day	2.9[b]	1.9[a]	2.1[c]	4.7[d]	5.1[e]	0.2	0.40	0.43	0.06	<0.01
Total tract digestibility, %	58.0	53.6	61.0	67.0	67.0	5.5	0.38	0.17	0.99	0.12
Fat										
Intake, lb/day	0.90[a]	1.02[a]	1.46[b]	1.46[b]	1.64[c]	0.08	0.07	<0.01	0.05	<0.01
Total tract digestibility, %	87.3[a]	89.6[ab]	93.1[c]	91.2[bc]	90.6[b]	1.2	0.03	0.02	0.68	0.01

[a-e]Means with different superscripts differ ($P < 0.10$).
[1]27% CDS = 27% inclusion of condensed distillers solubles; 40% MDGS = 40% inclusion of modified distillers grains plus solubles.
[2]Int = Interaction *P*-value for byproduct type and oil concentration.
[3]CDS = Pair-wise, contrast of de-oiled vs. normal CDS.
[4]MDGS = Pair-wise, contrast of de-oiled vs. normal MDGS.
[5]F-Test = Overall F-test representing variation due to treatment.

was analyzed using the biphasic lipid extraction procedure with NDF analyzed after fat had been extracted.

Period duration was 21 days with a 16 day adaptation phase and 5 day collection period. Beginning on day 10 of each period, titanium dioxide was dosed intraruminally at 0800 and 1600 hours to provide a total of 20 g/day. On day 17 to 21, fecal grab samples were collected three times/day at 0800, 1200, and 1600 hours and composited by steer and period. Fecal samples were analyzed for titanium dioxide to determine nutrient digestibility. Fecal samples were also analyzed for DM, organic matter (OM), fat, and NDF. Ruminal pH was measured continuously from day 17 to 21 with submersible wireless pH probes. Measurements for pH included average ruminal pH, minimum and maximum pH, magnitude of change, variance, and time and area below 5.6.

Digestibility, intake, and ruminal pH data were analyzed using the MIXED procedure of SAS (SAS Institute, Inc., Cary, N.C.). Treatment and period were included in the model as fixed effects while steer was treated as a random effect for all analyses. Pair-wise comparisons of treatments were determined by Fisher's LSD and two pre-planned contrasts were used to evaluate the effect of oil removal when 27% CDS or 40% MDGS were fed. Treatment differences were considered significant at $P < 0.10$.

Results

Dietary fat was 5.17% for 27% de-oiled CDS, 6.99% for 27% normal CDS, 5.93% for 40% de-oiled MDGS, and 7.16% for 40% normal MDGS compared to 4.01% fat for the control treatment. The nutrient analysis of CDS and MDGS are included in Table 2.

Intakes

No byproduct by fat concentration interactions were observed for intakes of DM, OM, or NDF ($P \geq 0.33$; Table 3). There were no differences due to oil removal for both 40% MDGS and 27% CDS on DMI and OM intake ($P \geq 0.29$ and $P \geq 0.29$, respectively). However, cattle fed 40% normal MDGS had greater intakes of NDF compared to cattle fed 40% de-oiled MDGS ($P = 0.06$). A byproduct by fat concentration interaction was observed for fat intake ($P = 0.07$). A greater fat intake difference, due to oil removal, was observed for cattle fed 27% CDS compared to 40% MDGS. This response should be expected as the corn oil was only removed from the CDS portion of the MDGS production process. When comparing all treatments, cattle fed 27% CDS had the lowest ($P < 0.01$) NDF intakes with cattle fed 40% MDGS having the greatest intakes and the control being intermediate. Cattle fed 27% de-oiled CDS had the lowest ($P \leq 0.05$) DM and OM intakes with cattle fed 40% de-oiled MDGS having the greatest intakes and 27% normal CDS, 40% normal MDGS, and control being intermediate.

Digestibility

No byproduct by fat concentration interactions were observed for DM, OM, and NDF digestibilities ($P \geq 0.14$; Table 3). Oil removal had no impact on DM, OM, and NDF digestibility for either cattle fed 27% CDS or 40% MDGS ($P \geq 0.17$). This contradicts our hypothesis that oil removal would improve nutrient digestibility. A byproduct by fat concentration interaction was observed for fat digestibility ($P = 0.03$). The magnitude of difference between de-oiled and normal was greater for cattle fed CDS than for MDGS. Cattle fed 27% normal CDS had a greater fat digestibility compared to 27% de-oiled CDS ($P = 0.02$), whereas no difference

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Table 4. Effects of dietary treatment on ruminal pH with steers fed 27% CDS and 40% MDGS with (de-oiled) or without (normal) a portion of oil removed.

		27% CDS[1]		40% MDGS[1]			*P*-value			
Item	Control	De-Oiled	Normal	De-Oiled	Normal	SEM	Int.[2]	CDS[3]	MDGS[4]	F-Test[5]
Average pH	5.40[a]	5.39[a]	5.36[a]	5.54[a]	5.72[b]	0.09	0.14	0.85	0.09	0.02
Maximum pH	6.05	6.15	6.02	6.19	6.38	0.11	0.21	0.43	0.24	0.21
Minimum pH	4.99	4.95	4.98	4.93	5.09	0.09	0.16	0.78	0.18	0.68
pH magnitude	1.08	1.15	1.02	1.30	1.31	0.13	0.60	0.51	0.92	0.44
pH variance[6]	0.072	0.101	0.065	0.074	0.131	0.023	0.33	0.28	0.10	0.26
Time < 5.6, minutes/day[7]	708	748	1080	733	769	104	0.37	0.04	0.81	0.12
Area < 5.6, minutes/day[8]	275	312	450	212	302	77	0.20	0.23	0.42	0.32

[a-c]Means with different superscripts differ ($P < 0.10$).
[1]27% CDS = 27% inclusion of condensed distillers solubles; 40% MDGS = 40% inclusion of modified distillers grains plus solubles.
[2]Int = Interaction *P*-value for byproduct type and oil concentration.
[3]CDS = Pairwise, contrast of de-oiled vs. normal CDS.
[4]MDGS = Pairwise, contrast of de-oiled vs. normal MDGS.
[5]F-Test = Overall F-test representing variation due to treatment.
[6]Variance of daily ruminal pH.
[7]Time < 5.6 = minutes that ruminal pH was below 5.6.
[8]Area < 5.6 = ruminal pH units below 5.6 by minute.

was observed between 40% de-oiled and normal MDGS ($P = 0.68$). When comparing all treatments, no differences were observed for DM digestibility ($P = 0.27$) or NDF digestibility ($P = 0.12$). However, steers fed 27% normal CDS had the greatest ($P = 0.08$) OM digestibility, while steers fed 40% normal MDGS had the lowest OM digestibility. Steers fed 27% normal CDS had the greatest ($P = 0.01$) fat digestibility, while control had the lowest.

Ruminal pH

No byproduct by fat concentration interactions were observed for all ruminal pH variables ($P \geq 0.14$; Table 4). Oil removal had no impact on ruminal pH in steers fed 27% CDS ($P \geq 0.23$) except for time spent below a pH of 5.6 ($P = 0.04$). Steers fed 27% normal CDS spent more time with a ruminal pH below 5.6 than steers fed 27% de-oiled CDS. Oil removal had an effect on average ruminal pH ($P = 0.09$) and pH variance ($P = 0.10$) in steers fed 40% MDGS. Average ruminal pH and variance were lower for steers fed 40% de-oiled MDGS compared to 40% normal MDGS. A treatment effect was observed for average ruminal pH ($P < 0.02$) with steers fed 40% normal MDGS having a greater ruminal pH than steers fed control, 27% de-oiled or normal CDS, and 40% de-oiled MDGS.

These data indicate that oil removal via centrifugation in dry milling byproducts has limited impact on digestibility in finishing cattle diets. These findings do not support our hypothesis of improved digestibilities in cattle fed de-oiled byproducts; however, it supports the findings as to why there have been little differences observed in finishing performance between de-oiled and normal byproducts.

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