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Impact of Feeding Distillers Grains With or Without Oil Removal As Well As Supplemental Corn Oil on Nutrient Digestibility by Finishing Cattle

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Summary with Implications

A digestion trial was conducted to determine the effects of the removal of corn oil from modified distillers grains plus solubles (MDGS) and the impact of supplemental corn oil on finishing cattle nutrient digestion. Four treatments were evaluated: a corn control diet (CON), 40% de-oiled MDGS (DO MDGS), or 38% de-oiled MDGS plus 2% corn oil (MDGS + Oil) formulated to equal the fat content of FF MDGS, or 40% full fat MDGS (FF MDGS). Treatment differences were observed for digestibility of dry matter, organic matter, and fiber, but not for fat. When oil was added to de-oiled MDGS, digestibility was decreased for dry matter, organic matter, and fiber when compared to de-oiled or full fat MDGS. Digestibility values from feeding DGS relative to corn control diets do not follow the same trend, digestible energy increases with DGS feeding, but OM digestibility decreases with DGS feeding.

Introduction

With ethanol companies removing a portion of corn oil from distillers grains, there has been uncertainty as to what impact there would be on performance and nutrient digestibility of finishing cattle. A metabolism experiment was conducted to evaluate the digestibility of wet distillers grains plus solubles (WDGS) compared with corn fiber and corn oil in finishing diets (2007 Nebraska Beef Cattle Report, pp. 39–42). Total tract DM, OM, and NDF digestibility were less ($P < 0.10$) for cattle fed the composite and composite plus oil diets compared to WDGS, control, and control plus oil. A metabolism trial was conducted to evaluate the effects of dietary fat source on the metabolism characteristics of feedlot steers (2010 Nebraska Beef Cattle Report, pp. 80–82). Cattle fed WDGS had the lowest total tract DM and fat digestibility, while cattle fed corn oil had the lowest total tract NDF digestibility. A third metabolism trial was conducted to determine the effects of corn oil removal from MDGS on nutrient digestibility and ruminal pH (2015 Nebraska Beef Cattle Report, pp. 80–82). Oil removal had no impact on DM, OM, or NDF digestibility. This is the only digestion trial that has evaluated that effects of de-oiled DGS compared to normal DGS, so further data was needed to confirm the results. In addition, there has never been a study that evaluated the removal of corn oil from distillers grains compared to adding corn oil back to de-oiled distillers grains. There was a feedlot trial performed with the same treatments as the current digestion trial to evaluate performance characteristics (2018 Nebraska Beef Cattle Report 102–04). When comparing FF MDGS to MDGS + Oil, steers fed FF MDGS had a numerically lighter final BW, gained less numerically, and in turn had a poorer feed conversion. When 2% corn oil was added to de-oiled MDGS, there was a 4.9% improvement in F:G compared to de-oiled MDGS. There was a numerical improvement in F:G by 3.7% for MDGS + Oil compared to FF MDGS. Economics were completed and it was determined that at current corn prices, the improved performance does not make up for the added cost to be economical to add corn oil back to diets. The objective of this study was to determine the effects of corn oil removal and supplemental corn oil to diets containing MDGS on total tract digestibility of finishing cattle.

Procedure

A 70-day metabolism experiment utilized five ruminally fistulated crossbred yearling steers (initial BW = 1195 lb ± 88 lb) in a 5 × 4 unbalanced rectangle design with five periods and four treatments. Steers were assigned randomly to one of four treatments, with a different one of the four treatments having two steers each period. The four treatments consisted of a corn control diet, 40% de-oiled MDGS, or 38% de-oiled MDGS plus 2% corn oil formulated to equal the fat content of FF MDGS, or 40% full fat MDGS (Table 1). The de-oiled MDGS contained 8.9% fat, while the full fat MDGS contained 11.6% fat. All byproducts utilized in the trial were sourced from the same plant (E Energy Adams, Adams, NE). Although the MDGS + Oil and FF MDGS treatments were formulated to have equal fat content, actual analysis showed the MDGS + Oil treatment contained 7.86% dietary fat and the FF MDGS treatment contained 7.09% dietary fat. On a DM basis, all diets contained 3.5% alfalfa hay, 4% sorghum silage, 5% supplement, and a 50:50 blend of DRC:HMC to make up the remainder of the diet. The control treatment supplement contained 1% Empyreal corn protein concentrate (Cargill Corn Milling) to meet metabolizable protein requirements. The supplement was formulated to provide 90 mg per steer daily of Tylan-40® (Elanco Animal Health) and 30 g per ton DM of Rumensin-90® (Elanco Animal Health).

Steers were housed in individual concrete slatted pens and allowed *ad libitum* access to feed and water. Cattle were fed once daily at 0800 with refused feed being removed prior to feeding. Ingredient samples were taken on days nine and 12 of each period and composited by period. Samples were lyophilized, ground through a 1-mm screen of a Wiley Mill, and analyzed for DM, OM, NDF, fat, CP, and gross energy using a bomb calorimetry to calculate nutrient composition of dietary treatments (Table 1).

Each period was 14 d, which consisted of a 10 d adaptation phase and 4 d collection phase. Titanium dioxide, an indigestible marker, was dosed intraruminally twice daily at 0800 and 1600 h throughout the

Table 1. Composition (% of diet DM) of dietary treatments fed to yearling steers.

	Treatment[1]			
Ingredient	CON	DO MDGS	MDGS + Oil	FF MDGS
Dry-rolled corn	43.75	23.75	23.75	23.75
High-moisture corn	43.75	23.75	23.75	23.75
MDGS De-oiled[2]	-	40	38	-
MDGS Full Fat[3]	-	-	-	40
Corn Oil	-	-	2	-
Alfalfa hay	3.5	3.5	3.5	3.5
Sorghum Silage	4	4	4	4
Supplement[4]				
Fine Ground Corn	0.773	2.787	2.787	2.787
Limestone	1.729	1.697	1.697	1.697
Tallow	0.125	0.125	0.125	0.125
Urea	1.517	-	-	-
Potassium Chloride	0.465	-	-	-
Salt	0.3	0.3	0.3	0.3
Beef Trace Minerals	0.05	0.05	0.05	0.05
Vitamin A-D-E	0.015	0.015	0.015	0.015
Rumensin-90®[5]	0.017	0.017	0.017	0.017
Tylan-40®[6]	0.009	0.009	0.009	0.009
Nutrient Composition, % of DM				
DM	78.5	67.0	68.0	67.3
NDF	11.0	22.7	22.0	22.6
Sulfur	0.17	0.44	0.44	0.48
CP	12.1	17.0	16.4	16.7
Fat	4.16	6.04	7.86	7.09

[1] Treatments included CON-control; DO MDGS-40% de-oiled modified distillers grains plus solubles; MDGS + Oil-38% de-oiled modified distillers grains plus solubles plus 2% corn oil; FF MDGS-40% full fat modified distillers grains plus solubles.
[2] DO MDGS: de-oiled modified distillers grains plus solubles containing 8.9% fat.
[3] FF MDGS: full fat modified distillers grains plus solubles containing 11.6% fat.
[4] Supplement fed at 5% of dietary DM
[5] Formulated to supply Rumensin-90® (Elanco Animal Health) at 30 g per ton DM
[6] Formulated to supply Tylan-40® (Elanco Animal Health) at 90 mg per steer daily

entire period to provide a total of 10 g/d for use as an estimate of fecal output. On d 10 to 13, fecal grab samples were collected four times/d at 0800, 1200, 1600, and 2000 h, and immediately frozen. At the end of each period, fecal samples were composited by day (wet basis), lyophilized, and ground through a 1-mm screen of a Wiley Mill, and composited by period. Fecal sample analysis consisted of DM, OM, NDF, fat, energy for calculation of digestible energy, and titanium dioxide.

Submersible wireless pH probes were placed in the rumen for the entire period; however, ruminal pH was only analyzed from d 9 to 12. Measurements for pH include average ruminal pH, minimum and maximum pH, and magnitude of pH change.

Rumen in-situ bags were used to determine DM digestibility and NDF digestibility at 20 and 30 hours of incubation. For DM digestibility, DRC was placed in the bag. For NDF digestibility, either dry corn bran or solvent extracted germ meal (SEM) were utilized. Following incubation, samples were immediately frozen and at the end of the trial, bags containing dry corn bran or SEM were analyzed for NDF. After the NDF procedure, bags were dried in a 140°F forced-air oven for 16 hours and weights were used to calculate NDF digestibility. The bags that contained DRC were not analyzed for NDF and were only dried in the 140°F forced-air oven for 16 hours to determine DM digestibility. At the time of in-situ bag removal, contents were mixed in the rumen and sampled. A portion was immediately frozen and later used to determine DM of whole rumen contents.

Production of volatile fatty acid was calculated over a six-hour gas production period. Two bottles (0 h) were filled with whole rumen contents when other rumen samples were taken and frozen in liquid nitrogen. After the gas run, contents of ANKOM bottles were emptied into bottles (6 h) and frozen in liquid nitrogen. Concentration of VFA was measured on the zero and six hour bottles, and slope calculated for VFA production rate in mM/hr.

Digestibility and intakes were analyzed using the MIXED procedure of SAS (SAS Institute, Inc. Cary, N.C.). The fixed effects in the model were treatment and period, while steer was a random effect. Ruminal pH data were summarized by hour and analyzed using the GLIMMIX procedure of SAS (SAS Institute, Inc.) to get an overall period treatment average for each parameter. Slope of VFA production was analyzed using the MIXED procedure of SAS, with steer being a random effect. Treatment effects were evaluated using the F-test statistic and assessed as significant at $P \leq 0.05$. If significant, then treatments were separated and compared using a t-test.

Results

No treatment differences were observed for DMI ($P > 0.94$; Table 2) with intake ranging from 19.6 to 20.7 lb/d. Dietary treatment had an impact on total tract DM digestibility ($P < 0.01$). The greatest digestibility was observed for the control treatment, DO MDGS was next, MDGS + Oil was lowest, with FF MDGS being intermediate and not differing from both DO MDGS and MDGS + Oil. Results of OM intake and total tract digestibility followed the same trend as DM, with intakes ranging from 19.0 to 19.8 lb/d and treatments impacting OM digestibility similarly to DM digestibility.

A treatment effect was observed for NDF intake ($P < 0.01$), with MDGS treatments having greater NDF intake than the control due to a greater dietary NDF concentration. There was a tendency ($P = 0.07$) for total tract NDF digestibility to be different between treatments. The greatest NDF digestibility was observed for FF MDGS and lowest for CON and MDGS + Oil, with DO MDGS being intermediate and not differing from all other treatments.

Table 2. Effect of feeding 40% de-oiled MDGS, 40% full fat MDGS, or 38% de-oiled MDGS plus 2% corn oil on digestible energy and intake and total tract digestibility of DM, OM, NDF, and fat.

	Treatment[1]					
	CON	DO MDGS	MDGS + Oil	FF MDGS	SEM	F-TEST
DM						
Intake, lb/d	19.6	20.5	19.8	20.7	1.94	0.94
Total Tract Digestibility, %	81.7[a]	77.2[b]	73.8[c]	75.9[bc]	1.28	<0.01
OM						
Intake, lb/d	19.0	19.4	19.0	19.8	1.85	0.96
Total Tract Digestibility, %	83.6[a]	79.1[b]	76.1[c]	78.1[bc]	1.43	<0.01
NDF						
Intake, lb/d	2.16[a]	4.72[a]	4.39[a]	4.78[a]	0.384	<0.01
Total Tract Digestibility, %	50.5[b]	55.3[ab]	51.3[b]	57.7[a]	2.19	0.07
Fat						
Intake, lb/d	0.82[c]	1.23[b]	1.57[a]	1.48[ab]	0.123	<0.01
Total Tract Digestibility, %	82.9	81.1	81.8	83.3	1.91	0.83
Energy						
Intake, Mcal	38.6	43.3	43.0	45.0	4.08	0.46
DE, Mcal/d	30.97	33.27	31.7	34.31	2.920	0.76
DE, Mcal/lb	1.59[b]	1.63[ab]	1.60[ab]	1.66[a]	0.03	0.13

[abc]Means with different subscripts differ (P < 0.05)

[1] Treatments included CON-control; DO MDGS-40% de-oiled MDGS, FF MDGS-40% full fat MDGS, or MDGS + Oil-38% de-oiled MDGS plus 2% corn oil

Table 3. Effect of feeding 40% de-oiled MDGS, 40% full fat MDGS, or 38% de-oiled MDGS plus 2% corn oil on in-situ NDF and DM digestibility.

	Treatment[1]							
	CON	DO MDGS	MDGS + Oil	FF MDGS	SEM	Int	Trt	Sample
NDFD								
Corn Bran	26.6[e]	27.6[de]	28.6[d]	27.7[de]	0.55	<0.01	<0.01	<0.01
Germ Meal	62.2[b]	60.1[c]	63.2[ab]	64.7[a]				
DMD								
DRC	49.1[c]	56.3[a]	53.4[b]	56.5[a]	1.64	-	<0.01	-

[a-c]Means with different subscripts differ (P < 0.05)

[1] Treatments included CON-control; DO MDGS-40% de-oiled MDGS, FF MDGS-40% full fat MDGS, or MDGS + Oil-38% de-oiled MDGS plus 2% corn oil

Table 4. Effect of feeding 40% de-oiled MDGS, 40% full fat MDGS, or 38% de-oiled MDGS plus 2% corn oil on ruminal pH.

	Treatment[1]					
	CON	DO MDGS	MDGS + Oil	FF MDGS	SEM	Trt
Average pH	5.64	5.70	5.88	5.83	0.138	0.14
Maximum pH	6.46	6.53	6.66	6.66	0.150	0.38
Minimum pH	5.03	5.06	5.22	5.18	0.120	0.36
pH magnitude	1.43	1.47	1.45	1.49	0.112	0.97

[a-c]Means with different subscripts differ (P < 0.05)

[1] Treatments included CON-control; DO MDGS-40% de-oiled MDGS, FF MDGS-40% full fat MDGS, or MDGS + Oil-38% de-oiled MDGS plus 2% corn oil

Digestibility of NDF was greater for FF MDGS compared to MDGS + Oil (*P* = 0.04). These results suggest that free corn oil may have a negative impact on NDF digestibility, which could be because free corn oil is thought to inhibit NDF digestion by coating feed or inhibiting microbes. Free oil is thought to impact fiber digestion in the rumen, while the fat in distillers grains is bound in the germ so it will pass through the rumen without inhibiting digestion. The lower NDF digestibility for MDGS + Oil may also be due to the lower amount of NDF in the diet coming from MDGS. In-situ NDF digestibility values for corn bran were approximately half of what was observed for total tract NDF digestibility of the entire diet (26.6 to 28.6%); however, values for SEM were greater than total tract (60.1 to 64.7%). Cattle fed MDGS + Oil resulted numerically in the greatest bran NDF digestion whereas NDF digestion was least in steers fed CON, with DO MDGS and FF MDGS being intermediate and not differing from all other treatments (Table 3). Cattle fed FF MDGS resulted in the greatest SEM NDF digestibility whereas NDF digestion was least in steers fed DO MDGS, with CON being intermediate and MDGS + Oil not differing from both FF MDGS and CON. When corn was incubated in steers fed DO MDGS and FF MDGS, corn DM digestibility was greatest. It was least in steers fed CON and intermediate in steers fed MDGS + Oil.

Fat intake was different among treatments ($P < 0.01$), with MDGS + Oil being numerically greatest, DO MDGS being intermediate, CON being lowest, and FF MDGS not differing from both MDGS + Oil and DO MDGS. There was no treatment effect observed for total tract fat digestibility (*P* = 0.83), with an observed range of 81.1 to 83.3%.

Energy intake (Mcal) and digestible energy (Mcal/d) were not impacted by treatment (*P* = 0.46 and 0.76, respectively). Energy intake ranged from 38.6 to 45.0 Mcal, while DE ranged from 30.97 to 34.31 Mcal/d. There was a tendency for DE concentration (Mcal/lb) to be different among treatments (*P* = 0.13). The greatest DE (Mcal/lb) was observed for FF MDGS and lowest for CON, with DO MDGS and MDGS + Oil being intermediate. The results of increased supply of DE in diets

Table 5. Effect of feeding 40% de-oiled MDGS, 40% full fat MDGS, or 38% de-oiled MDGS plus 2% corn oil on VFA production (mM/hr) and VFA molar proportion.

	Treatment[1]						
	CON	DO MDGS	MDGS + Oil	FF MDGS	SEM	Trt	Hr*Trt
VFA Production							
Total	13.6[b]	17.2[a]	12.5[b]	11.2[b]	1.74	<0.01	-
Acetate	5.4	6.8	5.4	5.1	0.88	0.40	-
Propionate	5.7[b]	7.7[a]	4.8[bc]	3.8[c]	0.87	<0.01	-
Butyrate	1.7	1.9	1.8	1.8	0.35	0.99	-
VFA molar %							
Acetate	48.1[ab]	45.4[b]	45.1[b]	51.6[a]	1.49	0.01	0.98
Propionate	35.1[ab]	38.3[a]	37.0[a]	29.7[b]	2.30	0.06	0.99
Butyrate	12.1	12.1	13.9	13.7	1.21	0.57	0.98
A:P	1.6[ab]	1.3[b]	1.3[b]	1.9[a]	0.23	0.07	0.96

[a-c]Means with different subscripts differ (P < 0.05)

[1] Treatments included CON-control; DO MDGS-40% de-oiled MDGS, FF MDGS-40% full fat MDGS, or MDGS + Oil-38% de-oiled MDGS plus 2% corn oil

containing DGS is a new concept and has not been studied heavily. This concept could help explain the increase in performance due to feeding DGS. Results of DE do not match performance results, where cattle fed MDGS+Oil were numerically the most efficient and had the greatest ADG.

Average, maximum, minimum, and magnitude of change for ruminal pH were not impacted by dietary treatment (Table 4; $P > 0.14$).

Total VFA production rate (mM/hr) was greatest for DO MDGS (Table 5; $P < 0.01$). There was a tendency ($P = 0.08$) for CON and FF MDGS to be different, while MDGS + Oil did not differ between both CON and FF MDGS ($P = 0.40$ and 0.34, respectively). Production rate of acetate and butyrate were not statistically different among treatments ($P = 0.40$ and 0.99, respectively). Propionate production was greatest for steers fed DO MDGS ($P < 0.01$), intermediate for CON, and lowest for FF MDGS, while MDGS + Oil was not differing from both CON and FF MDGS ($P > 0.10$). Total VFA production agrees with observed pH data, where MDGS + Oil and FF MDGS had the higher pH and the lower rate of production, while CON and DO MDGS had a lower pH with a higher rate of VFA production. There were no hour × treatment interactions for molar proportion of VFA. Molar proportion of acetate was greatest for FF MDGS ($P = 0.01$), least in cattle fed DO MDGS and MDGS + Oil and not differing from each other ($P = 0.88$), and CON was intermediate and not differing from all other treatments ($P > 0.09$). Molar proportion of propionate tended to be impacted by dietary treatment ($P = 0.06$). Propionate was similar and greatest ($P = 0.70$) for DO MDGS and MDGS + Oil, and lowest for FF MDGS, while CON was not differing from all other treatments ($P > 0.09$). There was no dietary treatment effect observed for molar proportion of butyrate ($P = 0.57$). The A:P molar proportion tended to be greatest for FF MDGS ($P = 0.07$), least in cattle fed DO MDGS and MDGS + Oil and not differing from each other ($P = 0.79$), and CON was intermediate and not differing from all other treatments ($P > 0.18$).

Conclusion

Digestion data from OM and DE are not consistent with observed performance between full fat and adding corn oil back to de-oiled MDGS. Cattle on the FF MDGS treatment had better OM digestibility and greater DE in the diet than MDGS + Oil; however, steers fed FF MDGS had a lighter final BW, gained less, and in turn had a poorer feed conversion (2018 Nebraska Beef Cattle Report 102–04). Digestibility values from feeding DGS relative to corn control diets are not consistent. Digestible energy increases with DGS feeding, but OM digestibility decreases with DGS feeding. Adding corn oil decreased fiber digestibility compared to de-oiled or full fat MDGS; however, this did not impact fiber digestion of bran when incubated in the rumen of cattle.

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