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Relationship between fat content and NE values for some ethanol byproducts[1,2,3]

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SUMMARY

A finishing phase study was conducted to measure the impact of the fat content of ethanol byproducts on the relative Net Energy values for these feedstuffs.

The three feedstuffs with varying crude fat content used included a commercially available corn gluten feed corn distillers grains blend (CGD); a corn wet distillers grains without solubles (WDG); and corn wet distillers grains plus solubles (WDGS). Byproducts were incorporated as 40% of the finishing diets (DM basis) replacing corn and SBM components of the control (CO) diet. There were 6 pens of 7 or 8 yearling steers on each treatment during the 130 d experiment.

The assayed average dietary fat content for the CO, CGD, WDG, and WDGS diets were 2.91%, 4.95%, 5.34% and 6.58%, respectively. Increasing fat content of diets (and byproducts) was associated with increased dietary NE content. Diet NE_G values derived from steer performance were 60.6, 59.7, 62.0 and 64.6 Mcal/cwt for CO, CGD, WDG and WDGS, respectively. Assuming that the substituted grain had a NE_G value of 68 Mcal/cwt, the derived NE_G values for the three byproducts were 65.8, 71.5 and 78.1 Mcal/cwt for the CGD, WDG and WDGS diets, respectively. Regression of diet fat content against NE_G content indicated that fat represented 2.02 times the NE content of non-fat diet components ($P < .02$; $r^2 = 0.26$).

INTRODUCTION

It is a logical priority in the advancement of renewable biofuels technology to seek to capture as much of the energy potential as possible from the basal feedstuff. The energy rich oil component of corn becomes a key focus of this strategy. The impact of this is an increase in production of lower fat content distillers grains. We now see a range of 4 to 15% fat in the distillers grains that are incorporated into feedlot diets.

Many finishing diets are based upon a high inclusion level of biofuels byproducts. An important question is how the changing fat content of the byproducts will impact dietary NE levels and cattle performance.

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MATERIALS AND METHODS

This experiment was conducted at the Ruminant Nutrition Center during June through October 2010. Yearling steers were on test for 130 d. The finishing diets were formulated to contain 8.5% roughage and a 50:50 ratio of Dry Rolled Corn:High Moisture Corn grain base. Byproducts were included at 40% of the diet replacing, corn and a protein supplement. Three byproducts were used to provide varying dietary fat content. Those included a commercially available corn gluten-feed distiller's grains blend (CGD), wet distiller's grains without solubles (WDG) and wet distillers grains with solubles (WDGS). These byproducts were received as needed in 20T loads and bagged to preserve quality while feeding.

Step-up diets of 50, 30 and 16% roughage were used to adapt steers to the final diets. Byproduct inclusion was at 30% in the first two step-up diets. Final test diets were first offered at d 19. Each feed ingredient was sampled weekly. Actual diet formulations and compositions were back calculated weekly from feed batching records and the weekly ingredient assay values. Diets shown in Table 1 reflect the actual formulation and composition values for the study for days 21 to 130. Feed was mixed and delivered twice daily.

Steers (n = 190) were from a single source and purchased through a South Dakota sale barn. Standard Ruminant Nutrition Center receiving protocols were followed. The BW recorded during processing was used for allotment purposes. The allotment involved stratifying the allotment BW similarly across four treatments and then across 6 replicate pens within treatment. At the onset of the study, there were 8 steers per pen in replicates 1 to 5 and 7 steers per pen in replicate 6.

Individual BW was acquired at the onset of the experiment and again at 28, 56, 84, 111 and 130d. Revalor S™ implants (Intervet) were administered concurrent to weighing steers on d 28. Weighing was done prior to making morning feed deliveries. Feed records were summarized at intervals corresponding to weigh dates. Shrink was not applied to interim performance data. At termination steers were co-mingled and slaughtered as a single lot. Individual identity was maintained during slaughter and matched to camera grading data acquired from the packing plant.

Cumulative live performance was calculated by applying a 3% shrink to the BW measured at d 130. Carcass adjusted performance was calculated using a final BW derived from HCW (HCW/0.625) to exclude potential diet effects on fill.

Data were analyzed as appropriate for a completely random design experiment with pen representing the experimental unit. Tests for linear or quadratic responses to diets were based upon equally spaced polynomials and were not weighted for actual dietary fat content. The dietary NE_M and NE_G values were calculated for each individual pen based upon BW, DMI and live weight gain. The NE_G value for each byproduct was estimated based on actual substitution level in the diet and an assumed NE_G of 68 Mcal/cwt for the displaced corn-supplement mixture. Regression analysis was used to predict the effect of dietary fat (actual) on the diet NE_G values derived from steer performance.

RESULTS AND DISCUSSION

Dietary targets were met (Table 1). Byproduct inclusion averaged 40.2% and did not differ ($P > .20$) among diets CGD, WDG and WDGS. Hay content (8.2%) did not differ among diets. As anticipated, crude protein was higher ($P < .05$) in diets containing byproducts. The rationale was to meet the CP requirements in the CO diet and assume no additional CP response in the higher CP content byproduct diets. The dry supplement used in the control diet contained 75% CP. The formulation was 91.2% SBM, 8.8% urea. All diets differed ($P < .001$) in EE content. The magnitude of differences was not as large or as uniform as anticipated because of higher than anticipated EE content of the CGD feed (Table 2).

Adaptation to diets was faster when byproducts were fed. This was a reflection of differences in dietary starch content influences on acid challenges to the rumen during adaptation and feeding aggression by the steers. Even at the lower DMI, the Control step-up diets resulted in twice as much daily corn intake compared to the corresponding steps of diets containing byproducts. Intakes by the steers fed the CO diet lagged behind the others through 56 d on feed (Table 3). It appears that the adaption to the more readily fermentable CO diet resolved during the period of 57 to 84 d on feed. During this period intakes were similar and CO steers exhibited higher ADG and lower F/G. The influence of WDGS to cause higher DMI became more pronounced as the days on feed progressed.

Cumulative performance was very good. Rankings appear similar whether assessing performance on a live BW or carcass adjusted BW basis. Increasing dietary fat content caused linear improvements ($P < .01$) in ADG, DMI and F/G. Most of this response was due to the WDGS treatment.

Generally carcass differences were small and consistent with increased DMI and growth rate. Dressing percentage and HCW increased linearly ($P < .01$) with increasing dietary fat (Table 5). There was also a trend for ($P = 0.11$) for Yield Grade to increase across treatments. The WDG treatment tended ($P = 0.11$) to cause lower marbling scores and that was reflected in a 20% point decline in premium grade carcasses. In several previous studies we observed reduced Quality Grade relative to total carcass fatness associated with feeding ethanol byproducts. The response has been inconsistent and we have not been able to identify a component within these feeds that leads to the effect.

There were 6 pen replicate estimates of dietary NE for each treatment. The NE values increased linearly across diets (Table 6). The CGD diet contained 2% more fat than the CO diet and only 0.4% less fat than the WDG diet, but had a NE_G value that ranked numerically lower than the CO diet. In contrast, the NE_G of the WDG diet was intermediate to the values for the CO and WDGS diets. This indicates that the NE of the CGD diet was driven by feed components other than fat. The estimate of byproduct NE_G content was calculated merely by substitution. Since actual byproduct inclusion levels were similar the statistical inferences are identical for the byproduct and complete diet NE_G estimates.

Obviously, there are several nutrition issues in play as we substitute ethanol byproducts for corn in finishing diets. Even so, these diets do allow a cursory approach to estimating how byproduct fat content may impact NE_G. When diet NE_G were regressed against dietary mean fat content the ensuing equation was: $NE_G = 57.32 + 1.02(\%EE)$ ($P = 0.02$; $r^2 = 0.26$). This suggests that NE_G changes 1 Mcal for every 1% point change in dietary fat. The r^2 is not compelling, but 1 Mcal NE_G/1% point fat is biologically reasonable. It infers that the fat has 2-fold the NE_G content of the fuel (carbohydrate) that it replaced.

We were fortunate to receive excellent cooperation from an ethanol producer that allowed us to have WDG and WDGS produced in the same production runs. That allows us to make a more direct comparison of these two products. Returning the solubles increases the fat content of the byproduct and dilutes the fiber component (Table 2). When the difference in NE_G between only the WDG and WDGS is divided by the change in fat content the coefficient becomes 2.02 Mcal NE_G/1% point fat. The coefficient is probably inflated by the NE_G value for the non-fat fuel contained in solubles being higher than the NE_G content of the non-fat fuel (fiber) of the distillers' grains.

These results support the argument that removing fat from biofuel byproducts will lower the NE value for the feeds. The rate of change is approximately 1.02 Mcal NE_G/cwt for each 1% point change in fat content. The WDG-WDGS comparison emphasizes the importance of components other than fat in affecting NE content of these feedstuffs. Knowledge of manufacturing processes that cause these compositional differences would be helpful when pricing and doing formulations. More extensive feed characterization is recommended to make effective predictions of relative energy values of these evolving feedstuffs.

Table 1. Actual formulation and composition for control, corn gluten feed-distiller's grains blend (CGD), wet distiller's grains (WDG) and wet distiller's grains plus solubles (WDGS) diets.[1, 2]

	Control	CGD	WDG	WDGS	
Hay, %	8.25 (0.17)[2]	8.19 (0.20)	8.22 (0.18)	8.31 (0.28)	
DRC, %	39.99 (0.74)	23.75 (0.30)	23.85 (0.48)	24.11 (0.43)	
HMC, %	39.99 (1.04)	23.71 (0.87)	23.81 (0.77)	24.09 (1.27)	
By-Product, %		40.63 (0.87)	40.39 (0.84)	39.72 (1.84)	
Susp. Suppl., %[3]	3.75 (0.08)	3.72 (0.05)	3.74 (0.08)	3.78 (0.07)	
Dry Suppl., %	8.08 (0.22)				
					SEM
DM, %	79.56	64.62	53.67	49.41	0.232
CP, %	13.10	14.48	18.14	16.93	0.089
NDF, %	13.58	24.96	30.67	25.76	0.150
ADF, %	6.22	9.24	11.14	9.33	0.067
Ash, %	3.09	3.84	2.88	4.10	0.019
EE, %	2.91	4.95	5.34	6.58	0.061
NE_m, Mcal/cwt[4]	93.65	94.11	94.08	94.02	
NE_G, Mcal/cwt[4]	61.89	62.66	62.63	62.57	

[1] DM basis.

[2] Based on weekly ingredient analyses; n = 17; mean (std dev.).

[3] Supplement contained 640 g /T monensin, 156g /T tylosin and provided minerals and vitamins to meet or exceed NRC requirements.

[4] Based upon tabular values for ingredients; assuming co-product NE at par with corn (100/68).

Table 2. Composition of corn gluten feed-distiller's grains blend (CGD), wet distiller's grains (WDG) and wet distiller's grains plus solubles (WDGS) byproducts fed[1]

	CGD (5)[2]		WDG (3)		WDGS (7)	
	Mean	S_d	Mean	S_d	Mean	S_d
DM, %	51.4	1.27	36.4	1.00	32.0	1.72
CP, %	24.9	0.96	33.5	1.11	31.4	2.22
NDF, %	37.4	1.55	51.8	2.30	40.1	1.98
ADF, %	10.9	0.49	15.8	1.54	11.3	0.89
Ash, %	4.4	0.32	2.1	0.07	5.2	0.21
EE, %	8.2	.62	8.9	0.25	12.2	1.10

[1] All values (except DM) are DM basis.

[2] Number of lots used and analyzed in this study.

Table 3. Interim periods cattle performance summary when control, corn gluten feed-distiller's grains blend (CGD), wet distiller's grains (WDG) and wet distiller's grains plus solubles (WDGS) diets were fed.[1]

	Control	CGD	WDG	WDGS	SEM	*P*=[2,3]
1 to 28 d						
Initial BW, lb	851	851	852	854	2.0	
d28 BW, lb	980	992	995	995	5.0	0.050
ADG, lb	4.57	4.99	5.12	5.12	0.178	0.050
DMI, lb	20.65	22.19	21.84	22.43	0.122	0.001
F/G	4.55	4.46	4.30	4.43	0.148	0.467
29-56 d						
d56 BW	1072	1089	1096	1105	5.4	L < 0.001
ADG	3.28	3.47	3.60	3.91	0.138	L < 0.01
DMI	21.45	23.14	22.26	22.58	0.286	L = 0.08; Q = 0.03
F/G	6.61	6.71	6.20	5.80	0.246	L = 0.02
57 to 84 d						
d84 BW	1204	1204	1218	1228	1.6	L < 0.02
ADG	4.71	4.10	4.38	4.42	0.265	Q < 0.10
DMI	24.08	24.14	23.39	24.09	0.317	NS[3]
F/G	5.19	5.94	5.44	5.51	0.299	Q = 0.15
85 to 111 d						
d111 BW	1312	1310	1325	1351	7.8	L 0.002; Q 0.10
ADG	3.99	3.92	3.96	4.58	0.125	L 0.005; Q 0.017
DMI	25.72	25.91	25.35	26.66	0.309	L 0.12; Q 0.09
F/G	6.52	6.66	6.46	5.88	0.182	L 0.02; Q 0.07
112 to 130 d						
d130 BW	1380	1387	1388	1431	9.0	L < 0.002; Q 0.06
ADG	3.60	4.04	3.37	4.22	0.205	NS
DMI	25.65	25.90	25.13	27.21	0.374	L < 0.05; Q < 0.05
F/G	7.19	6.44	7.64	6.51	0.365	NS

[1] non shrunk BW basis.
[2] Probability of linear (L) and quadratic (Q) contrasts of relative diet fat content.
[3] NS *P* > 0.20.

Table 4. Cumulative performance summary on live and carcass weight adjusted basis when control, corn gluten feed-distiller's grains blend (CGD), wet distiller's grains (WDG) and wet distiller's grains plus solubles (WDGS) diets were fed.

	Control	CDG	WDG	WDGS	SEM	*P*=[1]
Initial BW, lb	851	851	852	854	2.0	
Live Basis						
Final BW, lb[2]	1339	1345	1346	1388	8.7	L 0.002; Q 0.06
ADG, lb	3.76	3.80	3.81	4.11	0.074	L 0.005; Q 0.102
DMI, lb	23.36	24.14	23.49	24.38	0.162	L 0.005
F/G, lb	6.23	6.36	6.17	5.93	0.106	L 0.039; Q 0.106
Carcass Adjusted[3]						
Final BW, lb	1333	1343	1347	1394	9.4	L 0.001; Q 0.072
ADG, lb	3.71	3.79	3.82	4.16	0.080	L 0.002; Q 0.120
F/G, lb	6.30	6.39	6.16	5.87	0.129	L 0.019; Q 0.170

[1] Probability of linear (L) and quadratic (Q) contrasts of diet fat content.
[2] d130 BW with 3% shrink.
[3] HCW/0.625.

Table 5. Carcass traits, Quality Grade, and Yield Grade distributions when control, corn gluten feed-distiller's grains blend (CGD), wet distiller's grains (WDG) and wet distiller's grains plus solubles (WDGS) diets were fed.

	Control	CDG	WDG	WDGS	SEM	*P*[1]
Dress, % [2]	62.25	62.42	62.56	62.75	0.214	L 0.010; Q NS[4]
HCW, lb	833	839	843	871	5.7	L 0.001; Q 0.064
Ribfat, in.	0.50	0.52	0.54	0.55	0.021	L 0.125; Q NS
REA, in[2]	12.74	12.48	12.47	12.90	0.246	L NS; Q 0.162
Marbling [3]	569	578	533[‡]	572	12.1	NS
YG	3.21	3.39	3.46	3.49	0.098	L 0.1101; Q NS
Y1 & 2, %	23.9	17.0	18.2	17.4	}	Chi square NS
Y 3, %	47.8	38.3	38.6	30.4		
Y3.5-4.0, %	21.7	36.2	29.6	39.1		
Y4, %	6.5	8.5	13.6	13.0		
Prime & Prem. Choice, %	32.6	36.1	11.4	34.8	}	Chi square NS
Low choice, %	43.5	44.7	59.1	43.5		
Select, %	21.7	19.2	29.6	21.7		
No Roll, %	2.2	0	0	0		

Table 6. Performance based calculations of diet and by-product NE values for corn gluten feed-distiller's grains blend (CGD), wet distiller's grains (WDG) and wet distiller's grains plus solubles (WDGS).

	Control	CGD	WDG	WDGS	SEM	P =
Diet						
NE_m, Mcal/cwt[1]	90.42	89.13	91.78	94.88	1.3	L 0.017
NE_G, Mcal/cwt[1]	60.56	59.65	61.99	64.56	1.2	L 0.014
By-product NE_G, Mcal/cwt[2]		65.77	71.54	78.07		

[1] Derived using actual performance data in NE calculations published by Galyean (2005).

[2] Assumed corn = 68 Mcal/cwt. Eq. [(Test NE_G - Control NE_G) / % co-product] + 68.