DIGESTIBLE ENERGY CONTENT OF CORN- VS SORGHUM-BASED DRIED DISTILLERS GRAINS WITH SOLUBLES AND THEIR EFFECTS ON GROWTH PERFORMANCE AND CARCASS CHARACTERISTICS IN FINISHING PIGS

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Summary

Two experiments were conducted to determine the nutritional value of corn- and sorghum-based dried distillers grains with solubles (DDGS). In Exp. 1, 120 finishing pigs (average initial weight of 244 lb) were used in a 19-d DE determination. The reference diet was 97% corn with vitamins, minerals, and amino acids added to meet or exceed all NRC suggested nutrient concentrations. Treatments were corn-based (Sioux River Ethanol, Hudson, SD and MGP Ingredients, Atchison, KS) and sorghum-based (US Energy Partners, Russell, KS and Western Plains Energy, Oakley, KS) DDGS substituted as 50% of the reference diet in place of corn. Comparisons among the treatments indicated that DDGS from corn had 101 kcal/lb greater DE than DDGS from sorghum (P<0.02). However, DE was different among the sources of corn-based DDGS (P<0.001) and sorghum-based DDGS (P<0.03) suggesting that plant of origin affects DE of DDGS.

In Exp. 2, 176 finishing pigs (average initial weight of 141 lb) were used in a 72-d growth assay. There were 11 pigs/pen and four pens/treatment with feed and water consumed on an *ad libitum* basis until the pigs were slaughtered at an average weight of 286 lb. Treatments were a corn-soybean meal-based control diet and diets with 40% corn-based, high-energy DDGS (Sioux River Ethanol), 40% corn-based, moderate-energy DDGS (MGP Ingredients), and 40% sorghum-based, moderate-energy DDGS (US Energy Partners). Pigs fed the control diet had greater overall ADG (P<0.003) and digestibility of DM (P<0.001), N (P<0.02), and GE (P<0.001) compared to pigs fed the DDGS treatments. Among the DDGS treatments, pigs fed the high-energy product had lower overall ADG (P<0.06), ADFI (P<0.02), and digestibility of DM (P<0.03) but tended to have better F/G (P<0.07) than pigs fed the moderate energy DDGS sources. As for carcass data, hot carcass weight (P<0.001) and dressing percentage (P<0.003) were greater and iodine value of jowl fat lower (P<0.001) for pigs fed the control vs DDGS treatments. Among the DDGS treatments, pigs fed the sorghum-based DDGS had greater dressing percentage (P<0.04) and lower iodine value (P<0.001) than pigs fed the corn-based DDGS. Backfat thickness (P>0.58) and percentage carcass lean (P>0.25) were not affected by treatment. In conclusion, plant of origin and substrate used in the fermentation process (corn vs sorghum) affected the nutritional value of DDGS for finishing pigs.

(Key words: DDGS, feed ingredient, meat quality, sorghum.)

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Introduction

Current government policy is to increase ethanol production in an effort to improve air quality, stabilize farm prices, and reduce dependence on foreign oil. According to the Renewable Fuels Association, there are 128 ethanol bio-refineries in the United States as of August 29, 2007 with capacity to produce about 6.8 billion gallons of ethanol each year. However, production from plants that are under construction will more than double those numbers in the near future. Thus, dried distillers grains with solubles (DDGS), as a coproduct of the ethanol industry, will increase in availability for use in livestock diets.

Previous research from our laboratory suggested that as much as 60% DDGS could be used in diets for finishing pigs without negative effects on growth performance and carcass characteristics while other researchers have recommended a maximum of 10 to 20% inclusion to avoid negative effects. Furthermore, most results are from experiments with only corn-based DDGS originating from a single source. Therefore, the objective of the experiments reported herein was to determine the DE content of corn- vs sorghum-based DDGS from different processing plants and to elucidate the effects of those DDGS on growth performance and carcass characteristics in finishing pigs.

Procedures

In Exp. 1, 120 finishing pigs (average initial wt of 244 lb) were used in a 19-d DE determination. The pigs were sorted by sex and ancestry, blocked by weight, and assigned to pens. There were 12 pigs/pen and two pens/treatment in each of two replicates for a total of four observations per treatment. The pigs were housed in a finishing facility with 6-ft × 16-ft pens that had half solid and half slatted concrete flooring. Each pen had a self-feeder and nipple waterer to allow *ad libitum* consumption of feed and water.

The reference diet (Table 1) was 97.5% corn with vitamins, minerals, and amino acids added to meet or exceed all nutrient concentrations suggested by the NRC. Treatments were corn-based (Sioux River Ethanol, Hudson, SD and MGP Ingredients, Atchison, KS) and sorghum-based (US Energy Partners, Russell, KS and Western Plains Energy, Oakley, KS) DDGS substituted as 50% of the reference diet in place of corn. Diets were formulated to 0.52% lysine, 0.45% Ca, and 0.40% total P with 0.25% chromic oxide added as an indigestibility marker.

Table 1. Composition of Diets for the DE Determination, % [a]

Ingredient	Corn	DDGS
Corn	97.49	48.63
DDGS [b]	---	50.00
Limestone	0.89	0.94
Monocalcium P (21% P)	0.60	-
Salt	0.20	-
L-lysine HCl	0.34	0.11
L-threonine	0.03	---
L-tryptophan	0.04	---
L-isoleucine	0.02	---
Vitamin premix	0.03	0.03
Sow add pack	0.02	---
Trace mineral premix	0.09	0.04
Chromic oxide [c]	0.25	0.25
Total	100.00	100.00

[a]Formulated to 0.52% lysine, 0.45% Ca, and 0.40% total P.
[b]Substituted for corn on a lb:lb basis.
[c]Used as an indigestible marker.

The pigs were allowed to adjust to the experimental diets for 4 d. Each morning for the next 2 d, grab samples of feces were collected from at least six pigs/pen via rectal massage. Then, the pigs were fed a common diet for 7 d, and the treatments were reassigned for a second replicate with the restriction that a pen could not receive the same treatment twice.

The result was four observations per treatment for determination of DE.

Pigs and feeders were weighed on d 0 and 6 for Replicate 1, and d 13 and 19 for Replicate 2 to verify the pigs were gaining weight and consuming feed. Additionally, feed and fecal samples were dried, ground, and analyzed for concentrations of DM, N, GE, and Cr to allow calculation of apparent digestibilities using the indirect ratio method.

All digestibility data were analyzed as a randomized complete block design using the MIXED procedure of SAS. Orthogonal contrasts were used to separate treatment means with comparisons among the control vs DDGS diets, corn- vs sorghum-based DDGS, the two corn-based DDGS sources, and the two sorghum-based DDGS sources.

In Exp. 2, 176 finishing pigs (average initial wt of 141 lb) were used in a 72-d growth assay. The pigs were sorted by sex and ancestry, blocked by weight, and assigned to pens. There were 11 pigs/pen and four pens/treatment. The experimental diets (Table 2) were fed in two phases and formulated to 1.10% lysine, 0.60% Ca, and 0.50% total P for d 0 to 35, and 0.80% lysine, 0.55% Ca, and 0.45% total P for d 35 to 72. Treatments were a corn-soybean meal-based control diet and diets with 40% high-energy DDGS from Sioux River Ethanol (corn-based, crude fat of 10.4%, mean particle size of 328 μm, and DE of 1,646 kcal/lb as determined in Exp. 1), 40% moderate energy DDGS from MGP Ingredients (corn-based, crude fat of 8.5%, mean particle size of 796 μm, and DE of 1,333 kcal/lb as determined in Exp. 1), and 40% moderate energy DDGS from US Energy Partners (sorghum-based, crude fat of 7.3%, mean particle size of 563 μm, and DE of 1,454 kcal/lb as determined in Exp. 1).

Feed and water were consumed on an *ad libitum* basis with the pigs and feeders weighed on d 0, 35, and 72 to allow calculation of ADG, ADFI, and F/G. Chromic oxide (0.25%) was added to the diets as an indigestible marker and on d 40 and 41, fecal samples were collected via rectal massage. Concentrations of DM, N, GE, and Cr in the diets and feces were determined to allow calculation of apparent digestibility of nutrients. The pigs were killed on d 72 (average wt of 286 lb) and carcass data were collected. Because differences in slaughter weight and, thus, hot carcass weight are known to affect carcass measurements, hot carcass weight was used as a covariate to separate any effect of treatment from the effects of slaughtering our pigs at a constant age rather than constant weight. Samples of jowl fat were collected and fatty acid profile was determined to allow estimation of iodine value (AOCS Cd 1c-85 Official Method) as an indicator of carcass firmness.

All growth, digestibility, and carcass data were analyzed as a randomized complete block design using the MIXED procedure of SAS. Orthogonal contrasts were used to separate treatment means with comparisons of control vs the DDGS treatments, high vs moderate energy DDGS, and corn- vs sorghum-based DDGS.

Results and Discussion

Analyses of the DDGS sources (Table 3) indicated that protein and fiber content were greater in DDGS that originated from sorghum vs corn whereas fat and GE were greater for the corn-based DDGS. Particle size of DDGS varied among sources, primarily when originating from corn. Hunter LAB (color) measurements showed that sorghum-based DDGS were darker (lower L*) and less yellow (lower b*) than corn-based DDGS which is logical considering the differences in color of seed coat for corn vs sorghum.

When the dietary treatments were fed to pigs, they gained weight (an average of 0.70

lb/d) and ate the diets well (greater than 6 lb/d) during this brief (6-d) feeding assay. As for nutrient utilization among pigs fed the treatments (Table 4), corn had greater (P<0.001) digestibility of DM and GE than the DDGS treatments. Corn-based DDGS had greater (P<0.002) digestibility of N than sorghum-based DDGS and this result is in agreement with the greater N digestibility that we have reported previously for corn grain itself when compared to sorghum grain. Within the corn-based DDGS, those originating from Hudson had greater (P<0.002) digestibility of DM, N, and GE compared to DDGS from Atchison. There also was variability among the sorghum-based DDGS, with those from Russell having greater (P<0.03) digestibility of DM and GE compared to DDGS from Oakley. Digestible energy content of the DDGS themselves was calculated by multiplying the digestibility of GE in the DDGS by their total GE. Analyses of those data indicated that DDGS from the Hudson plant were higher (P<0.001) in DE content compared to DDGS from the Atchison plant. The greater DE of the Hudson DDGS corresponded well with its high fat content (10.4%) and small particle size (328 μm) compared to all of the other DDGS sources.

Finally, it has been suggested by some researchers and commodity brokers that lighter and more yellow DDGS are of greater nutritional value. However, in our experiment the darkest and least yellow DDGS had greater DE content than two of the other three DDGS treatments. This suggested that DDGS color was not a good predictor of nutritional value.

In Exp. 2 (Table 5), pigs fed the control diet had greater overall ADG (P<0.003) and digestibility of DM (P<0.001), N (P<0.02), and GE (P<0.001) compared to pigs fed the DDGS treatments. Among the DDGS treatments, pigs fed the high-energy product had lower ADG (P<0.06), ADFI (P<0.02), and digestibility of DM (P<0.03) but tended to have better F/G (P<0.07) and digestibility of N (P<0.05) than pigs fed the moderate energy DDGS sources.

As for carcass data, the effects of DDGS on ADG were reflected on greater (P<0.001) HCW for pigs fed the control diet. Furthermore, even when corrected to a constant HCW (via covariate analysis), dressing percentage (P<0.003) and loin depth (P<0.05) were greater, and iodine value of jowl fat was lower (P<0.001) for pigs fed the control vs DDGS treatments. Among the DDGS sources, iodine value was greater (P<0.001) for pigs fed the high vs moderate energy and corn- vs sorghum-based DDGS treatments. These results confirm that increased oil content in corn-based, high energy DDGS causes increased unsaturation of carcass fat. Backfat thickness (P>0.58) and percentage carcass lean were not affected (P>0.25) by treatment.

In conclusion, these experiments indicate that both plant of origin and substrate used in the fermentation process (corn vs sorghum) affect the nutritional value of DDGS when fed to finishing pigs. Yet, our data do not support the idea that color of DDGS is an acceptable indicator of nutritional value.

Table 2. Composition of Diets for the Growth Assay, %[a]

	d 0 to 35		d 35 to 72	
Ingredient	Control	DDGS	Control	DDGS
Corn	69.69	46.91	81.42	54.62
DDGS[b]	---	40.00	---	40.00
Soybean meal (46.5% CP)	28.00	11.00	16.15	3.25
Limestone	1.04	1.31	1.06	1.24
Monocalcium phosphate (21% P)	0.66	---	0.53	---
Salt	0.43	0.20	0.38	0.15
L-lysine HCl	0.10	0.50	0.13	0.40
DL-methionine	0.01	---	---	---
Vitamin premix	0.04	0.04	0.04	0.04
Trace mineral premix	0.03	0.04	0.04	0.05
Chromic oxide[c]	---	-	0.25	0.25
Total	100.00	100.00	100.00	100.00

[a]Formulated to 1.10% lysine, 0.60% Ca, and 0.50% total P for d 0 to 35, and 0.80% lysine, 0.55% Ca, and 0.45% total P for d 35 to 72.
[b]Substituted for corn on a lb:lb basis.
[c]Used as an indigestible marker.

Table 3. Analyses of DDGS Sources

		Corn-based DDGS		Sorghum-based DDGS	
Item	Corn	Hudson	Atchison	Oakley	Russell
Chemical analysis[a]					
DM, %	87.0	90.1	88.2	88.5	88.1
CP, %	8.7	26.4	25.6	29.8	30.5
EE, %[c]	3.4	10.4	8.5	7.9	7.3
CF, %	1.8	6.0	6.0	7.9	6.4
Ash, %	1.1	5.1	4.7	3.5	3.7
NFE, %	72.0	42.2	43.4	39.4	40.2
P, %	0.25	0.77	0.77	0.62	0.66
GE, mcal/lb	1.77	2.15	2.05	1.85	2.09
Physical characteristics					
d_{gw}, μm[b]	666	328	796	606	563
s_{gw}[b]	2.5	1.7	1.9	1.8	1.9
L*[c]	86	61	65	60	57
a*[c]	4	12	8	9	9
b*[c]	27	32	25	20	16

[a]DM (AOAC 930.15), CP (AOAC 990.03), EE (AOAC 920.39), CF, ash, P, and GE were determined using AOAC procedures.
[b]ANSI/ASAE S319.3.
[c]Hunter LAB MiniScan. Illuminant D65.

Table 4. Digestible Energy Content of Corn and Corn- or Sorghum-based DDGS for Finishing Pigs[a]

		Corn DDGS		Sorghum DDGS			*P* value			
Item	Corn	Hudson	Atchison	Oakley	Russell	SE	Cont vs DDGS	Corn vs Sorg	Hud vs Atch	Oak vs Rus
Digestibility, %										
Dry matter	87.4	81.6	76.1	76.6	80.6	1.1	0.001	---[b]	0.002	0.02
N (protein)	74.4	82.9	74.3	73.9	72.4	1.5	-	0.002	0.001	---
GE	85.4	81.1	74.6	74.0	77.9	1.1	0.001	0.10	0.001	0.03
DE, kcal/lb	1,507	1,646	1,333	1,323	1,454	40	0.13	0.02	0.001	0.03

[a]A total of 120 finishing pigs (12 pigs/pen and two pens/treatment with two replicates) with an average initial weight of 244 lb.
[b]Dashes indicate *P*>0.15.

Table 5. Effects of Corn- and Sorghum-based DDGS in Diets for Finishing Pigs[a]

		Corn-based		Sorg-based		*P* value		
		High energy	Moderate energy					
Item	Control	Hudson	Atchison	Russell	SE	Control vs DDGS	High vs Mod energy	Corn vs Sorg
D 0 to 35								
ADG, lb	2.08	1.92	2.05	2.01	0.06	0.10	0.06	---[b]
ADFI, lb	6.35	5.79	6.24	6.28	0.42	0.14	0.02	---
F/G	3.05	3.02	3.04	3.12	0.15	---	---	---
D 0 to 72								
ADG, lb	2.08	1.96	2.02	2.00	0.05	0.003	0.06	---
ADFI, lb	6.93	6.44	6.89	7.15	0.30	---	0.02	---
F/G	3.33	3.29	3.41	3.58	0.09	---	0.07	---
Digestibility, %[c]								
Dry matter	82.5	76.0	78.4	78.4	1.3	0.001	0.03	---
N (Protein)	75.4	73.8	74.9	66.3	1.7	0.02	0.05	0.001
Gross energy	80.0	74.7	76.2	75.2	1.3	0.001	---	---
HCW, lb	217.5	208.0	208.4	209.8	3.7	0.001	---	---
Dress, %[d]	74.8	73.7	72.7	73.6	0.8	0.003	0.12	0.04
Carcass lean, %[d]	54.1	53.4	53.6	53.7	0.6	---	---	---
Backfat, in[d]	0.64	0.64	0.62	0.64	0.05	---	---	---
Loin depth, in[d]	2.46	2.31	2.32	2.37	0.05	0.05	---	---
Iodine value[d]	69.3	80.2	78.4	74.2	0.8	0.001	0.001	0.001

[a]A total of 176 finishing pigs (11 pigs/pen and four pens/treatment) with an average initial weight of 141 lb.
[b]Dashes indicate *P*>0.15.
[c]Fecal samples for digestibility determinations were taken on d 40 and 41.
[d]Hot carcass weight used as a covariate.