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EFFECTS OF WHOLE GRAIN AND DISTILLERS DRIED GRAINS WITH SOLUBLES FROM NORMAL AND HETEROWAXY ENDOSPERM SORGHUMS ON GROWTH PERFORMANCE, NUTRIENT DIGESTIBILITY, AND CARCASS CHARACTERISTICS OF FINISHING PIGS [1]

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Summary

No differences occurred in ADG, ADFI, F/G, digestibilities of DM and GE, dressing percentage, 10th rib fat depth, or fat free lean index in pigs fed normal vs heterowaxy sorghums. As anticipated, with the greater fiber and lower energy in distillers dried grains with solubles (DDGS) than the parent cereal grains, ADG and digestibilities of DM and GE were lower and F/G was worse for pigs fed DDGS. However, the energy value of the DDGS was affected less adversely when heterowaxy sorghum was used for fermentation to ethanol.

(Key Words: Sorghum, Distillers Grains, Waxy, Endosperm, Finishing Pigs.)

Introduction

Several factors can affect the feeding value of sorghum grain. One of those factors, endosperm type, has been examined by many researchers in an attempt to improve the quality and digestibility of sorghum compared to corn. Sorghum endosperm can be classified as normal, intermediate (heterowaxy), or waxy. Waxy sorghums have poor seed germination and vigor, but these agronomic maladies are not shared by normal or heterowaxy sorghums.

Distillers dried grains with solubles (DDGS) are coproducts of the ethanol industry. Previous research from our laboratory has shown that finishing pigs can be fed up to 60% DDGS with no adverse effects on performance, if fat is added to keep ME of the diets constant. However, few data exist to evaluate the source of the DDGS (i.e., from normal, heterowaxy, or waxy sorghum). Therefore, we designed two experiments to compare the effects of normal and heterowaxy endosperm sorghums and their respective DDGS on finishing pigs.

Procedures

One-hundred ninety-two finishing pigs (PIC line 326 boars × C-15 and C-22 sows) were blocked by weight (average initial wt of 143 lb) and allotted to treatments on the basis of sex and ancestry. They were housed in a modified-open-front building with 50% solid concrete and 50% concrete slat flooring. Sixteen pens (eight pens of barrows and eight pens of gilts) were used with four pens per treatment. Each 6-ft × 16-ft pen had a two-hole feeder and a nipple waterer to allow ad libitum access to feed and water.

The heterowaxy sorghum was obtained from NC+ Hybrids, and the normal endosperm sorghum (mill run) was supplied by High Plains Ethanol of Colwich, KS. Both sorghums were grown in south-central Kansas and fermented at High Plains Ethanol. The diets (Table 1) were formulated to .9% lysine, .6% Ca, and .5% P. The diets with whole grain had 3.2 Mcal ME/lb and the

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diets with DDGS had 3.0 Mcal ME/lb. All diets were fed in mash form.

Pigs and feeders were weighed at initiation and conclusion of the experiment to allow calculation of ADG, ADFI, and F/G. Six weeks after initiation of the experiment, Cr_2O_3 was added (.25%) to all diets as an indigestible marker. Feed and fecal samples were collected twice on d 52 and pooled within pen. Concentrations of DM, N, GE and Cr in the feces and feed were determined to allow calculation of apparent digestibilities of DM, N, and GE. On d 59, nine pigs from each pen (144 total) were slaughtered to determine 10th rib fat depth and hot carcass weight. Dressing percentage was calculated, with hot carcass weight as a percentage of preshipping live weight. Fat-free lean index was calculated using NPPC equations.

All data were analyzed as a randomized complete block design with initial weight as the blocking criterion and pen as the experimental unit. Orthogonal contrasts were used to separate treatment means. Slaughter weight was used as a covariate for analyses of the carcass data.

In a second experiment, 48 barrows and gilts (avg initial BW of 257 lb and avg final BW of 263 lb) were used in a 6-d experiment to determine the digestibilities of DM, N, and GE for the two sorghum grains and the two distillers grains. Sorghum diets (Table 2) had 97% sorghum and DDGS diets had 98% DDGS. The diets were formulated to meet NRC recommendations for all nutrients and had .25% Cr_2O_3 included as an indigestible marker. All diets were fed in mash form.

Feed and fecal samples were taken on d 5 and 6, pooled within pen, dried, and ground. Concentrations of DM, N, GE, and Cr in the feces and feed were determined to allow calculation of apparent digestibilities.

The data were analyzed as a randomized complete block design with initial weight as the blocking criterion and pen as the experimental unit. Orthogonal contrasts were used to separate the treatment means of endosperm type (normal vs heterowaxy) and grain vs DDGS.

Results and Discussion

Chemical analyses (Table 3) of the sorghums and DDGS indicated nutrient compositions similar to those observed in previous work here at KSU. Values for CP, ether extract, crude fiber, ash, and amino acids were similar for the two sorghum types. However, the fermentation process (conversion of starch to ethanol) concentrated all nonstarch nutrients.

Endosperm waxiness did not affect ($P>.15$) growth performance or carcass measurements. However, digestibility of N was greater for the heterowaxy sorghum vs normal sorghum ($P<.003$).

Fermentation of the sorghum grain to yield ethanol resulted in DDGS that supported poorer ($P<.03$) rates and efficiencies of gain and lower ($P<.005$) digestibilities of DM and GE. We should note, however, that these responses were anticipated, because no attempt was made to equalize ME in the diets (e.g., by adding fat). Instead, we decided to let any difference in energy value of the DDGS be expressed.

Interactions occurred among endosperm type and grain vs DDGS for ADG ($P<.04$) and digestibility of DM ($P<.03$). These interactions resulted from the greater loss of nutritional value when normal sorghum was fermented to ethanol than when heterowaxy sorghum was used to generate DDGS.

For the digestibility experiment, the diets were virtually all sorghum grain or all DDGS (with minor additions of vitamins and minerals). The heterowaxy sorghum had greater digestibility of N ($P<.10$) and GE ($P<.02$), and greater DE/lb ($P<.003$) than the normal sorghum. Fermentation to yield DDGS decreased digestibility of DM and GE ($P<.001$) and DE/lb ($P<.002$). The only interaction approaching significance ($P<.08$) was for digestibility of DM. Loss of DM digestibility was greater for normal vs

heterowaxy sorghum when fermented to yield DDGS; DE was 1,471 kcal/lb for the normal sorghum and decreased by 145 kcal/lb (to 1,326 kcal/lb) in the normal DDGS. This is in close agreement with the 1998 NRC values for corn DDGS that are reported as 147 kcal/lb less in DE than the parent grain. However, the DE of heterowaxy sorghum (1,552 kcal/lb) decreased by only 83 kcal/lb (to 1,469 kcal/lb) in the DDGS.

In conclusion, heterowaxy sorghum did not improve pig performance or affect carcass measurements compared to normal sorghum. However, our data suggest that all DDGS do not have the same energy value but are affected by endosperm type of the parent grain. Thus, nutritionists should be cautious when using a single NRC value for all DDGS to formulate diets.

Table 1. Compositions of Diets for the Growth Assay (Exp. 1)

Item	Sorghum Grain	DDGS
Ingredient, %		
Sorghum	83.33	-
Corn	-	56.67
Soybean meal (46.5 % CP)	13.11	-
Distillers dried grains w/solubles	-	40.00
L-lysine-HCl	.40	.67
DL-methionine	.17	-
Threonine	.18	.11
Tryptophan	-	.04
Monocalcium phosphate	.86	.38
Limestone	1.01	1.21
Vitamin premix	.15	.15
Trace mineral premix	.10	.10
Salt	.3	.3
Chromic oxide[a]	.25	.25
Antibiotic[b]	.12	.12
Calculated analysis		
CP, %	14.0	15.6
Lysine, %	.90	.90
Ca, %	.60	.60
Total P, %	.50	.50
ME, kcal/lb	1,449	1,364[c]

[a]Indigestible marker.
[b]Provided 100 g/ton of tylosin.
[c]Diets were formulated with ME concentration of sorghum-based DDGS assumed to be 1,260 kcal/lb (using earlier data from our laboratory).

Table 2. Compositions of Diets for Digestible Energy Determinations (Exp. 2)

Item	Sorghum Grain	DDGS
Ingredient, %		
Sorghum	96.86	-
Distillers dried grains w/solubles	-	98.12
L-lysine-HCl	.354	-
DL-methionine	.045	-
Threonine	.094	-
Monocalcium phosphate	.851	-
Limestone	.968	1.08
Vitamin premix	.045	.045
Trace mineral premix	.085	.085
Additional vitamin mixture	.025	-
Salt	.3	.3
Chromic oxide[a]	.25	.25
Antibiotic[b]	.12	.12
Calculated analysis		
CP, %	9.0	24.8
Lysine, %	.50	.57
Ca, %	.55	.55
Total P, %	.45	.65
ME, kcal/lb	1,455	1,157[c]

[a]Indigestible marker.
[b]Provided 100 g/ton tylosin.
[c]Diets were formulated with ME concentration of sorghum-based DDGS assumed to be 1,260 kcal/lb (based on earlier data from our laboratory).

Table 3. Chemical Compositions of Grain and Distillers Dried Grains with Solubles

	Normal Endosperm		Heterowaxy Endosperm	
Item	Grain	DDGS	Grain	DDGS
DM, %	87.38	89.97	88.60	90.92
CP, %[a]	9.56	25.26	10.24	26.03
Ether extract, %[a]	3.31	9.40	3.34	9.26
Crude fiber, %[a]	3.40	8.49	3.20	8.00
Ash,%[a]	1.36	3.94	1.44	4.77
GE, Mcal/lb[a]	1.7	2.0	1.8	2.1
Amino acids, %[a]				
Arginine	.36	1.00	.39	1.09
Histidine	.22	.64	.23	.65
Isoleucine	.38	1.31	.41	1.29
Leucine	1.27	3.84	1.36	3.78
Lysine	.22	.68	.24	.78
Methionine + cystine	.34	.86	.40	.92
Phenylalanine + tyrosine	.80	2.63	.85	2.61
Threonine	.31	1.03	.33	1.07
Tryptophan	.09	.21	.10	.23
Valine	.48	1.57.	.52	1.60

[a]Dry matter basis.

Table 4. Effects of Grain and Distillers Dried Grains from Normal and Heterowaxy Endosperm Sorghum on Growth Performance, Nutrient Digestibility, and Carcass Characteristics of Finishing Pigs (Exp. 1)[a]

	Normal		Heterowaxy			Contrasts[b]		
Item	Sorghum	DDGS	Sorghum	DDGS	CV	1	2	3
ADG, lb	2.02	1.79	1.91	1.89	3.2	-[c]	.03	.04
ADFI, lb	7.21	7.25	6.78	7.52	5.2	-	.10	.12
F/G	3.56	4.05	3.54	3.97	8.3	-	.02	-
Apparent nutrient digestibility, %								
DM	85.0	79.9	83.7	82.7	5.8	-	.005	.03
N	71.7	69.7	75.5	75.4	3.8	.003	-	-
GE	83.5	77.1	82.1	75.8	6.0	-	.001	-
Dressing %	72.2	72.6	72.5	72.5	1.4	-	-	-
10th rib fat thickness, in	.98	.97	1.01	.95	5.5	-	-	-
FLI, %[d]	48.4	48.4	48.1	48.6	1.0	-	-	-

[a]A total of 192 pigs (12 pigs per pen and four pens per treatment) with an avg initial BW of 143 lb and an avg final BW of 248 lb.
[b]Contrasts were: 1) normal vs heterowaxy; 2) sorghum vs DDGS; and 3) normal vs heterowaxy × sorghum vs DDGS.
[c]Dashes indicate P>.15.
[d]Fat free lean index (NPPC, 1994).

Table 5. Digestible Energy of Grain and Distillers Dried Grains from Normal and Heterowaxy Endosperm Sorghums in Finishing Pigs (Exp. 2)[a]

	Normal		Heterowaxy			Contrasts[b]		
Item	Sorghum	DDGS	Sorghum	DDGS	CV	1	2	3
Apparent nutrient digestibility, %								
DM	84.0	64.3	83.5	71.5	7.2	.11	.001	.08
N	62.9	63.3	65.3	71.2	8.8	.10	-[c]	-
GE	81.4	63.8	83.7	69.1	5.1	.02	.001	-
DE of the grain, kcal/lb	1,471	1,326	1,552	1,469	7.1	.003	.002	-

[a]A total of 48 pigs (three pigs per pen and four pens per treatment) with an avg initial BW of 257 lb and an avg final BW of 263 lb.
[b]Contrasts were: 1) normal vs heterowaxy; 2) sorghum vs DDGS; and 3) normal vs heterowaxy × sorghum vs DDGS.
[c]Dashes indicate P>.15.