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Abstract

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EFFECTS OF SORGHUM ENDOSPERM HARDNESS AND PROCESSING ON GROWTH PERFORMANCE AND NUTRIENT DIGESTIBILITY IN PIGS AND BROILER CHICKS [1]

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Summary

In nursery pigs, the greatest digestibilities of DM, N, and GE were observed with soft sorghum. In finishing pigs, no difference was observed in digestibility of nutrients among the sorghum genotypes. Chicks fed soft sorghum had better F/G than chicks fed medium and hard sorghum. Finally, thermal processing (steam flaking and extrusion) improved ADG and F/G and digestibilities of DM, N, and GE compared to grinding (coarse and fine).

(Key Words: Sorghum, Extrusion, Steam Flaking, Digestibility.)

Introduction

In previous research from our laboratory, we demonstrated that processing can change the physical/chemical nature of sorghum with decreased particle size improving ADG, F/G, and digestibility of nutrients in pigs and chicks. Others have reported that softer endosperm tended to improve growth performance and nutrient digestibility in pigs. However, nothing is known about the interactions among endosperm characteristics and processing technologies that might optimize animal performance and nutrient digestibility. The experiments reported herein were designed with the objectives to determine the digestibility of various sorghum genotypes in pigs and to characterize any interactions among sorghum genotype and processing technologies in broiler chicks.

Procedures

In Exp. 1, a total of 60 crossbred nursery pigs (14 d after weaning) was blocked by weight and allotted to pens based on sex and ancestry with five pigs/pen and three pens/treatment. The pigs were housed in an environmentally controlled building with wire-mesh floor during the 5-d experiment. A nipple waterer and self-feeder provided pigs ad libitum access to feed and water. Treatments were five sorghum genotypes grouped into soft (851111), medium (279 & PL-1), and hard (Segolane & 475) endosperm. All diets were formulated to .7% lysine, .7% Ca, and .6% P (Table 1). The ground sorghum (550 μm) was the only source of energy and protein in the diets. After a 3-d adjustment, fresh feces samples were collected twice per day for 2 d after a 3-d adjustment. The samples were dried and analyzed for concentrations of DM, CP, GE, and Cr.

For Exp.2, five finishing barrows (avg initial BW of 160 lb) were used in a 25-d metabolism trial with a 5×5 Latin square design. The pigs were housed in metabolism crates placed in an environmentally controlled building. The pigs were fed three times each day (7:00 am, 1:00 p.m., and 7:00 p.m.) with a feed allowance of $.05 \times BW^{0.9}$. After a 3-d adjustment period, fresh feces were collected twice a day for 2 d; dried; ground; and analyzed for DM, CP, GE, and Cr. The treatments were the same as in the nursery trial, except the diets were formu-

[1]Appreciation is extended to the Kansas State Board of Agriculture and the Kansas Sorghum Commission for funding this project.

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lated to .6% lysine, .55% Ca, and .5% P, with the sorghum ground to 550μm.

In Exp.3, 480 broiler chicks (avg initial BW of 98g) were used in a 21-d growth assay with 20 treatments (five genotypes × four processing methods). Chicks were housed (five chicks/pen and five pens/treatment) in brooder batteries and allowed ad libitum access to feed and water. Feces were collected during the last 2 d of the growth assay; dried; ground; and analyzed for DM, N, GE, and Cr. All diets were sorghum-SBM based and formulated to 1.32% lysine, 1.1% Ca, and 0.9% P. The sorghums used in the chick assay were cold (coarsely ground to 1000 μm and finely ground to 450 μm) and thermally (steam-flaking and extrusion) processed.

Results and Discussion

Physical and chemical characteristics of the grain were typical for sorghum (Table 2) except for the distinctions made about kernel hardness. Energy required to coarsely grind, steam flake, and extrude the sorghums was similar, except that less energy was needed to finely grind the soft vs medium and hard sorghums. When fed to nursery pigs, the greatest (P<.08) digestibilities of DM, N, and GE were observed with soft sorghum (Table 4). A difference in digestibility of DM and GE among the medium and hard sorghums also was observed (P<.04), primarily because of the poor digestibility of genotype 279.

In finishing pigs, endosperm hardness did not affect nutrient digestibility (P>.1). However, there was a trend for lower digestibility of N with genotype 279 vs PL-1 (P<.07).

For broiler chicks (Table 5 and 6), those fed soft sorghum were more efficient than those fed the medium and hard sorghums (P<.03). Also, chicks fed steam-flaked sorghum had greater ADG (P<.001) and better F/G (P<.06) than chicks fed extruded sorghum. One notable interaction (P<.03) occurred among the sorghum genotypes and processing technologies, with the nutritional value of soft sorghum responding most to cold processing (grinding) and the nutritional value of the medium and hard sorghums responding best to thermal processing.

Digestibilities of DM, N, and GE were less (P<.001) for soft sorghum than for the medium and hard sorghums, especially when extruded. These results are problematic, especially in view of the better digestibility for soft sorghum in nursery pigs and the better growth performance of broiler chicks fed soft sorghum. Digestibilities of DM, N, and GE were improved (P<.02) by thermal processing (Table 6). Fine grinding was better than coarse grinding (P<.001), and steam flaking was better than extrusion (P<.02).

In conclusion, soft sorghum required less energy to process (especially fine grinding) than the medium and hard sorghums. Also, nutrient digestibility in nursery pigs and F/G for chicks was best with the soft sorghum. Of the processing technologies, fine grinding seemed to have the greatest promise with soft sorghum, but steam flaking was particularly useful for the medium and hard endosperm genotypes.

Table 1. Compositions of Basal Diets with Exotic Sorghum Genotypes (Exps. 1, 2, and 3)[a]

Ingredient, %	Nursery (Exp.1)	Finisher (Exp. 2)	Chick (Exp. 3)
Sorghum	94.40	96.30	53.30
Soybean meal (46.5% CP)	--	--	39.80
Tallow	--	--	1.00
Monocalcium phosphate	1.60	1.10	2.30
Limestone	1.01	.85	1.50
Salt	.35	.30	.50
Vitamin premix	.25	.15	.23
Mineral premix	.15	.10	.28
Sow add pack	.03	.05	.26
L-lysine HCl	.60	.40	--
L-threonine	.20	.16	.10
DL-methionine	.14	.11	.26
L-tryptophan	.02	.12	--
Copper sulfate	--	--	.06
Antibiotics [b]	1.00	.125	.25

[a]Nursery diets were formulated to .7% lysine, .7% Ca, and .6% P. Finisher diets were formulated to .6% lysine, .55% Ca, and .5% P. Chick diets were formulated to 1.32% lysine, 1.1% Ca, and .9% P.
[b]Nursery diets had 150g/ton apramycin, finisher diets had 40g/ton tylosin, and chick diets had 100g/ton chlortetracycline and .0125% amprolium.

Table 2. Characteristics of Exotic Sorghum Genotypes

	Soft	Medium		Hard	
Item	851171	279	PL-1	475	Segolane
Physical traits					
Pericarp color	white	red	yellow	cream	cream
Endosperm color	white	white	yellow	white	white
Texture [a]	soft	medium	medium	hard	hard
Starch type [b]	normal	normal	normal	normal	normal
Chemical analyses					
Moisture, %	9.7	10.2	10.6	10.8	10.9
CP, %	9.2	9.2	10.5	8.6	9.9
Fat, %	3.3	3.5	3.4	3.0	3.6
Lysine, %	.28	.23	.23	.21	.21

[a]Texture was determined using the Single Kernel Characterization (SKC) method.
[b]Starch type was determined with the method of counting iodine-stained granules with a haemocytometer.

Table 3. Processing Energy Consumption of Sorghum Genotypes, kwh/t

	Soft	Medium		Hard		Processing
Item	851171	279	PL-1	475	Segolane	Mean
Coarse [a]	1.8	1.9	2.1	1.8	1.8	1.9
Fine [b]	1.9	3.2	2.9	2.6	2.9	2.7
Flaked [c]	3.0	3.5	3.0	3.3	2.7	3.1
Extruded [d]	68.2	76.6	67.5	71.8	70.0	70.8
Genotype mean	18.7	21.3	18.9	19.9	19.4	

[a]Ground in a roller mill to a mean particle size of 1,039 μm.
[b]Ground in a roller mill to a mean particle size of 440 μm.
[c]Steam flaked at 150°F.
[d]Extruded at 235°F.

Table 4. Effects of Sorghum Geneotype on Nutrient Digestibility in Nursery and Finishing Pigs

	Soft	Medium		Hard			Contrast[a]			
Item	851171	279	PL-1	Segolane	475	SE	1	2	3	4
Nursery, % [b]										
DM	84.3	75.0	84.8	83.1	83.9	1.2	.08	.03	.001	--[d]
N	65.8	30.3	62.0	53.4	55.9	3.9	.01	--	.001	--
GE	80.5	68.0	81.3	78.8	79.9	1.7	.07	.04	.001	--
Finishing, % [c]										
DM	90.2	89.5	90.1	90.5	90.0	.5	--	--	--	--
N	78.0	73.2	78.6	76.7	77.1	1.8	--	--	.07	--
GE	90.0	89.0	89.5	90.2	89.6	.6	--	--	--	--

[a]Contrast were: 1) soft vs others; 2) medium vs hard; 3) medium vs medium; and 4) hard vs hard.
[b]A total of 60 pigs (avg initial BW of 32 lb).
[c]Five finishing pigs (avg initial BW of 160 lb).
[d]Dashes indicated P>.1.

Table 5. Effects of Sorghum Genotypes and Processing on Growth Performance in Chicks[a]

	Soft	Medium		Hard		Processing
Item	851171	279	PL-1	475	Segolane	mean
ADG, g [b]						
Coarse	47.2	48.6	47.6	47.5	50.3	48.2
Fine	49.6	48.2	46.7	49.1	47.6	48.2
Flaked	48.7	51.7	49.9	49.6	49.3	49.8
Extrude	43.3	43.6	45.2	43.8	48.5	44.8
Genotype mean	47.4	48.3	47.3	47.5	48.9	SE 1.4
ADFI, g [c]						
Coarse	73.4	90.7	91.2	92.2	77.5	85.0
Fine	66.5	83.5	90.9	94.7	88.2	84.8
Flaked	77.6	75.6	84.4	74.3	71.9	76.4
Extruded	70.0	85.1	80.2	73.6	77.5	77.1
Genotype mean	72.0	83.7	87.2	83.7	78.8	SE 6.4
F/G [d]						
Coarse	1.53	1.87	1.91	1.79	1.50	1.70
Fine	1.33	1.71	1.77	1.92	1.85	1.69
Flaked	1.56	1.41	1.67	1.43	1.49	1.49
Extruded	1.61	1.92	1.75	1.64	1.52	1.67
Genotype mean	1.49	1.69	1.78	1.67	1.57	SE 0.1

[a]A total of 480 chicks was used (five chicks/pen and five pen/trt) with an avg initial BW of 98 g. [b]Flake vs extruded (P<.001). [c]Soft vs others (P<.003); ground vs thermally processed (P<.01); soft vs others × ground vs thermally processed (P<.05). [d]Soft vs others (P<.03); flaked vs extruded (P<.06); soft vs others × ground vs thermally processed (P<.03).

Table 6. Effects of Sorghum Genotypes and Processing on Nutrients Digestibility in Chicks[a]

	Soft	Medium		Hard		Processing
Item	851171	279	PL-1	475	Segolane	Mean
DM, % [b]						
Coarse	67.5	71.2	67.9	72.9	71.3	70.2
Fine	69.5	73.7	74.8	73.0	73.4	72.9
Flaked	75.1	77.1	77.0	72.3	75.4	75.3
Extrude	68.9	76.0	74.5	74.6	75.8	74.1
Genotype mean						
CP, % [c]						
Coarse	58.8	60.2	56.6	64.0	59.5	59.8
Fine	59.4	63.0	69.4	66.3	61.6	63.0
Flaked	62.9	65.9	66.7	62.1	63.8	64.2
Extruded	58.2	65.2	63.8	63.4	63.9	63.0
Genotype mean						
GE, % [d]						
Coarse	73.7	75.7	74.2	77.4	76.7	75.5
Fine	77.1	78.1	80.2	78.7	78.4	78.5
Flaked	80.1	81.8	81.1	77.8	81.4	80.6
Extruded	74.9	79.7	80.0	79.1	79.9	78.8
Genotype mean	76.5	78.8	78.9	78.3	79.1	SE .8

[a]A total of 480 chicks was used (five chicks/pen and 5 pen/trt) with an avg initial BW of 98 g. [b]Soft vs others (P<.001); ground vs thermally processed (P<.001); flaked vs extruded (P<.02); coarse vs fine (P<.001); soft vs others × flaked vs extruded. [c]Soft vs others (P<.001); ground vs thermally processed (P<.02); coarse vs fine (P<.001); soft vs others × coarse vs fine (P<.07). [d]Soft vs others (P<.001); ground vs thermally processed (P<.001); coarse vs fine (P<.001); flaked > extruded (P<.001); soft vs others × flaked vs extruded (P<.003).