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THE NUTRITIONAL VALUE OF HIGH MOISTURE AND RECONSTITUTED SORGHUM GRAIN FOR SWINE[1,2,3]

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Summary

A growing-finishing experiment involving 150 crossbred swine (replicated by time) and two metabolism experiments involving 36 crossbred barrows were conducted to determine the nutritional value of harvested high moisture (HMSG), reconstituted (RCSG) and dry sorghum grain (DSG) for swine. In Exp. 1, pigs fed HMSG diets gained the same, consumed similar amounts of feed, but less (P<.05) crude protein (equivalent dry matter basis) and had better (P<.05) feed conversion than pigs fed DSG diets. Dietary treatments for Exp. 2 were formulated with whole (WRCSG), rolled reconstituted sorghum grain (RRCSG) or DSG, balanced on an isonitrogenous dry matter basis. For Exp. 3, dietary treatments were WRCSG, HMSG and DSG diets balanced on an equivalent lysine and dry matter basis. The results of the metabolism experiments supported the improved feed conversion observed with HMSG in Exp. 1. In Exp. 2 and 3, pigs fed diets containing HMSG that had been stored in anaerobic structures consumed more (P<.02) digestible (DE) and metabolizable (ME) energy than did those fed DSG. In Exp. 3, N digestibility (ND) was higher (P<.02) in pigs fed WRCSG than in those fed the other two dietary treatments. Also for Exp. 3, dry matter digestibility, DE and ME intakes and energy digestibility were higher (P<.05) for WRCSG than for HMSG. Although pigs fed HMSG and WRCSG (Exp. 3) had a higher N balance (P<.01) than those fed DSG, the apparent biological value was not significantly different among the treatments, indicating that although fermentation enhances the ND of sorghum grain, it does not alter the efficiency by which the absorbed N is utilized.

(Key Words: Swine, High Moisture, Reconstitution, Sorghum Grain, Digestibility.)

Introduction

Storage of high moisture (HM) grain eliminates the drying process, thereby reducing energy needs. However, to store HM grain economically, continuous use of storage facilities is essential. When HM grain supplies are depleted, dry grain can be reconstituted (RC) with water and stored in a HM grain-storage structure. To economically justify reconstitution, the feeding value of RC grain must be superior to that of dry grain.

Tanksley (1972), Allee et al. (1975), Allee (1976) and Trotter and Allee (1976) have reported that for swine, HM sorghum grain (HMSG) has a feeding value similar to dry sorghum grain (DSG). Research comparing effects of physical form in storage and type of HM grain (harvested or reconstituted) on digestibility of sorghum grain by swine is limited. Thus, the purpose of the research reported herein was to compare the nutritional value of harvested high moisture, whole or rolled reconstituted sorghum grain with DSG for growing-finishing swine.

Experimental Procedures

Exp. 1. A growing-finishing experiment was conducted on a commercial farm[6] using its standard feeding program. Pigs were housed in a portable finishing unit divided into two pens.

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TABLE 1. COMPOSITION OF EXPERIMENTAL DIETS (EXP. 1)[a]

Ingredient	DSG Dry matter basis	DSG As-fed basis	HMSG Dry matter basis	HMSG As-fed basis
	%			
Dry sorghum grain[b] (IFN 4-05-643)	73.20	73.80		
High moisture sorghum grain[b] (IFN 4-05-643)			71.90	74.10
Soybean meal (44% CP, IFN 5-04-604)[b]	23.70	23.40	25.00	23.20
Salt (IFN 6-04-151)	.25	.20	.25	.20
Vitamin A, D, E supplement[c]	.10	.10	.10	.10
Commercial premix[d]	2.50	2.30	2.50	2.20
Antibiotic[e]	.25	.20	.25	.20

[a]Diets were those ordinarily fed by the commercial swine operation of Mr. Arnold Schroder, RFD, Palmyra, NE 68418.

[b]Percentages varied depending on calculations based on analyses of crude protein and dry matter content.

[c]Provided a minimum of 3,307 USP units vitamin A, 1,102 USP units vitamin D_3 and .55 IU vitamin E per kg of diet.

[d]Nutrients met or exceeded 1979 NRC recommendations.

[e]Excluded from 14% crude protein diets.

Because only one unit was available, only one replication/treatment was tested at a time. Fifty crossbred pigs were randomly allotted to two treatments with one pen$\cdot$treatment$^{-1}\cdot$replicate^{-1} (13 barrows and 12 gilts/pen). Replication 1 was started on April 14, 1979 and ended on August 8, 1979 (116 d) and replications 2 and 3 were started on December 21, 1979 and April 26, 1980 and ended on March 22, 1980 (91 d) and August 8, 1980 (104 d), respectively. Pigs used in the first replication were from the farm herd and those used in replications 2 and 3 were from the University of Nebraska herd.

The experimental treatments, shown in table 1, were formulated with DSG and HMSG. Pigs were fed a 16% crude protein diet during the growing phase (18 to 45 kg), then switched to a 14% crude protein diet for the finishing phase (45 to 91 kg). Sorghum grain for the diets fed in replication 1 was harvested in 1978, whereas the sorghum grain used in diets for replications 2 and 3 was harvested in 1979. Moisture contents of the sorghum grain are shown in table 2.

The HMSG was stored in an oxygen-limiting structure[7]; DSG was stored in a conventional metal bin. Diets for replications 1 and 2 were calculated biweekly on an equivalent (100%) dry matter basis to contain the suggested nutrient requirements for growing and finishing swine (NRC, 1979). The diets in replication 3 were calculated at the beginning of the experiment and at the changeover from a 16 to a 14% crude protein diet. Diets were formulated on the basis of analyzed crude protein and dry matter contents of DSG, HMSG and soybean meal samples collected the previous week. Samples of grain, soybean meal and experimental diets were collected weekly and frozen for later analysis. Diets were processed with a hammermill mixing system[8], weighed and placed in stainless steel feeders[7]. The mixing system was adjusted on a volume-flow rate basis and recalibrated according to variations in the moisture content of the grain. The diets were mixed and the feeders were filled daily or every other day; feed was available continuously. Pigs were weighed and feed intake was recorded biweekly, according to a standard protocol established by the Nebraska Experiment Station researchers.

Exp. 2 and 3. Thirty-six crossbred barrows were used in two metabolism experiments to determine the apparent digestibility of rolled

[7]A. O. Smith Harvestore Products, Inc., Arlington Heights, IL.

[8]Mix Mill, Model D, Ag-Matic Milling of Nebraska, Lincoln, NE.

(RRCSG) or whole reconstituted sorghum grain (WRCSG), HMSG and DSG diets. Two groups of nine barrows were randomly allotted to three treatments/experiment (six pigs·treatment^{-1}·experiment^{-1}). Average initial weight of barrows used in Exp. 2 and 3 was approximately 30 kg. Dietary treatments for Exp. 2 were (1) RRCSG, (2) WRCSG and (3) DSG diets formulated to be isonitrogenous on a dry matter basis (table 3). For Exp. 3, treatments were (1) WRCSG, (2) HMSG and (3) DSG diets formulated to contain the same lysine content on a dry matter basis (table 3). Diets for both experiments were formulated to meet the suggested nutrient requirements for growing (20 to 35 kg) swine (NRC, 1979).

Each group of pigs involved in the metabolism study was housed in a mechanically heated and ventilated room containing 1.5 × 1 m pens. The pigs were individually fed their assigned dietary treatments for 5 d, after which they were weighed and placed in adjustable, circular metabolism crates. After a 3-d adjustment period to the metabolism crates, urine, feces and orts were collected daily for 5 d. While in the metabolism crates, pigs were fed once daily. For DSG treatments, daily feed intake = body weight (kg)$^{.9}$ × .05; for HMSG, RRCSG or WRCSG treatments, daily feed intake = body weight (kg)$^{.9}$ × .05 × percentage dry matter of the DSG treatment ÷ the percentage dry matter of the respective HMSG, RRCSG or WRCSG treatments.

The feces and orts collected daily were frozen until analyzed. Urine was collected by allowing it to flow into a plastic container with 100 ml of a 10% (v/v) solution of technical grade concentrated HCl. Daily urine collections were measured and diluted with distilled water to the nearest 500 ml, mixed, subsampled (2% of daily diluted volume) and frozen for later analysis.

For Exp. 2, DSG was obtained from a local grain elevator. Whole or rolled DSG was reconstituted by adding sufficient amounts of water to raise the moisture content of the grain to 25%. The DSG and water were mixed in an industrial mixer[9] for about 15 min to allow time for the water to adhere or soak into the grain. The wet grain was then placed into

[9] Hobart L800 Food Mixer, The Hobart Mfg. Co., Troy, OH.

TABLE 2. PERCENTAGE OF MOISTURE AND CRUDE PROTEIN IN SORGHUM GRAIN TYPES

		Grain types							
		Moisture (%)				Crude protein (%)[a]			
Experiment	Replication	DSG	HMSG	WRCSG	RRCSG	DSG	HMSG	WRCSG	RRCSG
1[b]	1	11.6	21.0			10.9	9.9		
	2	16.6	25.7			11.0	9.5		
	3	14.6	25.9			10.3	9.9		
2		11.5		25.1	25.3	9.7		9.8	10.0
3		15.5	29.5	29.6		10.7	11.8	11.7	

[a]Values expressed on a 100% dry matter basis.

[b]Values are an overall average of weekly samples analyzed in duplicate.

TABLE 3. COMPOSITION OF DIETARY TREATMENTS (EXP. 2 AND 3)

Treatment (dry matter basis)[a]: Ingredient	Exp. 2 (1) RRCSG[b]	(2) WRCSG[b]	(3) DSG[b]	Exp. 3 (1) WRCSG[b]	(2) HMSG[b]	(3) DSG[b]
Sorghum grain (IFN 4-04-383)	76.01	75.53	75.26	75.10	75.10	75.14
Soybean meal (IFN 5-04-604)	21.35	21.83	22.14	22.14	22.14	22.15
Dicalcium phosphate (IFN 6-01-080)	1.12	1.11	1.06	.88	.88	.88
Limestone (IFN 6-01-069)	.87	.88	.89	1.23	1.23	1.18
Iodized salt	.50	.50	.50	.50	.50	.50
Trace mineral premix[c]	.05	.05	.05	.05	.05	.05
Vitamin premix[d]	.10	.10	.10	.10	.10	.10

[a]Respective analysis of percentage crude protein (dry matter basis) for experiment and dietary treatment were: 18.0, 18.0, 18.0, 20.0, 20.6 and 18.9. Respective analysis of percentage lysine (dry matter basis) for experiment and dietary treatment were: .81, .85, .82, .88, .85 and .90.

[b]RRCSG (rolled reconstituted sorghum grain); WRCSG (whole reconstituted sorghum grain); HMSG (high moisture sorghum grain) and DSG (dry sorghum grain).

[c]Contributed the following in mg/kg diet: Zn, 100; Fe, 50; Mn, 27.5; Cu, 5; Co, .5; I, .75.

[d]Contributed the following per kg diet: vitamin A, 3,300 USP; vitamin D_3, 440 IU; riboflavin, 2.2 mg; D-pantothenic acid, 13.2 mg; niacin, 17.6 mg; choline chloride, 110.2 mg; vitamin B_{12}, 22.0 g; ethoxyquin, 4.4 mg; menadione sodium bisulfate, 2.2 mg; vitamin E, 22.0 IU.

"laboratory silos" and allowed to ferment under anaerobic conditions at room temperature (20 C) for at least 21 d before feeding. Laboratory silos were 91.4-cm sections of 15.2-cm diameter, polyvinyl chloride (PVC) pipe, fitted and caulked to wooded bases. The tops of the experimental silos were covered with a plastic sheet, taped and sealed with rubber sealant. The nonensiled DSG was stored in paper sacks at room temperature (20 C).

The HMSG for Exp. 3 was harvested on a private farm[6] in 1979 and unloaded from a combine into 208-liter drums lined with plastic bags. The bags were sealed with tape and the HMSG was stored at room temperature until use. Later, DSG was harvested from the same field. Some of the DSG was reconstituted to 30% moisture as described in Exp. 2, placed in 208-liter drums lined with plastic bags, sealed and stored at room temperature for at least 21 d before feeding. The remaining DSG was stored in open 208-liter drums at room temperature (20 C).

For Exp. 2 and 3, each sorghum grain type was ground in a hammermill before mixing into complete diets. Reconstituted and HMSG diets were refrigerated (4 C) before feeding to prevent mold growth, then allowed to equilibrate to room temperature to reduce any possible effects of cold feed on palatability.

Laboratory Analysis. Nitrogen content of grain, soybean meal, diets, feces and urine was determined using a Kjeldahl procedure[10] similar to that described by AOAC (1980). Dry matter content of sorghum grain, soybean meal, diets and feces was determined by weighing about 4 g of freshly thawed sample into a crucible, drying the sample at 105 C for 12 h, then reweighing the dried sample after cooling in a dessicator. Weight loss of the sample was assumed to be moisture loss. Orts were dried in aluminum trays for about 48 h at 60 C, allowed to cool and the dried weight subtracted from the total dry matter intake. Gross energy contents of diets and feces were determined using a bomb calorimeter[11] by methods described by Parr (1978).

Total feces collections were thawed, mixed with distilled water and weighed. Subsamples of mixed feces were freeze dried, then ground before analysis for N and gross energy.

Gross energy content of urine (Exp. 2) was determined by pipeting 5 ml of urine onto

[10]Tecator Kjeltec System, 1003 distilling unit and Tecator Kjeltec System 20 digestor, Hoganas, Sweden.

[11]Model 1241 Adiabatic Calorimeter, Parr Instrument Co., Moline, IL.

cellulose blocks contained in metal cups. The prepared samples were allowed to dry at room temperature about 1 d, then analyzed for gross energy content by procedures previously described for feeds. Gross energy content of urine was corrected by subtracting the average analyzed energy content of five cellulose blocks. Urine samples from Exp. 3 were analyzed for energy content similarly to urine samples from Exp. 2 except that powdered cellulose was used as a carrier instead of cellulose blocks.

Statistical Analysis. A completely randomized design was used for Exp. 1 according to procedures outlined by Steel and Torrie (1960). Pen averages of treatment and replication were tested with the treatment × replication interaction (2 degrees of freedom) as the error term using the F-test with a general linear regression model described by Barr et al. (1976). Experiments 2 and 3 were designed as a randomized complete block design (Steel and Torrie, 1960). Initial weight of the pigs was used to determine their daily feed allotment. Therefore, means of the response criteria of the individual pigs were analyzed using the F-test with orthogonal treatment comparisons and a general linear regression model adjusted by initial weight as a covariate (Barr et al., 1976).

Results and Discussion

Exp. 1. The effects of dietary treatments on average daily gain (ADG), average daily feed intake (ADFI), feed to gain ratio (F/G) and average daily crude protein intake (ADCPI) are shown in table 4. Significant differences were observed among replications for ADG, ADFI, F/G and ADCPI. Lower ADG, ADFI, ADCPI and poorer F/G was noted for replications 1 and 3 compared with replication 2. Replications 1 and 3 were conducted during the summer months and replication 2 was conducted during the winter months. The internal environment in the portable finishing unit was more suitable for optimum performance during the winter months as compared with the summer months. Thus, the differences in response criteria between replications may have been due to seasonal variation.

Although there were no significant differences due to treatments, there was a tendency for ADG to be improved in pigs fed HMSG in replications 2 and 3; however, the reverse was observed in replication 1. Due to harvesting conditions (rapid field drying), HMSG used in replication 1 contained 21% moisture (table 2) while HMSG used in replications 2 and 3 contained 26% moisture. The slight differences of trend in gain among the replications may have been due to lack of adequate moisture for optimum fermentation in the HMSG fed in replication 1. In vitro studies by Neuhaus and Totusek (1971) showed that dry matter digestibility of HMSG increased with increasing moisture levels (13, 17, 22, 26, 30 and 35%), with the greatest increase occurring between 22 and 26% moisture. Goodrich et al. (1975) found that with increasing moisture levels (21.5, 27.5 and 33.1%) in corn, total acid and ethanol production increased, indicating that more fermentation occurred at the higher moisture levels. Similar results were obtained by Byers et al. (1971) with high moisture corn ensiled at 21.5, 27.8 and 33.1% moisture.

Average daily feed intake was not affected by treatments. Pigs fed HMSG consumed 2.48, 3.31 and 2.78% less feed, respectively, on an equivalent dry matter basis during the growing, finishing and growing-finishing phases than those fed DSG. The F/G was improved and replication effects were significant for pigs fed HMSG during the growing-finishing phase. During the growing, finishing and growing-finishing phases, pigs fed HMSG were, respectively, 6.61, 1.55 and 2.22% more efficient in converting feed to gain than those fed DSG. These results are similar to those obtained by others. Tanksley (1972) observed a 5.2% improvement in feed efficiency of growing-finishing swine fed HMSG stored in an oxygen-limiting structure compared with swine fed DSG. Similar trends in feed conversion were observed by Allee et al. (1975) and Allee (1976) with weanling pigs fed HMSG stored in oxygen-limiting structures.

Average daily crude protein intake was calculated from analyses of crude protein and dry matter of dietary samples taken on a weekly basis. Values shown (table 4) are the average of crude protein content (dry matter basis) times the feed intake (dry matter basis) from each biweekly period. Although the diets were balanced on an isonitrogenous dry matter basis, unexplained differences in the protein content of the diets occurred. Significant treatment and replication effects ($P<.05$) were observed in ADCPI during the growing and growing-finish-

TABLE 4. RESPONSE OF SWINE FED HIGH MOISTURE OR DRY SORGHUM GRAIN DIETS (EXP. 1)[a]

	Growing		Finishing		Combined growing-finishing	
Replication	HMSG	DSG	HMSG	DSG	HMSG	DSG
			Average daily gain, kg[b]			
1	.59	.65	.62	.64	.60	.64
2	.76	.69	.82	.83	.80	.79
3	.63	.55	.65	.66	.65	.63
Avg of replications	.66	.63	.69	.71	.68	.68
% difference[c]	4.76		−2.82		0	
CV[d]	8.76		.70		3.01	
			Average daily feed intake, kg[bef]			
1	1.52	1.68	2.08	2.25	1.87	2.04
2	1.71	1.69	2.65	2.71	2.35	2.39
3	1.49	1.47	2.28	2.30	2.07	2.07
Avg of replications	1.57	1.61	2.34	2.42	2.10	2.16
% difference[c]	−2.48		−3.31		−2.78	
CV[d]	4.42		2.36		2.87	
			Feed to gain ratio[efg]			
1	2.58	2.57	3.37	3.54	3.10	3.17
2	2.25	2.44	3.23	3.26	2.95	3.01
3	2.37	2.66	3.51	3.48	3.19	3.28
Avg of replications	2.40	2.57	3.37	3.43	3.08	3.15
% difference[c]	−6.61		−1.55		−2.22	
CV[d]	4.42		1.81		.35	
			Average daily crude protein intake, kg[ehi]			
1	.27	.32	.36	.39	.33	.37
2	.32	.37	.42	.48	.39	.40
3	.20	.29	.39	.40	.34	.37
Avg of replications	.27	.33	.39	.42	.35	.39
% difference[c]	−18.18		−7.14		−10.26	
CV[d]	5.34		3.94		2.16	

[a]Pen average, one pen•treatment^{-1}•replication^{-1}; 25 pigs/pen (23 pigs/pen for replication 3, dry treatment).

[b]Replication effects (P<.05) for the finishing phase.

[c]% difference = (avg HMSG value − avg DSG value) ÷ avg DSG value × 100.

[d]CV = coefficient of variation, %.

[e]Values expressed on an equivalent dry matter (100%) basis.

[f]Replication effects (P<.05) for the growing-finishing phase.

[g]Treatment effects (P<.05) for the growing-finishing phase.

[h]Treatment and replication effects (P<.05) for the growing and growing-finishing phases.

[i]Replication effects (P<.09) finishing phase.

ing phases. Also, slight differences (P<.07) existed among replications during the finishing phase. During the growing, finishing and growing-finishing phases, pigs given HMSG diets consumed 18.18, 7.14 and 10.26% less crude protein, respectively, than pigs fed the DSG diets. Apparently the pigs fed HMSG diets performed as well as or better than those fed DSG diets, even though they consumed less protein. However, the protein intakes of pigs fed both treatments met or exceeded NRC (1979) requirements for swine. Speer (1979) found no evidence that growing-finishing pigs respond differently to various crude protein levels when fed dry or high moisture corn. Yet, Trotter and Allee (1976) reported trends toward improved protein digestibility of HMSG diets compared with DSG diets for swine.

Exp. 2 and 3. Results of dry matter digestibility for both experiments are shown in table 5. Dry matter intake (DMI) and dry matter digestibility (DMD) were similar among treatments in Exp. 2. However, DMD was slightly higher in pigs fed RRCSG diets (91.0%) than in pigs fed WRCSG (90.2%) or DSG (90.0%). No reports on swine digestibility studies comparing WRCSG or RRCSG fed to swine were found in the literature. However, Neuhaus and Totusek (1971) found improvements in in vitro dry matter digestibility with WRCSG compared with RRCSG. Byers et al. (1971) reported similar improvements in in vitro dry matter digestibility of whole ensiled high moisture corn compared with rolled ensiled high moisture corn.

In Exp. 3, DMI was higher for pigs given WRCSG or HMSG diets than for those fed DSG ($P<.002$). The DMD was greater ($P<.03$) in pigs fed WRCSG (89.7%) than in those fed HMSG diets (87.2%). Research comparing DMD of WRCSG and HMSG for swine was not found in the literature but in an associated area of research, Danley and Vetter (1974) observed a higher in vitro DMD of dried reconstituted ensiled corn (22% moisture) compared with ensiled (22% moisture) corn.

Results of criteria used to assess energy utilization are shown in table 6. In Exp. 2, gross energy intake (GEI), digestible energy intake (DEI) and metabolizable energy intake (MEI) were higher ($P<.02$) in pigs fed RRCSG or WRCSG diets than in those fed DSG diets. Apparent energy digestibility (ED) was not influenced by dietary treatments.

For Exp. 3, higher GEI, DEI and MEI ($P<.02$) were noted in WRCSG and HMSG diets compared with the DSG diet. Also, DEI, MEI and ED were higher ($P<.05$) for the WRCSG diet than for the HMSG diet. The results suggest that harvesting or reconstituting sorghum grain ensiled at 30% moisture improves DEI and MEI compared with DSG. Also, reconstitution of natural dried sorghum grain at 30% moisture further enhances ($P<.05$) ED over HMSG ensiled at 30% moisture.

Research comparing ED of reconstituted or HMSG are limited. Holmes et al. (1973) and Bayley et al. (1974) have reported improved ED of ground-ensiled high moisture corn compared with dry corn when fed to swine. Trotter and Allee (1976) did not observe any differences in ED by swine fed HMSG (27% moisture) compared with those fed DSG.

Results of N metabolism are shown in table 7. No differences were observed among treatments in Exp. 2 for any of the N metabolism criteria evaluated. However, slightly improved N digestibility (ND) was observed in pigs fed RRCSG (85.6%) compared with those fed WRCSG (83.7%) or DSG (83.1%). Yet, in pigs fed RRCSG diets, lower N balance (NB), N retained (NR) and apparent biological value of N (BVN) were observed compared with pigs provided WRCSG or DSG. These trends suggest that the N of RRCSG diets may be readily digested and absorbed in the pig but may not be as efficiently utilized as the N contained in WRCSG or DSG.

In Exp. 3, the effect of dietary treatments on N metabolism was similar to that observed for energy metabolism. The NB and ND were higher ($P<.01$) for pigs fed WRCSG or HMSG diets than for those fed DSG diets. Also, higher

TABLE 5. EFFECT OF HIGH MOISTURE SORGHUM GRAIN ON DRY MATTER DIGESTIBILITY IN SWINE (EXP. 2 AND 3)[a]

Treatment	Dry matter intake g/d[bc]	Dry matter digestibility, %[d]
Exp. 2		
1 (RRCSG)	955.1	91.0
2 (WRCSG)	953.2	90.2
3 (DSG)	948.7	90.0
CV[e]	1.51	1.37
Exp. 3		
1 (WRCSG)	944.5	89.7
2 (HMSG)	941.8	87.2
3 (DSG)	903.8	88.1
CV[e]	1.05	1.21

[a]Treatment means (dry matter basis) adjusted by initial weight as a covariate; six pigs/treatment.

[b]Initial weight effect ($P<.001$).

[c]Treatments 1 + 2 vs 3 ($P<.002$) for Exp. 3.

[d]Treatments 1 vs 2 ($P<.03$) for Exp. 3.

[e]CV = coefficient of variation, %.

TABLE 6. EFFECT OF HIGH MOISTURE SORGHUM GRAIN ON ENERGY METABOLISM IN SWINE (EXP. 2 AND 3)[a]

Treatment	Gross energy intake, Mcal/d[bc]	Apparent digestible energy intake, Mcal/d[bcd]	Apparent metabolizable energy intake, Mcal/d[bcd]	Apparent energy digestibility, %[d]
Exp. 2				
1 (RRCSG)	4.24	3.81	3.57	89.89
2 (WRCSG)	4.23	3.76	3.56	88.85
3 (DSG)	4.13	3.65	3.45	88.50
CV[e]	1.48	1.93	2.12	1.68
Exp. 3				
1 (WRCSG)	4.20	3.71	3.58	88.39
2 (HMSG)	4.21	3.61	3.48	85.86
3 (DSG)	3.96	3.41	3.29	86.17
CV[e]	1.06	1.89	1.67	1.26

[a]Treatment means (dry matter basis) adjusted by initial weight as a covariate; six pigs/treatment.

[b]Initial weight effect ($P<.02$).

[c]Treatments 1 + 2 vs 3 ($P<.02$).

[d]Exp. 3, treatment 1 vs 2 ($P<.05$).

[e]CV = coefficient of variation, %.

TABLE 7. EFFECTS OF HIGH MOISTURE SORGHUM GRAIN ON NITROGEN METABOLISM IN SWINE (EXP. 2 AND 3)[a]

Treatment	N intake, g/d[bcdef]	N balance, g/d[e]	N retained, %	Apparent N digestibility, %[ef]	Apparent biological value of N, %
Exp. 2					
1 (RRCSG)	27.49	12.25	44.63	85.62	52.00
2 (WRCSG)	27.39	13.00	47.38	83.72	56.57
3 (DSG)	27.37	12.50	46.25	83.13	55.15
CV[g]	1.56	8.43	7.60	2.88	8.31
Exp. 3					
1 (WRCSG)	30.18	13.90	46.08	85.96	53.58
2 (HMSG)	31.01	13.60	43.86	82.84	53.01
3 (DSG)	27.39	11.64	42.53	79.38	53.64
CV[g]	1.10	6.04	6.08	2.13	6.50

[a]Treatment means (dry matter basis) adjusted by initial weight as covariate; six pigs/treatment.

[b]Exp. 2, treatment × group interaction ($P<.02$); initial weight effect ($P<.0002$).

[c]Exp. 3, group effects ($P<.02$).

[d]Exp. 3, initial weight effect ($P<.01$).

[e]Exp. 3, treatments 1 + 2 vs 3 ($P<.01$).

[f]Exp. 3, treatments 1 vs 2 ($P<.02$).

[g]CV = coefficient of variation, %.

ND were observed in pigs given WRCSG diets than in those fed the HMSG diets (P<.02). Dietary treatments did not influence BVN. These data indicate that the N components in WRCSG and HMSG were more readily digested than those in DSG. Also, reconstitution further enhanced ND for swine as compared with ensiling high moisture grain.

The digestibility coefficients and BVN were numerically higher for the WRCSG and DSG in Exp. 2 compared with the same two respective grain types in Exp. 3. The differences in digestibility coefficients between experiments may have been due to several factors such as grain variety, source and drying conditions. The sorghum grain used in Exp. 2 was grown at a different location and harvested and stored during a different year. Also, the variety of sorghum grain for each experiment was unknown. For Exp. 2 and 3, ND was not statistically compared between WRCSG and DSG. However, in Exp. 2 there were no differences in ND between WRCSG (83.7%) and DSG (83.1%). Yet in Exp. 3, ND was higher for WRCSG (86.0%) compared with DSG (79.4%). Because statistically WRCSG + HMSG was greater (P<.01) in ND compared with DSG, and WRCSG (86.0%) was greater (P<.02) in ND than HMSG (82.8%), the ND for WRCSG should be statistically greater than DSG. The type of drying (natural or artificial) before reconstitution of the grain may have had some effect on ND. The grain used in Exp. 2 was artificially dried, whereas that used in Exp. 3 was allowed to dry naturally. Rivera et al. 1978) observed a marked decrease in amino acid availability of corn with increasing drying temperature or prolonged drying time. The grain was field-dried in Exp. 3 and the ND of WRCSG was greater than that of DSG, suggesting that ND was enhanced by reconstitution of field-dried sorghum grain.

Based on the metabolism studies, there seems to be a small numerical improvement in the nutritional value of sorghum grain for growing swine when stored under oxygen-limiting conditions as harvested high moisture (30%) or reconstituted (25 or 30% moisture) grain. There is no nutritional advantage to rolling sorghum grain before reconstitution for feeding to growing swine. Further research is needed to determine the minimum and maximum moisture levels for ensiling sorghum grain to optimize its nutritional value for swine.

Literature Cited

Allee, G. L. 1976. Effects of processing methods on the nutritional value of sorghum for weaned pigs. Kansas Agr. Exp. Sta. Swine Industry Day. p 24.

Allee, G. L., B. A. Koch and R. H. Hines. 1975. Effect of grain processing methods on the nutritional value of milo for weaned pigs. Kansas Agr. Exp. Sta. Swine Industry Day. p 1.

AOAC. 1980. Official Methods of Analysis (13th Ed.). Association of Official Analytical Chemists, Washington, DC.

Barr, A. J., J. H. Goodnight, J. P. Sall and J. T. Helwig. 1976. SAS User's Guide. Statistical Analysis System Institute, Cary, NC.

Bayley, H. S., J.H.G. Holmes and K. R. Stevenson. 1974. Digestion by the pig of energy and nitrogen in dried, ensiled and organic acid-preserved corn: with observations on the starch content of digesta samples. Can. J. Anim. Sci. 54:377.

Byers, F. M., R. D. Goodrich, D. C. Pierson and J. C. Meiske. 1971. Fermentation studies with high moisture corn grain. J. Anim. Sci. 33:278 (Abstr.).

Danley, M. M. and R. L. Vetter. 1974. Artificially altered corn grain harvested at three moisture levels. III. In vitro utilization of the carbohydrate and nitrogen fractions. J. Anim. Sci. 38:430.

Goodrich, R. D., F. M. Byers and J. C. Meiske. 1975. Influence of moisture content, processing and reconstitution on the fermentation of corn grain. J. Anim. Sci. 41:876.

Holmes, J.H.G., H. S. Bayley and F. D. Horney. 1973. Digestion and absorption of dry and high-moisture maize diets in the small and large intestine of the pig. Brit. J. Nutr. 30:401.

Neuhaus, V. and R. Totusek. 1971. Factors affecting the in vitro digestibility of high moisture sorghum grain. J. Anim. Sci. 33:1321.

NRC. 1979. Nutrient Requirements of Domestic Animals, No. 2. Nutrient Requirements of Swine. Eighth Revised Ed. National Academy of Sciences-National Research Council, Washington, DC.

Parr. 1978. Instructions for the 1241 and 1242 adiabatic calorimeters. Manual No. 153. Parr Instrument Co., Moline, IL.

Rivera-L., P. H., E. R. Peo, Jr., B. D. Moser, T. D. Crenshaw and P. J. Cunningham. 1978. Effect of drying temperature on nutritional quality and availability of amino acids in normal and Opaque-2 corn for rats. J. Anim. Sci. 46:1275.

Speer, V. C. 1979. High moisture corn for baby pigs. Coop. Ext. Ser. Iowa State Univ., Proc. Pork Prod. Day. AS-494E.

Steel, R.G.D. and J. H. Torrie. 1960. Principles and Procedures of Statistics. McGraw-Hill Book Co., New York.

Tanksley, T. D., Jr. 1972. Organic acid preservation of high-moisture sorghum grain and its feeding value for growing-finishing swine. Proc. 21st Annu. Swine Short Course. College Station, TX. p. 71.

Trotter, M. and G. L. Allee. 1976. High-moisture sorghum for growing-finishing swine. Kansas Agr. Exp. Sta. Swine Day. p 22.