Effects of Fiber Addition (10% Soybean Hulls) to a Reduced Crude Protein Diet Supplemented With Synthetic Amino Acids Versus a Standard Commercial Diet on Pig Performance, Pit Composition, Odor and Ammonia Levels in Swine Buildings

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Introduction

The swine industry is facing many challenges. Environmental awareness and stewardship fall near the top of the list. Producers have to incorporate these criteria into any management decision on the farm. If not, they face the possibility of odor complaints and/or fines levied by state regulatory agencies. In efforts to reduce the amount of odor emission, researchers in industry and academia have designed many different ways to combat this problem. Pit additives, ventilation systems, manure treatment systems, and dietary manipulation are all ways currently available to reduce odor, with some more effective than others.

While many of the ventilation system and manure treatment system alternatives are effective, they are capital intensive. With these methods, there is no reduction in initial nutrient excretion from pigs, but the nutrients are in a more stable, less odorous form. Pit additives can be effective, but again there is no real reduction in the volume of nutrients that must be removed from the operation and it can be a significant increase in diet cost. Dietary manipulation has shown much promise, with most of the research attempting to reduce the crude protein of swine diets by including synthetic amino acids to more closely meet the actual needs of the pig. Some research with this type of dietary manipulation has shown a reduction in performance and an increase in backfat accretion. The poor performance has been attributed to many things, and is perhaps due to an amino acid deficiency, changes in the essential to nonessential amino acid ratio or an upset in the acid-base balance of the animal. Differences in backfat accretion are presumably due to the increased net energy content of the reduced crude protein diets. Adding a fiber source to the reduced crude protein diets should bring net energy into equilibrium.

Previous research at Purdue University has shown that the addition of fiber (soybean hulls) will serve to give microorganisms in the hindgut of the pig an energy source for the production of microbial crude protein (MCP) and volatile fatty acids (VFA). This benefits in three ways. First, additional energy is available to the pig in the form of VFAs for protein or lipid synthesis; second, the increased VFAs will decrease manure pH and reduce volatilization of odorous compounds; and third, more of the excreted nitrogen is incorporated into MCP. By shifting nitrogen excretion from the traditional form of urea in the urine to MCP in the feces, the nitrogen is not volatilized into ammonia. This creates a better building environment for pigs and people, less complaints of ammonia, and more usable N for field application. This trial was conducted to test whether a reduced crude protein diet with the addition of 10% soybean hulls could reduce odor while maintaining similar performance in a production setting.

Materials and Methods

One hundred sixty grow-finish pigs (initial body weight = 133 lb) were placed in two identical, environmentally controlled rooms where they were allotted by weight and sex. There were 4 replications (40 pigs/rep) with treatments rotated between rooms. Ventilation rates were maintained at a ratio of 75% recycled to 25% fresh air, and temperature was kept constant between rooms (68° F). The experiment was for nine weeks. Pigs in both rooms were fed a standard corn-soybean diet for the first 3 weeks (13.1% CP, .70% lysine). Pigs in each room were then fed either a corn-soybean diet (12.4% CP, .65% lysine; HCP) with supplemental lysine (.15%), or a reduced CP diet with the addition of 10% soybean hulls (9.7% CP, .65% lysine; RCPF) with supplemental lysine (.372%), tryptophan (.005%), and threonine (.042%) for the remaining 6 weeks (Table 1). Pigs were weighed and feed consumption recorded at 0, 3, 6, and 9 weeks. At weeks 3, 6, and 9, four-hour aerial ammonia concentration (AAC) samples were taken with Dräger long-term diffusion tubes at pig height (1.5 ft) in 3 different locations, and 10 L Tedlar plastic bags were filled with room air for assessment by an eight-member trained odor panel at Iowa State University. Pit depth was recorded and representative pit samples were collected at 3, 6 and 9 weeks for analysis of pit composition and calculation of pit volume. Pigs were ultrasonically scanned for backfat thickness at the 10th rib on weeks 3 and 9 using an Aloka 210 real-time ultrasound machine.

Results and Discussion

Table 2 shows the overall performance of all 4 replications of pigs. For average daily gain (ADG) and average daily feed intake (ADFI), there were sex differences throughout the trial, with the barrows gaining faster (P<.01) and consuming more feed (P<.001). There were also treatment differences, with the pigs fed HCP having .19 lb/day higher ADG than the RCPF-fed pigs for weeks 3-9 (P<.001). The HCP pigs also had greater gain:feed (G:F, P<.001), which would be expected because 10% soybean hulls was included in the RCPF diet. Ultrasonic measurements of 10th rib backfat showed the gilts accreting less backfat over the six-week test period (P<.01), and there was a trend for the RCPF-fed pigs to have less backfat as well (P<.10). By looking at the data thus far, it would indicate that feeding this level of soybean hulls in a reduced crude protein diet produces poor performance. However, there was much variability in the response to feeding the RCPF diet and in Table 3, ADG and ADFI are split into two groups, replications 1 & 2 and replications 3 & 4.

In the first two replications, there was no difference in ADG (1.74 vs. 1.68 lb/day) or ADFI (6.14 vs. 6.32 lb/day) between pigs fed HCP and RCPF (P>.30). In fact, the barrows fed RCPF had ADG identical to those fed HCP (1.83 lb/day). In addition, there were no differences in backfat at week 9 between pigs fed HCP and RCPF (.75 vs. .79 in.; P>.10). In the second two replications, pigs fed HCP had higher ADG (1.95 vs. 1.62 lb/day; P<.001), and ADFI (6.49 vs. 6.10 lb/day; P<.05), and had more 10th rib backfat accretion over the trial period (.29 vs. .17 in.; P<.001) compared to pigs fed the RCPF diet. The pigs fed RCPF in the second two replications simply did not consume enough feed to compensate for the additional soybean hulls in the diet; this was especially true for gilts. Trypsin inhibitor activity was analyzed in the feed for the trial diets and showed differences, with the pigs fed RCPF diets having higher trypsin inhibitor concentration (Table 7); however, the quantitative amount of trypsin inhibitor is so small that the difference in performance cannot be attributed to this. The investigators have been unable to conclude why the pigs fed RCPF performed so poorly in the latter replications. Further research is necessary to determine an optimum level of soybean hull inclusion without compromising growth in a reduced crude protein diet.

Results of the odor and ammonia data (Table 4) show that the rooms where RCPF was fed had 40% lower AAC readings at week 9 (21.3 vs. 12.5 ppm; $P<.05$). The odor samples collected for olfactometry analysis showed no differences in dilution ratio between HCP and RCPF at week 9 (533 vs. 500; $P>.10$), and hydrogen sulfide readings were numerically lower for pigs fed RCPF diets (.34 vs. .25 ppm; $P<.15$). No differences were detected by the odor panel, which surprised the researchers who worked in the two rooms. This illustrates the difficulty of measuring odor, the variability in odor perception by humans, and the need for an alternative means to quantitatively measure odor.

Pit composition (Table 5) shows differences in concentrations of total nitrogen (TN; $P<.10$) and ammonia ($P<.05$) at week 9, when adjusted for pit volume. There is a similar trend for TN ($P<.11$) and ammonia ($P<.02$) quantity added to the pit over the test period. This was calculated by taking the concentration of TN or ammonia at week 3, multiplying by the pit volume to obtain the total quantity of material in the pit, and subtracting this from week 9 values. Pit sample analysis (Table 6) showed the rooms with RCPF-fed pigs had a greater decrease in pit pH (-.03 vs. -.30 units; $P<.07$). A lower pit pH will acidify the slurry and reduce volatilization of ammonia. There were no differences in the concentration or quantity of phosphorus or potassium in the pit.

Implications

This research suggests that reducing the dietary CP and adding 10% soybean hulls to diets will lower AAC, pit TN, pit ammonia, pit pH, and possibly aerial hydrogen sulfide levels. In the case of the first two replications, it was shown that the RCPF treatment was comparable on a cost per pound of gain basis with the additional benefit of odor and nutrient reduction. However, with the variability in performance, the optimum level of soybean hull addition to a reduced crude protein diet for efficient production and effective odor remediation is being tested further at Purdue. There does appear to be a future for the utilization of soybean hulls and a reduced crude protein diet.

Table 1. Experimental diets.

Ingredient, %	Initial diet	HCP diet	RCPF diet
Corn	81.95	85.92	82.79
SBM-48%	14.18	10.53	3.32
Soybean hulls	---	---	10.00
Yellow swine grease	1.00	1.00	1.00
Dicalcium Phos.	1.27	1.06	1.28
Limestone	.76	.79	.64
Salt	.35	.25	.25
Purdue Swine Vit. Premix	.15[a]	.125[b]	.125[b]
Purdue Swine TM Premix	.0875[c]	.075[d]	.075[d]
Se 600 Premix	.05	.05	.05
Tylan 40	.05	.05	.05
Lysine-HCl	.15	.15	.372
L-Threonine	---	---	.042
Tryptosine (15% Trp, 70% Lys)	---	---	.033
Total	100.00	100.00	100.0
Producer Cost/ton[e]	109.05	104.40	100.54

[a] Provides per lb of diet: 1650 IU Vitamin A, 165 IU D3, 12 IU Vitamin E, .55 mg Menadione, .01 mg B12, 1.92 mg Riboflavin, 6 mg Pantothentic Acid, 9 mg Niacin.

[b] Provides per lb of diet: 1375 IU Vitamin A, 137.5 IU D3, 10 IU Vitamin E, .456 mg Menadione, .008 mg B12, 1.6 mg Riboflavin, 5 mg Pantothentic Acid, 7.5 mg Niacin.

[c] Provides per lb of diet: 85 ppm Zn, 85 ppm Fe, 10.5 ppm Manganese, 7.9 ppm Cu, .29 ppm I.

[d] Provides per lb of diet: 73 ppm Zn, 73 ppm Fe, 9 ppm Manganese, 6.75 ppm Cu, .25 ppm I.

[e] Delivered prices used as of 6/1/99: Corn, $.04/lb ($2.25/bu.); SBM (48%), $.09/lb ($180/ton); Soybean hulls, $.026/lb ($52/ton); Swine Grease, $.15/lb; Dical. Phos., $.15/lb; Limestone, $.05/lb; Salt, $.093/lb; Swine Vitamin Premix, $.80/lb; Swine Trace Mineral Premix, $.30/lb; Se Premix, $.105/lb; Tylan 40, $5.06/lb; Lysine-HCl, $.55/lb; L-Threonine, $1.88/lb; Tryptosine, $3.35/lb.

Table 2. Overall growth performance.

	ADG				ADFI			
Week	0-3	3-6	6-9	3-9	0-3	3-6	6-9	3-9
HCP[a]	1.91	1.87	1.81	1.84	5.21	6.17	6.45	6.32
RCPF[b]	1.93	1.70	1.60	1.65	5.17	5.99	6.43	6.21
Significance[c]	S***	S** T*	S' T***	S** T***	S***	S***	S***	S***
CV	11.6	17.1	14.1	11.8	11.2	11.1	11.3	9.2

	Gain:Feed				10th Rib Backfat		
Week	0-3	3-6	6-9	3-9	Initial	Ending	Change
HCP[a]	.37	.31	.29	.30	.57	.79	.22
RCPF[b]	.37	.28	.25	.27	.58	.75	.17
Significance[c]	NS	T*	T***	T***	S*	S***	S** T'
CV	9.4	19.9	17.4	16.0	20.5	19.6	60.3

[a] HCP = High crude protein diet.
[b] RCPF = Reduced crude protein diet with 10% soybean hulls.
[c] Significance: S = sex, T = treatment; P-values: ‘ P<.10, * P<.05, ** P<.01, *** P<.001.

Table 3. Growth performance by replicate.

	ADG				ADFI			
Week	0-3	3-6	6-9	3-9	0-3	3-6	6-9	3-9
Rep 1 & 2								
HCP[a]	1.87	1.73	1.75	1.74	5.32	5.92	6.35	6.14
RCPF[b]	1.99	1.77	1.60	1.68	5.49	6.15	6.50	6.32
Significance[c]	S***	S**	S* T*	S***	S***	S*** TxS*	S***	S***
CV	11.9	18.2	13.9	10.4	10.5	11.6	10.3	9.2
Rep 3 & 4								
HCP[a]	1.94	2.01	1.88	1.95	5.10	6.43	6.55	6.49
RCPF[b]	1.86	1.63	1.61	1.62	4.85	5.83	6.36	6.10
Significance[c]	S**	T***	T***	T***	S*	S* T***	S**	S** T*
CV	10.7	13.3	13.6	11.4	10.2	7.8	12.6	8.6

[a] HCP = High crude protein diet.
[b] RCPF = Reduced crude protein diet with 10% soybean hulls.
[c] Significance: S = sex, T = treatment; P-values: ‘ P<.10, * P<.05, ** P<.01, *** P<.001.

Table 4. Odor and gas analysis.

	4 hr Ammonia conc. (ppm)		Week 9 collection	
	Week 3	Week 9	Dilution Ratio (Fresh:Sample)	Hydrogen Sulfide (ppm)
HCP[a]	13.6	21.3	533.2	.36
RCPF[b]	12.7	12.5	500.1	.25
Significance	NS	.03	NS	.15
CV	11.7	17.8	12.8	19.3

[a] HCP = High crude protein diet.
[b] RCPF = Reduced crude protein diet with 10% soybean hulls.

Table 5. Pit nitrogen composition[a].

	Week 9 collection			Change from week 3 to week 9	
	Pit Volume	TN (ppm)[d]	Amm (ppm)[d]	TN (lb in the pit)	Amm (lb in the pit)
HCP[b]	2925	2571	2354	40.3	36.6
RCPF[c]	2490	2177	1794	30.9	25.9
Significance	NS	.10	.02	.11	.02
CV	22.2	10.5	9.4	15.4	11.5

[a] TN = Total Nitrogen, Amm = Ammonia.
[b] HCP = High crude protein diet.
[c] RCPF = Reduced crude protein diet with 10% soybean hulls.
[d] Values adjusted for calculated pit volume.

Table 6. Pit pH, phosphorous and potassium.

	Week 9 collection			Change from week 3 to week 9		
	Pit Volume	P (ppm)[c]	K (ppm)[c]	pH	Phosphorus (lb in pit)	Potassium (lb in pit)
HCP[a]	2925	457	7943	-.03	7.0	103
RCPF[b]	2490	498	7895	-.30	8.0	92
Significance	NS	NS	NS	.07	NS	NS
CV	22.2	41.0	12.4	79.4	62.6	33.4

[a] HCP = High crude protein diet.
[b] RCPF = Reduced crude protein diet with 10% soybean hulls.
[c] Values adjusted for calculated pit volume.

Table 7. Trypsin inhibitor (mg/g of sample).

Replication	1	2	3	4	AVG
HCP[a]	.345	.355	.373	.426	.375
RCPF[b]	.546	.576	.561	.550	.558
Significance					.01
CV					6.4

[a] HCP = High crude protein diet.
[b] RCPF = Reduced crude protein diet with 10% soybean hulls.