Effects of Soybean Hulls on Pig Performance, Manure Composition, and Air Quality

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Introduction

Environmental concerns of pork production have recently been highly debated topics among federal, state, and local governments and communities. With increasing pressure for sustaining and improving our environment, many producers and researchers alike are searching for methods to minimize the environmental impacts of meat production. One such method that has been researched is dietary manipulation to reduce unfavorable emissions from swine facilities. Soybean hulls (SH) are an inexpensive by-product of soybean processing that is high in fiber and low in energy and protein content. Past research has demonstrated that fiber additions can have a positive impact on manure nitrogen retention, odor production, aerial pit emissions, and volatile fatty acid production. However, adding fiber to the ration of growing pigs without supplemental energy may hinder growth performance.

Therefore, this study was conducted to quantify the effects of feeding soybean hulls with supplemental fat addition during the finisher phase on average daily gain (ADG), average daily feed intake (ADFI), feed efficiency (G:F), 10^{th} rib backfat thickness, loin depth, aerial ammonia concentration (AAC), hydrogen sulfide (HS), odor detection threshold (ODT), and manure characteristics; pH, total nitrogen, ammonium nitrogen, and volatile fatty concentrations (VFA).

Experimental Procedures

Four dietary treatments were formulated according to sex and treatment and fed for a six-week period using industry type control diets for barrows (BC) and gilts (GC), or the control diet with the addition of 10% soybean hulls and 3.4% supplemental fat (BSH and GSH). The diets were formulated to meet or exceed the nutrient requirements for sex and phase of growth based on NRC (1998). Diets are summarized in Table 1.

One hundred and fifty pigs (70 barrows and 80 gilts) with an initial body weight of 188.3 lb. were blocked by sex, ancestry, and weight and placed in two identical, environmentally controlled rooms (5 pigs/pen, 5 pens/room; 50 pigs/rep) with three replications and treatments rotating between rooms. Pigs were weighed and feed recorded every three weeks for the 6-week period to determine ADG and ADFI, from which G:F was calculated. Loin depth and tenth rib back fat thickness were measured on all pigs at week 0 and 6 with an Aloka 500 ultra sound. Aerial ammonia concentrations, ODT, HS, and pit manure samples were taken at weeks 0, 3, and 6. Aerial ammonia concentration was determined by hanging constant diffusion Dräger tubes (3 per room and 1 per exhaust) and recording values after 4 hours (0700-1100h). Odor samples were collected (2 per room and 2 per exhaust) with 10L Tedlar bags being filled at the rate of 1.5 liters/min for 5 minutes. Hydrogen Sulfide and ODT values were measured at Iowa State University. Pit manure samples were collected at three sites in each room after agitation, pooled, and analyzed for pH, total nitrogen, ammonium nitrogen, total phosphorus, water-soluble phosphorus, and VFA concentrations.

Statistical analysis of the data collected was performed using the GLM procedure of SAS. Pigs were blocked by sex and initial body weight. Dietary treatment, sex and the treatment *x* sex interaction were examined to determine their effect on growth and carcass composition. Dietary treatment was examined for its effects on odor, odorous gases, and manure composition.

Results and Discussion

The growth performance of the pigs is displayed in Table 2 by the interactions of the main effects of treatment and sex. During the initial period (weeks 0-3), pigs fed the soy hull diet had a 13.8% increase in ADG (2.00 vs 1.74 lb/d; P < .001). After this time period the response decreases in significance, which could be attributed to the elevated fat in the soy hull diet, possibly enhancing initial growth for those pigs fed the soy hull diet. However, overall ADG was increased (1.99 vs 1.89 lb/d; P < .03) for pigs fed the soyhull added diet. A numerical increase in final body weight was also observed for pigs fed the soy hull diet (3.8 lbs. heavier). Barrows had a greater ADG at all time points and overall (2.05 vs 1.85 lb/d; P < .001) than gilts. Feed intake was not different between the control or soy hull diet. However, there was a sex effect, with gilts eating less than barrows (P < .001). There was a 12% improvement (P < .002) in feed efficiency for those pigs fed soy hulls during weeks 0-3. However, overall there was no difference in feed efficiency between treatments. Again, this may be related to the added fat in the soy hulls diet, which was intended to make the diets isocaloric. This may indicate that we have under estimated the metabolizable energy of the soy hulls for today's pigs or the amino acid availability of soyhulls may be greater than past estimates.

Pigs fed soy hulls displayed a greater adjusted final backfat (.62 vs .58 in; P < .006) compared to the control fed pigs (Table 3). This is contributed to by the increase growth displayed by those pigs fed the soy hull diet, but also may be related to the higher fat level in the soy hull diet. There was also a sex effect on backfat, with the barrows having an increased change and final backfat (P < .01). No difference was detected between the diets in loin depth. This data indicates that the addition of 10% soy hulls into a standard corn and soybean base diet has no hindrance on growth performance and may increase backfat thickness as supplemented with additional dietary fat in this trial, decreasing carcass value.

The difference between the treatments with regards to odor and gases is displayed in Table 4. Pigs fed soy hulls had a 32% reduction in hydrogen sulfide gas in the room air (.701 vs 1.03 ppm; P < .001). Pigs fed soy hulls had a 20% decrease in 4-hr. aerial ammonia concentration (10.38 vs 13.05 ppm; P < .017), and an 11% numerical decrease in odor detection threshold (2424 vs 2162).

The final manure volume tended (P < .10) to be different between treatments, with less manure in the pits below the pigs fed soy hulls (Table 5). This may be partially explained by a malfunctioning nipple waterer in one of the control room reps. The manure dry matter content was increased from pigs fed the soy hulls (1.65 vs .97%; P < .0001) due to the increased fiber in the diet with the total manure DM content increasing for pigs fed SH (249 lb vs 376 lb). The soy hull fed pigs had a 21% increase (P < .001) in total nitrogen (49.7 vs 41.0 lbs) than the control fed pigs. Similar trends were noted with the change in ammonium N with the soy hull fed pigs having an 8% increase (40.4 vs 37.3 lbs; P < .05) total manure ammonium N. There was a change in manure pH with pigs fed soy hulls having a lower final pH (7.12 vs 7.26; P < .03). This change in pH happens when feeding a fiber source because of urinary nitrogen decreases causing an acidic pH shift in the urine plus the added fiber to the diet can increase VFA production and cause a lower manure pH. There was no difference in total pounds of P accumulation in the pits between dietary treatments. The effect of diet on volatile fatty acids in stored manure is displayed in Table 6. Pigs fed soy-hulls had an increase in all manure VFA's measured and total VFA concentrations (128 vs 97 mmol/L; P < .0008).

Application

As state and federal environmental regulations continue to increase, pork producers and researchers alike will attempt to identify methods in which to reduce environmental impacts of pork production. The results of this study suggest that the addition of 10% soybean hulls with supplemental fat to a commercial type diet can have a positive impact towards environmental stewardship, without hindering pig performance. In January 2002, the EPA will place new and more stringent CAFO regulations that have a focus on ammonia, odor, and hydrogen sulfide emissions from swine facilities. The addition of soybean hulls should allow producers to maintain production levels while helping comply with new federal standards as the addition of soybean hulls lowered AAC, ODT, and HS emissions while increasing manure nitrogen retention and VFA concentrations. Furthermore, as the price for anhydrous ammonia for crop production has sharply increased, improved nitrogen retention within pit manure will be an economically viable method to reduce the cost of production of grains through the use of swine manure as a fertilizer source.

Table 1. Ingredient composition of experimental diets

	Barrows		Gilts	
Ingredient, %	**Control**	**Soy Hulls**	**Control**	**Soy hulls**
Corn	86.18	73.00	84.40	71.25
Soybean Meal 48%	10.19	10.11	12.00	11.90
Soybean Hulls	0.00	10.00	0.00	10.00
Swine Yellow Grease	1.00	4.35	1.00	4.35
Dicalcium Phosphate	1.02	1.13	0.98	1.09
Limestone	0.91	0.72	0.92	0.73
Salt	0.25	0.25	0.25	0.25
Vit./Trace Min. Premix[ab]	0.20	0.20	0.20	0.20
Selenium	0.05	0.05	0.05	0.05
Tylan 40	0.05	0.05	0.05	0.05
Lysine-HCl	0.15	0.136	0.15	0.136
Calculated Values				
Metabolizable Energy	1529	1529	1529	1529
Lysine	0.650	0.700	0.665	0.715
Digestible Lysine	0.526	0.570	0.526	0.570
Calcium	0.60	0.60	0.60	0.60
Phosphorus	0.50	0.50	0.50	0.50
Available Phosphorus	0.24	0.23	0.27	0.26

[a] 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

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

Table 2. Effect of soyhulls in the diet on pig performance

	Control		Control + Soy Hulls			Probability P <		
	Barrows	Gilts	Barrows	Gilts	CV	Trt	Sex	Trt ´ Sex
Bodyweight, lb								
Wk 0	188.3	187.9	188.6	187.8	5.48	0.98	0.88	0.96
Wk 3	226.8	220.2	231.0	226.7	4.68	0.18	0.18	0.76
Wk 6	268.0	259.9	272.0	263.7	3.95	0.32	0.05	0.98
ADG, lb/d								
Wk 0-3	1.89	1.59	2.08	1.92	10.32	0.001	0.003	0.35
Wk 3-6	2.10	2.02	2.10	1.88	9.58	0.33	0.06	0.31
Overall	1.99	1.80	2.09	1.90	5.90	0.03	0.001	0.97
ADFI, lb/d								
Wk 0-3	6.00	5.05	6.04	5.19	5.46	0.42	0.001	0.66
Wk 3-6	7.14	6.42	7.22	6.49	9.66	0.76	0.007	0.99
Overall	6.65	5.72	6.62	5.94	8.21	0.60	0.001	0.50
Gain:Feed								
Wk 0-3	0.322	0.321	0.356	0.380	10.71	0.002	0.43	0.35
Wk 3-6	0.287	0.313	0.290	0.300	8.32	0.60	0.06	0.36
Overall	0.302	0.317	0.319	0.332	7.71	0.09	0.14	0.93

Table 3. Effect of soyhulls in the diet on carcass characteristics

	Control		Control + Soy Hulls			Probability P <		
	Barrows	Gilts	Barrows	Gilts	CV	Trt	Sex	Trt x Sex
Initial	.618	.504	.591	.472	22.43	.13	.001	.91
Ending	.759	.594	.843	.642	19.45	.004	.001	.45
Change	.136	.093	.240	.170	77.2	.001	.006	.51
Adjusted BF*	.654	.504	.673	.567	19.7	.006	.001	.27
Initial	1.669	1.756	1.717	1.760	9.63	.32	.02	.46
Ending	2.165	2.201	2.213	2.197	9.24	.24	.76	.89
Change	.496	.402	.492	.433	44.44	.66	.02	.62

* Adjust 10^{th} rib backfat depth to 250 lb using the NSIF, 1996 equation

Table 4. Effect of soyhulls in the diet on room odor and gases at week 6

	Control	Soy Hulls	CV	Significance
4 h Ammonia Conc. (ppm)	13.05	10.38	20.21	.017
Detection Threshold[a]	2424.13	2162.5	38.58	.560
Ammonia (ppm)	4.00	3.63	23.36	.420
Hydrogen Sulfide (ppm)	1.03	0.701	20.99	.003

[a]The ppm of clean air required to dilute the sample air to undetectable levels

Table 5. Effect of soyhulls in the diet on manure composition

	Control	Soy Hulls	CV	Significance
Manure Pit Volume (gal)				
Initial (as is)	840	840	--	--
Final (as is)	3209.6	2849.6	11.2	0.10
Manure Drymater, %				
Initial	0.26	0.28	4.2	0.07
Final	0.97	1.65	9.7	0.0001
TN				
Initial (ppm)	510.2	438.5	9.7	0.03
Final (ppm)	1681.3	2226.8	9.8	0.001
Total pit accumulation, lb	41.0	49.7	11.5	0.02
Ammonium N				
Initial (ppm)	340.3	321.8	2.6	0.006
Final (ppm)	1495.5	1817.2	7.3	0.002
Total pit accumulation, lb	37.3	40.4	6.0	0.05
Phosphorous				
Initial (ppm)	209.5	186.2	19.9	0.33
Final (ppm)	500.7	606.5	5.8	0.0005
Total pit accumulation, lb	11.9	12.6	15.1	0.49
pH				
Initial	8.21	8.26	2.0	0.69
Final	7.26	7.12	1.3	0.03
Change	-0.93	-1.15	20.2	0.19

Table 6. Effect of soyhulls in the diet on volatile fatty acids (VFA) in stored manure at week 6

	Control	Soy Hulls	Significance	SEM
VFA, mmol/L				
Ac	57.7	77.1	0.0004	2.84
Pr	16.7	23.3	0.0003	0.94
IB	2.1	2.5	0.013	0.11
B	16.8	20.3	0.036	1.05
IV	2.0	2.4	0.043	0.12
V	1.7	2.4	0.004	0.14
Total	97.0	128.0	0.0008	4.91