Effect of Several Known Dietary Manipulations Used In Combination on Nutrient Concentration and Ammonia Emission of Stored Manure

S. L. Hankins, D. C. Kendall, S. A. DeCamp, D. T. Kelly, A. L. Sutton, and B. T. Richert
Department of Animal Sciences, Purdue University

Introduction

As swine operations have grown larger and become concentrated in smaller land areas, handling of swine waste and controlling odor emissions are a top priority. Many dietary manipulations have been well documented as effective in reducing nutrient excretion and concentrations in stored manure. In a previous trial at Purdue, cellulose addition to a reduced CP amino acid supplemented diet reduced slurry pH, ammonium nitrogen, total nitrogen, and volatile fatty acid concentrations in stored manure compared to a standard corn-soy diet (Hankins et al., 2000). Kendall et al. (2000) reported reduced aerial ammonia concentrations when growing pigs were fed a reduced CP high-available phosphorus (HAP) corn diet supplemented with synthetic amino acids, 5% soybean hulls, 0.05% phytase, and reduced mineral sulfates. The objective of this trial was to determine nutrient concentration and ammonia production in stored manure from pigs fed a standard corn-soy diet, a reduced CP amino acid supplemented diet or a diet similar to that fed by Kendall et al. (2000) previously.

Procedures

Twelve crossbred barrows (initial BW = 112 lbs) were blocked by weight and randomly assigned to one of three dietary treatments. All diets (Table 1) were formulated to provide 0.48% digestible lysine (Lys) and are as follows:

1) Standard 13.1% CP corn-soy diet, 0.23% available P (CTL)
2) 11.5% CP corn-soy diet, 0.15% Lys-HCl, 0.26% available P (AA)
3) 8.25% CP diet with 5% soybean hulls, HAP corn, 0.05% phytase, reduced mineral sulfates, 0.40% Lys-HCl, and 0.16% available P (HRP)

Pigs were fed three times maintenance levels (NRC, 1988), approximately 5 lbs/d of feed divided equally among three feedings (0600, 1700, and 2200 h) and had ad libitum access to water. Pigs were adapted to metabolism stalls and dietary treatments for ten days followed by a two day total feces and non-acidified urine collection for the simulated anaerobic pit system. Simulated anaerobic pit systems are designed to mimic an anaerobic manure system to analyze nutrient content and odor production. Feces was collected twice daily and urine once daily. Feces and urine from the first day of collection was used fresh to blend a 7.5% DM slurry for each pig. The ratio of feces to urine for the slurry was based on the DM of the feces. Simulated pit systems were set up in four-liter glass jars with two liters of the blended mixture used as the initial inoculum in each jar. Each jar was fitted with a cap containing air inlet and outlet valves and maintained for 43 days. Feces and urine from the second day were collected and used fresh to blend a second 7.5% DM slurry for each pig. The mixture was then pipetted in 25 ml aliquots into round bottom culture tubes and frozen for later addition to feed the bacterial population in the simulated pits. Aliquots were added to each jar three times a week (Mon., Wed., and Fri.). Slurry samples were taken from each jar at day 0, 28, and 43. An initial 50 ml composite slurry sample was taken at d 0. At d 28 and 43, slurry samples were pipetted in 50 ml aliquots from each settled layer of the incubation giving three stratification samples (top layer, middle layer, and bottom layer). The entire incubation was then mixed using a magnetic stir bar and a composite sample was taken from each jar. Headspace ammonia concentrations in each jar were also measured prior to slurry sampling at d 27 and 42 using constant diffusion Drager tubes.

Composite slurry samples were analyzed for dry matter (DM), pH, total nitrogen (TN), ammonium nitrogen (AMM), total phosphorus (TP), water soluble phosphorus (WSP), potassium (K), and volatile fatty acids (VFA). Stratified slurry samples were analyzed for DM, TN, TP, and WSP. Dry matter was determined after drying samples at 203°F (95°C) for 24 hours and pH was measured using a calibrated glass electrode pH meter. Nitrogen was determined using micro-Kjeldahl techniques, phosphorus was determined colorimetrically, potassium was determined using atomic absorption, and VFAs were determined using gas chromatography.

Data were analyzed using the GLM procedure of SAS and means were separated using the probability of difference at $P < .05$.

Results and Discussion

Initial composite slurry DM (Table 2) was 8.1%, 8.2%, and 9.0% for the CTL, AA, and HRP treatments, respectively. Dry matter was not different among treatments at any time point. Although the addition of slurry to the incubations three times a week was intended to maintain a 7.5-8% DM, the lower DM observed at d 28 and 43 are likely due to the bacterial population utilizing the DM for nutrients which is supported by a sharp increase in VFA production at d 28. The pH of slurry contents was not different between treatments and remained stable at 8.1-8.4 throughout the trial.

Slurry TN and AMM (Table 2) from the composite samples were only numerically lower for the AA (15%) and HRP (18%) treatments compared to the CTL treatment at d 0. This same pattern is seen in TN and AMM concentration of composite slurry contents at d 28 and 43 since the slurry additions were similar in nutrient content to that of d 0.

Slurry TP from the composite sample was 62%, 63%, and 68% lower ($P < .05$) for incubations from the HRP treatments compared to those from the CTL treatment and were 58%, 58% and 64% lower ($P < .05$) for the HRP incubations compared to the incubations from the AA treatment for d 0, 28, and 43, respectively. Water soluble P was numerically greatest at all time points for incubations from the AA treatment, which correlates with the previous digestibility trial using similar diets presented in the 2001 Swine Research Report (Hankins, 2001). Slurry composites from the HRP treatment contained 61%, 75%, and 78% less ($P < .05$) WSP than the AA incubations with similar reductions (57-71%; $P < .05$) for the HRP incubations compared to the CTL incubations.

Composite slurry K values were not different among treatments, although the AA and HRP incubations did have numerically lower concentrations when compared to the CTL incubations.

Volatile fatty acid concentration in composite slurry contents was greatest for the HRP incubations at all time points being 41% higher ($P < .05$) at d 28 and 37% higher ($P < .05$) at d 43 compared to the CTL incubations. This is likely due to the fiber addition to the diet allowing for more microbial activity in the incubation. Volatile fatty acid concentration peaked at d 28 for all treatments indicating that the bacterial population was established and active. Greater concentrations of acetate and propionate at d 28 and 43 ($P < .05$) for the HRP incubations compared to the CTL and AA incubations were the primary contributors to the greater total VFA concentrations. Isovalerate was reduced ($P < .05$) in the incubations from the AA treatment when compared to the CTL and HRP treatments at d 28 and 43.

Ammonia nitrogen concentrations from the headspace air at d 28 and 43 were numerically lower for the AA treatment and further reduced for the HRP treatment by 60-63% when compared to the CTL treatment. This is consistent with previous results by Kendall et al. (2000) and should be expected with the decreased CP content of the diets.

The dry matter of stratification layers increased ($P < .05$) from the top to middle and bottom layer for all treatments at d 28 and 43. Total nitrogen concentration was 31% and 25% higher (as-is, $P < .05$) in the bottom layer stratification samples than the top layer at d 28 and 43, respectively. Total phosphorus was reduced 62% and 63% (as-is, $P < .05$) in stratifications from the HRP treatment compared to the CTL treatment at d 28 and 43, respectively. The concentration of TP in stratification layers increased ($P < .05$) as layers progressed from top to bottom at both d 28 and 43. Water soluble phosphorus was highest in the AA treatment with a 27% and 24% decrease when the CTL was compared to the AA at d 28 and 43, respectively, and an 82% and 78% reduction when the HRP treatment was compared to the CTL treatment at d 28 and 43, respectively (as-is, $P < .05$). The bottom layer stratification samples had the greatest concentration of WSP at both d 28 and 43 ($P < .05$) with the concentration increasing with the progression from the top to the bottom layer ($P < .05$) at d 28. At d 43, the bottom layer had 42% more WSP than the top layer (as-is, $P < .05$). The concentration of TP in the middle layer of stratifications from the CTL treatment was increased to a greater extent than the middle layer of the other treatments creating a treatment by layer interaction ($P < .05$). The magnitude of increase in TP from the top to the bottom layer is greater ($P < .05$) for the HRP treatment compared to the AA and CTL treatments for the stratifications, on both a wet and DM basis, creating a secondary cause for the interaction occurring with layer and treatment for TP. The concentration of WSP phosphorus inverts from top to bottom when comparing the values on a wet and DM basis suggesting that the rate of WSP (1.6-2.2 X) accumulation is less than DM (3.2-6.3 X). The interaction occurring with WSP on a DM basis at both d 28 and 43 is a result of the lower WSP concentration in the middle layer of stratifications from the CTL treatment when compared to the other treatments on a DM basis.

Implications

This study indicates that TP and WSP can be reduced in stored manure from pigs fed the HRP diet with the potential for lower K and aerial ammonia concentrations. It also indicates that the concentration of nutrients is greatest in the bottom layer of manure storage facilities with the HRP diet again contributing the least amount of nutrients. The inclusion of these dietary manipulations proves to be effective at reducing the nutrient content of stored manure as well as some reduction in potential nuisance or hazardous odors. This is important as producers are required to meet regulations governing the application of nutrients to land and supports the necessity for separate manure samples to be taken from manure storage areas with different settling areas and at different levels of manure depth in the handling system. It will also prove beneficial as producers begin developing the required manure management plans to meet current and future regulations.

References

Hankins, S., A. Sutton, J. Patterson, L. Adeola, B. Richert, A. Heber, D. Kelly, K. Kephart, R. Mumma, and E. Bogus. 2000. Reduction of Odorous Sulfide and Phenolic Compounds in Pig Manure Through Diet Modification. Purdue University Swine Day Report. p. 142.

Kendall, D. C., B. T. Richert, A. L. Sutton, K. A. Bowers, C. T. Herr, and D. Kelly. 2000. Effects of Dietary Manipulation on Pig Performance, Manure Composition, Hydrogen Sulfide and Ammonia Levels in Swine Buildings. Purdue University Swine Day Report. p. 152.

Table 1. Ingredient composition of experimental diets

Ingredient, %	CTL	AA	HRP*
Corn	83.64	87.80	--
High-available P corn	--	--	90.47
SBM-48%	13.03	8.71	--
Soybean hulls	--	--	5.00
Yellow swine grease	1.00	1.00	2.34
Dicalcium Phos.	0.95	1.10	--
Limestone	0.93	0.79	1.18
Salt	0.25	0.25	0.25
Purdue Swine Vit. Premix[1]	0.10	0.10	0.10
Purdue Swine TM Premix[2]	0.05	0.05	--
Low Sulfur TM Premix[3]	--	--	0.05
Natuphos	--	--	.05
Se 600 Premix	0.05	0.05	0.05
Lysine-HCl	--	0.15	0.40
L-Threonine	--	--	0.072
L-Tryptophan	--	--	0.040
Calculated Composition			
ME (Kcal/lb)	1533	1532	1534
Crude protein, %	13.1	11.5	8.25
Lysine, %	.61	.60	.57
Calcium, %	.60	.60	.50
Phosphorus, %	.50	.50	.26
Available Phosphorus, %	.23	.26	.16
Potassium, %	.56	.48	.36
Digestable amino acids			
Lysine, %	.477	.477	.477
Threonine, %	.355	.335	.300
Methionine + Cysteine, %	.394	.379	.300
Tryptophan, %	.102	.076	.080
Isoleucine, %	.420	.404	.270
Analyzed composition			
Crude protein, %	11.91	9.09	7.45
Total Phosphorus, %	0.60	0.59	0.33
Total Potassium, %	0.78	0.67	0.58

* HRP = 8.25% CP high-available P corn based diet with synthetic amino acids, 5% soyhulls, phytase and reduced mineral sulfates

[1] Provides per lb. of diet: 1100 IU Vitamin A, 110 IU D3, 8 IU Vitaman E, .365 mg Menadione, .006 mg B12, 1.28 mg Riboflavin, 4.0 mg Pantothenic Acid, 6.0 mg Niacin

[2] Provides per lb. of diet: 48 ppm Zn, 48 ppm Fe, 6 ppm Manganese, 4.5 ppm Cu, .16 ppm I

[3] Iron carbonate replacing ferrous sulfate, zinc oxide replacing zinc sulfate, manganese oxide replacing manganese sulfate, and copper chloride replacing copper sulfate formulated to provide equal quantities of available minerals

Table 2. Nutrient concentrations of slurry composite

	Day 0				Day 28				Day 43			
Diet[d]	**CTL**	**AA**	**HRP**	**CV**	**CTL**	**AA**	**HRP**	**CV**	**CTL**	**AA**	**HRP**	**CV**
DM, %	8.07	8.17	9.01	8.3	5.47	4.88	5.64	28.4	5.02	4.84	5.19	22.5
pH	8.39	8.32	8.40	5.0	8.39	8.39	8.40	3.6	8.27	8.19	8.10	3.0
Total N, ppm	6817	5785	5575	33.7	6500	5377	5348	32.6	6779	5686	5192	32.3
NH_4-N, ppm	4355	3151	3172	35.2	4916	4244	4148	34.8	5686	4813	4426	35.4
Total P, ppm	2626[a]	2381[a]	1007[b]	8.0	2287[a]	1994[a]	835[b]	24.8	2097[a]	1898[a]	680[b]	21.6
Water soluble P, ppm	728[a]	820[a]	319[b]	13.0	643[a]	773[a]	190[b]	18.7	469[a]	596[b]	134[c]	19.0
Total K, ppm	1984	1619	1707	24.5	2074	1882	1611	29.4	1933	1617	1687	26.0

[abc] Differing superscripts within a row indicate significance at $P < .05$

[d] CTL = 13.1% CP standard corn-soy; AA = 11.5% CP with synthetic Lys; HRP = 8.25% CP high-available P corn based diet with synthetic amino acids, 5% soyhulls, phytase and reduced mineral sulfates

Table 3. Volatile fatty acid concentration of slurry composite

	Day 0				Day 28				Day 43			
Diets [c]	**CTL**	**AA**	**HRP**	**CV**	**CTL**	**AA**	**HRP**	**CV**	**CTL**	**AA**	**HRP**	**CV**
VFA, mmol/L												
Acetate	70.88[a]	51.78[b]	82.89[a]	14.8	1694.8[b]	983.1[b]	2738.7[a]	30.3	1446.7[a]	802.2[a]	2218.9[b]	32.3
Propionate	21.26	17.55	23.70	26.9	211.43[b]	149.75[b]	547.39[a]	63.1	139.48[a]	110.74[a]	298.03[b]	41.8
Isobutyrate	2.36	2.07	2.29	20.5	63.18	35.92	65.61	43.0	53.69	36.59	71.34	38.0
Butyrate	14.65	11.97	17.15	29.5	225.81	83.60	437.63	105.2	128.84	50.03	256.29	91.0
Isovalerate	2.90	2.65	3.06	26.7	64.42[a]	34.03[b]	55.32[a]	24.1	47.27[a]	24.50[b]	44.10[a]	36.3
Valerate	2.48	1.85	2.70	34.8	22.42	12.61	33.06	100.9	11.66	6.62	15.30	67.1
Total	114.53[a]	87.87[b]	131.79[a]	10.0	2282.1[a]	1299.0[a]	3877.7[b]	37.9	1827.7[b]	1030.7[b]	2904.0[a]	32.3

[ab] Differing superscripts within a row indicate significance at $P < .05$

[c] CTL = 13.1% CP standard corn-soy; AA = 11.5% CP with synthetic Lys; HRP = 8.25% CP high-available P corn based diet with synthetic amino acids, 5% soyhulls, phytase and reduced mineral sulfates

Table 4. Effect of diet on ammonia concentration in headspace air

Diet[a]	Ammonia, ppm Day 28	 Day 43
CTL	142.5	167.5
AA	120.4	147.5
HRP	52.5	67.5
CV	113.2	96.6

[a] CTL = 13.1% CP standard corn-soy; AA = 11.5% CP with synthetic Lys; HRP = 8.25% CP high-available P corn based diet with synthetic amino acids, 5% soyhulls, phytase and reduced mineral sulfates