Effects of Intact Protein Diets Versus Reduced Crude Protein Diets Supplemented with Synthetic Amino Acids on Pig Performance and Ammonia Levels in Swine Buildings

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Introduction

Government regulations, neighbor complaints, and nuisance lawsuits are forcing the swine industry to address odor and manure management issues. The threat of odors from swine farms has restricted growth in some areas of the country and has created negative relationships between neighbors. Along with these, in certain situations, high levels of gases have been shown to reduce pig performance and compromise worker health. Ways to reduce nutrient excretion and compounds creating the odors in manure are needed to help nurture environmental stewardship and bolster relationships with those outside of agriculture. One manner in which this can be accomplished is by minimizing nutrient excesses in diets by more closely meeting the pig's actual needs. It has previously been demonstrated in metabolism studies that by reducing dietary crude protein levels and supplementing diets with synthetic amino acids, reductions in nitrogen excretion and aerial ammonia concentrations can reach upwards of 40 to 50%. The objectives of this study were to determine whether a reduced crude protein diet could significantly impact aerial ammonia levels and pit composition while maintaining similar growth performance in confinement swine buildings.

Materials and Methods

Three hundred sixty pigs, weighing 60 lb, were placed in two identical, environmentally controlled rooms of 9 pens with 4 pigs per pen; pigs were blocked by sex and initial body weight. There were five replications of the trial, with treatments alternating between rooms to eliminate room bias. Ventilation rates were maintained at a ratio of 75% recycled to 25% fresh air, and the temperature was kept constant between rooms at 70°F. The experiment was a nine-week trial with the pigs fed a common corn-soy diet (18.7% crude protein, CP; 1.0% Lysine, Lys) for the first three weeks to "load" the rooms. At week 3, one room was fed a corn-soy diet (16.7% CP, .85% Lys; HCP) and the other room was fed a reduced CP diet (12.2% CP, .85% Lys; RCP) with supplemental lysine, methionine, threonine, and tryptophan (Table 1). These diets were fed for the remainder of the trial.

At weeks 3, 6, and 9, pigs were weighed and feed consumption was recorded. Four-hour aerial ammonia concentration samples were taken with Dräger long-term diffusion tubes at pig height in 3 different locations, and plastic odor bags were filled with room air at weeks 3, 6 and 9 for a twelve member trained odor panel assessment at Iowa State University. Representative pit samples were obtained for determination of pit composition, and blood samples were taken for analysis of blood urea nitrogen (BUN), also at 3, 6, and 9 weeks. In addition, at weeks 3 and 9, tenth rib backfat was measured using an Aloka 210 real-time ultrasound machine.

Results and Discussion

There was an advantage in average daily gain (ADG) during weeks 3 to 6 (Table 2) for pigs fed the HCP diet (P<.007). However, this gap narrows to similar values during weeks 6 to 9, with an overall (weeks 3 to 9) advantage in ADG for the pigs fed the HCP diet (P<.02). There is a similar type of pattern for feed efficiency (Table 3), with pigs fed the HCP diet having an improvement in Gain:Feed for weeks 3 to 6 (P<.0001) and weeks 3 to 9 (P<.004). In this experiment, CP levels were dropped drastically (4.5%), which may have led to marginal deficiencies of other amino acids, such as isoleucine, which is the next limiting amino acid. This may in part explain some of the differences in growth. Certainly there are data to show that 3% reductions in CP do not influence growth or feed efficiency; however, 4.5% may have been too much of a reduction. There was also a tendency for the pigs fed the RCP diet to have more tenth rib backfat. With identical starting fat depths (.44 in), a difference of nearly .05 inch developed over the six-week period (P<.061). The increase in backfat is related to the RCP diet having a slightly higher net energy (NE) value. Over an entire 16-week grow-finish period, an increase in tenth rib backfat of .10 to .14 could be expected due to the higher NE value. Reducing the NE value of a reduced crude protein diet with the addition of fiber (wheat mids or soy hulls) could negate this difference in tenth rib backfat. This approach is being evaluated in current trials. Even though this difference has been calculated to be statistically different, with the use of high lean genotypes, carcass premiums should be minimally affected.

A 40% reduction in aerial ammonia concentrations occurred when rooms were fed the RCP diet (P<.026) when measured over a four-hour period (Table 4). The odor panel evaluation showed a 30% reduction in dilution ratio for pigs fed the RCP diet. This is a measure of the parts fresh air required to dilute one part sample air until it is indistinguishable from fresh air. The odor bags were also analyzed for ammonia and hydrogen sulfide concentrations. Samples from rooms fed RCP had significantly lower levels of ammonia (P<.023) and hydrogen sulfide (P<.008). The ammonia levels in the odor bags followed the same 40 to 50% reduction that was discussed earlier. When looking at blood parameters for protein absorption and utilization, the RCP-fed pigs had lower blood urea nitrogen (BUN) levels (P<.0001). These figures would indicate very low levels of excess amino acids in the RCP diet.

Pit sample composition (Table 5) demonstrates the lower manure pH for pigs fed the RCP diet (P<.008). A lower pit pH can reduce volatilization of odorous compounds and ammonia, which leads to lower aerial concentrations of these substances. Percent dry matter was increased slightly over the six-week period (P<.07) when pigs were fed the RCP diet. On a dry matter basis (DMB), total nitrogen, ammonia and potassium were significantly reduced with the RCP diet. Percent total nitrogen on a DMB was reduced by 40% (P<.025), while percent ammonia on a DMB had a 20% decline (P<.07). Percent potassium on a DMB was reduced by 30% in RCP diets, but much to our surprise, percent phosphorus on a DMB was increased by 12% in pigs fed RCP diets. This could possibly be explained by a poorer performance in growth and under-utilization of dietary phosphorus.

Applications

Based on this study, an approach of reducing CP and supplementing diets with synthetic amino acids can be an effective way to control ammonia and odor emissions from confinement buildings. There were 40% reductions in aerial and pit ammonia concentrations with pigs fed the RCP diet. Along with this, there was a 40% lowering of aerial hydrogen sulfide concentrations, and the odor dilution ratio decreased by 30% when pigs were fed the RCP diet. In this experiment, these reductions in odor and gases came at the expense of growth and carcass characteristics. A reduction in CP of 4.5% may be too much, but reducing the CP in diets by 3 to 3.5% could be a good compromise to still reduce odorous emissions and nutrient excretion while maintaining comparable growth and feed efficiency. Neighbor complaints and nuisance lawsuits have brought environmental issues related to swine manure to the top of the list of problems facing the swine industry. A look across the Atlantic shows how swine production is being legislated by government regulations. It is in the foreseeable future that these same types of restrictions could be put in place in the United States. The swine industry needs to be proactive in its search for ways to reduce odor and ammonia concentrations. This research shows promise as a cost-effective means to control aerial and pit ammonia concentration in confinement buildings.

Table 1. Experimental diets.

	% of Diet		Cost/Ton[c]	
Ingredients	HCP[a]	RCP[b]	HCP	RCP
Corn	73.77	84.82	63.22	72.70
Soybean Meal	22.11	10.30	36.48	17.00
Yellow Grease	1.00	1.00	2.20	2.20
Dicalcium Phosphate	1.67	1.92	5.01	5.76
Calcium Carbonate	.70	.70	.37	.37
Salt	.35	.35	.65	.65
Vitamin Premix[d]	.20	.20	3.20	3.20
Trace Mineral Premix[e]	.10	.10	.58	.58
Selenium Premix	.05	.05	.10	.10
L-Lysine HCl		.41		7.07
Methionine		.013		.40
Tryptophan		.03		1.51
Threonine		.039		1.51
Tylan	.05	.05	5.07	5.07
Total Cost/Ton			116.88	118.12

[a] HCP = High crude protein diet (Calculated Analysis: 16.7% CP, .85% Lys, .28% Met, .66% Thr, .19% Trp, .72% Ile, .75% Ca, .65% P).

[b] RCP = Reduced crude protein diet (Calculated Analysis: 12.2% CP, .85% Lys, .23% Met, .53% Thr, .15% Trp, .51% Ile, .75% Ca, .65% P).

[c] Prices based on Feedstuffs[R] May 25, 1998 and June 1998 Purdue University purchasing prices.

[d] Provides per lb of diet: 2200 IU Vitamin A, 220 IU D3, 16 IU Vitamin E, .728 mg Menadione, .0128 mg B12, 2.56 mg Riboflavin, 8 mg Pantothentic Acid, 12 mg Niacin.

[e] Provides per lb of diet: 96.8 ppm Zn, 96.8 ppm Fe, 12 ppm Manganese, 9.04 ppm Cu, .336 ppm I.

Table 2. Growth rate and feed intake.

	ADG, lb/day				ADFI, lb			
Weeks	0-3	3-6	6-9	3-9	0-3	3-6	6-9	3-9
HCP[a]	1.82	1.83	1.78	1.80	3.7	4.6	4.9	4.8
RCP[b]	1.83	1.69	1.75	1.72	3.8	4.8	4.9	4.9
Significance	NS	.007	NS	.02	NS	NS	NS	NS
CV	15.2	12.9	10.8	9.4	16.0	14.2	15.5	13.8

[a] High crude protein diet.
[b] Reduced crude protein diet.

Table 3. Feed efficiency and tenth rib backfat.

	Gain:Feed				10th Rib Backfat, in.		
Weeks	0-3	3-6	6-9	3-9	Initial	Ending	Change
HCP[a]	.50	.40	.37	.38	.44	.59	.16
RCP[b]	.49	.35	.36	.36	.44	.63	.20
Significance	NS	.0001	NS	.004	NS	NS	.061
CV	8.1	11.1	14.2	10.1	26	23.4	59.3

[a] High crude protein diet.
[b] Reduced crude protein diet.

Table 4. Odor/Gases, week 9 collection.

	4 hour Ammonia conc. (ppm)	Dilution Ratio (Fresh:Sample)	Ammonia (ppm)	Hydrogen Sulfide (ppm)	Blood Urea N (mg/dl)
HCP[a]	33.6	663	23.7	1.41	11.5
RCP[b]	17	472	11.3	.93	4.4
Significance	.026	NS	.023	.008	.0001
CV	40.2	42.4	24.1	21.1	30.9

[a] High crude protein diet.
[b] Reduced crude protein diet.

Table 5. Pit composition, week 9 collection.

	pH	% DM	% Total N DMB	% Ammonia DMB	% Phosphorus DMB	% Potassium DMB
HCP[a]	7.6	1.43	20.8	15.9	4.34	6.93
RCP[b]	7.3	2.17	15.9	12.7	4.93	4.79
Significance	.008	.07	.025	.07	.02	.01
CV	2.6	49.3	25.7	33.9	15.4	25.7

[a] High crude protein diet.
[b] Reduced crude protein diet.