Effects of Dietary Reductions in CP, P, and Trace Minerals on Nutrient Excretion of Finisher Pigs

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Story in Brief

An experiment was conducted to determine the effects of reducing CP by 3% units, P by .1% unit, and trace mineral premix (TMP) with addition of phytase on DM, N, P, and mineral excretion during the finishing period. A total of 76 crossbred pigs with an initial body weight of 61 lb were housed in an environmentally-controlled building, with a shallow pit, pull-plug and exhaust air monitoring system. The diets employed were a typical corn-soybean meal diet (control) and a low excretion diet (LED) with 3% units reduction in CP, .1% unit reduction in P, and 50, 77, 83 and 100% reduction in TMP, respectively, over 4 dietary phases, with addition of 500 phytase units/kg of diet. Pig weight and feed intake were recorded each week, and slurry samples were collected. Feed and slurry samples were analyzed for DM, N, P and minerals. Pig growth performance was not affected by dietary treatment. Slurry from pigs fed LED tended to be lower in DM, K, and Na, and had lower N, NH_4-N, P, Ca, Fe, Zn, Cu and Mn concentrations. The LED reduced daily DM, N and NH_4-N excretion by 12, 31, and 37%, respectively. Daily macro-mineral excretion was reduced by 20%. Reduction in TMP reduced trace mineral (TM) excretion by 46%. The reduction in CP reduced NH_3 emissions by 56%. These reductions in nutrient excretion and NH_3 emission occurred without affecting growth performance. Reduction of CP, P and TM levels in grower and finisher diets did not affect growth performance and markedly decreased N, P, and TM excretion, in addition to NH_3 emissions.

Key Words: Excretion, Nitrogen, Phosphorus, Mineral, Finishing Pigs

Introduction

Intensive swine production is demanding the development of a comprehensive nutrient management plan that takes into account all nutrients leaving a finisher facility. Previous studies suggest that 70% of the N (Kornegay and Verstegen, 2001), 68% of the P, and 50 to 95% of other minerals consumed are excreted by growing-finishing pigs (Kornegay and Harper, 1997). An effective strategy to reduce nutrients excreted is diet manipulation. Diets can be manipulated by reducing dietary crude protein (CP) with addition of crystalline AA (Lachmann et al., 2006, Lachmann et al., 2007), reducing dietary P with addition of phytase (Cromwell et al., 1995) and reducing trace mineral content of the diet (Creech et al., 2004). However, most data available have been produced using individually-fed pigs and direct measurements of nutrient excretion from group-fed pigs are very limited. Based on this lack of data, a series of studies was conducted in our lab with the overall objective to evaluate the effect of diet manipulation on nutrient excretion and pig growth performance. Results from two previous experiments within this series suggested a reduction of 10% in N excretion per each percentage unit reduction in dietary CP and a 24% reduction in P excretion due to a reduction in dietary P by .1% unit (Lachmann et al., 2006, Lachmann et al., 2007). Following these experiments, an experiment was conducted to determine the effects of reducing dietary CP by 3% units, P by.1% unit, trace mineral premix (TMP) by 50, 77, 83 and 100%, respectively, over 4 dietary phases, with addition of phytase on DM, N, P, and mineral excretion during the finishing period.

Materials and Methods

A total of 76 crossbred [Duroc x (Yorkshire x Landrace)] pigs with an initial body weight of 61 lb were housed in an environmentally-controlled building. The building had 4 identical rooms; each room with a shallow pit, pull-plug system. Pigs were stratified by sex and ancestry, blocked by body weight, and assigned to one of two dietary treatments. The experimental unit was a room with 19 pigs, and 2 rooms were used per treatment. A typical corn soybean meal diet was used as the control diet. The experimental diet (LED) was reduced in CP by 3% units, P by.1%, TMP by 50, 77, 83 and 100%, respectively, over 4 dietary phases. In addition, phytase was added to to the LED diet to provide 500 phytase units/kg of diet. Both diets were formulated to be fed in four dietary phases, based on true digestible lysine (.92, .79,.65, and .56%, respectively). The 3% units reduction in CP in the LED was obtained by reducing soybean meal inclusion with the addition of crystalline AA on an ideal basis. The.1% unit reduction in P was obtained by reducing dicalcium phosphate. Also, limestone inclusion was reduced to maintain a Ca:tP ratio of 1.2:1 (Table 1).

Table 1. Dietary formulation and calculated composition for the four dietary phases (as-fed basis).

Dietary phase	1 (61 - 119 lb)		2 (119 - 180 lb)		3 (180 - 220 lb)		4 (220 - 260 lb)	
	Control	LED	Control	LED	Control	LED	Control	LED
Corn	65.72	73.75	71.30	79.90	76.71	85.37	80.54	89.16
Soybean meal, 48%	29.11	20.57	23.66	15.07	18.30	9.73	14.,58	6.12
L-lysine		.30		.28		.27		.27
DL-methionine		.01						
L-threonine		.09		.09		.07		.04
L-tryptophan		.02		.02		.02		.004
Dicalcium P	.61	.27	.54	.20	.47	.12	.39	.04
TM mix[a]	.10	.05	.10	.03	.10	.02	.10	
Phytase[b]		.02		.02		.02		.02
Others	4.47	4.47	4.44	4.40	4.43	4.38	4.40	4.35
Composition								
CP, %	19.28	16.28	17.16	14.16	15.06	12.06	13.61	10.61
P, %	.50	.40	.46	.36	.43	.33	.40	.30
Fe, mg/kg	225.9	132.2	213.1	101.0	199.6	69.5	188.1	39.2
Zn, mg/kg	138.0	79.8	136.0	59.0	134.0	39.4	132.7	19.4
Cu, mg/kg	18.8	11.9	17.9	9.1	17.0	6.4	16.4	3.9
Mn, mg/kg	51.9	31.4	49.4	24.3	46.8	17.4	44.5	10.6

[a] Provided 11.01 g/kg Cu, 110.13 g/kg Fe, 26.43 g/kg Mn, 110.13 g/kg Zn in the control diet
[b] Provided 500 phytase units/kg of diet

Pig weights, feed intake, slurry volume, pH, electrical conductivity (EC), and temperature were measured and slurry samples were collected weekly over a 110-d period. Pigs were fed to a target weight of 260 lb. Feed and slurry samples were analyzed for DM, N, P, Ca, K, Mg, Na, Fe, Zn, Cu and Mn. Nutrient excretion was calculated using slurry volume and nutrient concentration in the slurry. The data were analyzed using a randomized complete block design. The model included the effects of diet, block, and the interaction.

Results and Discussion

The initial weight of the pigs was 61 lb. All pigs were fed to a target weight of 260 lb. Days on test, average daily gain (ADG), average daily feed intake (ADFI), and feed:gain ratio (F:G) were similar (P>.10) for both dietary treatments (Table 2); therefore, the use of the LED did not affect pig growth performance. Also, DM intake was similar (P>.10), however, N and P intake were reduced (P<.01) for pigs fed the LED (Table 2).

Table 2. Growth performance and nutrient intake of pigs fed control or LED for the 110-d period.

	Control	LED	SE	P-Value
Initial wt, lb	61	61	.04	>.10
Final wt, lb	259	257	2.728	>.10
Days on test	109.7	109.7		>.10
ADG, lb	1.80	1.78	.01	>.10
ADFI, lb	4.96	4.85	.02	>.10
F:G	2.74	2.72	.02	>.10
DM intake, g/d	1,925	1,897	9.4	>.10
N intake, g/d	53.4	45.0	.03	<.01
P intake, g/d	9.78	7.38	.09	<.05

Slurry volume and temperature were similar (P>.10) for both treatments; however, slurry EC tended (P<.10) to decrease and pH was reduced (P<.05) from 7.07 to 6.59 when pigs were fed the LED. Pigs fed the LED tended to have reduced DM and K concentrations in slurry (P<.10), and reduced (P<.05) N and NH_4-N, P, Ca, Fe, Zn, Cu and Mn concentrations (Table 3). Only, Na slurry concentration was similar (P>.10) for both treatments.

Table 3. Slurry characteristics of pigs fed control or LED for the 110-d period.

	Control	LED	SE	P-Value
EC, mS	8.70	6.48	.49	<.10
pH	7.07	6.59	.07	<.05
DM, %	1.21	1.04	.01	<.10
Concentration, DM basis				
N, %	11.40	8.99	.21	<.05
NH_4-N, %	6.99	5.01	.02	<.05
P, %	2.11	1.56	.06	<.05
Ca, %	2.71	2.33	.05	<.05
K, %	5.37	4.73	.04	<.10
Mg, %	1.05	1.06	.02	<.10
Na, %	1.50	1.72	.02	>.10
Fe, ppm	1,552	943	41.2	<.01
Zn, ppm	929	477	31.6	<.01
Cu, ppm	134	96	4.5	<.05
Mn, ppm	330	213	8.2	<.01

Slurry volume and nutrient concentration in the slurry were used to calculate nutrient excretion. Daily and total DM excretion was reduced (P<.05) by 12% for pigs fed LED (Table 4). The reduction in dietary CP by 3% units in the LED reduced daily and cumulative (P<.01) N (by 31%) and NH_4-N excretion (>34%). Additionally, NH_3 emission was monitored and the NH_3 emitted when pigs were fed LED was reduced (P<.05) by 56%. Ammonia emission from the LED treatment is associated with the reduction in NH_4-N concentration and slurry pH (Table 4).

Reduction in dietary P by.1% unit plus sequence reduction in TMP inclusion with addition of phytase reduced (P<.05) P (35%), Ca (26%), K (22%), Mg (13%), Fe (46%), Zn (55%), Cu (38%), and Mn (46%) excretion. When similar reductions in dietary P have been evaluated without phytase in the diet, P excretion has been reduced by 24% (Lachmann et al., 2006, Lachmann et al., 2007). Furthermore, inclusion of phytase enhanced the reduction in P excretion. It is important to emphasize the dramatic reduction in TM excretion (Table 4).

Table 4. Nutrient excretion and ammonia emission of pigs fed control or LED for the 110-d period.

Daily excretion	Control	LED	SE	P-Value
DM, g/pig	293.3	259.6	4.28	<.05
N, g/pig	33.40	23.10	.62	<.01
P, g/pig	6.20	4.05	.13	<.01
NH_4-N, g/pig	20.5	13.0	.28	<.01
Ca, g/pig	7.95	5.94	.11	<.05
K, g/pig	15.75	12.24	.47	<.01
Mg, g/pig	3.08	2.74	.03	<.05
Na, g/pig	4.40	4.46	.17	>.10
Fe, mg/pig	455	240	16.90	<.05
Zn, mg/pig	272	122	12.80	<.05
Cu, mg/pig	39.3	24.5	1.9	<.05
Mn, mg/pig	97.0	54.4	3.6	<.05
NH_3-N emission, g/pig/d	2.32	1.02	.02	<.05

Results from this experiment are in agreement with previous reports from our lab suggesting a 10% reduction in N excretion for each percentage unit reduction in dietary CP (Figure 1). Furthermore, the two previous experiments reported that a reduction in dietary P by.1% reduced P excretion by 24% (Lachmann et al., 2006, Lachmann et al., 2007). The addition of phytase in this experiment increased the reduction in P excretion to 35% (Figure 2).

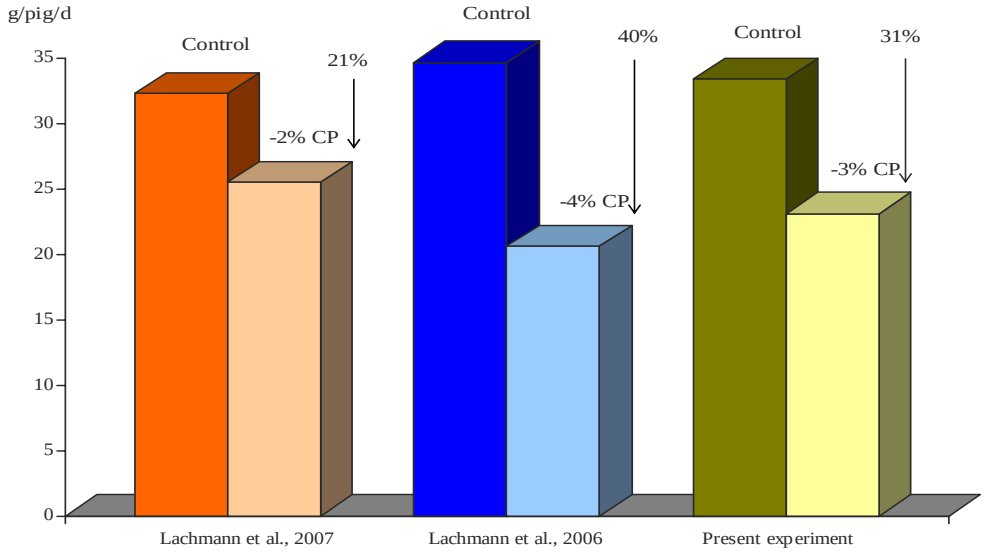

Figure 1. Comparison of results of manipulation of dietary CP on daily N excretion from three different experiments.

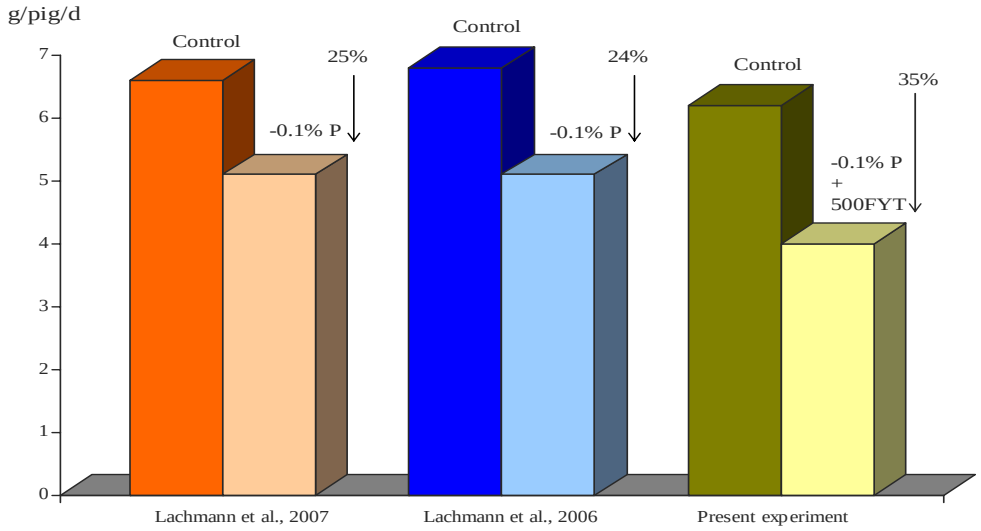

Figure 2. Comparison of results of manipulation of dietary P on daily P excretion from three different experiments

In summary, a reduction of 3% units of CP,.1% unit of P, TM, and addition of phytase in grower-finisher diets fed during the entire grow-finishing period (110 d) did not affect pig growth performance, but it decreased daily and total DM, N and P excretion by 12, 31 and 34%, respectively. Furthermore, it reduced NH_3 emission by 56%, and daily macro-mineral and micro-mineral excretion by 20 and 46%, respectively.

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