1999 Animal Science Research Report

EFFECTS OF CORN AND(OR) SOYBEAN MEAL ON NITROGEN AND PHOSPHORUS EXCRETION OF GROWING PIGS

Pages 280-286

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Story in Brief

Six groups of four littermate barrows with an average initial weight of 29.4 kg were used to determine nitrogen and phosphorus excretion and the magnitude of deviation from minimal excretion due to corn, soybean meal (SBM), or a combination of corn and SBM. Dietary treatments were: 1) a fortified corn starch-casein diet formulated to result in minimal excretion (control), 2) as 1 with corn replacing cornstarch, 3) as 1 with SBM replacing casein, and 4) corn-SBM. All diets were formulated to contain .82% digestible lysine, .31% available phosphorus, and were fed for 14 d followed by a 5-d collection period. Pigs were housed individually in metabolism chambers that allowed for the total collection of urine, feces and refused feed. Daily dry matter excretion was lowest (P<.05) for pigs fed the control diet followed by those fed SBM, corn, and corn-SBM. Total nitrogen and phosphorus excretion was highest (P<.05) for pigs fed the corn-SBM diet. Absorption and retention of nitrogen and phosphorus as a percentage of intake was lowest for pigs fed the corn-SBM diet and greatest for those fed the control diet. However, there were no differences in percent retention of nitrogen and phosphorus between pigs fed either corn or SBM. These results suggest that corn contributes more to dry matter excretion than soybean meal. However, in a typical corn-soybean meal diet for growing pigs, the excretion of nitrogen and phosphorus attributed to corn or soybean meal is similar.

Key Words: Pigs, Excretion, Nitrogen, Phosphorus, Dry Matter

Introduction

Nitrogen (N) and phosphorus (P) are currently two elements of concern in the pollution of land and water via large animal feedlots and excess fertilizer application. For the swine industry, several methods of reducing N and P excretion have been proposed and include phase feeding (Lenis, 1989), use of synthetic amino acids (Carter, 1996), formulating diets on a digestible amino acid basis (Chung and Baker, 1991), and use of enzymes such as phytase (Cromwell, 1991). Reduction of N excretion also has the potential to alleviate some of the problems associated with offensive odors due to ammonia production. Nitrogen and phosphorus are of keen interest to nutritionists because the protein and inorganic P supplements used in conventional swine diets represent the second and third most expensive ingredients, respectively. Thus, the purpose of this experiment was to examine the most common forms of energy (corn) and protein (SBM) used in pig diets and their relationship to N and P excretion.

Materials and Methods

Procedure. Twenty-four crossbred barrows (initial BW of 29.4 kg) were used to determine the amount of N and P excretion attributable to corn or SBM in a typical corn-SBM diet. There were six sets of four littermates with each pig within litter receiving one of four dietary treatments (Table 1). Diet 1 served as the control and was formulated to result in minimal N and P excretion. This was accomplished by utilizing corn starch and casein as highly digestible sources of carbohydrates and protein, respectively. Calcium carbonate and monosodium phosphate were utilized as highly available sources of Ca and P. Crystalline amino acids were added on an ideal basis (Baker and Chung, 1992), and trace minerals and

vitamins were added to meet or exceed NRC (1998) standards. In Diet 2, corn replaced a portion of the cornstarch on an equivalent digestible lysine basis. Diet 3 was formulated with soybean meal replacing casein on a digestible lysine basis. Diet 4 was formulated utilizing corn and soybean meal which replaced cornstarch and casein, respectively, on a digestible lysine basis. All diets were fed in meal form and were formulated to contain .82% digestible lysine and .31% available P (Table 2). Soybean oil was added to make all diets isocaloric. Crystalline lysine, threonine, methionine, and tryptophan were added as needed to provide an ideal ratio to lysine. Monosodium phosphate and calcium carbonate were added to diets to provide a constant ratio of Ca:available P (1.9:1), which was maintained across treatments. The control diet was formulated to minimize total N and P excretion so as to make comparisons between corn and SBM. Thus, excretion values (g/d) for pigs fed the control diet can be thought of as the lowest possible daily excretion values while maintaining normal growth.

Pigs were housed individually in metabolism chambers (.75 × 1.0 m) with galvanized mesh floors and allowed *ad libitum* access to both feed and water. Experimental diets were fed for a 14-d adaptation period followed by 5-d total collection of urine, feces, feed, and refused feed. Pigs were weighed at d 0 and 5 of the collection period to monitor daily gain and collection of urine, feces and refused feed was performed daily. Fecal weight and urine volume were recorded daily and frozen for lab analysis.

Analysis. Feed samples were dried at 100° C for 24 h and fecal samples were freeze dried for 7 d to determine dry matter content prior to analyses for percent N and P. Urinary N was determined by Kjeldahl method. Urinary urea N and ammonia (Sigma, Proc. 640) and percent P (Sigma, Proc. 670) were determined by colorimetric analysis.

Data were analyzed as a randomized complete block design with pig as the experimental unit. Analysis of variance was performed using GLM procedures of SAS (1992). Means were compared by protected least significant differences.

Results and Discussion

Rate and efficiency of gain during the 5 d collection period were similar (P>.05) for pigs fed corn, SBM, or the corn-SBM diets. Pigs fed the corn diet consumed more feed (P<.05) and tended to gain more (P<.10) compared with pigs fed the control diet. No differences were detected (P>.05) in efficiency of gain for any treatment. Daily DM excretion (Table 2) was lowest (P<.01) for pigs fed the control diet followed by those fed SBM, corn, and corn-SBM. Corn accounted for 66% of DM excreted by pigs fed the corn-SBM treatment while SBM contributed 33%.

Nitrogen. Daily N intake, fecal excretion of N, and total excretion of N were lowest (P<.01) for control pigs, similar (P>.05) for pigs fed either corn or SBM, and highest (P<.01) for pigs fed the corn-SBM diet (Table 3). Pigs fed the SBM diet had greater (P<.05) excretion of total urinary N and urea N when compared with pigs fed the corn diet. Pigs fed the corn-SBM diet had the greatest (P<.01) total urinary N and urea N excretion compared with all other treatments. No differences were detected (P>.05) in urine ammonia concentration. Absorption and retention of N (g/d) were lowest for control pigs (P<.01); however, there was no difference (P>.05) in grams per day of retained N for pigs fed corn or SBM. Pigs fed corn-SBM retained more N (P<.05) compared with pigs fed all other diets. Absorption and retention of N as percentage of intake were highest (P<.01) for the control pigs and lowest (P<.01) for pigs fed corn-SBM. No differences (P>.05) existed between pigs fed either corn or SBM for N retention as a percentage of intake.

Phosphorus. Daily P intake, fecal excretion of P, and total excretion of P were lowest

(P<.01) for pigs fed the control diet (Table 3). However, there were no differences in fecal, urinary, or total P excretion between pigs fed either corn or SBM (P>.05). Fecal excretion of P was highest (P<.01) for pigs fed the corn-SBM diet. Urinary excretion of P was lower (P<.05) for pigs fed the corn diet compared with pigs fed either SBM or corn-SBM. This increased excretion most likely occurred because phosphorus was more available in the casein compared with the SBM. Phosphorus absorption and retention as percentage of intake was highest for the control diet (P<.01). Pigs fed corn or SBM absorbed and retained more P (P<.05) as a percentage of intake when compared with pigs fed corn-SBM; however, no differences (P>.05) existed between pigs fed either corn or SBM.

It is interesting to note that the daily dry matter excretion, fecal N, urinary N, urea N as percentage of urine N, and fecal P values of pigs fed diets with corn and pigs fed diets with SBM were, when added together, nearly equal to the values for pigs fed the diet with a combination of corn and SBM. For example, DM excretion by the pigs fed the corn diet (Figure 1) was approximately 94 g and pigs fed the SBM diet excreted about 48 g of DM per day. When these two values are added together, the result approaches that value given for pigs fed a combination of corn and SBM (140 g). These numbers demonstrate the ability to partition excretion numbers and attribute them to either corn or SBM. Figure 2 shows that total N excretion, when expressed as percentage of intake, is nearly five times greater for pigs fed a corn-SBM diet compared with pigs fed the control diet. Similarly, phosphorus excretion was nearly three times greater when comparing the control vs corn-SBM diet.

Specifically, these values demonstrate that corn contributes significantly more to dry matter excretion when compared with SBM. Retained nitrogen as a percentage of intake was markedly decreased for pigs fed the corn-SBM combination. Soybean meal accounted for almost two-thirds of the N excretion attributed to urine; however, SBM and corn appear to contribute equally to the total N and P content of swine excreta when fed a typical corn-SBM diet.

Implications

Clearly, there is potential for reduction of nitrogen and phosphorus in the manure of pigs fed a corn-SBM diet. As swine operations become larger and more condensed, the need for minimization of nutrient excretion will most likely focus on manipulation of the diets fed to these animals.

Literature Cited

Baker, D.H. and T.K. Chung. 1992. Biokyowa Inc., Chesterfield, MO.

Carter, S.D. 1996. J. Anim. Sci. 74 (Suppl. 1):59.

Chung, T.K. and D.H. Baker. 1991. J. Nutr. 121:979.

Cromwell, G.L. 1991. Feedstuffs 63:14.

Lenis, N.P. 1989. J. Agric. Sci. 37:61.

NRC. 1998. Nutrient Requirements of Swine. National Academy Press, Washington, DC.

SAS. 1992. The SAS System for Windows (Release 6.08). SAS Inst. Inc., Cary, NC.

Table 1. Composition of diets.[a]

	Treatment			
Ingredient %	Control	Corn	SBM	Corn-SBM
Corn starch	79.17	17.90	61.27	--
Casein	11.70	10.21	1.49	--
Corn	--	60.51	--	60.51
SBM-48	--	--	27.78	27.78
Soy oil	3.69	6.39	4.65	7.35
DL-Methionine	.08	.07	.12	.11
L-Cystine	.08	.07	.01	--
L-Threonine	.12	.11	.08	.06
L-Tryptophan	.04	.03	--	--
NaH_2PO_4	.04	.00	.15	.11
$CaCO_3$	.47	.48	.15	.16
K_2SO_4	.75	.31	.51	.07
NaCl	.32	.27	.30	.25
$NaHCO_3$	.55	.65	.50	.59
Phos mix[b]	2.0	2.0	2.0	2.0
Vit TM mix[c]	1.0	1.0	1.0	1.0

[a]As fed basis. Diets were formulated to contain .82% digestible lysine and .31% available P
A constant ratio of Ca:available P (1.9:1) was maintained across treatments.

[b]Formulated to contain 40.5% NaH_2PO_4, 49.5% $CaCO_3$, and 10% MgCl.

[c]Vitamins and minerals met or exceeded NRC (1998) requirements.

Table 2. Analysis of diets.

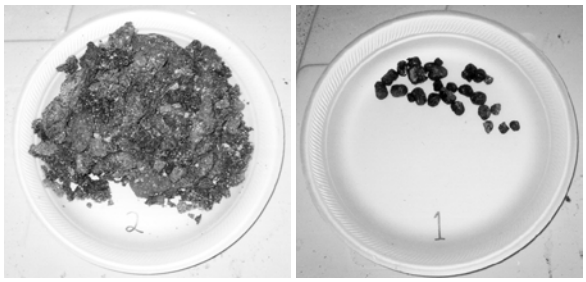
	Treatment			
Item	Control	Corn	SBM	Corn-SBM
Calculated analysis				
ME, Mcal/kg DM	4.1	4.1	4.1	4.1
Total AA, %				
Lysine	.85	.92	.92	.98
Threonine	.55	.65	.65	.76

TSAA	.48	.65	.57	.74
Tryptophan	.18	.18	.20	.20
Digestible AA, %				
Lysine	.82	.82	.82	.82
Threonine	.53	.53	.53	.53
TSAA	.49	.49	.49	.49
Tryptophan	.15	.15	.15	.15
Calculated analysis				
Calcium, %	.60	.60	.60	.60
Phosphorus, %	.38	.45	.54	.68
Available Phos, %	.31	.31	.31	.31
Analyzed values				
Nitrogen, %	1.83	2.51	2.64	3.33
Phosphorus, %	.38	.45	.54	.68

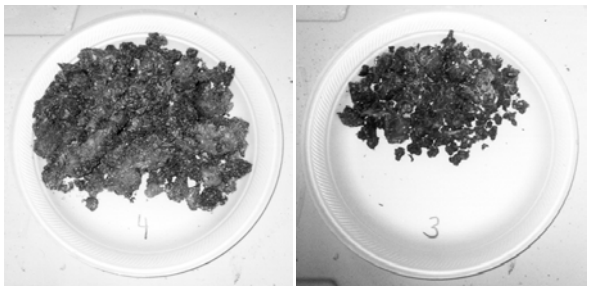
Table 3. Effects of corn and(or) soybean meal on nitrogen and phosphorus balance[a].

	Treatment				
Item	Control	Corn	SBM	Corn-SBM	SE
DM excretion, g/d	11.8[b]	93.5[c]	48.5[d]	139.5[e]	5.2
Apparent N balance, g/d					
N intake	22.2[b]	34.9[c]	32.5[c]	44.6[d]	1.5
Fecal N excretion	.33[b]	3.0[c]	2.5[c]	5.9[d]	.23
Urinary N	1.2[b]	2.7[c]	4.5[d]	7.3[e]	.45
Urinary urea N	.61[b]	3.5[c]	6.49[d]	10.0[e]	.66
Urinary NH_3	1.3[b]	1.0[b]	1.2[b]	1.4[b]	.17
Total N excretion	1.5[b]	5.9[c]	7.25[c]	13.3[d]	.62
Absorbed N	21.8[b]	31.9[c]	29.9[c]	38.7[d]	1.5
Retained N	20.6[b]	27.7[c]	25.4[c]	31.4[d]	1.3
Apparent N balance, %					
Absorbed N	98.5[b]	91.2[c]	92.1[c]	86.8[d]	.57
Retained N	92.9[b]	82.3[c]	78.3[c]	70.4[d]	1.3
Retention, % of absorbed	94.3[b]	90.9[c]	85.3[d]	81.1[e]	1.1
Apparent P balance, g/d					
P intake	4.5[b]	6.3[c]	6.7[c]	9.1[d]	.26
Fecal P excretion	.29[b]	1.7[c]	1.7[c]	3.2[d]	.14
Urinary P excretion	.22[b]	.12[bc]	.32[bd]	.34[bd]	.55
Total P excretion	.52[b]	1.9[c]	2.1[c]	3.5[d]	.14
Absorbed P	4.3[b]	4.5[b]	4.9[b]	5.9[c]	.26
Retained P	4.0[b]	4.1[b]	4.6[b]	5.5[c]	.23

Apparent P balance, %					
Absorbed P	93.4[b]	72.3[c]	74.5[c]	64.6[d]	2.3
Retained P	88.5[b]	68.1[c]	68.7[c]	60.7[d]	1.2
Retention,% of absorbed	94.9[b]	97.2[bc]	93.5[bd]	94.0[b]	1.2
[a]Least squares means for six individually-penned pigs per treatment. [b,c,d,e]Means within row with different superscripts differ, (P<.05).					



Cornstarch-casein Corn-casein



Cornstarch-SBM Corn-SBM

Figure 1. Daily fecal excretion from pigs fed the four dietary treatments.

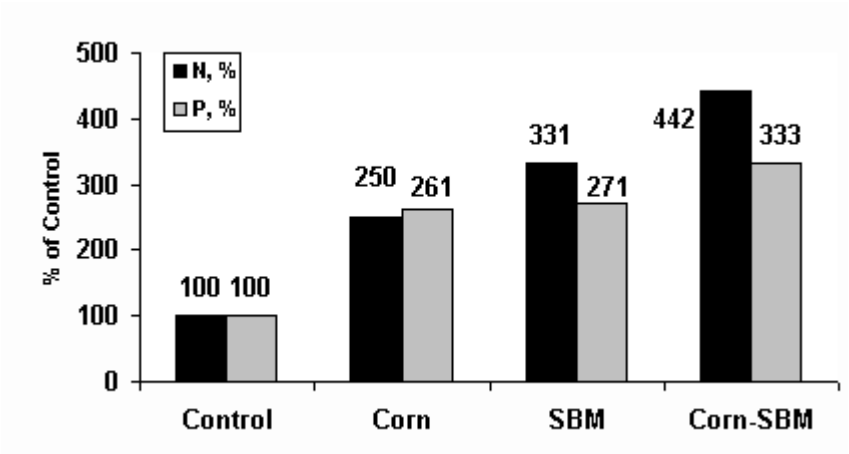


Figure 2. Nitrogen and phosphorus excretion (as a percentage of intake) for pigs fed corn, SBM, or corn-SBM diets compared with pigs fed a control diet formulated for minimal N and P excretion.

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