Amendment of nitrogen and phosphorus in swine manure by nutrition

R.R. Grandhi
Agriculture and Agri-Food Canada
Brandon Research Centre
P.O. Box 1000A, RR#3
Brandon, MB. R7A 5Y3

Introduction

A rapid expansion of swine production in prairie provinces increased the public awareness of the possible environmental risks of swine manure. The odours and water quality deterioration being the main concerns, and an excess nitrogen (N) and phosphorus (P) excreted in manure are responsible for adverse effect on water quality. Some of the large swine production units do not have sufficient land base for an effective utilization of manure as fertilizer resulting in manure storage and disposal problems. The new provincial environmental regulations require nutrient management plans from the farms when the swine production exceeds certain number of animal units. Some feeding strategies were developed for an amendment of the N and P content of swine manure to minimize the adverse effects on environment.

Materials and methods

A total of 224 lean genotype crossbred barrows and gilts were used in two experiments to determine the differences in pig performance and excretion of faecal dry matter in manure between covered-barley (CB) and hulless-barley (HB) grower-finisher diets. The effects of replacing soybean meal with amino acids - lysine, threonine, methionine and tryptophan, and supplemental carbohydrase (Ronozyme-B) enzyme in HB diets on pig performance and nitrogen excretion in manure were also determined. A total of 144 lean genotype crossbred barrows and gilts were used in another experiment to determine the effect of supplemental Ronozyme-phytase and amino acids in CB and HB diets on pig performance and excretion of P and N in manure. Nutrient balance studies were conducted to determine the metabolism and excretion of dry matter, energy, N and P. The experimental diets were fed as pellets ad libitum with free access to drinking water. Pigs were slaughtered at about 105 kg body weight for carcass merit evaluation. Pigs in all experiments were housed and managed according to the Canadian Council on Animal care guidelines.

Results and Discussion

<u>Effect of replacing soybean meal with amino acids</u>
In the first two experiments (Table 1), the ADG and feed efficiency were similar ($P > 0.05$) between CB and HB diets. The ADG and feed efficiency were similar between diets 2 and 3 except during the grower period when the feed efficiency was higher ($P < 0.05$) for diet 3 than diet 2 indicating that replacing soybean meal with amino acids did not adversely affect the pig performance. Supplemental carbohydrase in diet 4 increased the feed efficiency compared to diet 3 during the finisher and overall periods. The carcass value index was not different among

diets indicating that supplemental amino acids or carbohydrase enzyme did not influence the carcass quality.

Nutrient balance studies indicated that the absorption of feed dry matter was higher for diet 2 than diet 1 which decreased the faecal dry matter excretion by 31.6 % for diet 2. The energy absorption was also higher for diet 2 than diet 1 indicating that energy digestibility was higher for HB. The absorption of dry matter and energy were not different among diets 2, 3 and 4 indicating that supplemental amino acids or carbohydrase did not improve the metabolism of these nutrients. The N retention as % of intake was not different between diets 1 and 2. Although the N retention was 10.0 % higher for diet 3 than diet 2, the difference was not significant indicating that supplemental amino acids to HB diet did not influence the N utilization efficiency. The absolute N retention was not different among the diets 2, 3 and 4 indicating that supplemental amino acids did not influence the absolute N retention. The excretion of N in faeces and urine was not different between the diets 1 and 2. The total excretion of N was lower by 22.0 % for diet 3 and 24.5% for diet 4 than diet 2 indicating that soybean meal in HB diets can be replaced by lysine, threonine, methionine and tryptophan to minimize the N excretion. Addition of carbohydrase enzyme did not further decrease the N excretion. The hydrogen sulfide concentration was high in manure after agitation than prior to agitation indicating that agitation released the dissolved hydrogen sulfide from liquid manure. Manure from diet 3 had 30 % less ammonia and 66 % less hydrogen sulfide than diet 2 after agitation. The excretion of N in urine was positively correlated to ammonia production in manure.

Effect of supplemental phytase and amino acids

In phytase study (Table 2), the ADG during the grower, finisher and overall periods was not different between CB and HB diets but the feed efficiency was higher for HB than CB diets. The ADG was not different among diets 1, 2 and 3 during the grower, finisher and overall periods indicating that supplemental phytase to diets 2 and 3 overcame the adverse effect of omitting inorganic P in diets. Also, supplemental amino acids in diet 3 overcame the possible adverse effect of reducing soybean meal on growth performance. The feed efficiency was higher in pigs fed diet 3 than 1 and 2 during the finisher and overall periods probably due to a better amino acid balance of diet 3. The carcass index was not different between CB and HB or among the diets 1, 2 and 3 indicating that omitting of inorganic P with supplemental phytase did not have any adverse effect on carcass quality.

The dry matter absorption was higher for HB than CB diets resulting in a lower faecal dry matter excretion for HB than CB diets. The P intake was lower in pigs fed diets 2 and 3 than diet 1 because of omitting inorganic P in diets 2 and 3. The P retention as % of intake was not different between CB and HB or among the treatment diets indicating no difference in P retention efficiency. The absolute P retention (g d^{-1}) was higher in HB than CB probably because of a higher P intake in HB fed pigs. Although the absolute P retention values were 20.0 % lower for diets 2 and 3 than diet 1, the difference was not significant. The faecal and total excretion of P were lower for CB than HB, and for diets 2 and 3 than diet 1. The excretion of P in urine was low and not different between CB and HB or among the diets 1, 2 and 3. The reduction in total P excretion was 26.8 % for diet 2 and 29.3 % for diet 3 compared to diet 1.

The N retention (%) was similar between CB and HB diets but it was higher for diet 3 than diets 1 and 2. indicating that dietary ideal amino acid ratios improved the efficiency of N utilisation. Supplemental phytase had a minimal effect on N retention efficiency. The absolute N retention (g d^{-1}) was higher for HB than CB diets probably because of higher N intake for HB than CB diets. The absolute N retention was not different among diets 1, 2 and 3 indicating no difference in protein deposition. The excretion of N in urine was higher for HB than CB diets, and it was lower for diet 3 than diets 1 and 2. The decrease of N excretion in urine for diet 3 was probably due to a better amino acid balance and a relatively lower N intake. The combined total N excretion in both faeces and urine was low for diet 3 than diets 1 and 2 with a reduction of 8.0 % for diet 2 and 23.2 % for diet 3 than diet 1.

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The extra feed cost associated with supplemental phytase and amino acids may be offset by the cost saving of omitting inorganic P and reduction of soybean meal in CB or HB diets. The improvement in feed efficiency with supplemental amino acids may also offset the extra feed cost. If the environmental benefits caused by the reduction of P and N excretion are taken into consideration, then supplementation of phytase and amino acids to CB or HB diets will be economically sound and environmentally advantageous for an effective swine manure management and sustainable swine production.

Conclusions

Pigs fed HB diets had increased absorption of dry matter and energy, and a 31.6 % less fecal dry matter excretion resulting in less manure production for storage and disposal. This allows more pigs to be raised on same land base because manure from more pigs can be spread on same land base. Replacing soybean meal in HB diets with amino acids - lysine, threonine, methionine and tryptophan did not compromise the pig performance, and it decreased the N excretion by 22.0 % in manure. Supplemental carbohydrase improved the feed efficiency but did not further increase the energy digestibility or decrease the N excretion. The ammonia and hydrogen sulfide production in manure was decreased by feeding HB diets containing supplemental amino acids. Supplemental phytase at 500 FTU kg^{-1} eliminated the need for inorganic supplementation to CB or HB diets. It did not compromise the growth performance of pigs, and decreased the P excretion in manure. The combination of supplemental phytase and amino acids had an additive effect on reduction of P and N excretion, and this allows the utilization of more manure on a limited land base. These feeding strategies can be used to minimize the adverse effects of swine manure on environment and for sustainable swine production.

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Table 1. Effect of supplemental amino acids and carbohydrase to hulless-barley diets on pig performance and nutrient excretion

	Diet[z]				Pooled SEM	P-value Diet
	1	2	3	4		
Pig performance (20 to 105 kg):						
No. of pigs	56	56	56	56		
Ave. Daily weight gain (kg):						
Grower	0.78	0.78	0.82	0.82	<0.01	0.116
Finisher	0.91	0.88	0.88	0.90	0.07	0.945
Overall	0.84	0.83	0.85	0.86	0.01	0.404
Gain to feed ratio :						
Grower	0.431$_{ab}$	0.421$_{a}$	0.447$_{bc}$	0.454$_{c}$	<0.01	0.001
Finisher	0.295$_{a}$	0.303$_{a}$	0.302$_{a}$	0.323$_{b}$	<0.01	0.032
Overall	0.348$_{a}$	0.352$_{a}$	0.359$_{a}$	0.374$_{b}$	<0.01	0.001
Carcass value index	108.4	106.5	108.0	108.7	0.27	0.668
Nutrient metabolism and excretion (Finisher period):						
No. of gilts	4	4	4	4		
Dry matter:						
Intake (g d^{-1})	2339	2376	2373	2291	64.00	0.960
Absorption (%)	83.7$_{a}$	88.9$_{b}$	89.2$_{b}$	89.4$_{b}$	0.45	0.005
Excretion (g d^{-1}):						
In faeces	383.7a	262.3$_{b}$	256.9$_{b}$	247.8$_{b}$	13.10	0.020
Energy:						
Intake (MJ d^{-1})	44.5	42.5	42.6	40.9	1.15	0.765
Absorption (%)	84.1$_{a}$	87.8$_{b}$	89.2$_{b}$	89.5$_{b}$	0.52	0.027
Nitrogen:						
Intake (g d^{-1})	52.0	49.2	45.7	43.5	1.25	0.189
Retention (%)	55.7	43.1	53.1	51.6	2.67	0.420
Retention (g d^{-1})	28.2	21.5	24.5	22.8	1.56	0.569
Excretion (g d^{-1}):						
In faeces	10.2	10.5	7.7	6.3	0.58	0.098
In urine	12.9	17.2	13.9	14.6	1.26	0.680
Total	23.2	27.7	21.6	20.9	1.17	0.235

[z] Diets: 1 = CB control, 2 = HB control diet, 3 = same as diet 2 but soybean meal replaced by amino acids (lysine, threonine, methionine and tryptophan), 4 = same as diet 3 plus carbohydrase enzyme (Ronozyme-W supplied by Hoffmann-La Roche Ltd.).

Least square means followed by different letters are significantly different ($P < 0.05$).

Table 2. Effect of supplemental phytase enzyme and dietary ideal amino acid ratios in covered and hulless barley diets on pig performance and nutrient excretion

	Barley		Diet[z]			Pooled SEM	P-value	
	Covered	Hulless	1	2	3		Barley	Diet
Pig performance (20 to 105 kg):								
No. of pigs	72	72	48	48	48			
Ave. Daily weight gain (kg):								
Grower	0.68	0.71	0.69	0.69	0.70	0.01	0.999	0.737
Finisher	0.89	0.97	0.92	0.95	0.93	0.01	0.195	0.506
Overall	0.78	0.83	0.79	0.80	0.81	0.01	0.374	0.499
Gain to feed ratio (kg):								
Grower	0.437	0.461	0.447	0.445	0.457	<0.01	0.001	0.236
Finisher	0.340	0.371	0.341$_{a}$	0.357$_{ab}$	0.368$_{b}$	<0.01	0.001	0.023
Overall	0.380	0.408	0.383$_{a}$	0.394$_{ab}$	0.405$_{b}$	<0.01	0.001	0.008
Carcass index	109.3	107.6	108.2	108.1	108.9	0.28	0.188	0.941
Nutrient metabolism and excretion (Grower period):								
No. of gilts	12	12	8	8	8			
Dry matter:								
Intake (g d^{-1})	1335	1452	1464	1338	1378	36.8	0.130	0.352
Absorption (%)	83.1	88.8	85.3	85.9	86.5	0.30	0.001	0.348
Excretion (g d^{-1}):								
In faeces	226	164	212	188	185	7.20	0.001	0.278
Phosphorus:								
Intake (g d^{-1})	5.5	6.5	7.1$_{a}$	5.5$_{b}$	5.4$_{b}$	0.16	0.007	0.001
Retention (%)	43.4	45.1	41.1	44.4	47.1	1.24	0.499	0.178
Retention (g d^{-1})	2.4	2.9	3.0	2.4	2.5	0.11	0.028	0.146
Excretion (g d^{-1}):								
In faeces	3.09	3.57	4.11$_{a}$	3.01$_{b}$	2.86$_{b}$	0.108	0.042	0.001
In urine	0.02	0.02	0.02	0.02	0.02	0.001	0.371	0.274
Total	3.11	3.59	4.14$_{a}$	3.03$_{b}$	2.88$_{b}$	0.108	0.042	0.001
Nitrogen:								
Intake (g d^{-1})	37.0	43.2	43.5	39.4	37.2	1.06	0.001	0.074
Retention (%)	50.2	50.0	48.4$_{a}$	47.8$_{a}$	53.9$_{b}$	0.79	0.905	0.011
Retention (g d^{-1})	18.5	21.5	21.1	18.8	20.0	0.62	0.027	0.336
Excretion (g d^{-1}):								
In faeces	6.7	6.4	7.4	5.9	6.3	0.31	0.695	0.180
In urine	11.8	15.3	15.0$_{a}$	14.7$_{a}$	10.9$_{b}$	0.43	0.001	0.002
Total	18.5	21.7	22.4$_{a}$	20.6$_{a}$	17.2$_{b}$	0.63	0.023	0.012

[z] Diet: 1 = control; 2 = supplemental Ronozyme-phytase (supplied by Hoffmann-La Roche Ltd.; 3 = supplemental phytase + Amino acids (lysine, threonine, methionine and tryptophan).
Least square means within each group followed by different letters are significantly different ($P < 0.05$).