Effects of Ractopamine and Level of Dietary Crude Protein on Nitrogen and Phosphorus Excretion from Finishing Pigs

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Introduction

Ractopamine (RAC; Paylean®) is used as a feed ingredient for finisher swine diets that increases the amount of lean pork production with reduced feed inputs. Ractopamine functions as a leanness enhancer that acts as a nutrient-repartitioning agent, which directs nutrients away from fat deposition and to increase lean tissue accretion. Pigs fed the beta agonist, ractopamine have increased average daily gain (ADG), improved feed efficiency (G:F), increased nitrogen retention, and require a decreased number of days to market (Anderson et al., 1987; Watkins et al., 1990).

Because of this increased efficiency in producing pork resulting from the addition of ractopamine to the diet, there may be positive environmental benefits to using ractopamine. Potential benefits of ractopamine to improve stewardship of farmland resources may include, increasing nutrient retention, especially nitrogen and phosphorus, while decreasing these nutrients in total manure output. Currently, applications of nitrogen and phosphorus from manure to farmland is a major environmental concern. Excess nitrogen can leach into groundwater or runoff into surface water sources and soluble phosphorus can be a runoff threat to surface water. Moody et al. (2000) reports potential environmental impacts of ractopamine being decreased nitrogen excretion, decreased P excretion, and decreased total waste. However, this has not been verified through research. Therefore, the objective of this experiment was to determine the effects of dietary ractopamine and crude protein level on nitrogen and phosphorus retention and excretion in both urine and feces of finishing pigs.

Materials and Methods

Experimental Design

Twenty-four barrows (DeKalb EB sired) weighing approximately 185 lb (85 kg) were randomly assigned to one of four dietary treatments (Table 1). The pigs were housed in individual stainless steel metabolism crates. Each crate was 21" × 54" (53 cm × 137 cm) with rubber-coated, expanded-metal flooring. The pigs were tethered to the floor of the crate with a stainless steel collar and a webbed strap placed under the neck.

Pigs were acclimated to the crates and four times a day meal feeding for seven days on a pretrial diet, gradually increasing all pigs up to 4.85 lb/d (2200 g/d) of feed. The four equal feedings (1.21 lb/ feeding) were offered at 0600, 1200, 1800, 2400 h. In addition to the four feedings, water was offered in four equal amounts for a total of 1.27 gal/d (4800 mL/d).

Diets

The basal diet fed during acclimation to the crates and meal feeding was a corn-soybean meal diet formulated for 18.5% crude protein (CP) and supplemented with synthetic lysine to provide 1.13% total lysine. This diet was medicated with Tylan at 40 g/ton.

The experimental diets (Table 2) were formulated to provide similar amino acid ratios at two different protein levels. The amino acid ratios were based on the 1998 NRC recommendations for the finishing pig. Diets also contained either 0 or 18 g/ton Paylean. When pigs were assigned to test diets Tylan soluble was added to the water for 20 feedings since the test diets did not contain Tylan.

Data Collection and Analysis

Initial and final bodyweights were taken to determine ADG and G:F. The initial bodyweights were taken prior to offering the test diets and final weights were taken after the end of the 5-day collection period

Urine was collected for a 5-day period after a 5-day acclimation period to the test diets. Urine was collected daily after the 0600 h feeding. Each urine collection bucket contained 80 mls of 3 N HCl prior to placement under each crate. Each pig's urine volume was recorded daily and a 10% sub-sample was placed in a plastic bottle and frozen. Samples were then composited for each pig for the 5-day collection period and stored frozen prior to analysis. The urine samples were analyzed for total nitrogen, ammonium nitrogen, and total phosphorus.

Feces were collected from each pig twice daily, after 0600 and 1800 h feedings to minimize nutrient losses in the samples collected. Feces were weighed, recorded after each collection and stored frozen. Each pig's feces was composited and subsampled after the 5-day collection period. The feces were analyzed for pH, dry matter, total nitrogen, ammonium nitrogen, and total phosphorus.

Statistical Analysis

Data were analyzed using the GLM statistical procedure in SAS (1996). Growth data was analyzed using the initial body weight as a covariate. Treatment means were separated using the using Student-Newman-Keuls test at $P < .05$.

Results and Discussion

Table 3 displays the growth performance with the main effects of dietary CP levels with or without the addition of RAC. There was approximately a 4.2 lb spread across treatments in initial bodyweight of these pigs, so the initial bodyweight was used as a covariate. Pigs fed RAC had 4.1 lb greater final bodyweights ($P < .05$) than those fed no RAC. Average daily gain was increased by .52 lb/d ($P < .05$) for pigs fed RAC compared to the pigs fed non RAC diets, while G:F was also improved by 27% ($P < .05$).

The amount of urinary and fecal output (volume and nutrient contents) is an important environmental concern. If the land base for manure application is limited and storage capacity is limited, decreasing manure and nutrient outputs are crucial to swine operations. Table 4 indicates the output parameters for urine, feces, and manure by dietary CP and with or without the addition of RAC. To insure accurate comparison of outputs across all treatments, all pigs were fed and watered a constant amount. Pigs fed control diets had a .22 lb/d decrease ($P < .05$) in fecal output but a 13% increase ($P < .05$) in urine output, on an as is basis compared to pigs fed RAC. However, RAC fed pigs had an 8% reduction ($P < .05$) in total manure volume compared to control pigs on an as is basis. This overall reduction in manure output is a positive step towards environmental stewardship if manure production is a concern.

Pigs fed low CP diets excreted 2% less total manure and 24.5% less urinary N ($P < .05$), and tended to have lower fecal N ($P < .07$). Pigs fed RAC had a 43% decrease in urinary N ($P < .05$)

excretion and decreased total manure N ($P < .05$) excretion by 33% compared to pigs fed non-RAC diets. The amount of N retained increased with the addition of RAC ($P < .05$) by 38% along with an 8% increase when pigs were fed the higher CP diets. The N retained as percent of intake increased when pigs were fed the low CP diets. The increase in N retention when pigs are fed ractopamine is due to the increased lean tissue accretion while feeding ractopamine. On a daily basis ractopamine fed pigs had improved N utilization and decreased N excretion.

There is a shift in P excretion relative to dietary CP level. The amount of P excreted in the feces tended to decrease by 10% when pigs were fed low CP diets ($P < .06$). However, the amount of P excreted in the urine increased 53% when pigs were fed the low CP diets ($P < .05$). Urinary phosphorus excretion decreased 41% with the addition of RAC ($P < .05$). The percentage of retained P of that absorbed, increased 7% with the addition of RAC ($P < .05$) and 4% with high CP diets ($P < .05$). The use of ractopamine in swine diets improved P retention, however with only a minimal change in total P excretion.

As expected, the majority of P excretion is in feces compared to urine. However, in this study even though the level of P excreted in the urine was much less than feces, it is evident that CP and RAC affected the physiological status of P in the pig. The P level in all diets met or exceeded the NRC requirement estimates. Future research is needed to determine the effect of CP level and RAC on P retention and excretion in different genetic lines of pigs fed different levels of available P in the diet.

Total manure production and nutrient excretion was estimated in Table 5 if Paylean were to be fed for 28 days. Total manure produced could be decreased by 17.5 lb and nitrogen excretion by .56 lb in the 28 day feeding period. These numbers should help pork producers realize the potential benefit that Paylean may have in nutrient excretion if similar type diets were fed in their swine operations.

Implications

The addition of ractopamine to swine diets has displayed some environmental improvements that could be of value to pork producers. Overall manure output is decreased by 2.1 gallons, nitrogen retention in the pig is increased .64 lbs and nitrogen excretion per pig is decreased .56 lbs when a ractopamine diet compared to the control diet is fed to pigs over a 28 day period. When comparing the industry applicable diets of 13.8% control and the 16.1% ractopamine added diets, there was a 51% increase in nitrogen retention and a 14% reduction in daily nitrogen excretion. Ractopamine can improve the stewardship of farmland resources by increasing nutrient retention, especially nitrogen, while decreasing total manure and nitrogen output.

References

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Table 1. Treatment description

Treatment	Paylean g/ton	CP %	Lysine %
1	0	13.8	.80
2	0	16.0	1.10
3	18	16.0	1.10
4	18	13.8	1.10

Table 2. Experimental diet composition

Ingredient, %	Diet 1	Diet 2	Diet 3	Diet 4
Corn	78.79	73.52	73.40	79.36
Soybean Meal 48%	16.05	21.00	21.02	14.26
Fat	2.00	2.00	2.00	2.00
Dical. Phos.	1.61	1.51	1.51	1.67
Calcium Carbonate	0.78	0.81	0.81	0.75
Salt	0.40	0.40	0.40	0.40
Vit. And Min. Premix	0.20	0.20	0.20	0.20
Lysine-HCl	0.17	0.38	0.37	0.62
DL-Methionine	0	0.06	0.06	0.10
L-Threonine	0	0.12	0.12	0.23
L-Tryptophan	0	0.01	0.01	0.05
L-Isoleucine	0	0	0	0.11
L-Valine	0	0	0	0.15
Paylean - 9	0	0	0.10	0.10
Nutrient Analysis				
ME Swine, Kcal/lb	1490.2	1487.1	1485.6	1488.9
Crude Protein, %	13.78	16.10	16.10	13.80
Crude Fat, %	5.17	5.02	5.02	5.17
Crude Fiber, %	2.53	2.57	2.56	2.49
Calcium, %	.70	.70	.70	.70
Total Phosphorus, %	.60	.60	.60	.60
Available Phosphorus, %	.35	.34	.34	.36
Lysine, %	.80	1.10	1.10	1.10
Meth. + Cyst., %	.51	.62	.62	.58
Threonine, %	.52	.72	.72	.72
Tryptophan, %	.16	.20	.20	.20
Isoleucine, %	.54	.63	.63	.61
Valine, %	.63	.72	.72	.74

Table 3. Growth performance[*]

Dietary CP	13.8% CP		16.1% CP		
Paylean, 18 g/ton	**-**	**+**	**-**	**+**	**CV**
Initial BW, kg	85.15	84.16	85.23	83.33	2.81
Final BW, kg	97.12	99.47	97.5	98.86	1.90
ADG, kg/d	.871[a]	1.11[b]	.898[a]	1.13[b]	13.53
ADFI, kg/d	2.20	2.19	2.20	2.20	0.30
G:F	.396[a]	.507[b]	.406[a]	.513[b]	13.55
F:G	2.59[a]	2.01[b]	2.49[a]	1.97[b]	14.95

[*]Initial BW as covariate
[a,b]Row differences at $P < .05$

Table 4. Nitrogen and phosphorus excretion*

Dietary CP	13.8% CP		16.1% CP		
Paylean, 18 g/ton	-	+	-	+	CV
Water Intake, mL	4800	4800	4800	4800	--
Feed Intake, g/d	2200	2200	2200	2200	--
Feces, g/d, as is	484.7[a]	654.2[b]	578.0[c]	609.2[c]	6.24
Urine, mL/d, as is	3040.5[a]	2621.7[b]	3038.5[a]	2690.0[b]	6.28
Manure, g/d as is	3525.2[ab]	3275.9[b]	3616.5[a]	3299.2[b]	5.41
N, % digested	88.36	88.49	88.74	88.93	1.76
P, % digested	58.86	56.72	51.29	53.74	10.36
N					
Intake, g/d +	49.83	52.58	59.08	59.07	0
Feces, g/d	5.80	6.05	6.65	6.54	13.86
Urine, g/d	18.85[a]	9.79[b]	23.48[c]	14.43[d]	14.83
Total N excreted, g/d	24.64[a]	15.84[b]	30.14[c]	20.96[d]	9.40
Absorbed, g/d	44.03[a]	46.53[b]	52.43[c]	52.53[c]	1.78
Retained, g/d	25.19[a]	36.74[b]	28.94[c]	38.11[b]	6.67
Retained, % intake	50.55[a]	69.88[b]	48.99[a]	64.51[c]	6.66
Retained, % absorbed	57.22[a]	78.96[b]	55.31[a]	72.54[c]	7.08
P					
Intake, g/d +	12.54	13.42	12.76	12.98	0
Feces, g/d	5.16	5.81	6.22	6.00	13.23
Urine, g/d	1.30[a]	0.81[b]	0.89[b]	0.48[b]	35.61
Total P excreted, g/d	6.46	6.62	7.11	6.48	11.09
Absorbed, g/d	7.38	7.61	6.54	6.98	10.76
Retained, g/d	6.08	6.78	5.65	6.50	11.33
Retained, % intake	48.49	50.65	44.28	50.06	11.33
Retained, % absorbed	82.46[a]	89.16[bc]	86.43[ac]	93.17[b]	4.91

*No covariates used
+Intakes calculated from analyzed dietary N and P values
[a,b,c,d]Means with different superscripts differ by $P < .05$

Table 5. Estimated Nitrogen and Phosphorus Excretion in a 28 day feeding period*

Dietary CP	13.8% CP		16.1% CP		
Paylean, 18 g/ton	-	+	-	+	CV
Water Intake, gal	35.51	35.51	35.51	35.51	--
Feed Intake, lb	135.8	135.8	135.8	135.8	--
Feces, lb, as is	29.9[a]	40.3[b]	35.6[c]	37.6[c]	6.24
Urine, gal, as is	22.5[a]	19.4[b]	22.5[a]	19.9[b]	6.28
Manure, lb, as is	217.4[ab]	202.0[b]	223.0[a]	203.5[b]	5.41
Total N excreted, lb	1.52[a]	0.98[b]	1.86[c]	1.29[d]	9.40
Total P excreted, lb	0.40	0.41	0.44	0.40	11.09

* No covariates used
+ Intakes calculated from analyzed dietary N and P values
[a,b,c,d] Means with different superscripts differ by $P < .05$