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Summary and Implications

When feeding excessive amounts of protein, the nitrogen eliminated by the pigs in swine facilities has an important impact in the environment. Therefore, it is important to define nutritional strategies that promote a more efficient use of protein. This study was conducted to evaluate the effect of a low-protein non-amino acid supplemented diet and ractopamine (Paylean®) on performance of late-finishing pigs. Thirty-six finishing barrows and gilts with an initial body weight of 153.4 lb were used in a 42-day experiment. Pigs were penned individually and had ad libitum access to feed and water. The pigs were randomly allotted to one of four dietary treatments with different dietary protein (10 or 16 % CP) and ractopamine (0 or 20 ppm) concentrations. Body weight and feed disappearance were measured weekly. Average daily gain (ADG), average daily feed intake (ADFI), and feed efficiency (ADG/ADFI) were calculated. Blood samples were collected weekly by venipuncture and serum was collected. Data were analyzed as repeated measures and by orthogonal contrast (to examine differences among means). There were treatment differences for ADG (P < 0.05) for the overall experimental period with the highest ADG (2.26 lb/day) corresponding to the pigs receiving 16% CP and 20 ppm ractopamine. There was no ractopamine effect on serum urea nitrogen (SUN) for any weekly period or overall. Average daily feed intake was lower for diets with 16% CP compared to diets with 10%

Table 1. Ingredient and calculated nutrient composition of the experimental diets, as-fed basis.

Item, %	Dietary Protein Concentration, %			
	10 + 0 ppm RAC[a]	10+ 20 ppm RAC	16 + 0 ppm RAC	16 + 20 ppm RAC
Corn	89.1	89	74.02	73.92
Soybean meal, 46.5% CP[b]	5.5	5.5	20.75	20.75
Tallow	3	3	3	3
Dicalcium phosphate	1.05	1.05	0.95	0.95
Limestone	0.7	0.7	0.625	0.625
Salt	0.3	0.3	0.3	0.3
Vitamin mix[c]	0.2	0.2	0.2	0.2
Trace mineral mix[d]	0.15	0.15	0.15	0.15
Paylean®	—	0.1	—	0.1
Calculated composition				
ME, Mcal/lb[e]	1.58	1.57	1.58	1.57
CP, %	10	10	16	16
Total lysine, %	0.39	0.39	0.77	0.77
Calcium, %	0.6	0.6	0.6	0.6
Available phosphorus, %	0.23	0.23	0.23	0.23

[a]RAC = Ractopamine.
[b]CP = Crude protein.
[c]Supplied per kilogram of diet: retinyl acetate, 4,400 IU; cholecalciferol, 440 IU; a-tocopheryl acetate, 24 IU; menadione sodium bisulfite, 3.5 mg; riboflavin, 8.8 mg; d-pantothenic acid, 17.6 mg; niacin, 26.4 mg; vitamin B_{12}, 26.4 mg.
[d]Supplied per kilogram of diet: Zn (as ZnO), 128 mg; Fe (as $FeSO_4 \bullet H_2O$),128 mg; Mn (as MnO), 30 mg; Cu (as $CuSO_4 \bullet 5\ H_2O$), 11 mg; I (as $Ca(IO_3)H_2O$), 0.26 mg; Se (as Na_2SeO_3), 0.3 mg.
[e]ME = Metabolizable energy.

CP, ($P < 0.05$). For diets with 10% CP (vs. 16% CP), ADG/ADFI was lower ($P < 0.05$). There was an effect of protein on ADG and ADG/ADFI ($P < 0.05$), but not on SUN or ADFI. The lack of an effect of ractopamine on ADG, ADFI, ADG/ADFI or SUN was possible due to an inadequate protein or amino acid intake. Ractopamine tended to increase growth performance. In summary, the highest CP concentration used in this experiment failed to provide an adequate amino acid supply to allow ractopamine to increase growth performance of late-finishing pigs. It appears that ractopamine requires dietary CP concentrations greater than 16% to improve growth performance in late-finishing pigs from the University of Nebraska–Lincoln herd.

Introduction

The amount of protein retained by finishing pigs is a function of the quality and amount of protein consumed, as well as the body weight and age of the pigs. Feeding pigs with the adequate amount of protein and a correct balance among the essential amino acids help avoid feeding excess protein that would increase the need to eliminate nitrogen (N). Excess N eliminated by pigs in swine facilities has an important impact on the environment because N can contaminate soil and underground water supplies.

Researchers have investigated the effects of low-protein diets on finishing pig performance as a means to improve the efficiency of protein use and to reduce N excretion. Recent investigations have shown that a 1% reduction in dietary protein concentration for finishing pigs resulted in a 10% reduction in the N excretion. Researchers have also shown that growth performance is maintained when pigs are fed diets containing 4% less protein (amino acid-supplemented) compared to pigs receiving a complete corn-soybean meal diet.

The goal of the present investigation was to determine if feeding late-finishing pigs standard or low-protein non-amino acid-supplemented diets with or without ractopamine (Paylean®) results in similar growth performance. This was a preliminary study designed to establish a response range for dietary crude protein (CP) and ractopamine additions for pigs from the UNL herd.

Procedures

Animals and treatments

Thirty-six crossbred [Danbred × (Danbred × Nebraska white line)] late-finishing barrows and gilts were used in a 42-day experiment. The average initial weight was 153.4 lb and the final weight was 234.0 lb. Pigs were penned individually in fully-slotted pens with ad libitum access to feed and water. The room was maintained at 72°F. All management and experimental procedures were approved by the Institutional Animal Care and Use Committee of the University of Nebraska–Lincoln.

Experimental diets

Treatments were arranged as a 2 x 2 factorial. The pigs were randomly assigned to one of the four experimental diets formulated to contain 10 or 16 % CP with 0 or 20 ppm ractopamine. Except for amino acids, additions of all other nutrients met or exceeded the NRC requirements (Table 1).

Data and sample collections

Average daily gain (ADG) average daily feed intake (ADFI) and feed efficiency (ADG/ADFI) were estimated weekly based on pig weight and feed disappearance. Blood samples were taken by venipuncture to the vena cava region at the beginning of the experiment and weekly thereafter. The samples were centrifuged at 3000 × g for 20 min. The red blood cell-free serum was extracted and maintained at -4°F until analysis for urea nitrogen concentration (SUN).

(Continued on next page)

Table 2. **Response of average daily gain (ADG), average daily feed intake (ADFI), feed efficiency (ADG/ADFI), and serum urea nitrogen concentration (SUN) to 10 or 16% crude protein and 0 or 20 ppm ractopamine diets.**

	Dietary protein concentration, %					P values			
	10 + 0 ppm RAC[a]	10 + 20 ppm RAC	16 + 0 ppm RAC	16 + 20 ppm RAC	SEM[b]	CP[c]	RAC	CP x RAC	SEM
Total number of pigs	9	9	9	9					
Barrows	5	5	4	4					
Gilts	4	4	5	5					
Initial weight, lb	152.80	153.1	154.66	153.42	1.95	0.68	0.76	0.68	3.83
Final weight, lb	221.26^{d}	223.86^{d}	241.58^{e}	250.21^{e}	4.295	0.01	0.24	0.55	5.99
Day 0									
SUN, mg/100 mL	8.91	8.00	8.66	10.07	1.39	0.359	0.799	0.241	0.988
Day 0 to 7									
ADG, lb	1.68^{x}	1.91^{x}	2.55^{y}	2.48^{y}	0.253	<0.0001	0.669	0.402	0.178
ADFI, lb	5.68	5.64	5.44	5.17	0.429	0.230	0.601	0.715	0.301
ADG/ADFI, lb/lb	0.29^{x}	0.33^{x}	0.47^{y}	0.46^{y}	0.037	<0.0001	0.521	0.371	0.026
SUN, mg/100 mL	11.24^{x}	12.09^{xy}	12.21^{xy}	14.16^{y}	1.39	0.129	0.158	0.577	0.988
Day 7 to 14									
ADG, lb	1.58^{x}	1.99^{xz}	2.26^{yz}	2.60^{y}	0.253	0.0004	0.040	0.790	0.178
ADFI, lb	5.75	6.38	5.77	5.81	0.330	0.258	0.163	0.222	0.235
ADG/ADFI, lb/lb	0.27^{x}	0.31^{x}	0.39^{y}	0.45^{y}	0.028	<0.0001	0.027	0.642	0.02
SUN, mg/100 mL	10.84	12.10	12.21	13.18	1.39	0.216	0.259	0.881	0.988
Day 14 to 21									
ADG, lb	1.82^{xy}	1.56^{x}	1.87^{y}	2.29^{y}	0.253	0.032	0.669	0.056	0.178
ADFI, lb	5.90^{xz}	6.45^{x}	5.70^{z}	6.12^{xz}	0.370	0.305	0.072	0.815	0.262
ADG/ADFI, lb/lb	0.30^{x}	0.23^{y}	0.33^{xz}	0.37^{z}	0.031	0.007	0.466	0.008	0.022
SUN, mg/100 mL	11.76	11.83	13.42	13.36	1.39	0.108	0.991	0.946	0.988
Day 21 to 28									
ADG, lb	1.39^{x}	1.65^{xy}	2.03^{y}	1.98^{y}	0.253	0.007	0.530	0.396	0.178
ADFI, lb	5.70	6.27	5.72	5.72	0.370	0.336	0.271	0.292	0.262
ADG/ADFI, lb/lb	0.24^{x}	0.26^{x}	0.35^{y}	0.34^{y}	0.025	<0.0001	0.806	0.307	0.018
SUN, mg/100 mL	12.14	11.60^{y}	14.37^{z}	13.46	1.39	0.039	0.462	0.851	0.988
Day 28 to 35									
ADG, lb	1.78^{x}	1.59^{x}	1.95^{xy}	2.30^{y}	0.253	0.015	0.667	0.134	0.178
ADFI, lb	5.97	6.10	5.57	5.92	0.399	0.320	0.396	0.684	0.281
ADG /ADFI, lb/lb	0.29^{xz}	0.25^{x}	0.34^{xyz}	0.37^{y}	0.036	0.001	0.876	0.195	0.025
SUN , mg/100 mL	11.70	11.47	14.16	12.87	1.39	0.052	0.443	0.591	0.988
Day 35 to 42									
ADG, lb	1.49^{x}	1.38^{x}	1.71^{xy}	2.04^{y}	0.253	0.014	0.545	0.220	0.178
ADFI, lb	6.63	6.34	5.94	5.99	0.623	0.252	0.792	0.703	0.449
ADG/ADFI, lb/lb	0.22	0.21	0.32	0.34	0.067	0.017	0.840	0.768	0.047
SUN, mg/100 mL	11.68	11.56	13.97	13.9	1.39	0.019	0.945	0.963	0.988
Day 0 to 42									
ADG, lb	1.62^{x}	1.68^{x}	2.06^{y}	2.26^{z}	0.129	<0.0001	0.149	0.390	0.092
ADFI, lb	5.94^{xy}	6.19^{x}	5.68^{y}	5.79^{y}	0.324	0.160	0.437	0.740	0.229
ADG/ADFI, lb/lb	0.27^{x}	0.27^{x}	0.37^{y}	0.39^{y}	0.016	<0.0001	0.416	0.279	0.011
SUN, mg/100 mL	11.18	11.24	12.71	13.01	1.23	0.067	0.842	0.893	0.872

[a]RAC = Ractopamine.
[b]SEM = Standard error of the mean.
[c]CP = Crude protein.
[d, e, x, y, z] Within a row, means without a common superscript letter differ (P < 0.05).

Statistical analysis

Each pig was considered an experimental unit and data were analyzed as repeated measures in time using the mixed procedure of SAS (1999). Pen was considered to be a random effect. Orthogonal contrasts were used to analyze the effects of ractopamine and CP.

Results and Discussion

There were no significant protein × ractopamine interactions except for ADG/ADFI on days 14 to 21. The overall response of ADG, ADFI, ADG/ADFI and SUN to the dietary treatments is shown in Table 2. There were dietary treatment effects (P < 0.05) from days 0 to 42 for ADG; where the greatest ADG was observed for pigs receiving diets with 16% CP and 20 ppm ractopamine, the lowest ADG was recorded for pigs fed the diet with 10% CP and no ractopamine; however, pigs consuming diets with low CP concentration and 20 ppm ractopamine had performance similar to pigs fed the diet with

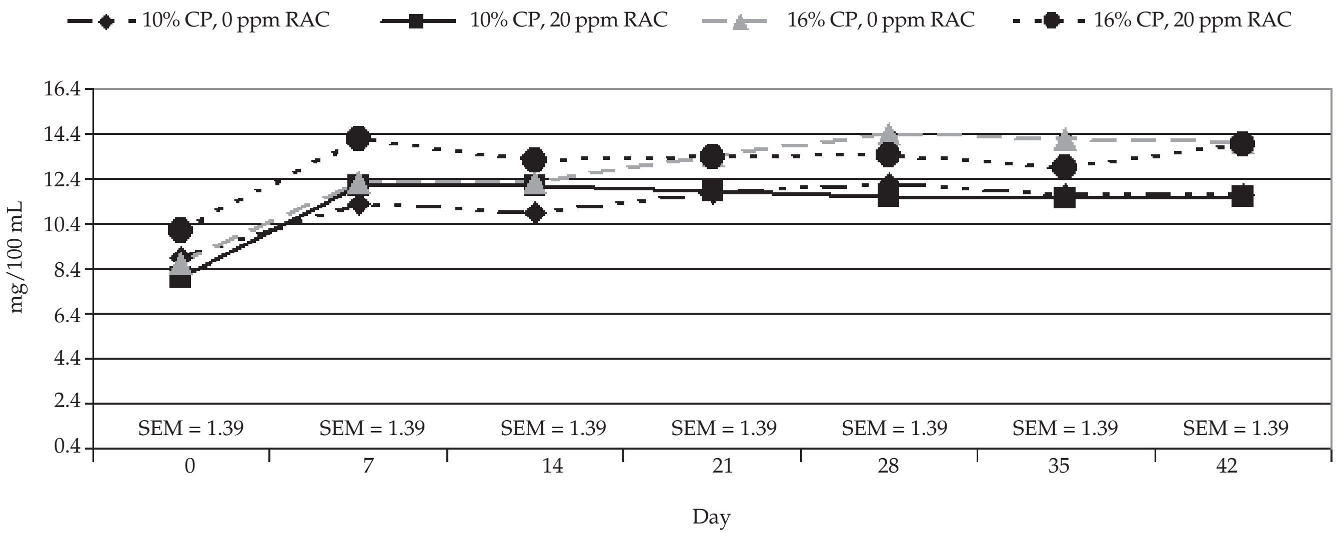

Figure 1. Response of serum urea nitrogen to experimental diets by weekly period.

0 ppm ractopamine and 10% CP. This observation was consistent for the six, seven-day periods and reflects the lack of effectiveness of ractopamine to improve ADG at low dietary CP concentrations. The addition of 20 ppm ractopamine was only effective increasing ADG when fed with a 16% CP diet (d 0-42; Table 2; $P < 0.05$). The greatest overall ADFI was for the treatment with 10% CP and 20 ppm ractopamine. There was no difference in SUN concentration among treatments.

There was no weekly or overall effect of ractopamine, except for week 2 ($P < 0.05$). The effect of ractopamine on ADG for week two is attributed to the previous observations that ractopamine increases ADG to a greater extent during the first three weeks after inclusion; however, for this study, during most periods and overall, a numeric trend showed that ractopamine inclusion resulted only in a small increase in ADG. These results demonstrate than an inadequate amino acid supply prevented pigs from responding to the inclusion of ractopamine. There was no effect of ractopamine on ADFI for period or overall experimental period; however, there was a small numerical reduction in ADFI due to increased dietary protein concentration. In contrast to literature findings, we showed a slight numerical increase in ADFI due to the inclusion of ractopamine. This trend was possibly due to the inadequate supply of amino acids, (especially lysine) needed to meet the augmented requirements for protein deposition of pigs fed diets containing ractopamine.

Increased protein concentration resulted in an improvement in ADG/ADFI for all the weeks throughout the experimental period. There was no effect of ractopamine on ADG/ADFI for all the experimental period except from days seven to 14. The inclusion of ractopamine did not improve ADG/ADFI, in contrast to responses reported by other researchers. Overall, SUN was not affected by dietary protein or ractopamine (Figure 1); however, there was an effect ($P < 0.05$) of CP on SUN on weeks 4 and 6 (Table 2). Previous reports have also shown that SUN increased when dietary CP intake increased.

Conclusions

Increasing dietary protein concentration from 10 to 16% improved growth performance when ractopamine was included at 20 ppm during the third week of the trial only; however, ractopamine showed a numerical trend to improve growth performance in every period. The 16% CP diet consistently improved growth performance (all periods and overall). Therefore, protein concentrations greater than 16% (or amino acid supplementation) are required to achieve the maximum ractopamine response in late-finishing pigs from the UNL herd.

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[1]Roman Moreno is a graduate student, Robert L. Fischer is a former research technologist and graduate student, and Phillip S. Miller is a professor in the Animal Science Department.