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Effect of Increasing Lysine:net Energy Ratio on Growth Performance and Plasma Urea Nitrogen Concentration of Late-Finishing Barrows Fed Low-Protein Amino Acid-Supplemented Diets and Ractopamine

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Low-crude protein, amino acid-supplemented diets containing ractopamine balanced to contain 4.57 to 5.2 g of lysine/Mcal of net energy can adequately supply amino acids for growth in late finishing pigs.

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Summary

An experiment was conducted to determine the optimum lysine (lys):Net energy (NE) ratio of low-crude protein (CP) amino acid (AA)-supplemented diets needed in conjunction with ractopamine (RAC) to improve growth performance of late-finishing barrows from the University of Nebraska–Lincoln (UNL) herd. Treatments consisted of five low CP, AA-supplemented diets with addition of ractopamine (16% CP; 4.5 g/ton), formulated to contain 3.35, 3.95, 4.57, 5.2 and 5.83 g of lys/Mcal of NE. A corn-soybean meal diet with no RAC supplementation served as negative control (20% CP; 5.24 g of Lys/Mcal of NE). Treatment did not affect growth performance (P > 0.05). Despite the lack of treatment effect (P = 0.09), increasing dietary lys/NE concentration resulted in a linear decrease in final backfat (P = 0.01). Treatments did not affect final longissimus muscle area (P = 0.69). Results indicate that the optimum lys/NE for late-finishing pigs from the UNL herd fed low-CP AA-supplemented diets containing 4.5 g of RAC is between 4.57, and 5.2 g of lys/Mcal of NE.

Introduction

Ractopamine (RAC) is a beta-adrenergic compound which has been used in late-finishing pigs to increase protein and to reduce fat deposition by redirecting a portion of the energy that the pig would use for fat synthesis to protein accretion. There is evidence that these changes in energy distribution result in increments in average daily gain (ADG), and gain:feed (G:F) as well as reduction in average daily feed intake (ADFI). Pigs fed diets supplemented with RAC require increased amounts of limiting amino acids (AA) especially lysine (lys), in order to respond to RAC inclusion. Increasing crude protein (CP) concentration in the diets of pigs may result in an excess of dietary non-essential AA concentration. The nitrogen (N) generated by the degradation processes of the excess of amino acids, eliminated by the pigs in feces and urine, has the potential to contaminate soil and water. The use of low-CP AA-supplemented diets appears to be effective to provide essential AA to pigs in the adequate amounts while avoiding feeding excessive CP concentration which in turn will help to reduce N excretion into the environment.

The objective of the present investigation was to determine the optimum lys:Net energy (NE) ratio of low-CP AA-supplemented diets needed in conjunction with RAC to improve growth performance of late-finishing barrows from the UNL herd. The present experiment was designed based on the results obtained in two previous experiments performed to define adequate CP and lys:NE dietary contents to maximize response to RAC of late-finishing from the UNL herd.

Procedures

Animals and treatments

Twenty-four crossbred [(Nebraska XL line × Danbred) × Pietrain] late-finishing barrows were used in a 28-day experiment. The average initial body weight (BW) was 184 lb and the final average BW was 254 lb. Pigs were individually penned in fully-slotted pens, maintained at 72°F, and had ad libitum access to feed and water. All management and experimental procedures were approved by the UNL Institutional Animal Care and Use Committee.

Experimental diets

The pigs were randomly assigned to one of six dietary treatments. To create the dietary treatments six diets were balanced for lys:NE. The control diet contained 5.2 g/Mcal NE and 20% CP. The five low-CP AA-supplemented counterparts contained 16% CP and varying lys:NE concentration ranging from 3.4 to 5.8 g of lys/Mcal of NE and 4.5 g RAC/ton (Table 1). Two of these diets had lys:NE less than adequate (3.35 and 3.95 g of lys/Mcal of NE), one of them was adequate (4.57 g of lys/Mcal of NE) and two had excessive lys:NE (5.2 and 5.83 g of lys/Mcal of NE) compared to NRC recommendations. All diets meet or exceed the lys to limiting AA ratios (Met + Cys, Trp,

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

	Treatment					
CP, %[a]	20	16	16	16	16	16
Lys:NE, g/Mcal[b]	5.24	3.35	3.95	4.57	5.2	5.83
RAC, g/ton[c]	0	4.5	4.5	4.5	4.5	4.5
Item, %						
Corn	65.91	75.58	75.99	76.08	76.04	75.93
Soybean meal, 46.5% CP	30.20	20.5	20	19.5	19.1	18.8
Tallow	2	2	2	2	2	2
Dicalcium phosphate	0.25	0.5	0.5	0.5	0.5	0.51
Limestone	0.75	0.70	0.7	0.7	0.7	0.7
Salt	0.3	0.3	0.3	0.3	0.3	0.3
Vitamin mix[d]	0.15	0.15	0.15	0.15	0.15	0.2
Mineral mix[e]	0.1	0.1	0.1	0.1	0.1	0.1
L-Lysine·HCl	0.23	0.01	0.21	0.4	0.6	0.79
L-Tryptophan	0	0	0	0.04	0.08	0.1
L-Threonine	0.05	0	0.03	0.12	0.23	0.34
DL-Methionine	0.06	0	0	0.09	0.18	0.26
Paylean® (ractopamine•HCl; 9 g/lb)	0	0.02	0.02	0.02	0.02	0.02
Total	100	100	100	100	100	100
Calculated composition						
ME, Mcal/lb[f]	1.55	1.56	1.56	1.55	1.55	1.53
CP, %	20.00	16.00	16.00	16.00	16.00	16.00
Total Lysine, %	1.2	0.78	0.92	1.06	1.2	1.34
Calcium, %	0.51	0.51	0.51	0.51	0.51	0.51
Available phosphorus, %	0.44	0.44	0.44	0.44	0.44	0.44

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

and Thr) proposed by the Nebraska-South Dakota Swine Nutrition Guide for late-finishing pigs fed RAC. All other nutrients met or exceeded the NRC (1998) requirements.

Data and sample collection

Average daily gain (ADG) average daily feed intake (ADFI) and feed efficiency (G:F) were estimated based on pig weight and feed disappearance. Blood samples for the PUN determinations were taken by venipuncture of the vena cava region at the beginning of the experiment and weekly thereafter. The samples were centrifuged at 2,000 × *g* for 20 min. Plasma was maintained at -4°F until analysis for urea nitrogen concentration (PUN).

Statistical analyses

Each pig was considered an experimental unit and data were analyzed for treatment, linear and quadratic effects using the MIXED procedure (SAS Inst., Inc., Cary, N.C.). Pen was considered a random effect.

Results and Discussion

Growth performance

Table 2 shows the growth response of pigs to RAC inclusion and increasing dietary lys/NE. There was no difference among treatments, linear or quadratic response to lys/NE on final weight (FW), ADG, ADFI or G:F ($P > 0.05$).

Ultrasound measurements

Despite the lack of treatment effect ($P = 0.09$), increasing dietary lys/NE concentration resulted in a linear decrease in final BF ($P = 0.01$). This reduction in BF as lys/NE increased may be partially explained by the numeric reduction in ADFI as lys/NE increased. The later could be an indication that feeding diets containing less than adequate lys/NE concentrations may affect the ability of the pigs to use energy for protein deposition; therefore, the energy that otherwise would be use for protein accretion may be used for fat deposition. Treatments did not affect LMA ($P = 0.69$).

Plasma Urea Nitrogen

There was a significant treatment effect for PUN on d 21 and 28 ($P = 0.01$, and 0.03 respectively; Table 3); however, there were no linear or quadratic effects of lys/NE ($P > 0.05$). The PUN concentration recorded for the control treatment was the greatest for all sampling days except for day 14. These differences may be the consequence of a greater protein concentration of the control diet compared to the low-CP AA-supplemented diets plus RAC treatments (20 vs. 16% CP). The later is supported by findings reported in the literature that showed increased PUN as dietary CP concentration increased. This increase in PUN in pigs receiving the control diet may be the consequence of an excess of AA supplied by the diet. The low-CP AA-supplemented and RAC dietary treatments, demonstrated decreased PUN which may be an indication that the concentration of AA supplied was closer to the adequate concentration of AA in the diet.

Conclusions

The outcome of this experiment indicates that the optimum lys/NE for late-finishing pigs from the UNL herd fed low-CP AA-supplemented diets

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Table 2. Response of ADG[a], ADFI[b], G:F[c] backfat and LMA[d] to treatment and significance of linear and quadratic responses to lys/NE.

	Treatment							*P*-value		
CP, %[e]	20	16	16	16	16	16				
Lys/NE, g/Mcalf[f]	5.24	3.35	3.95	4.57	5.2	5.83				
RAC, g/ton[g]	0	4.5	4.5	4.5	4.5	4.5				
Item							SEM[h]	Treatment	Linear	Quadratic
No. of pigs	4	4	4	4	4	4				
Initial wt, lb	183.01	185.22	185.33	184.56	184.72	183.29	4.39	0.99	0.75	0.89
Final weight, lb	247.95	258.26	256.61	260.47	257.71	251.87	5.23	0.62	0.51	0.47
Growth performance										
ADG, lb	2.32	2.61	2.54	2.71	2.61	2.44	0.15	0.51	0.59	0.41
ADFI, lb	5.82	6.43	6.01	6.74	6.05	5.78	0.33	0.33	0.22	0.36
G:F	0.40	0.40	0.42	0.40	0.43	0.42	0.01	0.55	0.36	0.95
Ultrasound measurements										
Backfat, in										
Initial	0.57	0.64	0.55	0.54	0.51	0.52	0.07	0.79	0.21	0.49
Final	0.79	0.89	0.75	0.72	0.65	0.67	0.06	0.09	0.01	0.25
Change	0.23	0.26	0.20	0.18	0.14	0.15	0.06	0.70	0.14	0.69
LMA, in^2										
Initial	4.89	5.37	5.31	5.17	5.84	5.38	0.23	0.19	0.48	0.97
Final	6.81	7.44	7.33	7.41	7.85	7.63	0.44	0.69	0.53	0.92
Change	1.91	2.06	2.01	2.23	2.01	2.24	0.43	0.99	0.79	0.93

[a]ADG = Average daily gain.
[b]ADFI = Average daily feed intake.
[c]G:F = Average daily gain/average daily feed intake.
[d]LMA = Longissimus muscle area.
[e]CP = Crude protein.
[f]Lys:NE = Lysine:Net energy ratio g/Mcal NE.
[g]RAC = Ractopamine.
[h]SEM = Standard error of the mean.

Table 3. Response of PUN[a] to treatment and significance of linear and quadratic responses to lys/NE[b].

	Treatment							*P*-value		
CP, %[c]	20	16	16	16	16	16				
Lys:NE, g/Mcal[b]	5.24	3.35	3.95	4.57	5.2	5.83				
RAC, g/ton[d]	0	4.5	4.5	4.5	4.5	4.5				
Day	PUN[a], mg/100 mL						SEM[e]	Treatment	Linear	Quadratic
0	8.94	12.76	10.38	11.72	11.70	10.23	1.19	0.30	0.33	0.91
7	16.34	13.95	11.78	13.90	10.89	12.35	1.29	0.09	0.33	0.66
14	13.55	13.71	11.19	12.97	10.00	12.17	1.72	0.62	0.44	0.48
21	19.07	13.90	11.77	15.13	12.85	12.80	1.24	0.01	0.77	0.75
28	19.70	13.88	12.06	16.79	12.58	13.74	1.64	0.03	0.96	0.63

[a]PUN = Plasma urea nitrogen.
[b]Lys:NE = Lysine:Net energy.
[c]CP = Crude protein.
[d]RAC = Ractopamine.
[e]SEM = Standard error of the mean.

added with 4.5 g RAC is between 4.57 and 5.2 g of lys/Mcal of NE. Increments above 5.8 g lys/ Mcal of NE may negatively affect growth performance.

Barrows from the UNL herd showed a reduction in BF in response to increasing lys/NE fed low-CP AA-supplemented diets and with 4.5 g of RAC/ton.

The results of this experiment also suggest that pigs receiving RAC and low-CP AA-supplemented diets received more adequate AA concentration compared to the standard diet.

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