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Evaluation of Standardized Ileal Digestible Tryptophan:Lysine Ratio on Growth Performance and Carcass Characteristics of Finishing Pigs Fed with or without Ractopamine HCl

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Abstract

Previous research has shown that increasing the SID Trp:Lys ratio up to 24.5% in finishing pigs fed ractopamine HCl (RAC) improved ADG by 0.15 and 0.08 lb/d in comparison with ratios of 18 and 21%, respectively. The objective of the present experiment was to determine the effects of feeding higher SID Trp:Lys ratios with and without RAC on growth performance and carcass characteristics of finishing pigs. A total of 1,101 pigs (PIC 1050 × 327, initially 218.9 lb BW) was used in a 30-d experiment. Pens of 26 pigs were randomly assigned to 1 of 6 dietary treatments arranged in a 2 × 3 factorial, with main effects of RAC (0 or 10 ppm) and SID Trp:Lys (20, 24, and 28%) with 7 replications per treatment. Diets with and without RAC were formulated to 0.90 and 0.66% SID lysine, respectively. Overall (d 0 to 30), RAC × SID Trp:Lys interactions were observed (linear, $P < 0.05$) where increasing SID Trp:Lys ratio in pigs fed RAC improved BW, ADG, and F/G; however, these criteria decreased when pigs did not receive diets containing RAC. Similarly, RAC × SID Trp:Lys interactions were observed (linear, $P < 0.05$) for carcass criteria with improvements in carcass ADG, carcass G:F, and HCW when pigs were fed increasing SID Trp:Lys in diets containing RAC, but not without RAC. In summary, increasing SID Trp:Lys ratio to more than 20% improved growth and carcass performance when diets contained RAC, whereas for pigs fed diets without RAC, increasing SID Trp:Lys ratio to more than 20% had poorer performance.

Keywords

growth, late finishing pig, ractopamine HCl, tryptophan

Cover Page Footnote

The authors thank Ajinomoto Heartland, Inc. (Chicago, IL) for providing feed-grade amino acids and financial support, and New Horizons Farms (Pipestone, MN) for providing with animals and research facilities and Marty Heintz for technical assistance.

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Evaluation of Standardized Ileal Digestible Tryptophan:Lysine Ratio on Growth Performance and Carcass Characteristics of Finishing Pigs Fed with or without Ractopamine HCl[1]

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Summary

Previous research has shown that increasing the SID Trp:Lys ratio up to 24.5% in finishing pigs fed ractopamine HCl (RAC) improved ADG by 0.15 and 0.08 lb/d in comparison with ratios of 18 and 21%, respectively. The objective of the present experiment was to determine the effects of feeding higher SID Trp:Lys ratios with and without RAC on growth performance and carcass characteristics of finishing pigs. A total of 1,101 pigs (PIC 1050 × 327, initially 218.9 lb BW) was used in a 30-d experiment. Pens of 26 pigs were randomly assigned to 1 of 6 dietary treatments arranged in a 2 × 3 factorial, with main effects of RAC (0 or 10 ppm) and SID Trp:Lys (20, 24, and 28%) with 7 replications per treatment. Diets with and without RAC were formulated to 0.90 and 0.66% SID lysine, respectively. Overall (d 0 to 30), RAC × SID Trp:Lys interactions were observed (linear, $P < 0.05$) where increasing SID Trp:Lys ratio in pigs fed RAC improved BW, ADG, and F/G; however, these criteria decreased when pigs did not receive diets containing RAC. Similarly, RAC × SID Trp:Lys interactions were observed (linear, $P < 0.05$) for carcass criteria with improvements in carcass ADG, carcass G:F, and HCW when pigs were fed increasing SID Trp:Lys in diets containing RAC, but not without RAC. In summary, increasing SID Trp:Lys ratio to more than 20% improved growth and carcass performance when diets contained RAC, whereas for pigs fed diets without RAC, increasing SID Trp:Lys ratio to more than 20% had poorer performance.

[1] The authors thank Ajinomoto Heartland, Inc. (Chicago, IL) for providing feed-grade amino acids and financial support, and New Horizons Farms (Pipestone, MN) for providing with animals and research facilities and Marty Heintz for technical assistance.

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Introduction

Tryptophan (Trp) is generally considered the second or third limiting amino acid in corn soybean-meal-based diets fed to growing and finishing swine.[4] Although considerable research has been conducted to determine the optimum Trp requirement for swine, there are important discrepancies between studies.[5] The NRC[6] SID Trp:Lys ratio requirement for pigs above 165 lb is 17.7% of lysine. Zhang[7] et al. suggested an ideal SID Trp:Lys ratio ranged from 19.7 to 23.6% for finishing pigs depending on the response variable. Most recently, Goncalves et al.[8] reported that by increasing the SID Trp:Lys ratio to 24.5% in late finishing pigs fed diets with ractopamine HCl, ADG was improved by 0.15 and 0.08 lb/d in comparison with ratios of 18 and 21%, respectively. To our knowledge there is no research available to establish if there is any benefit to increasing the SID Trp:Lys ratio further in late finishing pigs, nor research performed evaluating higher Trp:Lys ratios without ractopamine HCl. Therefore, the objective of the present study was to determine the effects of feeding high SID Trp:Lys ratios with and without ractopamine HCl on growth performance, carcass characteristics and economics in finishing pigs.

Procedures

The Kansas State University Institutional Animal Care and Use Committee approved the protocol used in this experiment. The study was conducted at a commercial research-finishing site in southwest Minnesota. The barn was naturally ventilated and double-curtain-sided. Each pen was equipped with a 5-hole stainless steel feeder and bowl waterer for ad libitum access to feed and water. Feed additions to each individual pen were made and recorded by a robotic feeding system (FeedPro; Feedlogic Corp., Wilmar, MN).

In August 2016, a total of 1,101 pigs (PIC 1050 x 327, initially 218.9 lb BW) was used in a 30-d trial. There were 26 pigs per pen at a floor space of 6.78 ft^2 per pig, and 7 replications per treatment. Pigs were allotted based on initial body weight and assigned to 1 of 6 treatments in a completely randomized block design. Dietary treatments were arranged in a 2×3 factorial, with or without ractopamine (0 vs. 10 ppm) and three Trp:Lys ratios (20, 24, or 28% of lysine). Diets with and without ractopamine were formulated to 0.90 and 0.66% SID lysine, respectively. Prior to the trial, from 180 to 218 lb, these pigs were fed a corn-soybean meal-dried distillers grains with solubles-based diet that contained 14.0% CP, 0.77 SID Lys, 20% SID Trp:Lys ratio, and 1,150 Kcal NE/lb.

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[4] Burgoon, K. G., D. A. Knabe, and E. J. Gregg. 1992. Digestible tryptophan requirements of starting, growing, and finishing swine. J. Anim. Sci. 70:2493-2500.

[5] Susenbeth, A. 2006. Optimum tryptophan: lysine ratio in diets for growing pigs: analysis of literature data. Livest. Sci. 101:32–45.

[6] NRC. 2012. Nutrient Requirements of Swine. 11th ed. Natl. Acad. Press, Washington, DC.

[7] Zhang, G. J., Q. L. Song, C. Y. Xie, L. C. Chu, P. A. Thacker, J. K. Htoo, and S. Y. Qiao. 2012. Estimation of the ideal standardized ileal digestible tryptophan to lysine ratio for growing pigs fed low crude protein diets supplemented with crystalline amino acids. Livest. Sci. 149:260–266.

[8] Gonçalves, M. A. D. 2015. Effects of standardized ileal digestible tryptophan:lysine ratio on growth performance of finishing gilts under commercial conditions. Ph.D. diss., Kansas State University, Manhattan, KS.

Pigs were weighed on d 0, 9, 16, 23, and 30 to determine ADG, ADFI, and F/G. On d 23, the 3 heaviest pigs in each pen were weighed and sold per standard farm procedures. Prior to marketing, the remaining pigs were individually tattooed with a pen ID number to allow for carcass measurements to be recorded on a pen basis. On d 30, final pen weights were taken, and pigs were transported to a commercial packing plant (JBS Swift and Company, Worthington, MN) for processing and carcass data collection. Carcass measurements taken at the plant included HCW, loin depth, backfat, and percentage lean. Percentage carcass yield was also calculated by dividing the individual HCW at the plant by the pig's pen average final live weight at the farm.

An economic analysis was completed to determine the financial impact of the dietary treatments. Income over feed cost (IOFC) was calculated assuming that other costs, such as utility and labor, were equal across treatments and the only variables were carcass ADG and feed usage for the experimental period. For the analysis, ingredients were valued at: corn $120/ton; soybean meal $380/ton; dried distillers grains with solubles $130/ton; L-Lys HCl $0.75/lb, and ractopamine HCl $32.00/lb. The total feed cost per pig was calculated by multiplying the ADFI by the feed cost per pound and the number of days in each respective period, then taking the sum of those values for each period. Cost per pound of gain was calculated by dividing the total feed cost per pig by the total pounds gained overall. Gain value per pig was calculated by multiplying carcass gain by an assumed carcass value of $72.00 per cwt. To calculate IOFC, total feed cost was subtracted from gain value per pig.

Diet samples were taken from 6 feeders per dietary treatment 3 d after the beginning of the trial and 3 d prior to the end of the trial and stored at -20°C until they were homogenized, subsampled, and submitted for total AA analysis (except Trp; method 994.12[9]) and Trp (method 994.13[9]) by Ajinomoto Heartland, Inc. (Chicago, IL). Samples of the diets were also submitted to Cumberland Valley Analytical Service (Hagerstown, MD) for analysis of DM, CP, Ca, P, ether extract, and ash.

Data were analyzed using the GLIMMIX procedure of SAS version 9.4 (SAS Institute, Inc., Cary, NC) in a randomized complete block multilevel design with pen and pig serving as the experimental units and initial BW serving as the blocking factor. Preplanned linear and quadratic orthogonal contrast were built using coefficients for equally spaced treatment and used to determine the main effects of increasing Trp:Lys ratio. Main effects of RAC, as well as their interaction, were tested. Random effects of block and treatment × block were included in the model for growth performance and carcass characteristics response variables, respectively. Hot carcass weight served as a covariate for the analysis of backfat, loin depth, and lean percentage. Results from the experiment were considered significant at $P < 0.05$ and a marginally significant between $P > 0.05$ and $P \leq 0.10$.

Results

The analyzed total amino acids, DM, CP, Ca, P, ether extract, and ash contents of experimental diets (Table 2) were reasonably consistent with formulated estimates.

[9] AOAC International. 2012. Official Methods of Analysis of AOAC Int. 19rd ed. Assoc. Off. Anal. Chem., Gaithersburg, MD.

For overall growth performance (d 0 to 30), RAC × SID Trp:Lys interactions were observed (linear, $P < 0.05$) for BW, ADG, F/G, G:F, and NE caloric efficiency, where increasing SID Trp:Lys improved performance in pigs fed diets containing RAC; however, the opposite effect was observed when diets did not contain RAC. In addition, a marginally significant interaction RAC × SID Trp:Lys was observed (quadratic, $P < 0.075$) for grams of SID Trp intake per kilogram of gain, where increasing SID Trp:Lys ratio from 20 to 24% increased SID Trp intake per kilogram of gain in pigs fed diets without RAC than when diets contained RAC. Pigs fed diets with RAC had decreased ($P = 0.003$) ADFI compared with pigs fed diets without. No differences in ADFI were observed in pigs fed diets with increasing SID Trp:Lys ratios with or without RAC.

For carcass traits, RAC × SID Trp:Lys interactions were observed (linear, $P < 0.05$) for carcass ADG, carcass G:F, and carcass NE caloric efficiency, and a marginally significant interaction (linear, $P = 0.057$) was observed for HCW. The interaction was the result of improvements in these criteria when pigs were fed increasing SID Trp:Lys ratio in diets containing RAC, but not when pigs were fed diets without RAC. Pigs fed diets with RAC had improved ($P < 0.05$) carcass yield, backfat, loin depth, and lean percentage compared with pigs fed diets that did not contain RAC. In addition, carcass yield was marginally improved (linear, $P < 0.075$) in pigs fed increasing SID Trp:Lys ratio in diets containing RAC.

Economically, feed cost was greater ($P < 0.001$) for pigs fed RAC compared with pigs fed diets that did not contain RAC, and costlier ($P < 0.001$) when increasing SID Trp:Lys in diets containing RAC. Interactions of RAC × SID Trp:Lys were observed (linear, $P < 0.05$) for feed cost per pound, gain value, and income over feed cost, where increasing SID Trp:Lys worsened these responses in pigs not fed RAC, but the opposite was true when diets contained RAC. Gain value compensated the greater feed cost in pigs fed increasing SID Trp:Lys ratio in diets containing RAC, resulting in a higher income over feed cost compared with pigs not fed RAC.

The results of this study are consistent with the findings of Zhang et al.[7] and Goncalves et al.,[8] where the estimated SID Trp:Lys ratio requirements ranged from 19.7% to 23.5% and 16.9% and 23.5%, respectively depending on the response variable. Furthermore, Goncalves et al.[8] observed a maximum growth response in finishing gilts fed diets with 24.5% SID Trp:Lys ratio and RAC. Contrary to our findings, where there were no differences in ADFI, increased growth performance in research of Goncalves et al.[8] resulted from differences in feed intake, with an increase of 0.21 and 0.14 lb/d in pigs fed 24.5% Trp:Lys ratio compared with pigs fed ratios of 18 and 21%, respectively.

In summary, increasing SID Trp:Lys ratio to more than 20% improved growth, carcass performance and economics when diets contained RAC, whereas pigs fed SID Trp:Lys ratios greater than 20% had reduced performance when diets did not contain RAC. The reason for poorer performance of pigs fed diets with SID Trp:Lys ratio more than 20%, not containing RAC, remains unclear. Further research is needed to determine the breakpoint estimate of feeding SID Trp:Lys at more than 24% in diets containing RAC.

Table 1. Diet composition (as-fed basis)[1]

	Ractopamine HCl,[2] ppm					
	0			10		
SID Trp:Lys, %:	20	24	28	20	24	28
Ingredient, %						
Corn	84.99	84.96	84.93	74.87	74.80	74.84
Soybean meal (46.5% CP)	12.79	12.79	12.79	21.74	21.74	21.74
Choice white grease	---	---	---	1.10	1.10	1.05
Limestone	1.00	1.00	1.00	0.95	0.98	0.95
Monocalcium P (21% P)	0.33	0.33	0.33	0.25	0.25	0.25
Salt	0.35	0.35	0.35	0.35	0.35	0.35
L-Lys-HCl	0.23	0.23	0.23	0.25	0.25	0.25
DL-Met	0.05	0.05	0.05	0.11	0.11	0.11
L-Thr	0.08	0.08	0.08	0.12	0.12	0.12
L-Trp	0.02	0.05	0.08	0.03	0.06	0.10
L-Val	---	---	---	0.02	0.02	0.02
Ractopamine[2]	---	---	---	0.05	0.05	0.05
Phytase[3]	0.02	0.02	0.02	0.02	0.02	0.02
Trace mineral premix	0.10	0.10	0.10	0.10	0.10	0.10
Vitamin premix	0.06	0.06	0.06	0.06	0.06	0.06
Total	100.00	100.00	100.00	100.00	100.00	100.00
Calculated analysis						
Standard ileal digestible amino acids, %						
Lys	0.66	0.66	0.66	0.90	0.90	0.90
Ile:Lys	63	63	63	63	63	63
Leu:Lys	154	154	154	136	136	136
Met:Lys	34	34	34	37	37	37
Met and Cys:Lys	62	62	62	62	62	62
Thr:Lys	67	67	67	67	67	67
Trp:Lys	20	24	28	20	24	28
Val:Lys	71	71	71	71	71	71
His:Lys	42	42	42	40	40	40
SID Lys: NE, g/Mcal	2.59	2.59	2.59	3.53	3.53	3.53
NE NRC, kcal/lb	1,157	1,157	1,157	1,157	1,157	1,157
CP, %	12.4	12.4	12.4	16.0	16.0	16.0
Ca, %	0.50	0.50	0.50	0.50	0.50	0.50
P, %	0.38	0.38	0.38	0.40	0.40	0.40
Available P, %	0.24	0.24	0.24	0.24	0.24	0.24
Standardized digestible P, %	0.29	0.29	0.29	0.29	0.29	0.29

[1] Diets were fed from d 218 to 285 lb.
[2] Payean (Elanco Animal Health, Greenfield, IN) provided the final diet with 10 ppm of ractopamine.
[3] Optiphos 2000 (Enzyvia LLC, Sheridan, IN) provided 136.5 FTU per pound of diet.

Table 2. Chemical analysis of experimental diets (as-fed basis)[1]

	Ractopamine HCl, ppm					
	0			10		
SID Trp:Lys, %:	20	24	28	20	24	28
Proximate analysis, %						
DM	85.9	86.0	85.3	85.6	86.5	86.1
CP	12.5	12.1	12.4	15.2	15.6	15.7
Ca	0.58	0.52	0.60	0.70	0.70	0.71
P	0.35	0.36	0.38	0.39	0.39	0.38
Ether extract	3.4	3.5	3.2	4.1	4.3	4.2
Ash	3.2	2.9	3.3	3.6	3.7	3.6
Amino acids, %[2]						
Lys	0.80	0.73	0.74	0.98	1.08	1.00
Ile	0.47	0.45	0.45	0.63	0.71	0.63
Leu	1.17	1.12	1.13	1.37	1.50	1.40
Met	0.22	0.23	0.24	0.32	0.32	0.34
Met and Cys	0.47	0.44	0.44	0.56	0.59	0.59
Thr	0.51	0.50	0.51	0.64	0.72	0.70
Trp	0.15	0.16	0.17	0.20	0.23	0.25
Val	0.59	0.55	0.55	0.72	0.79	0.72
His	0.32	0.30	0.30	0.38	0.41	0.40
Phe	0.64	0.61	0.61	0.76	0.84	0.82
Free Lys	0.23	0.21	0.22	0.26	0.26	0.20
Free Trp	0.03	0.05	0.06	0.05	0.07	0.08

[1] Diet samples were taken from 6 feeders per dietary treatment 3 d after the beginning of the trial and 3 d prior to the end of the trial and stored at -20°C, then amino acid analysis was conducted on composite samples by Ajinomoto Heartland, Inc. (Chicago, IL). Samples of the diets were also submitted to Cumberland Valley Analytical Service (Hagerstown, MD) for analysis of DM, CP, Ca, P, ether extract, and ash.

[2] Method 994.12; AOAC Int., 2012 except for free Lys and free Trp. Free Trp and Lys Method 994.13; AOAC Int., 2012.

Table 3. The effects of feeding high standardized ileal digestible (SID) tryptophan to lysine ratio with and without ractopamine HCL on growth performance, carcass characteristics, and economics of finishing pigs[1]

	Ractopamine HCL,[2] ppm							Probability, $P <$				
	0			10				RAC × Trp:Lys			SID Trp:Lys Linear	
SID Trp:Lys, %:	20	24	28	20	24	28	SEM	Linear	Quadratic	RAC	No RAC	RAC
BW, lb												
d 0	218.8	218.9	218.9	218.9	218.9	218.9	3.17	0.900	0.951	0.900	0.881	0.977
d 30	275.7	273.5	271.9	282.1	287.1	285.1	2.75	0.030	0.155	<0.001	0.084	0.165
d 0 to 30												
ADG, lb	1.95	1.85	1.81	2.17	2.28	2.26	0.049	0.012	0.183	<0.001	0.030	0.141
ADFI, lb	5.53	5.37	5.47	5.26	5.20	5.34	0.075	0.351	0.814	0.003	0.556	0.462
F/G	2.84	2.92	3.01	2.43	2.28	2.37	0.047	0.007	0.110	<0.001	0.003	0.298
G:F	0.351	0.343	0.331	0.412	0.438	0.422	0.007	0.010	0.056	<0.001	0.015	0.196
SID Trp, g/kg gain	3.8	4.6	5.6	4.4	4.9	6.0	0.09	0.172	0.075	<0.001	<0.001	<0.001
NE Caloric efficiency[3]	3,290	3,381	3,494	2,815	2,643	2,743	55.3	0.005	0.125	<0.001	0.003	0.275
Carcass characteristics												
Carcass ADG,[4] lb	1.41	1.34	1.32	1.58	1.66	1.66	0.036	0.009	0.233	<0.001	0.039	0.090
Carcass G/F[5]	0.255	0.250	0.241	0.301	0.320	0.310	0.005	0.005	0.071	<0.001	0.017	0.096
NE Caloric efficiency	4,544	4,650	4,811	3,861	3,620	3,738	77.7	0.003	0.165	<0.001	0.004	0.167
HCW, lb	199.7	198.9	197.4	205.7	209.5	209.2	2.14	0.057	0.499	<0.001	0.841	0.102
Carcass yield, %	72.4	72.7	72.6	72.9	73.0	73.4	0.20	0.490	0.293	0.001	0.399	0.075
Backfat,[6] in.	0.68	0.66	0.69	0.61	0.59	0.63	0.014	0.675	0.964	<0.001	0.452	0.184
Loin depth,[6] in.	2.36	2.38	2.40	2.50	2.45	2.56	0.035	0.640	0.197	0.001	0.512	0.193
Lean,[6] %	55.6	55.9	55.5	57.0	57.1	56.1	0.22	0.892	0.443	<0.001	0.724	0.587
Economics, $/pig												
Feed cost	14.45	14.22	14.70	19.05	19.34	19.86	0.235	0.240	0.567	<0.001	0.448	0.019
Feed cost/lb gain[7]	0.248	0.258	0.271	0.294	0.283	0.294	0.005	0.009	0.187	<0.001	0.001	0.956
Gain value[8]	25.62	25.01	23.98	29.85	32.69	32.44	0.947	0.005	0.284	<0.001	0.114	0.015
IOFC[9]	11.17	10.78	9.28	10.80	13.35	12.57	0.786	0.002	0.253	0.001	0.021	0.029

[1] A total of 1,101 pigs (PIC 1050 × 327) were used with 26 pigs per pen and 7 replications per treatment.
[2] Paylean (Elanco Animal Health, Greenfield, IN).
[3] Caloric efficiency is expressed as kcal/lb of gain.
[4] Carcass average daily gain = overall ADG × carcass yield.
[5] Carcass G/F = overall average feed intake/carcass average daily gain.
[6] Adjusted using HCW as a covariate.
[7] Feed cost/lb gain = total feed cost divided by total gain per pig.
[8] Gain value = (HCW × $0.72) - (d 0 BW × 0.75× $0.72).
[9] Income over feed cost = gain value – feed cost.