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Determining the Effects of Tryptophan Biomass on Growth Performance of 25- to 50-lb Nursery Pigs[1]

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Summary

A total of 315 barrows (DNA; 200 × 400; initially 24.9 lb) were used in a 21-d growth trial evaluating the effects of feeding TRP Pro (CJ America-Bio, Downers Grove, IL) as a source of Trp on nursery pig performance. Pigs were weaned at approximately 21 d of age, placed in pens based on initial body weight (BW), and fed common starter diets for 21 d. On d 21 after weaning, considered d 0 of the study, pigs were weighed and pens were allotted to 1 of 4 dietary treatments with 5 pigs per pen and 15 or 16 pens per treatment. Dietary treatments included a negative control (16% SID Trp:Lys ratio), positive control (21% SID Trp:Lys ratio from crystalline Trp), or diets containing Trp with biomass to provide 21 or 23.5% standardized ileal digestible (SID) Trp:Lys ratios (included at 0.104 or 0.156% of the diet, respectively). Diets were corn-soybean meal-based and contained 1.25% SID Lys with other amino acids set to meet or exceed NRC[4] requirement estimates. The TRP Pro contained 60% Trp per the supplier's specifications. Growth data were analyzed as a randomized complete block design using the PROC GLIMMIX procedure of SAS with pen as the experimental unit. Overall (d 0 to 21), pigs fed the 21% Trp:Lys ratio from crystalline Trp or Trp with biomass had increased ($P < 0.05$) average daily gain (ADG) compared to pigs fed the negative control diet, with pigs fed the 23.5% Trp:Lys ratio with biomass intermediate. There was no evidence for difference in overall average daily feed intake (ADFI); however, pigs fed the 21% Trp:Lys ratio from Trp with biomass had improved ($P < 0.05$) feed efficiency (F/G) compared to the negative control diet, with others intermediate. In conclusion, TRP Pro appears to be a suitable alternative to crystalline Trp in nursery pig diets but further evaluation at higher inclusion levels is needed.

Introduction

Tryptophan (Trp) is an essential amino acid in swine diets that is important for stimulating feed intake and subsequently, growth performance. Monogastrics cannot

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[1] Appreciation is expressed to CJ America-Bio (Downers Grove, IL) for their support in this trial.

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[4] National Research Council. 2012. Nutrient Requirements of Swine: Eleventh Revised Edition. Washington, DC: The National Academies Press. https://doi.org/10.17226/13298.

naturally synthesize Trp in the body, thus supplying enough Trp in the diet is crucial to meeting the animal's requirements. Crystalline Trp is a readily available source of Trp that is manufactured for food and feed purposes. In 2015, the global demand for crystalline Trp was 30,000 tons, a 27,000 ton increase from 2005.[5,6] The production of crystalline Trp occurs through the fermentation of *Corynebacterium glutamicum* in a culture medium containing salts, trace elements, and carbohydrate sources.[6] Following fermentation, the first step of amino acid purification is the separation of biomass.[7] This results in a nutrient-rich byproduct that often ends up as waste. As the world demand for Trp continues to increase, amino acid suppliers are looking for methods to increase Trp supply while decreasing production costs. Thus, Trp biomass has been considered a viable option because of its opportunity to decrease manufacturing inputs while still providing an amino acid rich product.[7] CJ America-Bio. (Downers Grove, IL) has developed TRP Pro, a Trp with biomass product, but no research is available to determine its effectiveness as a Trp source for pigs.

The current NRC[4] Trp requirement estimate for 24- to 55-lb nursery pigs is 16% of Lys.[8] Gonçalves et al.[8] concluded that increasing the SID Trp:Lys ratio up to 21% improved ADG, ADFI, and F/G in 25- to 45-lb nursery pigs, while formulating diets below 18% SID Trp:Lys ratio had negative impacts on performance. The objective of this study was to determine the effects of TRP Pro compared to crystalline Trp on the growth performance of 25- to 50-lb nursery pigs.

Procedures

The Kansas State University Institutional Animal Care and Use Committee approved the protocol used in this experiment. The study was conducted at the Kansas State University Segregated Early Weaning Facility in Manhattan, KS. Each pen contained a 4-hole, dry self-feeder and nipple waterer for *ad libitum* access to feed and water.

A total of 315 barrows (DNA; 200 × 400; initially 24.9 lb) were used in a 21-d growth trial. Pigs were weaned at approximately 21 d of age and following arrival to the research facility, were randomized to pens based on initial BW and fed common starter diets for 21 d. On d 21 after weaning, considered d 0 of the study, pigs were weighed and pens were allotted to 1 of 4 dietary treatments with 5 pigs per pen and 15 or 16 pens per treatment. Dietary treatments consisted of a negative control (16% SID Trp:Lys ratio), positive control (21% SID Trp:Lys ratio from crystalline Trp), or diets containing Trp with biomass to provide 21 or 23.5% SID Trp:Lys ratios (included at 0.104 or 0.156% of the diet, respectively). Diets were corn-soybean meal-based and formulated to contain 1.25% SID Lys. The TRP Pro (CJ America-Bio, Downers Grove, IL) had a granulated, cream-colored appearance and contained 60% Trp (assumed to have 100%

[5] United Nations Partnerships for SDGs platform. 2016. A CJ Collaborative R&D on Amino Acids & Eco-Friendly Bio Project for SDGs. https://sustainabledevelopment.un.org/partnership/?p=11284.

[6] Leuchtenberger, W. K. Huthmacher. K. Drauz. 2005. Biotechnological production of amino acids and derivatives: current status and prospects. Appl Microbiol Biotechnol. 69:1-8. doi 10.1007/s00253-005-0155-y.

[7] Hermann, T. 2003. Industrial production of amino acids by coryneform bacteria. Journal of Biotechnol. 104:155-172. doi:10.1016/S0168-1656(03)00149-4.

[8] Gonçalves, M. A., M. D. Tokach, S. S. Dritz, N. M. Bello, K. J. Touchette, J. M. DeRouchey, J. C. Woodworth, and R. D. Goodband. 2015. Effect of standardized ileal digestible tryptophan:lysine ratio on growth performance of 11 to 20 kg nursery pigs. J. Anim. Sci. 93 (Suppl.2):92 (Abstr.).

digestibility coefficient) per the supplier's specifications. The SID Trp:Lys ratio was formulated based on these specifications.

All dietary treatments were manufactured at the Kansas State University O.H. Kruse Feed Technology Innovation Center in Manhattan, KS, and were formulated to meet or exceed NRC[4] requirement estimates (Table 1). Complete dietary samples were taken during the bagging of experimental diets with a subsample collected from every fourth bag and pooled into one homogenized sample per dietary treatment. Samples were stored at -20°C until they were subsampled and submitted for analysis of complete amino acid profile, crude protein, Ca, and P (Eurofins Scientific Inc., Des Moines, IA). In addition, the total free Trp concentration of the Trp biomass was also analyzed (Eurofins Scientific Inc., Des Moines, IA).

Data were analyzed as a randomized complete block design using the PROC GLIMMIX procedure of SAS version 9.4 (SAS Institute, Inc., Cary, NC) with pen as the experimental unit. Weight block was included in the model as a random effect. Least square means were applied to estimate the effects of Trp source and level. Results were considered significant at $P \leq 0.05$.

Results and Discussion

Analysis of manufactured diets (Table 2) resulted in Trp values consistent with diet formulation, as the negative control diet had the lowest level of analyzed Trp while the addition of either fermented Trp with biomass or crystalline Trp increased the total analyzed dietary Trp concentration.

For growth performance, there was no evidence for treatment differences ($P > 0.17$) for ADG, ADFI, or F/G from d 0 to 7 or 7 to 14 (Table 3). From d 14 to 21, pigs fed the 21% Trp:Lys ratio from crystalline Trp or Trp with biomass had increased ($P < 0.05$) ADG compared to pigs fed the 23.5% Trp:Lys ratio with biomass, with pigs fed the negative control intermediate. This was a result of increased ($P < 0.05$) ADFI as pigs fed the 21% Trp:Lys ratio from crystalline Trp or Trp with biomass had greater ADFI compared to pigs fed the 23.5% Trp:Lys ratio with biomass and the negative control. Overall (d 0 to 21), pigs fed the 21% Trp:Lys ratio from crystalline Trp or Trp with biomass had increased ($P < 0.05$) ADG compared to those fed the negative control diet, with pigs fed the 23.5% Trp:Lys ratio with biomass intermediate. There was no evidence for difference in overall ADFI; however, pigs fed the 21% Trp:Lys ratio from Trp with biomass had improved ($P < 0.05$) F/G compared to the negative control diet, with the others intermediate.

In conclusion, TRP Pro appears to be a suitable alternative to crystalline Trp in nursery pig diets as there was no evidence for difference in performance when pigs were fed the same SID Trp:Lys ratio from either source. When pigs were fed the high Trp biomass diet, there was a numeric decrease in feed intake when compared to the low Trp biomass diet. While the reason is unknown, this could be a result of an increased SID Trp:Lys ratio creating an imbalance to other amino acids, or it could be a reflection of the high concentration of biomass causing a reduction in performance. Additional research is warranted to determine the repeatability of the response observed in this trial and to further evaluate the optimal inclusion level of TRP Pro.

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

	Experimental diets			
Tryptophan source :	None	Crystalline	Biomass	
Item SID Trp:Lys, %:	16	21	21	23.5
Ingredients				
Corn	69.51	69.44	69.40	69.34
Soybean meal	25.43	25.44	25.44	25.44
Choice white grease	1.00	1.00	1.00	1.00
Calcium carbonate	0.65	0.65	0.65	0.65
Monocalcium phosphate	1.20	1.20	1.20	1.20
Sodium chloride	0.60	0.60	0.60	0.60
L-Lysine-HCl	0.55	0.55	0.55	0.55
DL-Methionine	0.19	0.19	0.19	0.19
L-Threonine	0.28	0.28	0.28	0.28
L-Tryptophan	---	0.06	---	---
L-Valine	0.15	0.15	0.15	0.15
L-Isoleucine	0.04	0.04	0.04	0.04
Trace mineral premix	0.15	0.15	0.15	0.15
Vitamin premix	0.25	0.25	0.25	0.25
Phytase[2]	0.02	0.02	0.02	0.02
Tryptophan biomass[3]	---	---	0.104	0.156
Total	100	100	100	100

continued

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

	Experimental diets			
Tryptophan source :	None	Crystalline	Biomass	
Item SID Trp:Lys, %:	16	21	21	23.5
Calculated analysis				
Standard ileal digestible (SID) Lys, %	1.25	1.25	1.25	1.25
Total lysine, %	1.38	1.38	1.38	1.38
Total tryptophan, %	0.22	0.29	0.29	0.32
SID amino acid ratios				
Isoleucine:lysine	57	57	57	57
Leucine:lysine	111	111	111	111
Methionine:lysine	36	36	36	36
Methionine and cystine:lysine	57	57	57	57
Threonine:lysine	65	65	65	65
Tryptophan:lysine	16	21	21	23.5
Valine:lysine	70	70	70	70
Histidine:lysine	34	34	34	34
Metabolizable energy, kcal/lb	1,512	1,513	1,510	1,510
NE, kcal/lb[4]	1,135	1,135	1,134	1,133
SID lysine:NE, g/Mcal	5.00	4.99	5.00	5.00
Crude protein, %	18.8	18.9	18.8	18.8
Calcium, %	0.72	0.72	0.72	0.72
Phosphorus, %	0.62	0.62	0.62	0.62
Available phosphorus, %	0.42	0.42	0.42	0.42
STTD P, %[5]	0.46	0.46	0.46	0.46

[1]Diets were fed for 21 days from approximately 25- to 50-lb BW.
[2] Ronozyme HiPhos 2700 (DSM Nutrition Products, Parsippany, NJ) provided 184 FTU per lb of feed.
[3]CJ America-Bio, Downers Grove, IL.
[4]NE = net energy.
[5]STTD P = Standardized total tract digestible phosphorus.

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

		Experimental diet				
	Tryptophan source:	None	Crystalline	Biomass		Trp
Item	SID Trp:Lys, %:	16	21	21	23.5	biomass[2]
Proximate analysis, %[3]						
Crude protein		18.19	17.31	18.56	19.13	77.69
Calcium		0.75	0.75	0.80	0.59	0.02
Phosphorus		0.60	0.59	0.64	0.62	0.42
Amino acids, %						
Lysine		1.29	1.31	1.23	1.49	0.79
Isoleucine		0.80	0.72	0.71	0.79	0.84
Leucine		1.62	1.49	1.48	1.59	1.41
Methionine		0.48	0.46	0.42	0.45	0.18
Threonine		0.91	0.88	0.89	0.99	0.86
Tryptophan		0.22	0.27	0.29	0.33	52.56
Valine		1.03	0.96	0.92	0.99	1.05
Histidine		0.48	0.45	0.45	0.50	0.38
Phenylalanine		0.90	0.80	0.81	0.89	0.73
Arginine		1.13	1.04	1.05	1.13	---

[1]Diets were fed for 21 d from approximately 25- to 50-lb BW.
[2]CJ America-Bio, Downers Grove, IL.
[3]A sample of all experimental diets and the Trp biomass were submitted to Eurofins Scientific Inc. for proximate analysis of complete amino acid profile, crude protein, calcium, and phosphorus (Eurofins Scientific Inc., Des Moines, IA).

Table 3. Effects of using tryptophan biomass as a source of tryptophan on nursery pig performance[1,2]

	Experimental Diets					
Tryptophan source:	None	Crystalline	Biomass[3]			Probability,
Item SID[4] Trp:Lys, %:	16	21	21	23.5	SEM[5]	$P <$
Body weight, lb						
d 0	24.9	24.9	24.7	24.9	0.54	0.723
d 7	30.8	31.2	31.0	30.9	0.64	0.787
d 14	39.6	40.5	40.4	40.1	0.72	0.217
d 21	50.3[b]	51.9[a]	51.7[ab]	50.6[ab]	0.82	0.019
d 0 to 7						
ADG, lb	0.83	0.86	0.88	0.86	0.030	0.686
ADFI, lb	1.30	1.28	1.31	1.31	0.048	0.821
F/G	1.56	1.51	1.49	1.54	0.042	0.506
d 7 to 14						
ADG, lb	1.26	1.33	1.34	1.32	0.030	0.171
ADFI, lb	1.92	2.01	1.99	1.93	0.044	0.189
F/G	1.53	1.51	1.49	1.48	0.028	0.573
d 14 to 21						
ADG, lb	1.54[ab]	1.62[a]	1.62[a]	1.51[b]	0.032	0.007
ADFI, lb	2.30[b]	2.45[a]	2.35[ab]	2.27[b]	0.041	0.003
F/G	1.50	1.52	1.46	1.51	0.025	0.199
d 0 to 21						
ADG, lb	1.21[b]	1.27[a]	1.28[a]	1.23[ab]	0.020	0.004
ADFI, lb	1.84	1.91	1.88	1.84	0.040	0.132
F/G	1.52[b]	1.50[ab]	1.47[a]	1.50[ab]	0.017	0.043

[ab]Values with different superscripts differ ($P < 0.05$).
[1]A total of 315 barrows (DNA; 200 × 400; initially 24.9 lb) were used in a 21-d nursery study with 5 pigs per pen and 15 or 16 pens per treatment.
[2]ADG = average daily gain. ADFI = average daily feed intake. F/G = feed efficiency.
[3]CJ America-Bio, Downers Grove, IL.
[4]SID = standard ileal digestible.
[5]SEM = standard error of the mean.