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K-STATE Research and Extension

SWINE DAY 2022

KANSAS STATE UNIVERSITY SWINE INDUSTRY DAY 2022

Effects of Increasing Soybean Meal and Valine:Lysine and Tryptophan:Lysine Ratios on Finishing Pig Performance[1]

Macie E. Reeb, Jamil E. G. Faccin, Robert D. Goodband, Jason C. Woodworth, Joel M. DeRouchey, Mike D. Tokach, and Jordan T. Gebhardt[2]

Summary

A total of 621 pigs (DNA 241 × 600; initially 138.0 ± 5.5 lb) were used in a 65-d growth trial to determine the effect of increasing soybean meal (SBM) and Val:Lys and Trp:Lys ratios on finishing pig performance. Experimental diets were corn-soybean meal-DDGS-based and fed in 3 phases. The 6 dietary treatments were arranged in a 3 × 2 factorial with main effects of SBM level (low, medium, high) and Val:Lys and Trp:Lys ratios (standard and high). The additional amino acids (AA) provided by increasing levels of SBM in diets with standard AA ratios were expected to result in a higher ADG by balancing out the high leucine from corn. Conversely, ADG was expected to stay the same as SBM increased when the Val:Lys and Trp:Lys ratios in the feed were increased. Pens of pigs were assigned to treatments in a randomized complete block design with BW as a blocking factor. There were approximately 8 or 9 pigs per pen and 12 replicate pens per treatment. No evidence ($P > 0.05$) of SBM × AA ratio interactions or treatment differences were observed for any response criteria for phases 1 and 2 of the study. In phase 3, a marginally significant ($P = 0.084$) SBM × AA ratio interaction was observed for ADG. The medium level of SBM with standard Val:Lys and Trp:Lys ratios resulted in greater (quadratic, $P = 0.003$) ADG compared to other SBM levels. No differences in ADG were observed with increasing SBM when Val:Lys and Trp:Lys ratios were increased ($P = 0.501$). Additionally, F/G improved (quadratic, $P = 0.007$) at the medium level of SBM in phase 3. In spite of the improvement observed in phase 3, there were no significant differences ($P > 0.10$) observed in overall ADG or ADFI. A marginally significant ($P = 0.052$) SBM × AA ratio interaction was observed for overall F/G. Increasing SBM in diets with greater Val:Lys and Trp:Lys ratios resulted in poorer ($P = 0.049$) F/G. There was no difference ($P = 0.435$) in F/G observed with increasing SBM in feeds with standard Val:Lys and Trp:Lys ratios. In conclusion, in early finishing there were no responses to increasing SBM; however, in the late finishing period when diets included 0, 4, or 8% SBM, pigs fed 4% SBM diets with standard BCAA ratios had improved ADG and F/G. Throughout the study, increasing Val:Lys and Trp:Lys ratios had little effect on pig performance.

[1] The authors appreciate the United Soybean Board for their partial financial support.

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Introduction

Branched-chain amino acids (BCAA) are a collective group of structurally similar amino acids comprised of isoleucine (Ile), leucine (Leu), and valine (Val), all of which also share the same first steps in catabolism.[3] Excess of any one of the BCAA leads to an increase in catabolism of all the BCAA, with Leu being the most potent stimulator of branched-chain amino acid transferase (BCAT), which is responsible for the first step of BCAA catabolism.[4] Of the three BCAA, Val and Ile are frequently limiting. In contrast, Leu is usually present in excess in corn-based diets due to its high concentration in corn and corn by-products, such as distillers dried grains with solubles (DDGS). Large neutral amino acids (LNAA), such as tryptophan (Trp), also share the same brain transporters as BCAA.[5,6] Tryptophan is a precursor for the neurotransmitter serotonin, which is involved in feed intake regulation.[7]

Cemin et al.[8] developed a growth prediction model suggesting that high Leu:Lys negatively impacts growth performance due to insufficient levels of other BCAA and LNAA relative to Leu. However, the addition of different combinations of Ile, Val, and/or Trp can increase growth performance. If this model is accurate, it will help nutritionists make more assertive decisions when formulating pig diets.

Recent research has indicated that in corn-crystalline amino acid, or corn-wheat midd-based diets, at least 8% SBM is needed to maximize finishing pig growth performance. However, increasing SBM had no effect when diets contained DDGS. This response could be due to BCAA, LNAA (e.g. Trp), or interactions between the two. Within diets with standard AA ratios, the high Leu content from corn and DDGS will increase catabolism of all BCAA, and therefore some amino acid deficiencies might develop and thus more SBM would be needed to increase performance. On the other hand, in diets where Val:Lys and Trp:Lys ratios are adjusted for this higher Leu content, the additional SBM might not be needed to further improve performance as it is not likely that these two amino acids will be deficient. Understanding if these amino acid interactions cause the lack of response to increasing SBM in diets with DDGS would allow nutritionists to utilize SBM more effectively in DDGS-based diets. Thus, this study was designed to evaluate the effects of increasing SBM in DDGS-based diets while accounting for increased requirements for Ile, Val, or Trp, as suggested by the Cemin et al.[8] model. We hypothesized that increasing Val:Lys and Trp:Lys would improve performance of pigs fed corn-SBM-DDGS-based diets.

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[4] Harper, A. E., R. H. Miller, and K. P. Block. 1984. Branched-chain amino acid metabolism. Annu. Rev. Nutr. 4:409–454. doi:10.1146/annurev.nu.04.070184.002205.

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[7] Henry, Y., B. Sève, Y. Colléaux, P. Ganier, C. Saligaut, and P. Jégo. 1992. Interactive effects of dietary levels of tryptophan and protein on voluntary feed intake and growth performance in pigs, in relation to plasma free amino acids and hypothalamic serotonin. J. Anim. Sci. 70:1873–1887. doi:10.2527/1992.7061873x.

[8] Cemin, H. S, Tokach, M. D., Dritz, S. S, Woodworth, J. C., DeRouchey, J. M., Goodband, R. D. (2019). Meta-regression analysis to predict the influence of branched-chain and large neutral amino acids on growth performance of pigs. Journal of Animal Science, 97(6), 2505-2514.

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 Swine Research and Teaching facility. The facility was naturally ventilated, and each pen was equipped with a 2-hole stainless steel dry self-feeder and a bowl waterer for *ad libitum* access to feed and water. Pigs were provided 7.83 ft^2 of floor space per pig.

Animals and diets

Two groups of approximately 310 pigs (Group 1: 303 pigs, Group 2: 318; 621 pigs total; DNA 241 × 600; initially 138.0 ± 5.5 lb) were used in the study. There were 8 or 9 pigs per pen and 6 pens per treatment in each of the two groups. Daily feed additions to each pen were accomplished using a robotic feeding system (FeedPro; Feedlogic Corp., Wilmar, MN) able to record the amount of feed provided for individual pens. Pens were assigned to 1 of 6 dietary treatments in a randomized complete block design with BW as a blocking factor. Treatments were arranged in a 3 × 2 factorial with main effects of SBM level (low, medium, high) and Val:Lys and Trp:Lys ratios (standard and high). Before the start of the experiment, we used the model developed by Cemin et al.[8] to evaluate BCAA and LNAA ratios to Lys and see what effects practical changes in diet formulation would have on growth performance. The increased ratios were formulated such that ADG was expected to increase with increasing SBM level for the standard Val:Lys and Trp:Lys diets, whereas ADG was expected to stay constant within the diets with increased Val:Lys and Trp:Lys ratios. Samples of the corn, DDGS, and SBM used in this study were analyzed for proximate analysis and amino acid profile. Analyzed amino acid concentrations and SID coefficients (NRC[9]) were used in diet formulation. Dietary treatments were fed in meal form in three BW phases from approximately 120 to 180, 180 to 240, and 240 to 300 lb (Tables 1 to 3). Pigs were weighed approximately every 14 days to determine ADG, ADFI, and F/G.

Statistical analysis

Data were analyzed as a randomized complete block design for a 3 × 2 factorial using the lmer function from the lme4 package in R (version 3.5.2 (02-07-2018), R Foundation for Statistical Computing, Vienna, Austria) with pen serving as the experimental unit and weight block as a random effect. Pre-planned contrast statements were used to evaluate the main effects of increasing SBM and Val:Lys and Trp:Lys ratios, and the associated interactions. Results were considered significant at $P \leq 0.05$ and marginally significant at $P \leq 0.10$.

Results and Discussion

For phases 1 and 2, and in the overall data, no SBM × AA ratio interactions were observed ($P > 0.05$).

In phases 1 and 2, no evidence for treatment differences ($P > 0.10$) were observed for ADG, ADFI, and F/G (Table 4). In phase 3, a marginally significant SBM × AA ratio interaction was observed for ADG ($P = 0.084$). The medium level of SBM with standard Val:Lys and Trp:Lys ratios resulted in greater ADG compared to other SBM

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

levels (quadratic, $P = 0.003$). No difference in ADG was observed with increasing SBM when Val:Lys and Trp:Lys ratios were increased ($P = 0.501$). Additionally, F/G was improved for pigs fed the medium level of SBM in phase 3 (quadratic, $P = 0.007$). In spite of the improvement observed in phase 3, there were no differences ($P > 0.10$) observed in overall ADG or ADFI. A marginally significant SBM × AA ratio interaction was observed for overall F/G ($P = 0.052$). Increasing SBM in diets with high Val:Lys and Trp:Lys ratios resulted in poorer F/G ($P = 0.049$), whereas no difference in overall F/G was observed with increasing SBM with standard Val:Lys and Trp:Lys ratios ($P = 0.435$).

Using the meta-regression model and equations provided by Cemin et al.,[8] relative differences between the predicted and observed performance of these pigs were calculated (Table 5). Comparing predicted and actual responses, the model tended to underestimate performance with the standard Val:Lys and Trp:Lys ratios (as indicated by % of predicted performance generally being > 100%) and overestimated performance for increased Val:Lys and Trp:Lys ratios (as indicated by % of predicted performance generally being < 100%).

In conclusion, this study confirms the importance of SBM in late finishing diets, but provides little evidence that increasing Val:Lys and Trp:Lys while increasing SBM influenced growth performance.

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

Val:Lys and Trp:Lys:	Standard			High		
Item, % SBM level:	Low	Medium	High	Low	Medium	High
Corn	65.85	62.15	58.45	65.60	62.00	58.35
Soybean meal	5.15	9.10	13.10	5.15	9.10	13.10
Corn DDGS, 7.5% oil	25.00	25.00	25.00	25.00	25.00	25.00
Choice white grease	1.00	1.10	1.10	1.00	1.10	1.10
Calcium carbonate	1.10	1.10	1.10	1.10	1.10	1.10
Monocalcium phosphate	0.35	0.30	0.30	0.35	0.30	0.30
Sodium chloride	0.50	0.50	0.50	0.50	0.50	0.50
L-Lys HCl	0.54	0.41	0.29	0.54	0.41	0.29
DL-Met	0.04	0.02	---	0.04	0.02	---
L-Thr	0.10	0.10	0.02	0.10	0.10	0.02
L-Trp	0.06	0.03	0.01	0.10	0.07	0.05
L-Val	0.02	0.01	---	0.20	0.12	0.04
L-Ile	0.05	0.02	---	0.05	0.02	---
Vitamin premix	0.13	0.13	0.13	0.13	0.13	0.13
Trace mineral premix	0.13	0.13	0.13	0.13	0.13	0.13
Total, %	100	100	100	100	100	100
Calculated analysis						
Standard ileal digestible (SID) amino acids, %						
Lys	0.85	0.85	0.85	0.85	0.85	0.85
Ile:Lys	60	65	71	60	65	71
Leu:Lys	167	177	188	166	177	188
Met:Lys	34	34	35	34	34	35
Met and Cys:Lys	60	62	64	60	62	64
Thr:Lys	65	65	65	65	65	65
Trp:Lys	19.0	19.0	19.1	23.6	23.6	23.7
Val:Lys	70	77	83	87	87	88
His:Lys	41	45	49	41	45	49
Total Lys, %	1.01	1.03	1.04	1.01	1.03	1.04
NE NRC,[2] kcal/lb	1,174	1,175	1,175	1,175	1,176	1,176
SID Lys:NE, g/Mcal	3.28	3.28	3.28	3.28	3.28	3.28
Crude protein, %	15.8	17.0	18.3	15.9	17.1	18.4
Ca, %	0.59	0.59	0.59	0.59	0.59	0.59
P, %	0.47	0.47	0.48	0.47	0.47	0.48
STTD P, %	0.42	0.42	0.42	0.42	0.42	0.42

[1]Phase 1 was fed from approximately 120 to 180 lb. Analyzed ingredient composition for corn, soybean meal (SBM), and DDGS varied slightly between groups. Formulations were adjusted to maintain AA ratios and nutrient concentrations.

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

Table 2. Diet composition (as-fed basis) Phase 2[1]

Val:Lys and Trp:Lys:	Standard			High		
Item, % SBM level:	**Low**	**Medium**	**High**	**Low**	**Medium**	**High**
Corn	69.75	66.05	62.30	69.60	65.95	62.30
Soybean meal	1.70	5.65	9.60	1.70	5.65	9.60
Corn DDGS, 7.5% oil	25.00	25.00	25.00	25.00	25.00	25.00
Choice white grease	1.00	1.05	1.10	1.00	1.05	1.10
Calcium carbonate	1.03	1.01	1.00	1.03	1.01	1.00
Monocalcium phosphate	0.10	0.05	---	0.10	0.05	---
Sodium chloride	0.50	0.50	0.50	0.50	0.50	0.50
L-Lys HCl	0.51	0.38	0.30	0.51	0.38	0.30
L-Thr	0.10	0.05	---	0.10	0.05	---
L-Trp	0.06	0.03	0.01	0.09	0.07	0.04
L-Val	---	---	---	0.14	0.07	---
L-Ile	0.04	0.02	---	0.04	0.02	---
Vitamin premix	0.10	0.10	0.10	0.10	0.10	0.10
Trace mineral premix	0.10	0.10	0.10	0.10	0.10	0.10
Total, %	100	100	100	100	100	100
Calculated analysis						
Standard ileal digestible (SID) amino acids, %						
Lys	0.74	0.74	0.74	0.74	0.74	0.74
Ile:Lys	60	67	73	60	67	73
Leu:Lys	181	194	206	181	194	206
Met:Lys	32	35	38	32	35	37
Met and Cys:Lys	61	65	70	61	65	70
Thr:Lys	65	66	66	65	66	66
Trp:Lys	19.2	19.1	19.0	23.8	23.6	23.3
Val:Lys	70	79	88	88	88	88
His:Lys	43	47	52	42	47	52
Total Lys, %	0.90	0.91	0.92	0.90	0.91	0.92
NE, kcal/lb	1,178	1,179	1,180	1,179	1,180	1,180
SID Lys:NE, g/Mcal	2.85	2.85	2.85	2.85	2.85	2.84
Crude protein, %	14.4	15.7	17.0	14.5	15.8	17.1
Ca, %	0.50	0.50	0.50	0.50	0.50	0.50
P, %	0.40	0.41	0.41	0.40	0.41	0.41
STTD P, %	0.35	0.35	0.35	0.35	0.35	0.35

[1]Phase 2 was fed from approximately 180 to 240 lb. Analyzed ingredient composition for corn, soybean meal (SBM), and DDGS varied slightly between groups. Formulations were adjusted to maintain AA ratios and nutrient concentrations.

Table 3. Diet composition (as-fed basis) Phase 3[1]

Val:Lys and Trp:Lys:	Standard			High		
Item, % SBM level:	**Low**	**Medium**	**High**	**Low**	**Medium**	**High**
Corn	71.75	68.00	64.25	71.60	67.90	64.20
Soybean meal	---	3.95	7.90	---	3.95	7.90
Corn DDGS, 7.5% oil	25.00	25.00	25.00	25.00	25.00	25.00
Choice white grease	1.00	1.05	1.10	1.00	1.05	1.10
Calcium carbonate	0.90	0.90	0.90	0.90	0.90	0.90
Monocalcium phosphate	0.10	0.05	---	0.10	0.05	---
Sodium chloride	0.50	0.50	0.50	0.50	0.50	0.50
L-Lys HCl	0.45	0.32	0.20	0.45	0.32	0.20
L-Thr	0.10	0.05	---	0.10	0.05	---
L-Trp	0.05	0.02	0.01	0.08	0.05	0.03
L-Val	---	---	---	0.14	0.07	---
L-Ile	0.02	0.01	---	0.02	0.01	---
Vitamin premix	0.08	0.08	0.08	0.08	0.08	0.08
Trace mineral premix	0.08	0.08	0.08	0.08	0.08	0.08
Total, %	100	100	100	100	100	100
Calculated analysis						
Standard ileal digestible (SID) amino acids, %						
Lys	0.65	0.65	0.65	0.65	0.65	0.65
Ile:Lys	60	70	79	60	69	79
Leu:Lys	201	215	229	201	215	229
Met:Lys	35	38	41	35	38	41
Met and Cys:Lys	67	72	78	67	72	78
Thr:Lys	68	70	72	68	70	72
Trp:Lys	19.2	19.1	19.0	23.4	23.5	23.5
Val:Lys	76	86	96	96	96	96
His:Lys	46	52	57	46	52	57
Total Lys, %	0.80	0.81	0.82	0.80	0.81	0.82
NE NRC,[2] kcal/lb	1,179	1,180	1,181	1,181	1,181	1,181
SID Lys:NE, g/Mcal	2.50	2.50	2.50	2.50	2.50	2.50
Crude protein, %	13.7	15.0	16.4	13.8	15.1	16.4
Ca, %	0.44	0.44	0.44	0.44	0.44	0.44
P, %	0.39	0.40	0.41	0.39	0.40	0.41
STTD P, %	0.31	0.31	0.31	0.31	0.31	0.31

[1]Phase 3 was fed from approximately 240 to 300 lb. Analyzed ingredient composition for corn, SBM, and DDGS varied slightly between groups. Formulations were adjusted to maintain AA ratios and nutrient concentrations.

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

Table 4. Effects of increasing soybean meal and valine:lysine and tryptophan:lysine ratios in diets containing DDGS on finishing pig performance[1,2]

Val:Lys and Trp:Lys:	Standard			High				*P* = SBM level		AA
Item SBM level:	Low	Medium	High	Low	Medium	High	SEM	Linear	Quadratic	ratio
BW, lb										
d 0	138.6	138.6	138.6	138.7	138.6	138.8	1.630	0.936	0.947	0.832
d 19	185.3	187.1	186.6	185.5	185.7	187.1	2.034	0.236	0.794	0.802
d 48	254.4	256.8	256.4	255.0	255.2	257.7	2.040	0.144	0.969	0.939
d 61	285.9	291.9	288.9	289.5	289.7	291.8	3.227	0.192	0.315	0.390
Phase 1 (d 0 to 19)										
ADG, lb	2.29	2.36	2.34	2.29	2.30	2.36	0.044	0.162	0.838	0.762
ADFI, lb	5.70	5.86	5.70	5.71	5.87	5.94	0.088	0.172	0.164	0.244
F/G	2.49	2.49	2.43	2.49	2.55	2.51	0.039	0.739	0.236	0.116
Phase 2 (d 19 to 48)										
ADG, lb	2.42	2.45	2.43	2.44	2.44	2.48	0.034	0.484	0.952	0.524
ADFI, lb	6.88	7.09	6.94	6.89	7.00	7.08	0.092	0.129	0.185	0.734
F/G	2.83	2.90	2.85	2.82	2.87	2.86	0.032	0.339	0.110	0.683
Phase 3 (d 48 to 61)										
ADG, lb[3]	1.91	2.11	1.93	2.04	2.05	1.99	0.063	0.760	0.009	0.254
ADFI, lb	6.78	6.96	6.86	6.78	6.91	7.01	0.122	0.133	0.375	0.661
F/G	3.56	3.31	3.56	3.34	3.37	3.52	0.073	0.192	0.007	0.244
Overall (d 0 to 61)										
ADG, lb	2.24	2.32	2.27	2.29	2.29	2.32	0.034	0.281	0.260	0.413
ADFI, lb	6.49	6.67	6.53	6.49	6.61	6.70	0.086	0.103	0.187	0.509
F/G[4]	2.89	2.87	2.87	2.84	2.88	2.90	0.023	0.389	0.832	0.746

[1] A total of 626 pigs (initial BW of 138 ± 5.5 lb) were used in 2 groups in a 65-d finisher trial with 8-9 pigs per pen and 6 pens per treatment. Pigs were allotted to treatment in a completely randomized design. Dietary treatments were arranged in a 3 × 2 factorial with three inclusion levels of soybean meal (SBM; low, medium, high) and two levels of Val:Lys and Trp:Lys (standard, meeting requirement estimates, or high diets supplemented with additional Val:Lys and Trp:Lys to improve performance based on Cemin et al. (2019) model).

[2]SBM × AA ratio interactions ($P > 0.10$) unless otherwise specified.

[3] SBM × AA ratio, $P = 0.084$. Quadratic SBM within standard Val:Lys and Trp:Lys, $P = 0.003$; Quadratic within increased Val:Lys and Trp:Lys, $P = 0.501$.

[4]SBM × AA ratio, $P = 0.052$. Linear SBM within standard Val:Lys and Trp:Lys, $P = 0.435$; Linear within increased Val:Lys and Trp:Lys, $P = 0.049$.

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Table 5. Comparison of predicted performance characteristics based on Cemin[1] (2019) model to actual observed data[2]

Val:Lys and Trp:Lys:		Standard			High		
Item	**SBM level:**	**Low**	**Medium**	**High**	**Low**	**Medium**	**High**
Phase 1							
Predicted							
ADG, lb		2.29	2.33	2.34	2.43	2.44	2.43
ADFI, lb		5.70	5.71	5.67	5.94	5.92	5.86
F/G		2.49	2.45	2.42	2.44	2.42	2.41
Actual							
ADG, lb		2.29	2.36	2.34	2.29	2.30	2.36
ADFI, lb		5.70	5.86	5.70	5.71	5.87	5.94
F/G		2.49	2.49	2.43	2.49	2.55	2.51
% of predicted							
ADG, lb		100	102	100	93	94	97
ADFI, lb		100	103	101	96	99	101
F/G		100	101	101	102	105	104
Phase 2							
Predicted							
ADG, lb		2.42	2.47	2.48	2.57	2.57	2.55
ADFI, lb		6.85	6.91	6.91	7.09	7.13	7.10
F/G		2.83	2.80	2.79	2.76	2.78	2.79
Actual							
ADG, lb		2.42	2.45	2.43	2.44	2.44	2.48
ADFI, lb		6.88	7.09	6.94	6.89	7.00	7.08
F/G		2.83	2.90	2.85	2.82	2.87	2.86
% of predicted							
ADG, lb		100	99	98	95	95	97
ADFI, lb		100	103	100	97	98	100
F/G		100	103	102	102	103	103

continued

Table 5. Comparison of predicted performance characteristics based on Cemin[1] (2019) model to actual observed data[2]

Val:Lys and Trp:Lys:		Standard			High		
Item	**SBM level:**	**Low**	**Medium**	**High**	**Low**	**Medium**	**High**
Phase 3							
Predicted							
ADG, lb		1.91	1.96	1.95	2.06	2.07	2.03
ADFI, lb		6.80	6.88	6.77	7.15	7.19	7.04
F/G		3.56	3.51	3.48	3.47	3.47	3.47
Actual							
ADG, lb		1.91	2.11	1.93	2.04	2.05	1.99
ADFI, lb		6.78	6.96	6.86	6.78	6.91	7.01
F/G		3.56	3.31	3.56	3.34	3.37	3.52
% of predicted							
ADG, lb		100	107	99	99	99	98
ADFI, lb		100	101	101	95	96	100
F/G		100	94	102	96	97	101
Overall							
Predicted							
ADG, lb		2.24	2.28	2.29	2.39	2.39	2.37
ADFI, lb		6.47	6.52	6.48	6.74	6.76	6.69
F/G		2.89	2.85	2.83	2.82	2.82	2.82
Actual							
ADG, lb		2.24	2.32	2.27	2.29	2.29	2.32
ADFI, lb		6.49	6.67	6.53	6.49	6.61	6.70
F/G		2.89	2.87	2.87	2.84	2.88	2.90
% of predicted							
ADG, lb		100	102	99	96	96	98
ADFI, lb		100	102	101	96	98	100
F/G		100	101	102	101	102	103

[1] Cemin, H. S, Tokach, M. D., Dritz, S. S, Woodworth, J. C., DeRouchey, J. M., Goodband, R. D. (2019). Meta-regression analysis to predict the influence of branched-chain and large neutral amino acids on growth performance of pigs. Journal of Animal Science, 97(6), 2505-2514.

[2] Predicted values were calculated using the equations from the Cemin et al. (2019) model, and then adjusted to the observed performance of the treatment with low SBM and standard Val:Leu and Trp:Leu ratios by adjusting the y-intercept of the prediction equation.