Kansas Agricultural Experiment Station Research Reports

Volume 9
Issue 7 *Swine Day*

Article 26

2023

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Recommended Citation

Kim, Ty H.; Faccin, Jamil E. G.; Goodband, Robert D.; Tokach, Mike D.; DeRouchey, Joel M.; Woodworth, Jason C.; and Gebhardt, Jordan T. (2023) "Effects of Increasing Energy or Lysine in Soybean Meal-Based Diets on Early and Late Finishing Pig Performance," *Kansas Agricultural Experiment Station Research Reports*: Vol. 9: Iss. 7. https://doi.org/10.4148/2378-5977.8527

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Funding Source

This research was supported by the United Soybean Board. Appreciation is expressed to New Horizon Farms (Pipestone, MN) for technical support and expertise in conducting the experiment.

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K-STATE Research and Extension

SWINE DAY 2023

KANSAS STATE UNIVERSITY SWINE INDUSTRY DAY 2023

Effects of Increasing Energy or Lysine in Soybean Meal-Based Diets on Early and Late Finishing Pig Performance[1]

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

Summary

A total of 2,265 finishing pigs (337 × 1050 PIC; initially 110.7 ± 6.14 lb) were used in two 28-d trials to determine the effect of increasing energy or lysine in soybean meal-based diets on early and late finishing pig performance. Pigs were housed in mixed gender pens with 27 pigs per pen and 21 pens per treatment. Soybean meal (SBM) NE values used in diet formulation were either 946 kcal/lb (78% NE of corn; NRC)[3] or 1,212 kcal/lb (100% NE of corn). The treatments were structured as a completely randomized design. Treatments consisted of: 1) a diet containing a high level of SBM which was estimated at 100% NE of corn (High SBM); 2) a diet containing a low level of SBM which was estimated at 100% NE of corn with added feed-grade amino acids (Low SBM); 3) a diet containing a low level of SBM which was estimated at 78% NE of corn with added fat (Low SBM w/fat) to equal the NE in diets 1 and 2; and 4) a diet containing a low level of SBM which was estimated at 100% NE of corn with increased feed-grade AA and increased Lys:NE (Low SBM w/AA). Following the 28-d growth trial in the early finishing phase, pigs were fed a common diet for approximately 30 d. Pens were then randomly allotted to 1 of the same 4 treatments for the late finishing phase (initially 251.5 ± 7.40 lb BW). For both experiments, pigs were weighed and feed disappearance was measured every 14 d to determine ADG, ADFI, F/G, and caloric efficiency (CE). In the early finishing study, there were no differences in ADG ($P > 0.10$), but pigs fed a low level of SBM with increased feed-grade AA and increased Lys:NE (Low SBM w/AA) had increased ($P < 0.05$) ADFI compared to pigs fed a high level of SBM (High SBM). The increased ADFI without increased ADG resulted in poorer F/G ($P < 0.05$) in pigs fed a low level of SBM with increased feed-grade AA and increased Lys:NE (Low SBM w/AA) compared to pigs fed a low level of SBM with added fat (Low SBM w/fat). For CE, pigs fed a low level of SBM with added fat (Low SBM w/fat) had improved ($P < 0.05$) CE compared to pigs fed a low level of SBM with increased feed-grade AA and increased Lys:NE (Low SBM w/AA). In the late finishing study, there was a tendency ($P = 0.092$) for a treatment effect on F/G where pigs fed

[1] This research was supported by the United Soybean Board. Appreciation is expressed to New Horizon Farms (Pipestone, MN) for technical support and expertise in conducting the experiment.

[2] Department of Diagnostic Medicine/Pathobiology, College of Veterinary Medicine, Kansas State University.

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

the High SBM diet had the best F/G, but there was not a significant difference between any two treatments when using a Tukey multiple comparison adjustment ($P > 0.05$). There was no evidence ($P > 0.10$) for a difference in ADG, ADFI, or CE. Based on the performance of pigs fed the low level of SBM with increased AA and increased Lys:NE (Low SBM w/AA), the lost performance of low SBM diets is not due to a lower Lys:Cal ratio that results when NE is underestimated. Using caloric efficiency, SBM is estimated to contain 94% of the NE of corn based on results of the early finishing study and 125% of the NE of corn based on results of the late finishing study.

Introduction

Soybean meal is the primary plant-based protein source used in swine diets in the United States due to its well-balanced amino acid profile and competitive cost compared with other protein sources. The NE content of SBM has been reported as 947 kcal/lb, which is 78% of NE content of corn.[3] However, previous research has shown improvements in feed efficiency with increasing SBM levels.[4] This improved performance could be attributed to the NRC underestimating the NE of SBM.

Net energy can be measured using direct or indirect calorimetry studies. However, this requires expensive and specialized equipment and procedures. Feeding increasing levels of an ingredient and using the differences in CE to estimate the energy content of the test ingredient relative to a known ingredient, such as corn, is a more practical approach. If the energy estimate of the test ingredient is accurate, CE should remain the same as the test ingredient's level increases. Changes in CE with increasing ingredient levels is an indicator of over- or under-estimating the energy content of the ingredient. The objective of this study was to determine the effects of increasing energy or lysine in corn-soybean meal-based diets on early and late finishing pig performance.

Procedures

The protocol used in this experiment was approved by the Kansas State University Institutional Animal Care and Use Committee. The study was conducted in two barns at a commercial research finishing site in southwest Minnesota. The barns were naturally ventilated and double-curtain-sided with totally slatted floors. Each pen was equipped with a 5-hole stainless steel dry self-feeder and a bowl waterer for *ad libitum* access to feed and water. All diets were manufactured at the New Horizon Farms Feed Mill (Pipestone, MN) and were in mash form. Daily feed additions to each pen were accomplished using a robotic feeding system (FeedPro; Feedlogic Corp., Wilmar, MN) that recorded feed deliveries for individual pens.

Two groups of pigs (a total of 2,265 pigs; 337 × 1050 PIC) were used in two, 28-d growth trials. Pigs were housed in mixed gender pens with 27 pigs per pen and 21 pens per treatment. Pigs were allotted to an early finishing phase (initially 110.7 ± 6.14 lb). After completing the initial 28-d trial, pigs were fed a common diet for 30 d. Then pigs were reallotted to a late finishing phase (initially 251.5 ± 7.40 lb BW). For both studies, pens were allotted to 1 of 4 dietary treatments in a completely randomized design. Treatments consisted of: 1) a diet containing a high level of SBM which was estimated

[4] Cemin, H. S., H. E. Williams, M. D. Tokach, S. S. Dritz, J. C. Woodworth, J. M. DeRouchey, R. D. Goodband, K. F. Coble, B. A. Carrender, and M. J. Gerhart. 2020. Estimate of the energy value of soybean meal relative to corn based on growth performance of nursery pigs. J. Anim. Sci. Biotechn. 11:70. doi:10.1186/s40104-020-00474-x.

at 100% NE of corn (High SBM); 2) a diet containing a low level of SBM which was estimated at 100% NE of corn with added feed-grade amino acids (Low SBM); 3) a diet containing a low level of SBM which was estimated at 78% NE of corn with added fat (Low SBM w/fat) to equal the NE in diets 1 and 2; and 4) a diet containing a low level of SBM which was estimated at 100% NE of corn with increased feed-grade AA and increased Lys:NE (Low SBM w/AA). For the diet with increased feed-grade AA and increased Lys:NE, the Lys:NE ratio was determined by formulating a diet with a high level of SBM (the same level used in the High SBM treatment) estimated at 78% NE of corn. This fourth treatment was included to determine if the lost performance of low SBM diets is because of a lower Lys:Cal ratio that results when NE is underestimated. For both experimental periods, pigs were weighed and feed disappearance was measured every 14 d to determine ADG, ADFI, and F/G. Caloric efficiency was determined on an NE basis. Caloric efficiency (CE) was calculated by multiplying total feed intake × energy content of the diet (kcal/lb) and dividing by total gain.

Diets were formulated using NRC values for all ingredients except NE of SBM. The NE content of SBM used in formulation was either 947 kcal/lb (78% of corn NE)[3] or 1,212 kcal/lb (100% of corn NE). Representative samples of corn and SBM were submitted for total AA analysis (Ajinomoto Health and Nutrition, Inc., Eddyville, IA).

Representative diet samples were collected and stored at -4°F until analysis. Samples were submitted to Midwest Laboratories (Omaha, NE) for complete proximate analysis.

Data analysis

Experimental data were analyzed using R Studio (Version 4.2.2, R Core Team, Vienna, Austria) with pen serving as the experimental unit in a completely randomized design within each of the two experimental barns using the lmer function in R. Treatment served as a fixed effect within the statistical model, with barn serving as a random effect. Initial body weight was used as a covariate for all responses other than itself. Fixed effects were tested using the joint tests function in R, and treatment means were determined using the emmeans function. Differences between treatments were evaluated using pairwise comparisons using the Tukey-Kramer multiplicity adjustment to control for type I error. Results were considered significant at $P \leq 0.05$ and marginally significant at $P \leq 0.10$.

Results and Discussion

The analyzed AA profiles of corn and SBM were, in general, within expected values (Table 1). Soybean meal had a similar AA composition to NRC values,[3] whereas corn was slightly lower than NRC. The chemical analysis of diets was consistent with formulated values (Table 2 to 3).

In the early finishing phase, there were no differences in ADG, but pigs fed a low level of SBM with increased feed-grade AA and increased Lys:NE (Low SBM w/AA) had increased ($P < 0.05$) ADFI compared to pigs fed the High SBM diet. The increased ADFI without increased ADG resulted in poorer F/G ($P < 0.05$) in pigs fed the low level of SBM with increased AA and increased Lys:NE (Low SBM w/AA) compared to pigs fed a low level of SBM with added fat (Low SBM w/fat). There was no evidence ($P > 0.10$) for a difference in final BW. Pigs fed a low level of SBM with added fat (Low

SBM w/fat) had improved ($P < 0.05$) CE compared to pigs fed a low level of SBM with increased feed-grade AA and increased Lys:NE (Low SBM w/AA).

In the late finishing phase, there was a tendency ($P = 0.092$) for a treatment effect on F/G where pigs fed the High SBM diet had the best F/G, but there was not a significant difference between any two treatments when using a Tukey multiple comparison adjustment ($P > 0.05$). There was no evidence ($P > 0.10$) for a difference in ADG, ADFI, or CE.

Based on the performance of pigs fed the low level of SBM with increased AA and increased Lys:NE (Low SBM w/AA), the lost performance of low SBM diets is not due to a lower Lys:Cal ratio that results when NE is underestimated.

An estimate of the NE of SBM was calculated by adjusting the NE of SBM used in formulation (thus changing dietary NE) until the CE for the High SBM and Low SBM treatments were equal. Net energy of SBM was also estimated by adjusting NE of SBM until variation in CE was minimized across treatments. Both calculations resulted in similar values for NE of SBM relative to the NE of corn. Based on results of the early finishing study, SBM was estimated to contain 94% of the NE of corn. Based on the results of the late finishing study, SBM was estimated to contain 125% of the NE of corn.

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

Item, %	Corn	SBM
Crude protein	6.71	46.14
Amino acids		
Alanine	0.49	2.05
Arginine	0.33	3.43
Aspartic acid	0.48	5.29
Cysteine	0.17	0.61
Glutamic acid	1.26	8.38
Glycine	0.34	2.56
Histidine	0.19	1.20
Isoleucine	0.23	2.14
Leucine	0.82	3.57
Lysine	0.24	2.89
Methionine	0.15	0.63
Methionine + cysteine	0.32	1.24
Phenylalanine	0.28	2.37
Proline	0.54	1.91
Serine	0.34	2.36
Threonine	0.26	1.85
Tryptophan	0.05	0.67
Tyrosine	0.04	1.34
Valine	0.31	2.19

[1] Values represent the mean of two individual samples analyzed by near-infrared spectroscopy (Ajinomoto Animal Health and Nutrition, Eddyville, IA).

Table 2. Composition of early finishing diets (as-fed basis)[1]

Ingredient, %	High SBM	Low SBM	Low SBM w/fat[2]	Low SBM w/AA
Corn	64.39	77.32	74.79	76.99
Soybean meal, 46.5% CP[3]	33.44	19.06	19.07	19.04
Choice white grease	----	----	2.50	----
Monocalcium P	0.60	0.80	0.80	0.75
Limestone	0.90	0.90	0.90	0.90
Sodium chloride	0.50	0.50	0.50	0.50
Liquid lysine 55%	----	0.64	0.65	0.80
DL-Met	----	0.15	0.15	0.19
L-Trp	----	0.06	0.06	0.08
L-Val	----	0.11	0.12	0.18
L-Ile	----	0.06	0.06	0.11
Thr[4]	----	0.23	0.23	0.30
Tribasic copper chloride	0.03	0.03	0.03	0.03
Vitamin-trace mineral premix	0.10	0.10	0.10	0.10
Phytase[5]	0.05	0.05	0.05	0.05
Total	100.00	100.00	100.00	100.00

continued

Table 2. Composition of early finishing diets (as-fed basis)[1]

Ingredient, %	High SBM	Low SBM	Low SBM w/fat[2]	Low SBM w/AA
Calculated analysis				
Standardized ileal digestible (SID) amino acids, %				
Lys	1.00	1.00	1.00	1.09
Ile:Lys	78	60	59	60
Leu:Lys	160	125	123	115
Met:Lys	29	37	37	38
Met and Cys:Lys	59	60	60	59
Thr:Lys	67	65	65	65
Trp:Lys	23.2	21.0	20.9	21.2
Val:Lys	85	72	72	72
His:Lys	51	37	37	34
Total Lys, %	1.15	1.11	1.11	1.20
NE, kcal/lb	1,186	1,185	1,186	1,187
SID Lys:NE, g/Mcal	3.83	3.83	3.83	4.15
CP, %	21.3	16.3	16.1	16.6
Ca, %	0.56	0.55	0.55	0.54
STTD P, %	0.40	0.40	0.40	0.40
Ca:P	1.04	1.07	1.08	1.08
Analyzed values, %				
DM	85.2	84.4	84.7	84.4
CP	18.6	15.3	16.2	14.1
Crude fat	2.3	2.9	3.9	2.5
Acid detergent fiber	3.6	3.1	2.5	2.2
Ash	4.1	3.4	3.4	3.4

[1]Early finishing diets were fed from approximately 110 to 178 lb.
[2]Net energy of SBM used in formulation was 78% NE of corn (947 kcal/lb). Fat was added at 2.5% to achieve a similar dietary NE as the other treatments, in which NE of SBM used in formulation was 100% NE of corn (1,212 kcal/lb).
[3]CP = crude protein.
[4]Thr Pro; CJ America-Bio, Downers Grove, IL.
[5]Optiphos (Huvepharma, Sofia, Bulgaria) was included at 500 FTU/kg providing an estimated release of 0.13% STTD P for all the diets.

Table 3. Composition of late finishing diets (as-fed basis)[1]

Ingredient, %	High SBM	Low SBM	Low SBM w/fat[2]	Low SBM w/AA
Corn	75.30	86.22	84.71	86.08
Soybean meal, 46.5% CP[3]	23.18	11.16	11.16	11.17
Choice white grease	----	----	1.50	----
Monocalcium P	0.12	0.30	0.30	0.30
Limestone	0.75	0.75	0.75	0.75
Sodium chloride	0.50	0.50	0.50	0.50
Liquid lysine 55%	----	0.54	0.54	0.61
DL-Met	----	0.06	0.07	0.08
L-Trp	----	0.05	0.05	0.06
L-Val	----	0.06	0.06	0.06
L-Ile	----	0.05	0.05	0.05
Thr[4]	----	0.18	0.18	0.21
Tribasic copper chloride	0.03	0.03	0.03	0.03
Vitamin-trace mineral premix	0.10	0.10	0.10	0.10
Phytase[5]	0.02	0.02	0.02	0.02
Total	100.00	100.00	100.00	100.00

continued

Table 3. Composition of late finishing diets (as-fed basis)[1]

Ingredient, %	High SBM	Low SBM	Low SBM w/fat[2]	Low SBM w/AA
Calculated analysis				
Standardized ileal digestible (SID) amino acids, %				
Lys	0.75	0.75	0.75	0.79
Ile:Lys	82	61	60	58
Leu:Lys	182	143	142	136
Met:Lys	33	34	34	35
Met and Cys:Lys	67	60	60	60
Thr:Lys	71	67	67	67
Trp:Lys	23.4	21.0	20.9	21.2
Val:Lys	91	72	72	68
His:Lys	56	40	40	38
Total Lys, %	0.87	0.84	0.84	0.88
NE, kcal/lb	1,194	1,193	1,193	1,193
SID Lys:NE, g/Mcal	2.85	2.85	2.85	3.00
CP, %	17.3	13.1	13.0	13.2
Ca, %	0.38	0.38	0.38	0.38
STTD P, %	0.26	0.26	0.26	0.26
Ca:P	0.99	1.02	1.03	1.02
Analyzed values, %				
DM	85.1	84.4	84.6	84.5
CP	15.3	12.7	11.9	11.7
Crude fat	2.8	3.0	3.8	2.7
Acid detergent fiber	2.5	2.2	2.1	2.2
Ash	3.0	2.8	2.5	2.7

[1]Late finishing diets were fed from approximately 251 lb. to market.
[2]Net energy of SBM used in formulation was 78% NE of corn (947 kcal/lb). Fat was added at 2.5% to achieve a similar dietary NE as the other treatments, in which NE of SBM used in formulation was 100% NE of corn (1,212 kcal/lb).
[3]CP = crude protein.
[4]Thr Pro; CJ America-Bio, Downers Grove, IL.
[5]Optiphos (Huvepharma, Sofia, Bulgaria) was included at 500 FTU/kg providing an estimated release of 0.10% STTD P for all the diets.

Table 4. Effects of increasing energy or lysine in soybean meal-based diets on early finishing pig performance[1]

Item[2]	High SBM	Low SBM	Low SBM w/fat	Low SBM w/AA	SEM	*P* =
BW, lb						
d 0	110.7	110.6	110.8	110.5	6.14	0.999
d 28	176.6	177.2	178.4	178.9	0.95	0.118
d 0 to 28						
ADG, lb	2.30	2.33	2.38	2.35	0.022	0.074
ADFI, lb	5.36[b]	5.38[ab]	5.43[ab]	5.59[a]	0.180	0.026
F/G	2.33[ab]	2.31[ab]	2.28[b]	2.38[a]	0.080	0.015
CE,[3] kcal/lb gain	2,764[ab]	2,737[ab]	2,704[b]	2,824[a]	95.2	0.011

[1]A total of 2,265 (initially 110.6 ± 6.14 lb BW) were used in two groups with 27 pigs per pen and 21 replicates per treatment.
[2]Weight on d 0 was used as a covariate for all responses other than itself.
[3]CE = caloric efficiency.

Table 5. Effects of increasing energy or lysine in soybean meal-based diets on late finishing pig performance[1]

Item[2]	High SBM	Low SBM	Low SBM w/fat	Low SBM w/AA	SEM	*P* =
BW, lb						
d 0	251.1	251.4	250.7	252.9	7.40	0.883
d 28	305.3	304.2	307.0	304.2	2.26	0.212
d 0 to 28						
ADG, lb	2.04	2.04	2.07	1.99	0.037	0.532
ADFI, lb	6.91	7.08	7.04	7.01	0.230	0.454
F/G	3.40	3.49	3.41	3.53	0.156	0.092
CE,[3] kcal/lb gain	4,062	4,160	4,070	4,212	186.5	0.104

[1]A total of 2,219 (initially 251.5 ± 7.40 lb BW) were used in two groups with 27 pigs per pen and 21 replicates per treatment.
[2]Weight on d 0 was used as a covariate for all responses other than itself.
[3]CE = caloric efficiency.