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Effects of Dietary Soybean Meal Concentration with Dietary Crude Protein Fixed at 12% on Growth and Carcass Performance of Finishing Pigs from 250 to 300 lb

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Summary

A total of 280 pigs (DNA 600 × 241, initially 251.8 lb) were used in a 23-d trial to determine the effects of dietary soybean meal (SBM) concentration with dietary crude protein, fixed at 12%, on growth performance of finishing pigs from 250 to 300 lb. Pens of 7 or 8 pigs were allotted by BW and randomly assigned to 1 of 6 dietary treatments with 6 replications per treatment. Treatments consisting of 5 levels of SBM (10.6, 7.7, 4.9, 2.7, and 0%) with 12% CP and a negative control treatment with 4.0% SBM and 10% CP. Corn gluten meal was increased as SBM decreased to maintain the 12% CP. At d 23, pigs were transported to a packing plant for processing and carcass data collection. For overall growth performance, decreasing SBM marginally decreased (linear, $P < 0.10$) ADG. Decreasing SBM increased (linear, $P < 0.05$) ADFI with the highest intake in pigs that were fed 2.7% SBM. The high ADFI worsened (linear, $P < 0.05$) F/G and caloric efficiency, resulting in pigs fed 2.7% SBM having the poorest caloric efficiency. Feed intake was lowered ($P < 0.05$) in pigs fed the diet with 12% CP and 10.6% SBM compared with pigs fed the diet with 10% CP and 4.0% SBM, resulting in a marginal improvement ($P < 0.10$) in F/G and caloric efficiency for pigs fed the 12% CP and 10.6% SBM diet. For carcass characteristics, decreasing SBM decreased (linear, $P < 0.05$) carcass ADG and worsened (linear, $P < 0.05$) carcass feed efficiency and caloric efficiency. Pigs fed the diet with 12% CP and 10.6% SBM had improved ($P < 0.05$) F/G and marginally improved ($P < 0.10$) carcass caloric efficiency compared with pigs fed the diet with 10% CP and 4.0% SBM. In conclusion, regardless of the 12% CP level, reducing the concentration of SBM worsened ADG, F/G, caloric efficiency, carcass ADG, and carcass feed efficiency, and caloric efficiency. In addition, pigs fed the 12% CP and 10.6% SBM had improved F/G, caloric efficiency, carcass feed efficiency, and carcass caloric efficiency, compared with pigs fed the negative control diet with 10% CP.

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Introduction

Soybean meal (SBM) is a major protein ingredient used in swine diets and represents the standard to which all other protein sources are measured.[2] Soybean meal amino acid (AA) profile, high digestibility, lack of variation in nutritional composition, and relatively low price make it an excellent protein source for feeding pigs and poultry.[3] In addition, SBM contains several biologically active compounds, such as isoflavones, saponins, proteins, and peptides, that may also be important for growth performance.[4] Nonetheless, other vegetable protein supplements can be used to replace SBM in swine diets. These sources include canola, cottonseed, sunflower, pea, corn gluten meal, and peanut meals. Previous research[5] suggested that a significant reduction in performance and carcass characteristics occurs when finishing pigs are fed corn-soybean meal diets formulated with less than 12% CP, fortified with all AA at or greater than minimum requirement estimates relative to lysine. In this study, the concentration of SBM where growth performance was negatively affected was less than 10.5%. The question remains whether the reduced performance of pigs fed low CP diets was due to the low CP itself or decreased concentrations of SBM. Thus, the objective of the present study was to determine the effects of dietary soybean meal concentration, with dietary crude protein fixed at 12%, on growth performance of finishing pigs from 250 to 300 lb.

Procedures

The Kansas State University Institutional Animal Care and Use Committee approved the protocol used in this experiment. This study was conducted at the Kansas State University Swine Teaching and Research Center in Manhattan, KS. The facility was totally enclosed and environmentally regulated, containing 36 pens. Each pen was equipped with a dry, single-sided feeder (Farmweld, Teutopolis, IL) and a 1-cup waterer. Pigs were stocked at a floor space of 7.83 ft^2 per pig. Pens were equipped with adjustable gates to allow space allowances per pig to be maintained if a pig died or was removed from a pen during the experiment. Pens were located over a completely slatted concrete floor with a 4-ft pit underneath for manure storage. A robotic feeding system (FeedPro; Feedlogic Corp., Wilmar, MN) was used to deliver and record daily feed additions to each individual pen.

A total of 280 pigs (DNA 600 × 241, initially 251.8 lb) were used in a 23-d trial. There were 7 or 8 mixed-gender pigs per pen and pigs were allotted by BW to pens. Pens were randomly assigned within weight blocks in a completely randomized block design with 6 replications per treatment. There were 6 dietary treatments that included 5 diets with

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[2] Shelton, J., M. Hemann, R. Strode, G. Brashear, M. Ellis, F. Mckeith, T. Bidner, and L. Southern. 2001. Effect of different protein sources on growth and carcass traits in growing-finishing pigs. J. Anim. Sci. 79:2428-2435.

[3] Van Kempen, T., I. Kim, a. Jansman, M. Verstegen, J. Hancock, D. Lee, V. Gabert, D. Albin, G. Fahey, C. Grieshop, and D. Mahan. 2002. Regional and processor variation in the ideal digestible amino acid content of soybean meal measured in growing swine. J. Anim. Sci. 80:429-439.

[4] Rochell, S. J., L. S. Alexander, G. C. Rocha, W. G. Van Alstine, R. D. Boyd, J. E. Pettigrew, and R. N. Dilger. 2015. Effects of dietary soybean meal concentration on growth and immune response of pigs infected with porcine reproductive and respiratory syndrome virus. J. Anim. Sci. 93:2987-2997.

[5] J. A. Soto, M. D. Tokach, S. S. Dritz, J. C. Woodworth, J. M. DeRouchey and R. D. Goodband. 2017. Optimum Level of Dietary Crude Protein for Growth Performance and Carcass Characteristics of Finishing Pigs from 245 to 300 lb. *Kansas Agricultural Experiment Station Research Reports*: Vol. 3: Iss. 7.

decreasing SBM (10.6, 7.7, 4.9, 2.7, and 0%) all fixed at 12% CP, and a negative control diet with 4.0% SBM and 10% CP.

To create the experimental diets, a 12% CP corn-soybean meal diet with 10.6% SBM and 0.13% L-Lys HCl was formulated. Then, a 12% CP corn-corn gluten meal diet with 0.39% L-Lys HCl at 12% CP was formulated. The 10.6 and 0% SBM diets were blended to create the 7.7, 4.9, and 2.7% SBM diets and maintaining 12% CP (Table 1). Lastly, a 10% CP corn-soybean meal with 4.0% SBM and 0.33% L-lysine HCl was formulated. In all these diets ratios of other AA to Lys were maintained well above minimum requirement estimates to ensure that other AA relative to lysine were not limiting. Diets contained 1,206 kcal/lb NE by adjusting the amount of fat as corn, corn gluten meal and SBM changed in the diet.

Pigs were weighed on d 0, 7, 14, and 23 of the trial to determine ADG, ADFI, and F/G. At d 23, pigs were individually tattooed with a unique ID number to allow for carcass measurements to be recorded on a pig basis. On d 23, final pen weights and individual pig weights were taken, and pigs were transported to a commercial packing plant (Triumph, St. Joseph, MO) for processing and determination of carcass characteristics.

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 (method 994.12[6]) 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 design with pen serving as the experimental unit and initial BW serving as the blocking factor. Dietary treatments were the fixed effect and block served as the random effect in the analysis. Preplanned orthogonal contrasts were built using coefficients for unequally spaced treatment and used to determine the main effects of increasing soybean meal inclusion. Hot carcass weight served as a covariate for the analysis of backfat, loin depth, and lean percentage.

Results and Discussion

The analyzed total AA, DM, CP, Ca, P, ether extract, and ash contents of experimental diets (Table 2) agreed closely with formulated estimates.

For overall growth performance (d 0 to 23), decreasing SBM marginally decreased (linear, $P = 0.061$) ADG with the lowest response observed in pigs fed less than 4.9% SBM. Decreasing SBM increased (linear, $P = 0.018$) ADFI with the greatest intake in pigs fed 2.7% SBM. The high ADFI worsened (linear, $P < 0.05$) F/G and caloric efficiency, resulting in pigs fed the diet with 2.7% SBM having the poorest caloric efficiency on a NE basis. There was no evidence for differences in ADG for pigs fed the negative control diet with 10% CP and 4.0% SBM, compared with pigs fed the diet with 12% CP and 10.6% SBM. Nonetheless, ADFI was decreased ($P = 0.007$) in pigs fed the diet with

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

12% CP and 10.6% SBM compared with pigs fed the diet with 10% CP and 4.0% SBM. Therefore, there was a marginal improvement ($P < 0.10$) in F/G and caloric efficiency for pigs fed the diet with 12% CP and 10.6% SBM, compared with pigs fed the negative control diet with 10% CP and 4.0% SBM.

For carcass characteristics, decreasing SBM decreased (linear, $P = 0.037$) carcass ADG with the lowest response observed in pigs fed less than 4.9% SBM. Similarly, decreasing SBM worsened (linear, $P < 0.05$) carcass feed efficiency and carcass caloric efficiency, resulting in pigs fed the diet with 2.7% SBM having the poorest caloric efficiency on NE basis. There was no evidence for differences in carcass ADG for pigs fed the negative control diet with 10% CP and 4.0% SBM compared with the pigs fed the diet with 12% CP and 10.6% SBM. Nonetheless, feeding the higher CP diet improved ($P = 0.048$) carcass G:F and marginally improved ($P = 0.075$) carcass caloric efficiency compared with pigs fed the negative control diet with 10% CP and 4.0% SBM.

In conclusion, with all diets maintaining 12% CP, reducing the amount of SBM worsened ADG, F/G, caloric efficiency, carcass ADG, carcass feed efficiency, and caloric efficiency. In addition, pigs fed the diet with 12% CP and 10.6% SBM had improved F/G, caloric efficiency, carcass feed efficiency, and carcass caloric efficiency, compared with pigs fed the 10% CP diet. These results suggest that dietary SBM concentration could represent one of the reasons why we observed decreased growth performance in finishing pigs fed low CP diets. Additionally, it suggests that one or more biologically active compound found within SBM may be contributing to the responses observed. Further research is needed to understand the reasons why pigs fed diets with seemingly adequate levels of AA, but with less than 10.6% SBM, have decreased growth performance.

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

	CP, %					
	10	12				
Soybean meal, %:	4.0	10.6	7.7	4.9	2.7	0.0
Ingredient, %						
Corn	91.76	84.89	86.14	87.30	88.23	89.31
Soybean meal (46.5% CP)	4.00	10.63	7.67	4.88	2.69	0.01
Corn gluten meal	---	---	1.81	3.63	5.00	6.70
Choice white grease	1.35	2.25	2.00	1.70	1.48	1.25
Monocalcium P (21% P)	0.56	0.52	0.54	0.56	0.58	0.60
Limestone	1.05	0.98	1.00	1.03	1.05	1.08
Salt	0.35	0.35	0.35	0.35	0.35	0.35
L-Lys-HCl	0.33	0.13	0.20	0.27	0.33	0.39
DL-Met	0.11	0.06	0.04	0.03	0.02	---
L-Thr	0.10	0.01	0.02	0.03	0.04	0.04
L-Trp	0.04	0.00	0.02	0.03	0.04	0.05
L-Val	0.06	---	---	---	---	---
L-Ileu	0.11	---	0.01	0.02	0.03	0.04
Trace mineral premix	0.10	0.10	0.10	0.10	0.10	0.10
Vitamin premix	0.08	0.08	0.08	0.08	0.08	0.08
Phytase[2]	0.02	0.02	0.02	0.02	0.02	0.02
Total	100.00	100.00	100.00	100.00	100.00	100.00
Calculated analysis						
Standardized ileal digestible (SID) amino acids, %						
Lys	0.55	0.55	0.55	0.55	0.55	0.55
Ile:Lys	75	75	75	75	75	75
Leu:Lys	164	191	209	228	242	259
Met:Lys	51	47	46	46	46	45
Met and Cys:Lys	86	86	86	86	86	86
Thr:Lys	67	67	67	67	67	67
Trp:Lys	20.5	20.5	20.5	20.5	20.5	20.5
Val:Lys	80	88	87	86	86	85
His:Lys	40	50	48	47	45	44
SID Lys:NE, g/Mcal	2.07	2.07	2.07	2.07	2.07	2.07
NE NRC, kcal/lb	1,206	1,206	1,206	1,206	1,206	1,206
CP, %	10.0	12.0	12.0	12.0	12.0	12.0
Ca, %	0.53	0.53	0.53	0.53	0.53	0.53
P, %	0.41	0.43	0.43	0.42	0.41	0.41
Available P, %	0.26	0.26	0.26	0.26	0.26	0.26
Standardized digestible P, %	0.29	0.30	0.30	0.29	0.29	0.29

[1] Diets were fed from 245 to 300 lb.

[2] Ronozyme Hiphos (GT) 2700 (DSM Nutritional Products, Inc, Parsippany, NJ). Provided 181.8 phytase units (FYT) per lb of diet with a release of 0.10% available P.

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

	CP, %					
	10	12				
Soybean meal, %:	4.0	10.6	7.7	4.9	2.7	0.0
Proximate analysis, %						
DM	86.6	86.5	86.4	86.7	86.6	86.6
CP	10.3	13.0	11.9	12.4	11.7	12.4
Ca	0.64	0.67	0.80	0.70	0.69	0.66
P	0.40	0.45	0.43	0.41	0.43	0.40
Ether extract	3.7	4.3	4.1	4.1	3.8	3.9
Ash	3.6	4.6	4.6	3.9	4.0	3.7
Amino acids, %						
Lys	0.60	0.63	0.62	0.61	0.60	0.57
Ile	0.47	0.52	0.49	0.48	0.49	0.46
Leu	1.09	1.24	1.33	1.39	1.46	1.51
Met	0.28	0.26	0.26	0.26	0.26	0.26
Met and Cys	0.50	0.50	0.50	0.51	0.50	0.50
Thr	0.45	0.46	0.43	0.44	0.42	0.43
Trp	0.10	0.14	0.12	0.11	0.11	0.11
Val	0.54	0.61	0.58	0.56	0.58	0.55
His	0.24	0.31	0.29	0.28	0.28	0.26
Phe	0.51	0.64	0.63	0.63	0.64	0.64

[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. 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.

Table 3. Effects of different levels of soybean meal with dietary crude protein fixed at 12% on growth performance of finishing pigs from 250 to 300 lb[1]

	CP, %								Probability, *P* <	
	10	12						NC[2]		
Soybean meal, %:	4.0	10.6	7.7	4.9	2.7	0.0	SEM	vs. PC[3]	Linear	Quadratic
Item										
BW, lb										
d 0	251.8	251.8	251.8	251.8	251.8	251.8	2.16	0.981	0.963	0.998
d 23	300.5	300.2	299.3	299.1	297.5	297.4	2.35	0.883	0.077	0.994
d 0 to 23										
ADG, lb	2.12	2.10	2.06	2.06	1.99	1.98	0.049	0.774	0.061	0.952
ADFI, lb	7.93	7.41	7.42	7.56	7.84	7.71	0.132	0.007	0.018	0.858
F/G	3.76	3.54	3.61	3.67	3.96	3.91	0.100	0.087	0.007	0.950
G:F	0.267	0.284	0.278	0.273	0.253	0.257	0.0070	0.062	<0.001	0.930
NE efficiency,[4] kcal/lb gain	4,535	4,267	4,357	4,434	4,769	4,711	120.8	0.081	<0.001	0.983
Carcass characteristics										
Carcass ADG, lb[5]	1.62	1.61	1.58	1.57	1.51	1.52	0.037	0.889	0.037	0.967
Carcass G:F[6]	0.204	0.218	0.213	0.209	0.193	0.197	0.005	0.048	<0.001	0.858
NE efficiency, kcal/lb gain	5,923	5,554	5,691	5,786	6,265	6,170	161.5	0.075	<0.001	0.973
HCW, lb	230.2	230.3	230.0	230.1	228.0	228.1	1.93	0.223	0.125	0.704
Carcass yield, %	76.5	76.8	76.6	76.6	76.2	76.5	0.42	0.556	0.387	0.717

[1] A total of 280 pigs (DNA 600 × 241) were used with 7 or 8 pigs per pen and 6 replications per treatment.
[2] NC: negative control with 10% CP and 4.0% soybean meal.
[3] PC: positive control with 12% CP and 10.6% soybean meal.
[4] Caloric efficiency = Kcal of NE per lb of gain ((ADFI × NE/lb) /ADG).
[5] Carcass average daily gain = overall ADG × carcass yield.
[6] Carcass G:F = carcass ADG/ADFI.