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Summary

A total of 282 pigs (DNA 600 × 241, initially 259.3 lb) were used in a 26-d trial to determine the effect of added soybean isoflavones on growth performance and carcass characteristics of finishing pigs fed low crude protein (CP) diets. Pens of 7 or 8 pigs were allotted by body weight (BW) and randomly assigned to 1 of 4 dietary treatments with 9 replications per treatment. Experimental diets were arranged in a 2 × 2 factorial with main effects of CP (13% or 10%) and isoflavone (none or 0.05% of the diet). To achieve desired CP levels, soybean meal (SBM) inclusion was reduced from 13.6 to 4.1% of the diet. Pigs were weighed weekly and at d 26 transported to a packing plant for processing and carcass data collection. For overall growth performance, there was no evidence for an interaction between CP and added isoflavones. Pigs fed diets containing 13% CP had increased ($P < 0.005$) average daily gain (ADG) and subsequently final BW and better feed efficiency (F/G) compared with pigs fed 10% CP. Carcass yield increased ($P = 0.030$) for pigs fed the 10% CP diet compared to pigs fed the 13% CP diet. There was no evidence that including isoflavones in the diets influenced growth performance or carcass characteristics. In summary, the reduced growth performance observed in pigs fed the 10% CP and 4.1% SBM diets does not appear to be related to soy isoflavone concentration.

Introduction

Soybean meal (SBM) is the primary dietary protein source for swine in the United States. It is generally regarded as the best plant protein source in terms of its nutritional value and amino acid (AA) profile.[2] Previous research indicates that a reduction in growth performance and carcass characteristics occurs when late finishing pigs are fed corn-soybean meal diets formulated to contain less than 12% CP, yet still maintaining

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[2]Dourado, L. R. B., L. A. F. Pascoal, N. K. Sakomura, F. G. P. Costa, and D. Biagiotti. 2011. Soybeans (Glycine max) and Soybean Products in Poultry and Swine Nutrition. In: Recent trends for enhancing the diversity and quality of soybean products. InTech, London, UK. p 175-190. doi 10.5772/1005.

AA levels at or greater than minimum requirement estimates relative to lysine.[3] This reduction in performance has been attributed to the decreased concentration of SBM rather than low CP itself.[4]

When reducing the concentration of SBM in the diet, there is a proportional decrease in numerous biologically active compounds.[5] Soto et al.[6] investigated the addition of choline and potassium in low CP diets in an attempt to recover the reduction in growth performance and carcass characteristics, but was unsuccessful. Another biologically active compound that is significantly reduced in diets with low SBM concentrations is isoflavones. Isoflavones have several biological properties including antioxidant activity, immune system activity, and estrogenic and antiestrogenic activities.[7] Considering that isoflavones have hormone-like functions, they may play a role in affecting growth and carcass composition in pigs.[8] Therefore, the objective of the present study was to determine the effect of added soybean-derived isoflavones on growth performance and carcass characteristics of finishing pigs from 260 to 320 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) with two 14.0 × 4.5 in. (length × width) feeder spaces and a 1-cup waterer. 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 282 pigs (DNA 600 × 241, initially 259.3 lb) were used in a 26-d trial. There were 7 or 8 mixed-gender pigs per pen 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 during the experiment. Pigs were allotted by BW and randomly assigned to 1 of 4 dietary treatments in a completely randomized block design

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

[4]Soto, J. A., M. D. Tokach, S. S. Dritz, J. C. Woodworth, J. M. DeRouchey, and R. D. Goodband. 2017. 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. *Kansas State Agricultural Experiment Station Research Reports:* Vol. 3: Iss. 7.

[5]Omoni, A. O., and R. E. Aluko. 2005. Soybean foods and their benefits: Potential mechanisms of action. Nutr. Rev. 63:272-283. doi:10.1111/j.1753-4887.2005.tb00141.x.

[6]Soto, J. A., M. D. Tokach, S. S. Dritz, J. C. Woodworth, J. M. DeRouchey, and R. D. Goodband. 2017. Dietary Supplementation of Choline or Potassium in Low Crude Protein Diets on Growth Performance of Finishing Pigs from 245 to 295 lb. *Kansas State Agricultural Experiment Station Research Reports:* Vol. 3: Iss. 7.

[7]Payne, R. L., T. D. Bidner, L. L. Southern, and K. W. McMillin. 2001. Dietary effects of soy isoflavones on growth and carcass traits of commercial broilers. Poultry Sci. 80:1201-1207.

[8]Payne, R. L., T. D. Bidner, L. L. Southern, and J. P. Geaghan. Effects of dietary soy isoflavones on growth, carcass traits, and meat quality in growing-finishing pigs. J. Anim. Sci. 79:1230-1239.

with 9 replications per treatment. Experimental diets were arranged in a 2 × 2 factorial with main effects of CP (13% or 10%) and isoflavone (none or 0.05% of the diet).

To create experimental diets, a 13% CP corn-soybean meal diet with 13.6% SBM and 0.04% L-lysine HCl was formulated (positive control). Then, a 10% CP corn-soybean meal diet with 4.1% SBM and 0.32% L-lysine HCl was formulated (negative control). The high and low CP diets were each supplemented with 0.05% soy-derived isoflavone (Novasoy 400, ADM, Decatur, IL) to complete the factorial. Isoflavone content in soybean meal has been reported in previous literature from Flachowskey et al.[9] as 900 mg/lb. This value was used as our loading value for isoflavone concentration in SBM in our diet formulation and thus, the positive and negative control provided 122 and 37 mg/lb isoflavones, respectively. The isoflavone product contained 181,436 mg/lb of isoflavones. Consequently, after adding 0.05% of the isoflavone product to the positive and negative control diets, isoflavone concentration increased to 213 and 128 mg/lb, respectively. In each diet, ratios of other AA to lysine were maintained well above minimum requirement estimates to ensure that other AA relative to lysine were not limiting (Table 1). Diets contained 1,197 kcal/lb of net energy by adjusting the amount of fat as the ratios of corn and SBM changed in the diet.

Pigs were weighed on d 0, 7, 14, 21, and 26 of the trial to determine ADG, average daily feed intake (ADFI), and F/G. On d 26, pigs were individually tattooed with a unique ID number, and an RFID transponder was inserted into the left ear to allow carcass measurements to be recorded on a pig basis. On d 26, final pen weights and individual pig weights were taken, and pigs were transported approximately 2.5 h to a commercial packing plant (Triumph, St. Joseph, MO) for processing and determination of carcass characteristics.

Diet samples were taken from 4 feeders per dietary treatment 4 times throughout the study. Samples were stored at -20°C until they were homogenized, subsampled, and submitted (Ward Laboratories, Inc., Kearney, NE) for analysis of dry matter (DM), CP, calcium, phosphorus, ether extract, and ash.

Data were analyzed using the GLIMMIX procedure of SAS version 9.4 (SAS Institute, Inc., Cary, NC) in a randomized completed 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. Main effects of CP and isoflavone, as well as their interactions, were tested. Hot carcass weight (HCW) 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 marginally significant $P > 0.05$ and $P \leq 0.10$.

Results and Discussion

The analyzed total DM, CP, calcium, phosphorus, ether extract, and ash contents of experimental diets were reasonably consistent with formulated values (Table 2).

[9]Flachowsky, G., M. Hunerberg, U. Meyer, D. R. Kammerer, R. Carle, M. Goerke, and M. Eklund. 2011. Isoflavone concentration of soybean meal from various origins and transfer of isoflavones into milk of dairy cows. J. Verbr. Lebensm. 6:449-456. doi: 10.1007/s00003-011-0702-7.

For overall growth performance (d 0 to 26), pigs fed diets containing 13% CP had greater ($P < 0.005$) ADG and final BW compared to those fed 10% CP (Table 3). There was no evidence for differences in ADFI, therefore F/G was improved ($P = 0.001$) in pigs fed diets containing 13% CP. There was no evidence that adding isoflavones to the diets influenced pig growth performance. For carcass characteristics, there was no evidence for differences in HCW, backfat, or lean percentage. Pigs fed diets containing 13% CP had decreased ($P = 0.030$) carcass yield and tended to have greater ($P = 0.078$) loin depth compared to those fed 10% CP. Adding isoflavones to the diets did not influence pig carcass characteristics.

In conclusion, these results suggest that the reduced dietary concentration of isoflavones do not appear to be the reason for reductions in late finishing growth performance when low SBM and low CP diets are fed. The difference in performance between pigs fed the low and high CP diets is consistent with the findings of Soto et al.,[4] where pigs fed a diet with 12% CP and 10.6% SBM had improved F/G, compared to pigs fed 10% CP and 4.0% SBM. Further research is necessary to understand what other components in SBM may be responsible for the reduction in growth performance when SBM inclusion level is reduced.

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

	Crude protein, %	
Ingredient, %	13	10
Corn	82.09	92.17
Soybean meal (46.5% CP)	13.59	4.12
Choice white grease	2.25	1.00
Monocalcium phosphate, 21%	0.52	0.56
Limestone	0.98	1.05
Salt	0.35	0.35
L-Lysine HCL	0.04	0.32
L-Threonine	---	0.13
L-Tryptophan	---	0.05
L-Valine	---	0.03
L-Isoleucine	---	0.03
Vitamin and trace mineral premix	0.18	0.18
Phytase[2]	0.02	0.02
Isoflavone[3]	---	---
Total	100.00	100.00
Calculated analysis		
Standardized ileal digestible (SID) amino acids, %		
Lysine	0.55	0.55
Isoleucine:lysine	84	61
Leucine: lysine	204	165
Methionine: lysine	39	32
Methionine and cysteine: lysine	80	66
Threonine: lysine	73	73
Tryptophan: lysine	22.6	22.8
Valine: lysine	97	75
SID Lysine: net energy, g/Mcal	2.08	2.08
Net energy, kcal/lb	1,197	1,197
Crude protein, %	13.0	10.0
Calcium, %	0.55	0.53
Phosphorus, %	0.45	0.42
Available P, %	0.26	0.26
Standardized digestible P, %	0.30	0.29

[1]Diets were fed from 260 to 320 lb.
[2]Ronozyme Hiphos (GT) 2700 (DSM Nutritional Products, Inc, Parsippany, NJ) provided 181.8 phytase units (FYT) per lb of diet, with an assumed release of 0.10% available P.
[3]Isoflavone product provided 181,436 mg of soy-derived isoflavone per lb and was included at 0.05%.

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

	Crude protein, %			
	13		10	
Item, %	None	Isoflavone	None	Isoflavone
Dry matter	88.6	88.3	87.6	87.6
Crude protein	13.1	12.1	9.0	9.5
Calcium	0.55	0.76	0.68	0.69
Phosphorus	0.41	0.42	0.41	0.39
Ether extract	5.2	4.7	4.1	3.9
Ash	3.1	3.3	3.1	3.0

[1]Diet samples were taken from 4 feeders per dietary treatment 4 times throughout the study. Samples were stored at -20°C until they were homogenized, subsampled, and submitted for analysis to Ward Laboratories, Inc. (Kearney, NE) for analysis of DM, CP, Ca, P, ether extract, and ash.

Table 3. Effects of soy-derived isoflavone in low crude protein (CP) diets on growth performance of finishing pigs from 260 to 320 lb[1]

	Crude protein, %					Probability, *P* <		
	13		10					
Item[2]	None[3]	Isoflavone[4]	None[5]	Isoflavone[6]	SEM	CP	Isoflavone	CP × Isoflavone
BW, lb								
d 0	259.3	259.3	259.3	259.3	2.73	0.992	0.992	0.992
d 26	322.2	323.0	319.3	318.5	3.21	0.005	0.989	0.519
d 0 to 26								
ADG, lb	2.41	2.45	2.31	2.28	0.039	0.001	0.929	0.358
ADFI, lb	8.10	8.08	8.18	8.05	0.136	0.794	0.478	0.623
F/G	3.36	3.30	3.55	3.54	0.035	0.001	0.283	0.438
Carcass characteristics								
HCW, lb	242.1	242.7	241.6	242.1	2.74	0.552	0.571	0.933
Carcass yield, %	75.3	75.3	75.6	75.9	0.24	0.030	0.445	0.639
Backfat, in.[7]	0.76	0.75	0.74	0.77	0.019	0.753	0.841	0.339
Loin depth, in.[7]	2.46	2.49	2.41	2.44	0.028	0.078	0.208	0.919
Lean, %[6]	52.2	52.5	52.2	52.2	0.28	0.360	0.483	0.421

[1]A total of 282 pigs (DNA 600 × 241, initially 259.3 lb) were used in a 26-d experiment with 7 or 8 pigs per pen and 9 replications per treatment.
[2]ADG = average daily gain. ADFI = average daily feed intake. F/G = feed-to-gain ratio. HCW = hot carcass weight.
[3]Total isoflavone content of 122 mg/lb.
[4]Total isoflavone content of 213 mg/lb.
[5]Total isoflavone content of 37 mg/lb.
[6]Total isoflavone content of 128 mg/lb.
[7]Adjusted using HCW as a covariate.