EVALUATION OF DIFFERENT SOY PROTEIN CONCENTRATE SOURCES ON GROWTH PERFORMANCE OF WEANLING PIGS[1]

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Summary

Three experiments were conducted using 486 weanling pigs (216 in Experiment 1; 210 in Experiment 2; 60 in Experiment 3) to determine the effects of different soy protein concentrate (SPC) sources on growth performance. Soy protein concentrate source 1 is dried with a torus disk following the concentration of soy proteins. This drying procedure will generate some degree of heat and possibly mechanical forces somewhat similar to extrusion processing (Soycomil P®, ADM). Soy protein concentrate source 2 is dried by a different process, and then it is moist extruded (Profine E, Central Soya). Therefore, the objective of our study was to determine the relative feeding value of the different SPC sources compared with a complex diet containing milk and other specialty proteins (no soy protein), or a diet containing 40% soybean meal.

In Experiment 1, each SPC source (28.6%) replaced all the soybean meal (SBM) in the control diet on a lysine basis. Pigs fed the diet containing 40% SBM had similar performance to pigs fed the milk-protein based diet from d 0 to 14. Pigs fed either SPC source had lower ADG and ADFI compared to pigs fed either the diet containing 40% SBM or the milk-protein based diet. Pigs fed the diet containing 40% SBM and SPC from source 2 had better F/G than pigs fed the milk-protein based diet or SPC from source 1.

In Experiment 2, either all or half of the soybean meal was replaced by the 28.6 or 14.3% SPC from source 1 and 2. From d 0 to 14 and d 0 to 28, an SPC source by level interaction was observed for ADG (P<0.01) and ADFI (P<0.07). Replacing soybean meal with SPC from source 1 did not influence pig performance. However, replacing soybean meal with SPC from source 2 resulted in a quadratic (P<0.05) improvement in ADG with performance being improved for the diet containing 14.3% SPC, but no benefit to replacing all the soybean meal with SPC. Replacing soybean meal with SPC from either source influenced feed efficiency in a quadratic (P<0.01) manner with feed efficiency being optimal for pigs consuming the diet with half the soybean meal replaced by SPC.

Because replacing all of the soybean meal with SPC reduced ADFI in Experiments 1 and 2, we hypothesized that pigs may not prefer the taste of a diet with a high inclusion rate of SPC (28.6%). To test this theory, a 7-day preference test was conducted to determine feed

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feed intake of weanling pigs provided the option of consuming diets containing either 40% soybean meal or 28.6% SPC (from source 2). Average daily feed intake was 0.41 and 0.01 lb for the 40% soybean meal and 28.6% soy protein concentrate diets, respectively ($P<0.0001$). The poor intake of the SPC diet may indicate a palatability problem when high levels of SPC are included in the diet. Our results suggest replacing a portion of the soybean meal in the diet with SPC from source 2 improves ADG and feed efficiency; however, high levels (28.6%) of SPC should not be included in the diet.

Introduction

Commercial diets for early-weaned pigs currently contain relatively low levels of soybean meal. It has been suggested by researchers that the quantity of soybean meal in diets is limited by delayed-type hypersensitivity reactions of young pigs to high levels of soybean meal. However, if increased amounts of soybean meal could replace more expensive protein sources without affecting pig performance, this would be an economic advantage for producers. A greater inclusion of soy proteins may be possible without negatively affecting pig performance due to different processing methods of soybean meal. Further processed soy proteins such as soy protein concentrate and extruded soy protein concentrate – may be alternatives to animal-based protein sources.

Soy protein concentrates (SPC) are protein sources produced from defatted soy flakes. Soluble carbohydrates – primarily sucrose, raffinose, and stachyose – are removed from the defatted flakes. Soy protein concentrate source 1 is dried with a torus disk following the concentration of soy proteins. This drying procedure generates some degree of heat and possibly mechanical forces somewhat similar to extrusion processing (Soycomil P®, ADM). Soy protein concentrate source 2 is dried by a different process, then moist extruded (Profine E, Central Soya). The objective of our study was to determine the relative feeding value of the different SPC sources compared with a complex diet containing milk and other specialty proteins, or a diet containing 40% soybean meal.

Procedures

In Experiment 1, a total of 216 weanling pigs (each initially 14.7 lb and 18 d of age, PIC) were used in a 28-d growth assay. The pigs were blocked by initial weight and allotted to one of four dietary treatments in a randomized complete block design. All pigs were housed in the KSU Swine Teaching and Research Center’s environmentally controlled nursery. Each pen contained six pigs, and there were nine replicate pens per treatment. Each pen contained a stainless steel self-feeder and one nipple waterer to allow ad libitum access to feed and water. The four treatments consisted of a positive control diet containing milk products and other specialty proteins, a negative control diet containing 40% soybean meal, and two diets containing SPC source 1 or 2 (Table 1). In each of these two diets, soybean meal was completely substituted by SPC on a lysine basis. Energy level across the diets was maintained constant at 1,554 ME, kcal/lb. Energy and amino acid values supplied by the manufacturers were used in diet formulation. An energy value of 1,874 ME kcal/lb was used for the SPC sources, while a value of 1,533 ME kcal/lb was used for soybean meal.

In Experiment 2, 210 weanling pigs (each initially 14.0 lb and 18 d of age) were used in a 28-d growth assay. Pens of pigs were randomly assigned to dietary treatments, similar to that in Experiment 1. There were six pigs per pen and seven pens per treatment. Each pen had ad libitum access to feed and water as in Experiment 1. There were five treatments used in Experiment 2. In addition to the diet containing 40% soybean meal and the SPC diets used in Experiment 1, two additional diets of 14.3% SPC source 1 and 14.3% SPC source 2 were fed (Table 2). These diets replaced 50% of the soybean meal component. Energy was maintained at 1,513 kcal of ME per lb for all diets. For Experiment 2, a more conservative energy value of 1,533 ME kcal/lb was used for both SPC sources and soybean meal.

After analyzing Experiments 1 and 2, it appeared that feed intake had a large influence on results. To test the hypothesis that palatability was a problem with SPC, a total of 60 weanling gilts (each initial BW of 13.4 lb and 15 ± 2 d of age) were used in a 7-d preference trial. Pigs were offered a choice of eating the diet containing 40% SBM or the diet containing 28.6% SPC source 2. Pigs were blocked by weight and allotted to a pen containing two feeders to give a total of 10 pens with six pigs per pen. Pigs were housed at the Segregated Early Weaning Facility at Kansas State University. Each pen was 8 × 8 ft and contained two self-feeders and two nipple waterers to provide ad libitum access to feed and water. The placement of feeders in each pen was alternated twice daily to enable a more accurate portrayal of preference by the pigs for the diets. Pigs and feeders were weighed after 7 days in order to calculate ADFI. Temperature was maintained at approximately 92°F over the experiment's duration.

In both Experiment 1 and Experiment 2, experimental diets were fed from d 0 to d 14 after weaning. From d 14 to d 28, pigs were fed a common diet (Table 3). All diets were fed in meal form. The response criteria of ADG, ADFI, and F/G were determined by weighing pigs and measuring feed disappearance on d 7, 14, 21, and 28 of both experiments. Data were analyzed as a randomized complete block design with pen as the experimental unit using the MIXED procedure of SAS.

Results

From d 0 to 14 in Experiment 1, pigs fed the milk and specialty protein based diet and the diet containing 40% soybean meal had similar ADG, and both were greater than pigs fed either SPC source (Table 4). The improved performance in pigs fed the milk based protein diet and the diet containing 40% SBM appears to be a result of greater ADFI than pigs fed either SPC source. Pigs fed SPC source 2 had better F/G than pigs fed SPC source 1 and the milk protein-based diet, while those fed the diet containing 40% soybean meal had intermediate F/G.

From d 14 to 28, when all pigs were fed a common diet, protein source fed from d 0 to 14 after weaning had no effect on growth performance.

For the overall experimental period (d 0 to 28), pigs fed the diet containing 40% soybean meal or the milk protein-based diet from d 0 to 14 had greater ADG and ADFI than pigs fed either SPC source. No differences were seen in F/G among dietary treatments.

From d 0 to 14 in Experiment 2, there was an SPC source by level interaction ($P < 0.02$) for ADG and ADFI. Pigs fed the diet containing 14.3% SPC from source 2 had greater ADG than pigs fed other diets, resulting in a quadratic effect ($P<0.01$) of level for SPC from source 2. No improvement was seen when SPC from source 1 replaced soybean meal. The SPC source by level interaction for ADFI ($P<0.02$) was due to a linear reduction in ADFI for pigs from SPC from source 2. Feed efficiency improved ($P<0.01$) in a quadratic manner as increasing levels of SPC were added to the diet, with pigs fed the diets with 50% of the soybean meal replaced by SPC having the best F/G. Pigs fed SPC from source 2 also had improved ($P< 0.01$) F/G compared to pigs fed SPC from source 1.

When all pigs were fed the same diet from d 14 to 28, ADG of pigs that were fed 14.3% SPC from either source from d 0 to 14 tended (P<0.09) to be greater than pigs fed the other diets. Pigs fed SPC from source 1 from d 0 to 14 had improved (P<0.03) F/G from d 14 to 28 compared with pigs fed SPC from source 2 from d 0 to 14.

The response for the overall experiment (d 0 to 28) was similar to the response from d 0 to 14. Increasing SPC from source 2 resulted in a quadratic (P<0.05) improvement in ADG, with pigs fed 14.3% SPC from source 2 having the best ADG (SPC source by level interaction, P<0.01). Feed intake decreased (quadratic, P<0.05) as level of SPC from source 2 increased in the diet. Pigs fed SPC from source 2 had improved F/G compared to pigs fed SPC from source 1 (P<0.013). Feed efficiency also improved (quadratic, P<0.01) as level of SPC increased in the diet. Overall, pigs fed SPC from source 2 at a level of 14.3% of the diet outperformed pigs fed the other diets, showing the highest ADG and ADFI, in addition to the best F/G.

The reason for the similar performance of the milk protein-based diet compared with pigs fed 40% soybean meal in Experiment 1 is unknown. Trypsin inhibitor activity in soybean meal and SPC from source 1 and 2 (Experiment 1) was non-detectable, suggesting adequate processing. Urease activity also was shown to be negligible. Protein solubility values also were obtained for these diets with values of 80.06, 58.86, and 74.28 for soybean meal, SPC source 1, and SPC source 2, respectively. Values below 70% are suggestive of overprocessing, indicating that poorer performance of pigs fed SPC from source 1 may be due to overprocessing. Analysis of crude protein also was conducted on these diets. Crude protein content of the diet containing SPC from source was lower than expected, at 20.34% compared to the diet formulation value of 25%.

In Experiment 1, it appeared that feed intake was responsible for the differences in ADG. Over the experimental period, both ADG and ADFI in pigs fed SPC was lower than in pigs fed the milk protein-based diet and the diet containing 40% soybean meal. These data suggest that it is not possible to replace all the soybean meal in the diet with SPC because a depression in intake results, presumably because pigs find it unpalatable at high levels, as shown by the preference trial.

In Experiment 2, there was a large difference observed in pigs fed different sources of SPC. While pigs fed the diet with 14.3% SPC from source 2 showed the best performance, an unknown adverse effect appears to be induced with the higher level of 28.6% SPC from source 2. Pigs fed SPC source 1 performed more poorly than SPC from source 2. From the data, it is apparent that SPC from source 1 cannot be included in the diet at as high a level as SPC from source 2.

Overall, the pigs grew faster in the second experiment. This finding may be partly due to the method of diet formulation. In formulating the diets for Experiment 1, a value for energy of 1,874 ME, kcal/lb was used for both SPC sources, taken from the manufacturer's suggested nutrient profile. It is possible that we overestimated the energy value of the SPC sources in Experiment 1, so a more conservative energy value of 1,533 ME, kcal/lb was used for both SPC sources in Experiment 2.

In the preference trial, preference by the pigs for 40% soybean meal quickly became apparent during the duration of the 7-d trial (Table 6). Average daily feed consumption was 0.41 and 0.01 lb for the 40% soybean meal and 28.6% SPC from source 2 diets, respectively (P<0.0001).

In conclusion, these experiments do not reflect previous work carried out by other researchers on this topic. We did not see the much-reported greater performance in nursery pigs when protein from milk sources is used in diets rather than protein from soybean meal. It appears that soybean meal diets can perform as effectively as more complex diets when considering the age, weight, and health status of pigs in our studies. Regarding sources of soy protein concentrate, we predict that there is a certain level to which they can be substituted for soybean meal. Substitution above that amount results in a decrease in performance. The results of the preference trial suggest a palatability problem when SPC completely replaces soybean meal in the diet. Further research needs to be completed regarding the optimum level at which sources of soy protein concentrate can be included in nursery pig diets.

Table 1. Diet Composition, Experiment 1

			SPC	
Ingredient, %	Control	40% Soybean meal	Source 1	Source 2
Corn	55.01	31.18	46.88	46.88
Soybean meal, 46.5%	---	40.0	---	---
Soy protein concentrate source[a]	---	---	28.55	28.55
Spray-dried animal plasma	8.60	---	---	---
Select menhaden fishmeal	7.50	---	---	---
Spray-dried blood meal	2.50	---	---	---
Spray dried whey	20.0	20.0	20.0	20.0
Soy oil	2.85	4.30	---	---
Monocalcium phosphate, 21% P	0.55	1.40	1.45	1.45
Limestone	0.60	0.90	0.975	0.975
Salt	0.30	0.30	0.30	0.30
Vitamin premix	0.25	0.25	0.25	0.25
Trace mineral premix	0.15	0.15	0.15	0.15
Medication[b]	1.00	1.00	1.00	1.00
Zinc oxide	0.375	0.375	0.375	0.375
L-isoleucine	0.185	---	---	---
Lysine HCl	0.03	0.05	---	---
DL-methionine	0.10	0.10	0.075	0.075
Total	100.0	100.0	100.0	100.0
Total lysine, %	1.51	1.51	1.51	1.51
Isoleucine:lysine ratio, %	60	71	77	77
Leucine:lysine ratio, %	137	132	143	143
Methionine:lysine ratio, %	29	30	30	30
Met & Cys:lysine ratio, %	58	57	57	57
Threonine:lysine ratio, %	6%	65	70	70
Tryptophan:lysine ratio, %	18	21	19	19
Valine:lysine ratio, %	79	76	84	84
ME, kcal/lb	1,554	1,554	1,554	1,554
Protein, %	20.8	23.7	25.0	25.0
Ca, %	0.90	0.90	0.90	0.90
P, %	0.80	0.80	0.80	0.80
Lysine:calorie ratio, g/mcal	4.41	4.41	4.41	4.41

[a]An energy value of 1,874 ME kcal/lb was used for both SPC sources.
[b]Provided 50g/ton carbadox.

Table 2. Diet Composition, Experiment 2

		SPC[a]	
Ingredient, %	40% Soybean meal	14%	28%
Corn	32.98	38.68	44.40
Soybean meal, 46.5%	40.00	20.00	---
Soy protein concentrate source[b]	---	14.28	28.55
Spray dried whey	20.00	20.00	20.00
Soy oil	2.50	2.50	2.50
Monocalcium phosphate, 21% P	1.38	1.40	1.40
Limestone	0.925	0.95	0.975
Salt	0.30	0.30	0.30
Vitamin premix	0.25	0.25	0.25
Trace mineral premix	0.15	0.15	0.15
Medication[c]	1.00	1.00	1.00
Zinc oxide	0.375	0.375	0.375
Lysine HCl	0.05	0.03	0.01
DL-methionine	0.10	0.09	0.09
Total	100.0	100.0	100.0
Total lysine, %	1.51	1.51	1.51
Isoleucine:lysine ratio, %	72	74	77
Leucine:lysine ratio, %	133	137	142
Methionine:lysine ratio, %	30	30	30
Met & Cys:lysine ratio, %	57	57	57
Threonine:lysine ratio, %	65	67	70
Tryptophan:lysine ratio, %	21	20	19
Valine:lysine ratio, %	77	80	83
ME, kcal/lb	1,513	1,513	1,513
Protein, %	23.8	24.3	24.8
Ca, %	0.90	0.90	0.90
P, %	0.80	0.80	0.80
Lysine:calorie ratio, g/mcal	4.53	4.53	4.53

[a]14.3% and 28.6% of both SPC sources.
[b]An energy value of 1,533 ME kcal/lb was used for both SPC sources.
[c]Provided 50g/ton carbadox.

Table 3. Composition of Common Diet Fed From D 14 to 28 in Experiments 1 and 2

Ingredient, %	
Corn	51.17
Soybean meal, 46.5%	27.30
Soy oil	3.00
Monocalcium phosphate, 21% P	0.90
Limestone	0.60
Salt	0.30
Vitamin premix	0.25
Trace mineral premix	0.15
Medication[a]	1.00
Zinc oxide	0.25
L-threonine	0.13
Lysine HCl	0.30
DL-methionine	0.15
Select menhaden fishmeal	4.50
Spray dried whey	10.00
Total	100.00
Total lysine, %	1.50
Isoleucine:lysine ratio, %	61
Leucine:lysine, %	121
Methionine:lysine, %	34
Met & Cys:lysine ratio, %	58
Threonine:lysine ratio, %	65
Tryptophan:lysine, %	17
Valine:lysine, %	68
ME, kcal/lb	1,546
Protein, %	21.1
Ca, %	0.81
P, %	0.73
Lysine:calorie ratio, g/mcal	4.40

[a]Provided 50g/ton carbadox.

Table 4. Effect Of Different Soy Protein Concentrate Sources on Growth Performance of Weanling Pigs (Experiment 1)[abc]

Item	Control	40% Soybean Meal	28.6% SPC Source 1	28.6% SPC Source 2	SED
Day 0 to 14					
ADG, lb	0.694[d]	0.694[d]	0.544[e]	0.561[e]	0.035
ADFI, lb	0.864[d]	0.806[d]	0.672[e]	0.641[e]	0.040
Feed:Gain	1.231[de]	1.157[ef]	1.251[d]	1.146[f]	0.029
Day 14 to 28					
ADG, lb	1.162	1.181	1.141	1.123	0.043
ADFI, lb	1.595	1.634	1.529	1.510	0.045
Feed:Gain	1.379	1.388	1.343	1.355	0.039
Day 0 to 28					
ADG, lb	0.928[d]	0.937[d]	0.843[e]	0.842[e]	0.028
ADFI, lb	1.229[d]	1.220[d]	1.101[e]	1.075[e]	0.035
Feed:Gain	1.305	1.272	1.297	1.250	0.021

[a]A total of 216 pigs (6 pigs per pen) with an initial average BW of 14.7 lb.
[b]Treatment diets were fed from d 0 to 14.
[c]Common diet fed from d 14 to 28.
[def]Means in the same row with different superscripts differ ($P<0.05$).

Table 5. Effect Of Different Soy Protein Concentrate Sources On Growth Performance Of Weanling Pigs (Experiment 2)[abc]

Item	40% Soy-bean meal	SPC Source 1		SPC Source 2		SED	Probability (P<)		
		14.3%	28.6%	14.3%	28.6%		SPC Level	Soy Source	Level x Source
Day 0 to 14									
ADG, lb[de]	0.762	0.711	0.707	0.827	0.687	0.036	0.01	0.07	0.01
ADFI, lb[d]	0.918	0.847	0.876	0.914	0.780	0.044	0.11	0.65	0.02
Feed:Gain[f]	1.182	1.168	1.220	1.078	1.105	0.022	0.03	0.01	0.49
Day 14 to 28									
ADG, lb	1.077	1.126	1.115	1.142	1.066	0.036	0.09	0.53	0.20
ADFI, lb	1.539	1.584	1.557	1.618	1.554	0.044	0.17	0.64	0.57
Feed:Gain	1.429	1.406	1.398	1.417	1.466	0.022	0.26	0.03	0.11
Day 0 to 28									
ADG, lb[e]	0.920	0.918	0.911	0.984	0.876	0.031	0.01	0.40	0.01
ADFI, lb[e]	1.228	1.215	1.217	1.266	1.167	0.039	0.08	0.99	0.07
Feed:Gain[f]	1.306	1.287	1.309	1.248	1.286	0.017	0.02	0.02	0.50

[a]A total of 210 pigs (6 pigs per pen) with an initial average BW of 14.0 lb.
[b]Treatment diets were fed from d 0 to 14.
[c]Common diet fed from d 14 to 28.
[d]Linear effect for soy source 2 (P<0.05).
[e]Quadratic effect for soy source 2 (P<0.05).
[f]Quadratic effect of soy level (P<0.01).

Table 6. Preference Of Weanling Pigs For 40% Soybean Meal vs 28% Soy Protein Concentrate[a]

Item	40% Soybean meal	28% SPC Source	P <	SED
Day 0 to 7				
ADFI, lb	0.41[b]	0.01[c]	<.0001	0.02

[a]A total of 60 pigs (6 pigs per pen) with an initial average BW of 13.4 lb.
[bc]Means in same row with different superscripts differ (P<0.01).