Final Report: S12103* **October 30, 2012**

Title: Effect of low-oligosaccharide soybean meal and flakes on nursery performance.

Introduction:

Soybeans contain several anti-nutritional factors for pigs. The oligosaccharides raffinose and stachyose, which represent about 7% of soybean meal (SBM), are considered part of those anti-nutritional factors in SBM. Pigs do not produce the α-galactosidase enzyme, which is needed to cleave the glycosidic bonds in oligosaccharides to be digested. In addition, oligosaccharides increase the viscosity of digesta, thus reducing the digestion of nutrients. Nursery pigs are especially sensitive to SBM anti-nutritional factors; therefore, its inclusion in nursery pigs is typically limited. A new variety of soybeans with a lower concentration of oligosaccharides may have two opportunities for inclusion in nursery diets. First, SBM low in oligosaccharides may be used in larger amounts than current industry standards without reducing pig performance. Second, after hexane solvent extraction of oil, the soybean white flakes (SWF) low in oligosaccharides may be included in nursery diets without impairing pig performance. This project measured performance of nursery pigs fed conventional vs. low oligosaccharide (LO) SBM and SWF.

Objective:

Determine the effect of LO SBM and SWF on nursery pig performance.

Materials and Methods:

A total of 200 newly weaned pigs (6.0±0.3 kg BW; ~21-day old; PIC C29×337) were used in a completely randomized block design, with 5 dietary treatments (Table 1). There were 10 blocks defined by the combination of 5 initial body weight categories within each of 2 nursery rooms. The experimental unit was a pen with 2 barrows and 2 gilts per pen. Each treatment had 10 block-replicates.

Table 1. Dietary Treatments.

#	Code	Treatment
1.	PC	Positive control: nursery diets following industry standards
2.	SBM-C	Conventional SBM as a primary source of dietary protein
3.	SBM-LO	LO SBM as a primary source of dietary protein
4.	SWF-C	Conventional SWF as a primary source of dietary protein
5.	SWF-LO	LO SWF as a primary source of dietary protein

The experiment followed a 4-phase feeding program by increasing SBM or SWF inclusion, while reducing diets' complexity. During the last week in experiment, all pigs were fed the phase 4, treatment 1 diet to evaluate carry-over effects. The main changes in nutrients and soy protein inclusion throughout the 4-phase feeding program are shown in Table 2.

Diets in treatment 1 used a conventional SBM obtained from ADM Alliance Nutrition plant at Quincy, IL, and its chemical composition to formulate the diets was that reported by Swine NRC (1998). The SBM and SWF, both conventional and LO, used in dietary treatments 2 through 5 were supplied by the United Soybean Board; these ingredients were manufactured under a study conducted at Virginia Tech in 2010, and supported by the United Soybean Board. The same study reported the concentration of moisture, crude protein and amino acids in conventional and LO SBM, as well as the moisture and crude protein contents in conventional and LO SWF. The amino acids contents in conventional and LO SWF were calculated based on the amino acid profile reported in those SBM and adjusted to the SWF crude protein contents. The coefficients of Standardized Ileal Digestibility (SID) of amino acids and metabolizable energy (ME) content in all SBM and SWF were assumed to be the same as reported by Swine NRC (1998). A summary of the nutritional value of these ingredients is reported in Appendix Table 1. Those values were used to formulate experimental diets. The Appendix Table 2 shows the lab analyses of all soy protein sources used in diets.

Diets were formulated to provide a minimum Lys content, and then Met, Cys+Met, Thr, and Trp were provided as a minimum ratio to Lys (National Swine Nutrition Guide, 2010). All amino acids were provided on a SID basis. Diets in treatment 1 were formulated to have a SID Lys to ME ratio as recommended by the National Swine Nutrition Guide (2010), within phase. Diets in treatments 2 through 5 were formulated to have same SID Lys content and about 50 kcal of ME less than in treatment 1 (Table 2). Diet formulation per phase is reported in Appendix Tables 3 through 6. Appendix Table 7 shows the lab analyses of all experimental diets.

Table 2. Main Changes Throughout the 4-phase Feeding Program.

	Feeding program							
	Phase 1, 5 days		Phase 2, 6 days		Phase 3, 7 days		Phase 4, 7 days	
Treatments:	1	2 to 5	1	2 to 5	1		1	2 to 5
Soy source, % [a]	20	30	30	32	35	38	43	40
ME, Mcal/Lb.	1.59	1.54	1.56	1.52	1.53	1.48	1.53	1.48
SID Lys, %	1.56	1.56	1.49	1.49	1.33	1.33	1.27	1.27
SID Lys:ME [b]	4.46	4.61	4.34	4.47	3.95	4.08	3.77	3.89
Lactose, %	16	16	8	8	2	2	0	0

[a] Treatment 1, SBM; treatment 2, SBM-C; treatment 3, SBM-LO; treatment 4, SWF-C; treatment 5, SWF-LO
[b] Grams of SID Lys per Mcal of ME/kg

Variables of response were body weight (BW), weight gain (ADG), feed intake (ADFI), and gain to feed ratio (G:F). Body weight and feed disappearance were recorded on days 0, 5, 11, 18, 25, and 32, which represent the end of each feeding phase and follow-up period. The ADG and ADFI were calculated per experimental unit on a pig-day basis, and expressed as daily average per pig. Data was analyzed and expressed in metric units. In addition, daily observations on fecal consistency were recorded according to the following score: 1) Normal dry feces; 2) Moist feces; 3) Mild diarrhea; 4) Severe diarrhea; and 5) Watery diarrhea. These data are reported as the average per pen.

Performance data were analyzed as a complete randomized block design, using the PROC MIXED procedures of SAS. Block was used as a random variable in the model. Residual were tested for normal distribution; no extreme outliers were detected. The following 3 contrast analyses were conducted: 1) Positive control versus SBM diets (SBM-C and SBM-LO); 2) Positive control versus SWF diets (SWF-C and SWF-LO); and 3) Conventional versus LO soy sources (SBM-C and SWF-C versus SBM-LO and SWF-LO). Pairwise comparisons were included for individual treatment means separation.

The fecal score dataset was skewed to the left, because almost 87% of the records were score 1. Those data were analyzed with the PROC GLIMMIX procedures of SAS, using a cubic transformation of the data. The experimental model was the same as that described for performance data. Reported values were back-transformed.

Results and Discussion:

During the first 5 days post-weaning, pigs fed LO diets (SBM-LO and SWF-LO) eat 18% more (P=0.070) than those fed the conventional SBM-C and SWF-C diets (Appendix Table 8). This is relevant in newly weaned pigs because feed intake promotes the development of their intestinal structure.

Dietary effects on cumulative pig performance at days 11, 18, and 25 followed the same pattern (Appendix Table 8); that was the period in which experimental diets were fed. Cumulative performance at day 25 was as follows; pigs fed LO diets (SBM-LO and SWF-LO) had a larger (P<0.05) ADG by 6% and ADFI by 8% than those in pigs fed conventional SBM-C and SWF-C diets. Pigs fed the SBM-LO diet had the largest (P<0.05) ADFI (522 g/d) and ADG (388 g/d); however, their ADG was not different to that in pigs fed the PC diet (369 g/d) (Appendix Table 9). Pigs fed the SWF diets (SWF-C and SWF-LO) had a lower (P<0.001) ADG and G:F than pigs fed the PC diet.

Cumulative pig performance at day 32, which includes the 7-day follow-up period in which all pigs were fed the PC diet, showed that pigs previously fed SWF diets (SWF-C and SWF-LO) grew as much as those in PC treatment; however, their G:F still was lower (P=0.011) than those in PC treatment. Pigs fed LO diets (SBM-LO and SWF-LO) still had a larger (P<0.05) ADG by 5% and ADFI by 7% than those in pigs fed conventional SBM-C and SWF-C diets. Pigs fed diets with SWF did not show diarrheas.

Pigs fed diets with LO soy sources (SBM and SWF) consistently had a larger ADFI and ADG than those fed the conventional soy sources; however, their G:F was not different. Between LO soy sources, SBM-LO induced a better pig performance than SWF-LO. Although the efficiency to convert feed into body weight is an important parameter in pig production, feed intake and body weight gain are especially important in newly weaned pigs; a larger ADFI and ADG post-weaning represent good conditions for newly weaned piglets to become rapidly adapted to their new solid diet and environment. A rapid adaptation process in this post-weaning period also benefits their long-term performance.

Conclusions:

The LO soy sources (SBM and SWF) induced a larger ADFI in every phase, and a larger cumulative ADG, as compared to conventional soy sources.

Between conventional and LO SBM, pigs fed SBM-LO diets consistently had a larger ADFI and ADG than pigs fed SBM-C; no differences were detected in G:F.

Regardless of source, SWF diets induced a lower ADG and G:F as compared to those in PC diets; however, pigs fed SWF diets did not show diarrheas.

Appendix Table 1. Nutritional specifications of experimental ingredients.

		SBM, NSNG 47.5% CP (970433)				SBM, USB lab 52% CP DM (970434)				SBM LO, USB lab 54.5% CP DM (970435)				SWF, USB lab 53.7% CP DM (970436)				SWF LO, USB lab 54.65% CP DM (970437)			
		Total		SID		Total		SID		Total		SID		Total		SID		Total		SID	
Code	Item	as-is, %	DM, %	as-is, %	DM, %	as-is, %	DM, %	as-is, %	DM, %	as-is, %	DM, %	as-is, %	DM, %	as-is, %	DM, %	as-is, %	DM, %	as-is, %	DM, %	as-is, %	DM, %
2	DM, %	90.00	100.00			93.20	100.00			92.40	100.00			93.45	100.00			93.00	100.00		
	Hum., %	10.00	0.00			**6.80**	0.00			**7.60**	0.00			**6.55**	0.00			**7.00**	0.00		
4	CP,%	**47.50**	52.78			48.46	**52.00**			50.36	**54.50**			50.18	**53.70**			50.82	**54.65**		
365	Ala					2.03	2.18			2.10	2.27			2.11	2.26			2.13	2.30		
366	Arg	3.48	3.87	3.27	3.63	3.47	3.72	3.26	3.4968	3.83	4.14	3.60	3.8916	3.61	3.87	3.40	3.6344	3.86	4.15	3.63	3.9042
367	Asp					5.34	5.73			5.57	6.03			5.52	5.91			5.59	6.01		
368	Cys	0.74	0.82	0.64	0.72	0.77	0.83	0.67	0.7221	0.79	0.86	0.69	0.7482	0.80	0.86	0.70	0.7475	0.81	0.87	0.71	0.7607
369	Glu					8.45	9.07			8.64	9.35			8.78	9.40			8.69	9.35		
370	Gly					2.02	2.17			2.04	2.21			2.11	2.26			2.03	2.19		
371	His	1.28	1.42	1.16	1.29	1.29	1.38	1.17	1.2558	1.31	1.42	1.19	1.2922	1.35	1.45	1.23	1.3194	1.32	1.42	1.20	1.2930
372	Ile	2.16	2.40	1.92	2.14	2.26	2.42	2.01	2.1538	2.25	2.44	2.01	2.1716	2.36	2.52	2.10	2.2463	2.29	2.46	2.04	2.1887
373	Leu	3.66	4.07	3.26	3.62	3.73	4.00	3.32	3.5600	3.78	4.09	3.36	3.6401	3.86	4.13	3.44	3.6801	3.81	4.10	3.39	3.6479
374	Lys	3.02	3.36	2.72	3.02	3.08	3.30	2.77	2.9700	3.20	3.46	2.88	3.1140	3.21	3.44	2.89	3.0931	3.20	3.44	2.88	3.0987
377	Met	0.67	0.74	0.61	0.68	0.65	0.70	0.59	0.6370	0.67	0.72	0.61	0.6552	0.65	0.70	0.59	0.6353	0.66	0.71	0.60	0.6465
379	Phe	2.39	2.66	2.13	2.36	2.43	2.61	2.16	2.3229	2.48	2.68	2.20	2.3852	2.51	2.69	2.23	2.3897	2.49	2.68	2.22	2.3833
380	Pro					2.62	2.81			2.68	2.90			2.71	2.90			2.69	2.90		
381	Ser					2.04	2.19			2.11	2.28			2.11	2.26			2.13	2.30		
383	Thr	1.85	2.06	1.61	1.79	1.84	1.97	1.60	1.7139	1.88	2.03	1.63	1.7661	1.91	2.04	1.66	1.7753	1.88	2.02	1.64	1.7592
384	Trp	0.65	0.72	0.59	0.65	0.65	0.70	0.59	0.6300	0.67	0.72	0.60	0.6480	0.70	0.75	0.63	0.6766	0.66	0.71	0.59	0.6394
385	Tyr	1.82	2.02	1.64	1.82	1.76	1.89	1.59	1.7010	1.75	1.89	1.57	1.7010	1.81	1.93	1.63	1.7399	1.78	1.91	1.60	1.7215
386	Val	2.27	2.52	2.00	2.22	2.39	2.56	2.10	2.2528	2.44	2.64	2.15	2.3232	2.46	2.63	2.16	2.3155	2.44	2.62	2.15	2.3084
378	TSAA	1.41	1.57	1.25	1.39	1.43	1.53	1.27	1.3591	1.46	1.58	1.30	1.4034	1.46	1.56	1.29	1.3828	1.47	1.58	1.31	1.4072
525	Ile/Lys		0.72		0.71		0.7333		0.7252		0.7052		0.6974		0.7344		0.7262		0.71		0.7063
526	Met/Lys		0.22		0.22		0.2121		0.2145		0.2081		0.2104		0.2031		0.2054		0.21		0.2086
527	TSAA/Lys		0.47		0.46		0.4636		0.4576		0.4566		0.4507		0.4531		0.4470		0.46		0.4541
528	Thr/Lys		0.61		0.59		0.5970		0.5771		0.5867		0.5671		0.5938		0.5740		0.59		0.5677
529	Trp/Lys		0.22		0.22		0.2121		0.2121		0.2081		0.2081		0.2188		0.2188		0.21		0.2063
530	Val/Lys		0.75		0.73		0.7758		0.7585		0.7630		0.7461		0.7656		0.7486		0.76		0.7450

Appendix Table 2. Lab analyses of soy protein sources.

As-is nutrient content		Soy source and treatment number				
		1	2	3	4	5
		Standard SBM 47.5%	SBM-C USB 48.5%	SBM-LO USB 50.4%	SWF-C USB 50.2%	SWF-LO USB 50.8%
Test Name	**Units**					
MOISTURE	%	9.79	5.08	7.07	3.96	4.15
PROTEIN	%	47.9	48.1	50.0	50.0	50.9
ADF	%	6.6	8.1	4.7	9.9	12.3
aNDF	%	8.7	12.3	7.5	13.0	12.4

ADM Animal Nutrition Research - S12103

Appendix Table 3. Phase 1 diets.

Treatment number:	1	2	3	4	5
Diet number:	HSM1517	HSM1518	HSM1519	HSM1520	HSM1521
Ingredients, %					
CORN GROUND	31.82	35.24	35.30	35.31	35.31
OAT, FLOUR/MEAL FEED	10.00	2.00	2.00	2.00	2.00
WHEY, EXTRA GRADE	21.25	---	---	---	---
DAIRYLAC 80	0.64	20.00	20.00	20.00	20.00
GREASE MX CHOICE WHITE	4.75	1.00	1.00	1.00	1.00
FISH ML, SLCT MENHADEN	4.15	4.00	4.00	4.00	4.00
AP920 BOV/MIX PLASMA	4.11	4.00	4.00	4.00	4.00
CALCIUM CARBONATE 38	0.70	1.20	1.20	1.20	1.20
PHOS MONOCA 21	0.65	0.80	0.80	0.80	0.80
ZINC OXIDE 72%(>15 LB/BATCH)	0.40	0.40	0.40	0.40	0.40
LYSINE-HCL, 98%	0.34	0.22	0.18	0.17	0.18
METH, DL-99.5%	0.25	0.18	0.17	0.17	0.17
SALT	0.25	0.25	0.25	0.25	0.25
ADM SELECT ACID PACK	0.20	0.20	0.20	0.20	0.20
SWINE TM MIX	0.10	0.10	0.10	0.10	0.10
COPPER SUL 25.2	0.10	0.10	0.10	0.10	0.10
THREONINE, L-98.5	0.09	0.12	0.11	0.10	0.11
SOW-PRESTART VM	0.05	0.05	0.05	0.05	0.05
CHOLINE CHLOR 70	0.04	0.04	0.04	0.04	0.04
SEL .06%	0.03	0.03	0.03	0.03	0.03
SELENIUM YEAST 600	0.03	0.03	0.03	0.03	0.03
PIG FLAVOR #12	0.03	0.03	0.03	0.03	0.03
PHYZYME G XP 2500	0.02	0.02	0.02	0.02	0.02
L-TRYPTOPHAN 98.5	0.01	---	---	---	---
ENDOX	0.01	0.01	0.01	0.01	0.01
SBM NSNG 47.5%	20.00	---	---	---	---
SBM USB 48.5%	---	30.00	---	---	---
SBM-LO USB 50.4%	---	---	30.00	---	---
SWF USB 50.2%	---	---	---	30.00	---
SWF-LO USB 50.8%	---	---	---	---	30.00
Total Batch	100.00	100.00	100.00	100.00	100.00
Nutrients calculated, %					
DRY MATTER, %	90.86	91.46	91.21	91.53	91.39
PROTEIN, %	21.56	24.06	24.58	24.51	24.71
LACTOSE, %	16.02	16.00	16.00	16.00	16.00
ME SWINE NRC, Kcal/Lb	1,589.31	1,538.78	1,538.53	1,538.51	1,538.49
AVAIL LYS SWINE, %	1.56	1.56	1.56	1.56	1.56
SID Lys, g:ME, kcal/kg	4.46	4.61	4.61	4.61	4.61
AILE/LYS S	0.56	0.60	0.60	0.62	0.60
AMET/LYS S	0.35	0.33	0.32	0.32	0.32
ASAA/LYS S	0.58	0.58	0.58	0.58	0.58
ATHR/LYS S	0.62	0.62	0.62	0.62	0.62
ATRP/LYS S	0.17	0.19	0.19	0.20	0.19
AVAL/LYS S	0.65	0.70	0.71	0.72	0.71
CALCIUM, %	0.91	1.10	1.10	1.10	1.10
PHOSPHORUS, %	0.76	0.80	0.80	0.80	0.80
PHOS AVAIL-SWINE, %	0.67	0.60	0.60	0.60	0.60

ADM Animal Nutrition Research - S12103

Appendix Table 4. Phase 2 diets.

Treatment number:	1	2	3	4	5
Diet number:	HSM1522	HSM1523	HSM1524	HSM1525	HSM1526
Ingredients, %					
CORN GROUND	43.23	48.15	48.22	48.23	48.23
OAT, FLOUR/MEAL FEED	5.00	---	---	---	---
WHEY, EXTRA GRADE	6.95	---	---	---	---
DAIRYLAC 80	3.67	10.00	10.00	10.00	10.00
GREASE MX CHOICE WHITE	3.10	1.00	1.00	1.00	1.00
AP920 BOV/MIX PLASMA	2.00	2.00	2.00	2.00	2.00
FISH ML, SLCT MENHADEN	2.00	2.00	2.00	2.00	2.00
PHOS MONOCA 21	0.90	1.10	1.10	1.10	1.10
CALCIUM CARBONATE 38	0.85	1.45	1.45	1.45	1.45
SALT	0.60	0.59	0.59	0.59	0.59
ZINC OXIDE 72%(>15 LB/BATCH)	0.40	0.40	0.40	0.40	0.40
LYSINE-HCL, 98%	0.36	0.35	0.30	0.30	0.30
METH, DL-99.5%	0.22	0.21	0.20	0.20	0.19
ADM SELECT ACID PACK	0.20	0.20	0.20	0.20	0.20
THREONINE, L-98.5	0.15	0.18	0.17	0.16	0.17
SWINE TM MIX	0.10	0.10	0.10	0.10	0.10
COPPER SUL 25.2	0.10	0.10	0.10	0.10	0.10
SOW-PRESTART VM	0.05	0.05	0.05	0.05	0.05
SEL .06%	0.03	0.03	0.03	0.03	0.03
SELENIUM YEAST 600	0.03	0.03	0.03	0.03	0.03
PIG FLAVOR #12	0.03	0.03	0.03	0.03	0.03
PHYZYME G XP 2500	0.02	0.02	0.02	0.02	0.02
ENDOX	0.01	0.01	0.01	0.01	0.01
L-TRYPTOPHAN 98.5	0.00	---	---	---	---
SBM NSNG 47.5%	30.00	---	---	---	---
SBM USB 48.5%	---	32.00	---	---	---
SBM-LO USB 50.4%	---	---	32.00	---	---
SWF USB 50.2%	---	---	---	32.00	---
SWF-LO USB 50.8%	---	---	---	---	32.00
Total Batch	100.00	100.00	100.00	100.00	100.00
Nutrients calculated, %					
DRY MATTER, %	89.71	90.44	90.18	90.51	90.37
PROTEIN, %	22.06	22.60	23.16	23.09	23.30
LACTOSE, %	8.01	8.00	8.00	8.00	8.00
ME SWINE NRC, Kcal/Lb	1,560.17	1,516.38	1,516.11	1,516.09	1,516.07
AVAIL LYS SWINE, %	1.49	1.49	1.49	1.49	1.49
SID Lys, g:ME, kcal/kg	4.34	4.47	4.47	4.47	4.47
AILE/LYS S	0.57	0.58	0.58	0.60	0.59
AMET/LYS S	0.35	0.34	0.34	0.34	0.33
ASAA/LYS S	0.58	0.58	0.58	0.58	0.58
ATHR/LYS S	0.62	0.62	0.62	0.62	0.62
ATRP/LYS S	0.17	0.17	0.18	0.18	0.18
AVAL/LYS S	0.65	0.67	0.68	0.68	0.68
CALCIUM, %	0.86	1.11	1.11	1.11	1.11
PHOSPHORUS, %	0.71	0.74	0.74	0.74	0.74
PHOS AVAIL-SWINE, %	0.55	0.56	0.56	0.56	0.56

ADM Animal Nutrition Research - S12103

Appendix Table 5. Phase 3 diets.

Treatment number:	1	2	3	4	5
Diet number:	HSM1527	HSM1528	HSM1529	HSM1530	HSM1531
Ingredients, %					
CORN GROUND	56.16	54.59	54.68	54.68	54.69
DAIRYLAC 80	2.50	2.50	2.50	2.50	2.50
GREASE MX CHOICE WHITE	1.85	---	---	---	---
PHOS MONOCA 21	1.40	1.30	1.30	1.30	1.30
CALCIUM CARBONATE 38	1.00	1.65	1.65	1.65	1.65
SALT	0.79	0.85	0.85	0.85	0.85
LYSINE-HCL, 98%	0.34	0.22	0.16	0.16	0.16
ADM SELECT ACID PACK	0.20	0.20	0.20	0.20	0.20
METH, DL-99.5%	0.17	0.14	0.12	0.13	0.12
THREONINE, L-98.5	0.16	0.12	0.11	0.10	0.10
SWINE TM MIX	0.10	0.10	0.10	0.10	0.10
COPPER SUL 25.2	0.10	0.10	0.10	0.10	0.10
ZINC OXIDE 72%(>15 LB/BATCH)	0.06	0.06	0.06	0.06	0.06
SOW-PRESTART VM	0.05	0.05	0.05	0.05	0.05
SEL .06%	0.03	0.03	0.03	0.03	0.03
SELENIUM YEAST 600	0.03	0.03	0.03	0.03	0.03
PIG FLAVOR #12	0.03	0.03	0.03	0.03	0.03
PHYZYME G XP 2500	0.02	0.02	0.02	0.02	0.02
ENDOX	0.01	0.01	0.01	0.01	0.01
SBM NSNG 47.5%	35.00	---	---	---	---
SBM USB 48.5%	---	38.00	---	---	---
SBM-LO USB 50.4%	---	---	38.00	---	---
SWF USB 50.2%	---	---	---	38.00	---
SWF-LO USB 50.8%	---	---	---	---	38.00
Total Batch	100.00	100.00	100.00	100.00	100.00
Nutrients calculated, %					
DRY MATTER, %	88.64	89.76	89.44	89.84	89.67
PROTEIN, %	21.08	22.59	23.25	23.17	23.42
LACTOSE, %	2.00	2.00	2.00	2.00	2.00
ME SWINE NRC, Kcal/Lb	1,529.99	1,481.55	1,481.24	1,481.22	1,481.19
AVAIL LYS SWINE, %	1.33	1.33	1.33	1.33	1.33
SID Lys, g:ME, kcal/kg	3.95	4.08	4.08	4.08	4.08
AILE/LYS S	0.60	0.66	0.66	0.69	0.67
AMET/LYS S	0.35	0.33	0.32	0.32	0.32
ASAA/LYS S	0.58	0.58	0.58	0.58	0.58
ATHR/LYS S	0.62	0.62	0.62	0.62	0.62
ATRP/LYS S	0.17	0.19	0.19	0.20	0.19
AVAL/LYS S	0.66	0.73	0.74	0.75	0.74
CALCIUM, %	0.86	1.11	1.11	1.11	1.11
PHOSPHORUS, %	0.71	0.70	0.70	0.70	0.70
PHOS AVAIL-SWINE, %	0.52	0.51	0.51	0.51	0.51

ADM Animal Nutrition Research - S12103

Appendix Table 6. Phase 4 diets.

Treatment number:	1	2	3	4	5
Diet number:	HSM1532	HSM1533	HSM1534	HSM1535	HSM1536
Ingredients, %					
CORN GROUND	51.73	55.69	55.76	55.78	55.77
GREASE MX CHOICE WHITE	1.75	---	---	---	---
PHOS MONOCA 21	1.00	1.05	1.05	1.05	1.05
CALCIUM CARBONATE 38	0.85	1.55	1.55	1.55	1.55
SALT	0.87	0.92	0.92	0.92	0.92
LYSINE-HCL, 98%	---	0.07	0.02	0.01	0.02
ADM SELECT ACID PACK	0.20	0.20	0.20	0.20	0.20
METH, DL-99.5%	0.05	0.07	0.06	0.06	0.06
THREONINE, L-98.5	0.00	0.05	0.04	0.03	0.03
SWINE TM MIX	0.10	0.10	0.10	0.10	0.10
COPPER SUL 25.2	0.10	0.10	0.10	0.10	0.10
ZINC OXIDE 72%(>15 LB/BATCH)	0.06	0.06	0.06	0.06	0.06
SOW-PRESTART VM	0.05	0.05	0.05	0.05	0.05
SELENIUM YEAST 600	0.03	0.03	0.03	0.03	0.03
PIG FLAVOR #12	0.03	0.03	0.03	0.03	0.03
PHYZYME G XP 2500	0.02	0.02	0.02	0.02	0.02
ENDOX	0.01	0.01	0.01	0.01	0.01
SBM NSNG 47.5%	43.15	---	---	---	---
SBM USB 48.5%	---	40.00	---	---	---
SBM-LO USB 50.4%	---	---	40.00	---	---
SWF USB 50.2%	---	---	---	40.00	---
SWF-LO USB 50.8%	---	---	---	---	40.00
Total Batch	100.00	100.00	100.00	100.00	100.00
Nutrients calculated, %					
DRY MATTER, %	88.55	89.58	89.25	89.67	89.49
PROTEIN, %	24.02	23.30	23.99	23.91	24.17
LACTOSE, %	0.00	0.00	0.00	0.00	0.00
ME SWINE NRC, Kcal/Lb	1,530.36	1,483.34	1,483.01	1,482.99	1,482.96
AVAIL LYS SWINE, %	1.27	1.27	1.27	1.27	1.27
SID Lys, g:ME, kcal/kg	3.77	3.89	3.89	3.89	3.89
AILE/LYS S	0.74	0.72	0.72	0.75	0.73
AMET/LYS S	0.30	0.30	0.30	0.30	0.29
ASAA/LYS S	0.58	0.58	0.58	0.58	0.58
ATHR/LYS S	0.62	0.62	0.62	0.62	0.62
ATRP/LYS S	0.22	0.20	0.21	0.22	0.21
AVAL/LYS S	0.81	0.80	0.81	0.82	0.81
CALCIUM, %	0.75	1.02	1.02	1.02	1.02
PHOSPHORUS, %	0.65	0.65	0.65	0.65	0.65
PHOS AVAIL-SWINE, %	0.45	0.46	0.46	0.46	0.46

ADM Animal Nutrition Research - S12103

Appendix Table 7. Lab analyses of experimental diets.

As-is nutrient content		Treatment identification				
		1	2	3	4	5
		PC	SBM-C	SBM-LO	SWF-C	SWF-LO
				Phase 1		
Test Name	Units	HSM1517	HSM1518	HSM1519	HSM1520	HSM1521
MOISTURE	%	8.22	7.20	7.69	7.19	7.52
PROTEIN	%	22.5	25.0	25.5	24.2	24.3
ADF	%	4.3	4.2	3.6	4.8	4.6
aNDF	%	5.7	7.0	5.3	8.6	6.8
CALCIUM	%	0.99	1.00	0.98	1.30	1.10
PHOSPHORUS	%	0.69	0.70	0.73	0.72	0.69
				Phase 2		
Test Name	Units	HSM1522	HSM1523	HSM1524	HSM1525	HSM1526
MOISTURE	%	9.70	9.07	9.11	8.46	8.13
PROTEIN	%	24.1	23.2	24.0	21.5	24.4
ADF	%	4.4	4.7	4.2	5.0	6.1
aNDF	%	7.1	7.2	6.3	7.5	8.2
CALCIUM	%	0.99	1.00	0.95	0.98	0.92
PHOSPHORUS	%	0.69	0.64	0.68	0.60	0.65
				Phase 3		
Test Name	Units	HSM1527	HSM1528	HSM1529	HSM1530	HSM1531
MOISTURE	%	10.93	10.39	10.92	9.00	9.22
PROTEIN	%	23.0	23.2	24.2	24.7	24.4
ADF	%	4.1	4.4	3.9	5.8	4.8
aNDF	%	8.8	9.5	8.8	9.6	12.0
CALCIUM	%	0.91	1.10	1.00	1.30	0.77
PHOSPHORUS	%	0.64	0.65	0.75	0.62	0.56
				Phase 4		
Test Name	Units	HSM1532	HSM1533	HSM1534	HSM1535	HSM1536
MOISTURE	%	10.99	9.52	10.57	9.12	9.21
PROTEIN	%	25.9	25.9	24.8	25.0	24.8
ADF	%	4.6	4.8	3.7	3.4	3.7
aNDF	%	7.2	8.8	8.1	7.6	7.6
CALCIUM	%	0.76	0.95	0.90	0.91	0.88
PHOSPHORUS	%	0.62	0.62	0.64	0.62	0.63

ADM Animal Nutrition Research - S12103

Appendix Table 8. Nursery pig performance by soy protein source.

Treatment number	1	2	3	4	5	SE	Overall trt p-values	Contrasts p-values		
Treatment description	PC	SBM-C	SBM-LO	SWF-C	SWF-LO			PC vs SBM	PC vs SWF	Conv vs LO
Counts										
pens	10	10	10	10	10					
initial pigs	40	40	40	40	40					
removed days 1-5	0	0	0	0	0					
removed days 6-11	0	0	0	1	0					
removed days 12-18	0	0	0	0	0					
removed days 19-25	0	0	0	0	0					
removed days 26-32	0	1	0	0	0					
Body weights, kg										
day 0	6.0	6.0	6.0	6.0	6.1	0.3				
day 5	6.4	6.4	6.4	6.4	6.4	0.3	0.942	0.932	0.937	0.588
day 11	8.4	8.2	8.5	7.9	8.1	0.3	0.001	0.957	0.003	0.032
day 18	11.3	10.9	11.5	10.5	10.6	0.4	0.001	0.520	0.001	0.030
day 25	15.3	14.9	15.7	14.1	14.4	0.6	0.001	0.895	0.001	0.028
day 32	19.7	19.5	20.2	19.1	19.5	0.6	0.134	0.650	0.255	0.083
Weight gain, kg/hd/d										
days 1-5	0.077	0.073	0.085	0.079	0.067	0.013	0.898	0.913	0.812	0.993
days 6-11	0.327	0.309	0.345	0.248	0.276	0.014	0.001	0.992	0.001	0.009
days 12-18	0.422	0.382	0.425	0.366	0.367	0.021	0.038	0.397	0.013	0.211
days 19-25	0.561	0.569	0.602	0.521	0.534	0.020	0.005	0.190	0.079	0.131
days 26-32	0.636	0.644	0.645	0.708	0.728	0.022	0.006	0.726	0.002	0.618
days 1-11	0.213	0.201	0.227	0.170	0.181	0.010	0.001	0.933	0.001	0.040
days 1-18	0.294	0.272	0.304	0.245	0.253	0.011	0.001	0.551	0.001	0.030
days 1-25	0.369	0.355	0.388	0.322	0.332	0.013	0.001	0.844	0.001	0.024
days 1-32	0.427	0.416	0.444	0.406	0.418	0.013	0.091	0.819	0.210	0.044
Feed intake, kg/hd/d										
days 1-5	0.114	0.109	0.131	0.107	0.124	0.011	0.438	0.633	0.913	0.070
days 6-11	0.306	0.291	0.326	0.285	0.295	0.015	0.164	0.869	0.293	0.075
days 12-18	0.599	0.572	0.655	0.568	0.575	0.024	0.002	0.457	0.167	0.007
days 19-25	0.786	0.753	0.836	0.815	0.832	0.027	0.016	0.705	0.106	0.010
days 26-32	0.921	0.949	0.973	0.937	0.973	0.026	0.329	0.126	0.197	0.153
days 1-11	0.219	0.208	0.237	0.203	0.217	0.012	0.153	0.731	0.481	0.034
days 1-18	0.367	0.350	0.400	0.343	0.356	0.015	0.004	0.515	0.189	0.004
days 1-25	0.484	0.463	0.522	0.474	0.490	0.017	0.006	0.530	0.871	0.001
days 1-32	0.580	0.566	0.621	0.575	0.595	0.018	0.015	0.327	0.704	0.002
Gain:feed, g/kg										
days 1-5	632	607	613	707	513	79	0.550	0.820	0.823	0.241
days 6-11	1076	1064	1070	881	939	37	0.001	0.851	0.001	0.390
days 12-18	705	667	648	644	637	21	0.176	0.074	0.017	0.544
days 19-25	716	755	722	639	642	13	0.001	0.152	0.001	0.243
days 26-32	690	679	663	758	749	16	0.001	0.303	0.002	0.420
days 1-11	979	977	960	849	838	29	0.001	0.757	0.001	0.635
days 1-18	805	778	763	716	711	17	0.001	0.107	0.001	0.552
days 1-25	764	767	744	679	678	12	0.001	0.549	0.001	0.341
days 1-32	738	735	716	706	704	10	0.054	0.335	0.011	0.272
Fecal score, 1 to 5										
days 1-5	1.04	1.03	1.03	1.01	1.01	0.01	0.435	0.546	0.080	0.851
days 6-11	1.03	1.02	1.07	1.03	1.00	0.02	0.013	0.549	0.347	0.436
days 12-18	1.09	1.04	1.10	1.02	1.00	0.03	0.025	0.527	0.012	0.372
days 19-25	1.04	1.04	1.10	1.02	1.02	0.02	0.001	0.118	0.218	0.027
days 26-32	1.06	1.06	1.09	1.07	1.09	0.02	0.407	0.440	0.281	0.090

ADM Animal Nutrition Research - S12103

Appendix Table 9. Individual treatment Pairwise comparisons.

Treatment number	1	2	3	4	5	SE	Overall trt p-values	Pairwise p-values								
Treatment description	PC	SBM-C	SBM-LO	SWF-C	SWF-LO			1 vs 2	1 vs 3	1 vs 4	1 vs 5	2 vs 3	2 vs 4	2 vs 5	3 vs 4	3 vs 5	4 vs 5
Body weights, kg																	
day 0	6.0	6.0	6.0	6.0	6.1	0.3											
day 5	6.4	6.4	6.4	6.4	6.4	0.3	0.942	0.617	0.724	0.980	0.911	0.395	0.635	0.697	0.705	0.642	0.931
day 11	8.4	8.2	8.5	7.9	8.1	0.3	0.001	0.266	0.307	0.003	0.032	0.037	0.044	0.279	0.001	0.002	0.331
day 18	11.3	10.9	11.5	10.5	10.6	0.4	0.001	0.073	0.474	0.001	0.005	0.014	0.092	0.274	0.001	0.001	0.539
day 25	15.3	14.9	15.7	14.1	14.4	0.6	0.001	0.260	0.178	0.002	0.012	0.016	0.032	0.140	0.001	0.000	0.480
day 32	19.7	19.5	20.2	19.1	19.5	0.6	0.134	0.669	0.229	0.160	0.574	0.107	0.322	0.893	0.012	0.082	0.390
Weight gain, kg/hd/d																	
days 1-5	0.077	0.073	0.085	0.079	0.067	0.013	0.898	0.813	0.670	0.905	0.596	0.509	0.722	0.768	0.759	0.341	0.516
days 6-11	0.327	0.309	0.345	0.248	0.276	0.014	0.001	0.281	0.273	0.001	0.004	0.034	0.001	0.055	0.001	0.001	0.104
days 12-18	0.422	0.382	0.425	0.366	0.367	0.021	0.038	0.113	0.890	0.028	0.031	0.086	0.513	0.537	0.021	0.022	0.970
days 19-25	0.561	0.569	0.602	0.521	0.534	0.020	0.005	0.711	0.060	0.069	0.217	0.126	0.031	0.112	0.001	0.003	0.542
days 26-32	0.636	0.644	0.645	0.708	0.728	0.022	0.006	0.778	0.745	0.017	0.003	0.965	0.033	0.007	0.036	0.007	0.509
days 1-11	0.213	0.201	0.227	0.170	0.181	0.010	0.001	0.324	0.259	0.001	0.010	0.039	0.014	0.095	0.001	0.001	0.390
days 1-18	0.294	0.272	0.304	0.245	0.253	0.011	0.001	0.078	0.443	0.001	0.002	0.014	0.044	0.149	0.001	0.001	0.545
days 1-25	0.369	0.355	0.388	0.322	0.332	0.013	0.001	0.276	0.156	0.001	0.006	0.015	0.014	0.081	0.001	0.001	0.445
days 1-32	0.427	0.416	0.444	0.406	0.418	0.013	0.091	0.419	0.231	0.126	0.521	0.049	0.460	0.866	0.009	0.070	0.365
Feed intake, kg/hd/d																	
days 1-5	0.114	0.109	0.131	0.107	0.124	0.011	0.438	0.744	0.253	0.633	0.506	0.145	0.879	0.323	0.109	0.628	0.256
days 6-11	0.306	0.291	0.326	0.285	0.295	0.015	0.164	0.392	0.257	0.234	0.526	0.051	0.733	0.822	0.024	0.081	0.572
days 12-18	0.599	0.572	0.655	0.568	0.575	0.024	0.002	0.234	0.017	0.175	0.297	0.001	0.863	0.881	0.001	0.001	0.747
days 19-25	0.786	0.753	0.836	0.815	0.832	0.027	0.016	0.220	0.064	0.277	0.085	0.003	0.024	0.005	0.426	0.890	0.509
days 26-32	0.921	0.949	0.973	0.937	0.973	0.026	0.329	0.354	0.085	0.606	0.088	0.412	0.678	0.421	0.220	0.987	0.226
days 1-11	0.219	0.208	0.237	0.203	0.217	0.012	0.153	0.460	0.186	0.267	0.917	0.043	0.705	0.525	0.018	0.155	0.313
days 1-18	0.367	0.350	0.400	0.343	0.356	0.015	0.004	0.251	0.027	0.114	0.488	0.001	0.654	0.644	0.001	0.005	0.365
days 1-25	0.484	0.463	0.522	0.474	0.490	0.017	0.006	0.170	0.017	0.517	0.713	0.001	0.460	0.085	0.003	0.040	0.312
days 1-32	0.580	0.566	0.621	0.575	0.595	0.018	0.015	0.412	0.015	0.755	0.335	0.002	0.609	0.079	0.007	0.124	0.205
Gain:feed, g/kg																	
days 1-5	632	607	613	707	513	79	0.550	0.822	0.865	0.504	0.294	0.956	0.373	0.407	0.403	0.377	0.090
days 6-11	1076	1064	1070	881	939	37	0.001	0.829	0.912	0.001	0.013	0.916	0.001	0.021	0.001	0.016	0.268
days 12-18	705	667	648	644	637	21	0.176	0.208	0.064	0.049	0.029	0.534	0.455	0.327	0.899	0.717	0.814
days 19-25	716	755	722	639	642	13	0.001	0.036	0.725	0.001	0.001	0.076	0.001	0.001	0.001	0.001	0.884
days 26-32	690	679	663	758	749	16	0.001	0.601	0.208	0.003	0.010	0.456	0.001	0.002	0.001	0.001	0.690
days 1-11	979	977	960	849	838	29	0.001	0.954	0.633	0.003	0.002	0.675	0.004	0.002	0.011	0.006	0.800
days 1-18	805	778	763	716	711	17	0.001	0.274	0.088	0.001	0.001	0.524	0.013	0.008	0.058	0.037	0.838
days 1-25	764	767	744	679	678	12	0.001	0.885	0.240	0.001	0.001	0.189	0.001	0.001	0.001	0.001	0.981
days 1-32	738	735	716	706	704	10	0.054	0.877	0.133	0.033	0.021	0.176	0.046	0.030	0.497	0.382	0.844
Fecal score, 1 to 5																	
days 1-5	1.04	1.03	1.03	1.01	1.01	0.01	0.435	0.606	0.593	0.160	0.098	0.985	0.373	0.254	0.383	0.262	0.801
days 6-11	1.03	1.02	1.07	1.03	1.00	0.02	0.013	0.407	0.073	0.988	0.100	0.009	0.415	0.413	0.071	0.001	0.103
days 12-18	1.09	1.04	1.10	1.02	1.00	0.03	0.025	0.173	0.824	0.044	0.015	0.113	0.510	0.275	0.026	0.008	0.664
days 19-25	1.04	1.04	1.10	1.02	1.02	0.02	0.001	0.824	0.005	0.295	0.271	0.002	0.410	0.380	0.001	0.001	0.957
days 26-32	1.06	1.06	1.09	1.07	1.09	0.02	0.407	0.986	0.196	0.721	0.139	0.202	0.734	0.143	0.349	0.850	0.260

ADM Animal Nutrition Research - S12103

*Financial support for this study provided by the United Soybean Board