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Nitrogen Balance of Nursery Pigs Fed Different Soybean Fractions

B.W. Senne, S.D. Carter, L.A. Pettey and J.A. Shriver

Story in Brief

Eight sets of three littermate barrows weaned at 21 ± 2 d were used to determine the effects of different soybean components on nitrogen balance in nursery pigs. Treatments were typical starter diets with either soybean meal, soy protein concentrate, or soy protein isolate added on an equivalent digestible lysine basis. Phase 1 diets were fed from d 1 to 7 and were formulated to contain 1.26% digestible lysine and 3.3 Mcal/kg ME. Phase 2 diets were fed from d 8 to 21 and were formulated to contain 1.11% digestible lysine and 3.3 Mcal/kg ME. Soybean meal, soy protein concentrate, and soy protein isolate accounted for 22, 21, and 17% of the total Phase 1 diet, and 25, 21, and 18% of the total diet in Phase 2, respectively. Dextrose was used to make up the difference between nitrogen sources in both phases. Pigs were housed individually in metabolic chambers to allow for total collection of urine and feces. Rate and efficiency of gain were not affected by treatment. Dry matter excretion, as percentage of intake, was similar for all pigs in Phase 1; however, dry matter digestibility was greater for pigs fed soy protein isolate compared with pigs fed soybean meal or soy protein concentrate in Phase 2. Absorption of nitrogen, as percentage of intake, was higher for pigs fed isolate compared with meal. No differences were detected in retention of nitrogen as percentage of intake in Phase 1. In Phase 2, retention of nitrogen, as percentage of intake, was similar for pigs fed either the concentrate or isolate; however, pigs fed the isolate retained more nitrogen compared with pigs fed soybean meal. These results with nursery pigs suggest that nitrogen digestibility improves as refinement of the soybean increases.

Key Words: Pigs, Soybeans, Nitrogen, Balance, Excretion

Introduction

Typical starter diets for nursery pigs are routinely formulated to contain soybean meal (SBM) at levels ranging from 15-25%. Soybean meal may contain several anti-nutritional factors, i.e., trypsin inhibitors, oligosaccharides, and antigens, which have been implicated in the decreased growth performance and immune response of the newly weaned pig (Dreau et al., 1994; Li et al., 1991). Elimination of these compounds is achieved by further processing of the soybean into specialty products such as soy protein concentrate (SPC) and soy protein isolate (SPI). Soy protein concentrates are produced by removing most of the water soluble, non-protein constituents from defatted soybeans. Soy protein isolate is the most refined soy protein product which represents the major proteinaceous fraction of the soybean (Soy Protein Council, 1998). Therefore, the purpose of this experiment was to examine how these more refined fractions of soybeans affect the nitrogen balance of nursery pigs.

Materials and Methods

Procedure. Eight sets of three littermate (Yorkshire and Hampshire) barrows were weaned at 21 ± 2 d, weighed, and allotted randomly to three dietary treatments in a randomized complete block design. Diets contained one of three different soy products; SBM, SPC, or SPI, which were added on an equivalent digestible lysine basis (Table 1). Phase 1 (P1) diets were fed from d 1 to 7 and were formulated to contain 1.26% digestible lysine. Phase 2 (P2) diets were fed from d 8 to 21 and were formulated to contain 1.11% digestible lysine. Soy oil was added to make all diets isocaloric. Corn, dried whey, lactose, and spray dried plasma were included in equal amounts across treatments in both phases. Crystalline lysine, methionine, threonine, tryptophan, valine, and isoleucine were added as needed to provide an ideal ratio to lysine. Calcium carbonate and dicalcium phosphate were utilized to provide a constant ratio of Ca:available P (1.9:1), which was maintained across treatments.

Pigs were housed individually in metabolism chambers (2.5 × 3.3 ft) with galvanized mesh floors and allowed ad libitum access to both feed and water. Experimental diets were fed for a total of 21 d. Pigs were weighed on d 0, 7, 14, and 21 of the collection period to monitor average daily gain (ADG) and collection of urine, feces, and refused feed was performed daily. Pigs were bled by jugular venipuncture on d 7 and 21 for analysis of plasma urea nitrogen.

Analysis. Feed samples were dried to determine dry matter (DM) content (AOAC, 1990). Fecal samples were freeze-dried for 7 d prior to analysis. Feed, fecal, and urinary nitrogen were determined by Kjeldahl methodology. Blood samples were placed in ice prior to centrifugation. Plasma was harvested from blood and analyzed for plasma urea nitrogen (PUN) by colorimetric procedures.

Data were analyzed as a randomized complete block design using analysis of variance procedures described by Steel et al (1997). Means were compared by preplanned non-orthogonal contrasts.

Results and Discussion

There were no phase × treatment differences detected for any of the variables analyzed; however, each phase was distinguished by different diets and length of collection, thus, data are reported for each phase. Feed intake, gain, and efficiency of gain (Table 2) were not affected ($P>.10$) by treatment in either phase.

Phase 1. Dietary treatment did not affect ($P>.10$) DM digestibility or grams per day of DM excretion, which averaged 13.4 g/d across treatments for d 1 to 7 of the nursery phase. Intake of N, fecal excretion of N, and total excretion of N were not affected ($P>.10$) by dietary treatment; however, pigs fed SPI tended ($P<.10$) to excrete more urinary N compared with pigs fed either SBM or SPC.

Absorption of N, as a percentage of intake, was lower (P<.08) for pigs fed SBM compared to pigs fed SPI, but retention of N, as a percentage of intake, was similar (P>.10) across treatments. PUN was lowest (P<.03) for pigs fed SBM and greatest (P<.10) for pigs fed SPI compared with all other treatments.

Phase 2. Pigs fed SPI had greater (P<.07) DM digestibility than pigs fed SBM or SPC. Excretion of DM (g/d) was similar across dietary treatment and ranged from 28 to 38 g/d for pigs fed SPI and SBM, respectively. Intake of N was similar (15.5 g/d) across treatment. Pigs fed SPI excreted less (P<.04) fecal N than SBM and more (P<.03) urinary N than SPC; however, total excretion of N was similar (P>.10) for all treatments. Absorption of N, as a percentage of intake, was greatest (P<.05) for pigs fed SPI, but similar (P>.10) between pigs fed SBM or SPC. Retention of N, as a percentage of intake, was similar (P>.10) for pigs fed SPC and SPI; however, pigs fed SPI tended (P<.08) to retain more N than pigs fed SBM (Figure 1).

There were no increases in ADG or G:F observed in either phase for pigs fed the more refined soy proteins. In contrast, Goihl (1994) reported improvements in G:F when SBM was replaced with SPC in nursery pigs. In another experiment using growing pigs at OSU it was showed that pigs fed SPI had greater N absorption compared to pigs fed SBM or SPC. This is in agreement with our nursery pig results. Grala (1998) reported improved apparent digestibility of N for 6 wk-old pigs fed SPC vs pigs fed SBM. Results of our experiment showed a numerical increase in N digestibility as refinement increased. Retention of N (%) was not different in but there was a trend for SPI pigs to retain more N (85 vs 81%) than pigs fed SBM.

In conclusion, the use of higher quality soy proteins in nursery pigs did not affect growth performance or N retention but did increase DM digestibility and absorption of N in when compared to pigs fed SBM.

Implications

Soy protein concentrate and soy protein isolate do not contain the anti-nutritional factors, i.e., trypsin inhibitors, antigens, etc., which can decrease performance of the baby pig. A stepwise increase in nitrogen retention occurred throughout the nursery phase as level of refinement of the soybean increased. Also, a stepwise decrease in dry matter excretion, as percentage of intake, was observed as the soluble and insoluble sugars were removed from the soybean.

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Table 1. Composition of diets[a].

	Treatment					
	Phase 1			Phase 2		
Ingredient, %	SBM	SPC	SPI	SBM	SPC	SPI
Corn	42.5	42.5	42.5	55.0	55.0	55.0
SBM (48% CP)	22.0	--	--	25.0	--	--
SPC	--	20.6	--	--	21.0	--
SPI	--	--	17.4	--		17.8
Whey	20.0	20.0	20.0	10.0	10.0	10.0
Lactose	5.0	5.0	5.0	--	--	--
Plasma	4.0	4.0	4.0	2.0	2.0	2.0
Dextrose	.13	2.6	4.5	2.1	6.7	8.6
Soy oil	1.5	1.0	1.5	1.5	1.2	1.6
NaCl	.25	.25	.25	.25	.25	.25
Crystalline AA						
L-Lysine	.24	--	--	.19	--	--
DL-methionine	.22	.13	.13	.14	.06	.08
L-Threonine	.15	--	--	.12	--	--
L-Tryptophan	.01	--	--	--	--	--
L-Isoleucine	.05	--	--	--	--	--
L-Valine	.05	--	--	--	--	--
Dical. Phosphate	1.6	1.6	1.7	1.3	1.3	1.4
$CaCO_3$	.90	.93	1.0	.85	.93	.95
K_2CO_3	--	--	.70	.15	.25	.95
Vit, Min PM	.35	.35	.35	.35	.35	.35
Antibiotic	1.0	1.0	1.0	1.0	1.0	1.0

ME, Mcal/kg	3.3	3.3	3.3	3.3	3.3	3.3
Total lysine	1.47	1.43	1.48	1.31	1.25	1.31
Digestible AA						
Lysine	1.26	1.26	1.26	1.11	1.11	1.11
TSAA	.76	.77	.76	.67	.66	.67
Threonine	.82	.87	.82	.72	.77	.72
Tryptophan	.22	.26	.27	.19	.23	.24
Calcium	.97	.97	.97	.81	.81	.81
Available P	.55	.55	.55	.40	.40	.40

[a]As fed-basis.

Table 2. Effects of different soybean fractions on nursery pig perfo

	Treatment					
	Phase 1				Phas	
Item	SBM	SPC	SPI	SE	SBM	SPC
ADG, g	267.3	226.0	256.0	27.2	303.7	262.8
ADFI, g	279.0	262.5	271.9	35.4	491.8	451.0
G:F	.96	.94	.88	.06	.62	.58
DM excretion, g/d	14.8	12.5	12.9	2.9	38.5[b]	33.7[bc]
Apparent N balance (DM basis), g/d						
N intake	8.7	8.4	10.3	1.2	15.1	15.6
Fecal N excretion	1.3	1.1	1.0	.28	1.9[b]	1.8[bce]
Urinary N excretion	.66[b]	.64[be]	.87[bf]	.10	.96[bc]	.78[c]
Total N excretion	1.9	1.7	1.9	.35	2.9	2.5
Absorbed N	7.5	7.4	9.3	.96	13.2	13.8
Retained N	6.8	6.7	8.4	.91	12.2	13.1
Apparent N balance, %						
Absorbed	86.5[e]	89.4[ef]	90.6[f]	1.6	87.3[b]	88.8[b]
Retained	78.6	80.0	81.3	1.8	80.8[e]	84.1[ef]
Retained, % of absorbed	90.9	89.5	89.8	1.8	92.5[e]	94.7[f]
PUN, mg/dL	8.6[b]	12.9[ce]	15.6[cf]	1.1	18.2	18.1

[a]Least squares means for eight individually-penned pigs per treatment.

[b,c]Means within row within phase with different superscripts differ, P<.05.

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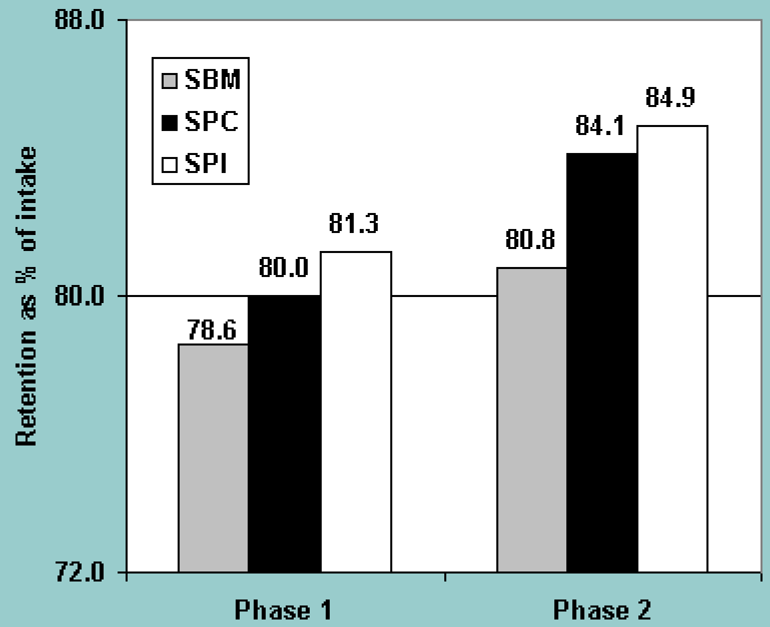

Figure 1. Retention of nitrogen as percentage of intake for nursery pigs fed different fractions of the soybean.

[2000 Research Report - Table of Contents]

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Phase 2. Pigs fed SPI had greater (P<.07) DM digestibility than pigs fed SBM or SPC. Excretion of DM (g/d) was similar across dietary treatment and ranged from 28 to 38 g/d for pigs fed SPI and SBM, respectively. Intake of N was similar (15.5 g/d) across treatment. Pigs fed SPI excreted less (P<.04) fecal N than SBM and more (P<.03) urinary N than SPC; however, total excretion of N was similar (P>.10) for all treatments. Absorption of N, as a percentage of intake, was greatest (P<.05) for pigs fed SPI, but similar (P>.10) between pigs fed SBM or SPC. Retention of N, as a percentage of intake, was similar (P>.10) for pigs fed SPC and SPI; however, pigs fed SPI tended (P<.08) to retain more N than pigs fed SBM (Figure 1).

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SBM (48% CP)	22.0	--	--	25.0	--	--
SPC	--	20.6	--	--	21.0	--
SPI	--	--	17.4	--		17.8
Whey	20.0	20.0	20.0	10.0	10.0	10.0
Lactose	5.0	5.0	5.0	--	--	--
Plasma	4.0	4.0	4.0	2.0	2.0	2.0
Dextrose	.13	2.6	4.5	2.1	6.7	8.6
Soy oil	1.5	1.0	1.5	1.5	1.2	1.6
NaCl	.25	.25	.25	.25	.25	.25
Crystalline AA						
L-Lysine	.24	--	--	.19	--	--
DL-methionine	.22	.13	.13	.14	.06	.08
L-Threonine	.15	--	--	.12	--	--
L-Tryptophan	.01	--	--	--	--	--
L-Isoleucine	.05	--	--	--	--	--
L-Valine	.05	--	--	--	--	--
Dical. Phosphate	1.6	1.6	1.7	1.3	1.3	1.4
$CaCO_3$	.90	.93	1.0	.85	.93	.95
K_2CO_3	--	--	.70	.15	.25	.95
Vit, Min PM	.35	.35	.35	.35	.35	.35
Antibiotic	1.0	1.0	1.0	1.0	1.0	1.0

ME, Mcal/kg	3.3	3.3	3.3	3.3	3.3	3.3
Total lysine	1.47	1.43	1.48	1.31	1.25	1.31
Digestible AA						
Lysine	1.26	1.26	1.26	1.11	1.11	1.11
TSAA	.76	.77	.76	.67	.66	.67
Threonine	.82	.87	.82	.72	.77	.72
Tryptophan	.22	.26	.27	.19	.23	.24
Calcium	.97	.97	.97	.81	.81	.81
Available P	.55	.55	.55	.40	.40	.40

[a]As fed-basis.

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Apparent N balance (DM basis), g/d						
N intake	8.7	8.4	10.3	1.2	15.1	15.6
Fecal N excretion	1.3	1.1	1.0	.28	1.9 [b]	1.8 [bce]
Urinary N excretion	.66 [b]	.64 [be]	.87 [bf]	.10	.96 [bc]	.78 [c]
Total N excretion	1.9	1.7	1.9	.35	2.9	2.5
Absorbed N	7.5	7.4	9.3	.96	13.2	13.8
Retained N	6.8	6.7	8.4	.91	12.2	13.1
Apparent N balance, %						
Absorbed	86.5 [e]	89.4 [ef]	90.6 [f]	1.6	87.3 [b]	88.8 [b]
Retained	78.6	80.0	81.3	1.8	80.8 [e]	84.1 [ef]
Retained, % of absorbed	90.9	89.5	89.8	1.8	92.5 [e]	94.7 [f]
PUN, mg/dL	8.6 [b]	12.9 [ce]	15.6 [cf]	1.1	18.2	18.1

[a]Least squares means for eight individually-penned pigs per treatment.

[b,c]Means within row within phase with different superscripts differ, P<.05.

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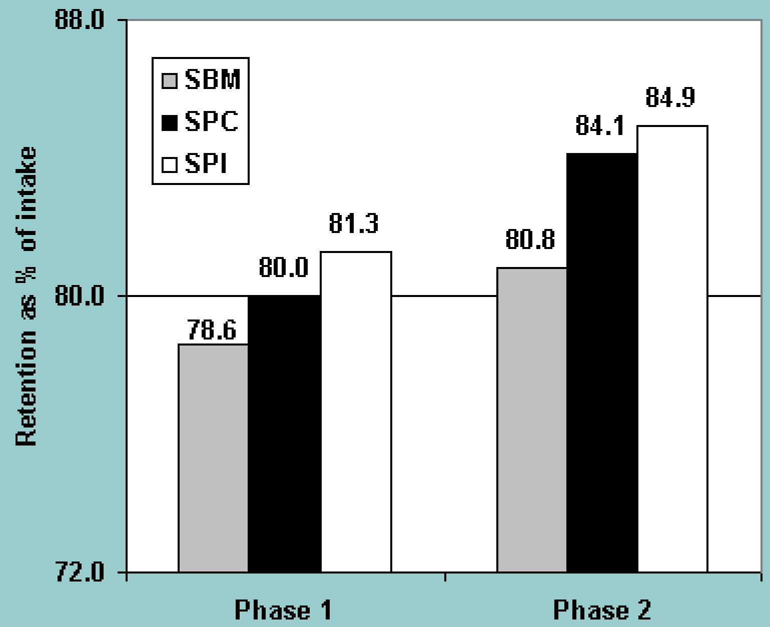

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2000 Research Report - Table of Contents