EFFECT OF DIETARY PROTEIN SOURCE ON NUTRIENT DIGESTIBILITY IN EARLY WEANED PIGS

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Story in Brief

Experimental diets with supplemental protein from either dried skim milk, two isolated soy proteins, three soy protein concentrates or soybean meal were fed to 36 Yorkshire pigs weaned at 21 days to determine dry matter, ash, nitrogen and amino acid digestibility. All diets were formulated to contain 1.5% lysine and 40% whey. Trials were 14 days in length. Digestibilities were determined from fresh fecal samples collected during the last three days of the first and second week on trial. The apparent digestibilities of dry matter, nitrogen and amino acids were lower in pigs fed the soybean meal diet when compared to those fed any other dietary treatments. The apparent fecal availability was higher for lysine and valine in pigs fed the dried skim milk diet than for pigs fed any of the soybean protein diets. There were no significant differences among dried skim milk, the two isolated soy proteins and the three soy protein concentrates for apparent digestibility of overall essential amino acids and nonessential amino acids.

(Key Words: Early Weaned Pig, Protein Source, Amino Acid Digestibility.)

Introduction

Numerous studies have indicated that a reduction in both performance and nutrient digestibility is associated with the replacement of dietary milk proteins with various soybean protein sources in the early weaned pigs. Possible explanations include: 1) antinutritional factors present in soybean protein; 2) lower amino acid availability in soybean protein than in milk protein; 3) a reduction in proteolytic activity which probably contributes to the poor digestibility of soybean proteins; 4) morphological changes of the small intestine due to soybean protein.

Much economic incentive exists to determine if soybean proteins could be improved by processing for young pigs. Alkali or acid treatment has met only limited success. Recently, isolated soy protein and soy protein concentrate,

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which are treated by alkali and acid, respectively, have been manufactured and may offer an alternative protein source for early weaned pigs. This study was conducted to determine the effect of protein source and soybean protein processing method upon dry matter, ash, nitrogen and amino acid digestibility in pigs weaned at 21 days of age.

Materials and Methods

Thirty-six Yorkshire pigs were alloted by sex, litter and weight to one of seven dietary treatments with a mean initial weight of 11 lb. Pigs began the trial after being weaned at approximately 21 days of age. One milk and six soybean protein sources were used to formulate experimental diets (Tables 1 and 2) which met NRC (1988) requirements for the 11- to 22-lb pig. Protein sources were dried skim milk, two isolated soy proteins (one soluble and one insoluble), three soy protein concentrates and soybean meal. Pigs were housed in individual 2.0 x 3.3 feet metal pens within an environmentally controlled feeding room maintained between 92°F and 90°F. Pigs had ad libitum access to feed and water throughout trial. Chromic oxide (.25%) was added to each diet as an indigestible marker. A fresh fecal sample was collected from each pig on the last three days of the first and second weeks, respectively. Samples were stored at -20°C composited by treatment prior to lypolyzation and grinding. Dry matter, ash and nitrogen content of both feed and feces were determined according to the AOAC (1980) methods. Chromic oxide was determined by an automic absorption spectrophotometer method. Amino acid analyses were performed following acid hydrolysis under nitrogen reflex in 6 N HCL using an automatic amino acid analyzer.

Results and Discussion

Performance data including feed intake, rate and efficiency of gain has been reported (Sohn and Maxwell, 1990). Apparent fecal availability of dry matter in pigs fed the soybean meal diet was lower than that observed in pigs fed the other protein sources which had similar values (Table 3). The apparent dry matter digestibility for pigs fed isolated soy protein diets was similar to that observed for pigs fed soy protein concentrate diets but higher ($P<.01$) than that observed for pigs fed soybean meal diet. Pigs fed the soybean meal diet during Period 2 had higher dry matter availability than during Period 1. Greater dry matter digestibility for the two isolated soy proteins and the three soy protein concentrates than the soybean meal may be due to the removal of complex indigestible carbohydrates during the isolation and extraction procedures. No differences in the fecal availability among dietary treatments for ash were observed.

Table 1. Composition of experimental diets fed during Period 1 (2 weeks).

Ingredient	Diets[ab]						
	DSM	ISP I	ISP II	SPC I	SPC II	SPC III	SBM
Soybean meal, 50% CP							24.12
Soy protein concentrate I[c]				25.09			
Soy protein concentrate II[d]					25.09		
Soy protein concentrate III[e]						25.09	
Isolated soy protein I[f]			20.29				
Isolated soy protein II[g]				20.29			
Dried skim milk	40.00						
Whey, dried whole	40.00	40.00	40.00	40.00	40.00	40.00	40.00
Lactose		20.62	20.62	20.62	20.62	20.62	20.62
Cerelose	7.31	4.77	4.77				.27
Soybean oil	10.00	10.00	10.00	10.00	10.00	10.00	10.00
Lysine, HCl	.19			.04	.04	.04	.44
DL-Methionine	.16	.30	.30	.24	.24	.24	.35
Tryptophan							.03
Threonine							.09
Lecithin	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Apralan[h]	.10	.10	.10	.10	.10	.10	.10
Calcium carbonate		.53	.53	.50	.50	.50	.39
Dicalcium phosphate		1.15	1.15	1.17	1.17	1.17	1.35

Table 1. (Continued).

Ingredient	Diets[ab]						
	DSM	ISP I	ISP II	SPC I	SPC II	SPC III	SBM
Vit. TM premix[i]	.94	.94	.94	.94	.94	.94	.94
Salt	.30	.30	.30	.30	.30	.30	.30
Total	100.00	100.00	100.00	100.00	100.00	100.00	100.00

[a] As fed basis.
[b] DSM: dried skim milk protein diet; ISPI: isolated soy protein (soluble) diet; ISP II: isolated soy protein (insoluble) diet; SPC I, II, and III: Soy protein concentrate diet; SBM: soybean meal diet.
[c] Promocon-plus, Central Soya, Fort Wayne, IN.
[d] Promine, Central Soya, Fort Wayne, IN.
[e] Promocalf, Central Soya, Fort Wayne, IN.
[f] pp-620, Protein Technologies International. St. Louis. MO.
[g] pp-HD-90, Protein Technologies International. St. Louis. Mo.
[h] Contained 75 g Apramycine per lb.
[i] Supplied 8,800 IU vitamin A, 880 IU vitamin D, 37 IU vitamin E, 44 mg pantothenic acid, 59 mg niacin, 8.8 mg riboflavin, 7.3 mg menadione sodium bisulfate, .04 mg vitamin B12, 3 mg biotin, 6 mg pyridoxine, 2 mg folic acid, 10 mg thiamine, 880 mg choline chloride, .2 mg selenium, .06 g manganese, .2 g zinc, .2 g iron, .2 g copper, .2 g magnesium, 1.0 g potassium and .4 mg iodine, per kg of feed.

Table 2. Protein and amino acid composition of experimental diets[a].

Item	Diet[a]						
	DSM	ISP I	ISP II	SPC I	SPC II	SPC III	SBM
Crude protein, %	19.36	22.76	22.84	22.77	21.53	21.32	17.73
Amino acids, %							
Essential							
Arginine	.96	1.28	1.27	1.17	1.22	1.21	1.07
Histidine	.51	.59	.59	.56	.59	.57	.49
Isoleucine	.82	.99	.95	.94	.98	.95	.80
Leucine	1.59	1.79	1.75	1.64	1.68	1.63	1.58
Lysine	1.48	1.53	1.52	1.48	1.57	1.56	1.54
Methionine	.51	.51	.48	.44	.47	.45	.46
Phenylalanine	.78	1.00	.99	.91	.90	.91	.76
Threonine	.93	1.04	1.03	1.00	1.04	1.02	.94
Valine	.94	1.00	.96	.96	.99	.96	.86

Table 2. (Continued).

Item	Diet[a]						
	DSM	ISPI	ISPII	SPCI	SPCII	SPCIII	SBM
Nonessential							
Alanine	.71	1.01	1.01	.94	.84	.95	.79
Aspartic acid	1.38	2.38	2.36	2.23	2.31	2.25	1.73
Cystine	.20	.28	.29	.26	.27	.32	.31
Glutamic acid	3.19	3.92	3.89	3.52	3.66	3.55	2.84
Glycine	.44	.76	.76	.72	.74	.73	.69
Proline	1.34	1.18	1.12	1.05	1.06	1.03	.92
Serine	.90	1.11	1.10	1.01	1.05	1.02	.91
Tyrosine	.67	.73	.72	.68	.70	.68	.62

[a] Dry matter basis.
[b] See Table 1 for explanation of diet code names.

Table 3. Apparent availability of dry matter and ash measured over the total digestive tract for early weaned pigs at first and second week postweaning.

	Diet[a]						
Item	DSM	ISP I	ISP II	SPC I	SPC II	SPC III	SBM
Dry matter, %							
Day 28	92.37[b]	91.08[b]	91.00[b]	90.43[b]	90.48[b]	90.22[b]	80.39[c]
Day 35	92.64[b]	92.43[b]	92.15[b]	91.98[b]	91.48[b]	91.24[b]	82.95[c]
Difference[d]	.27	1.35	1.15	1.55	1.00	1.02	2.56
Ash, %							
Day 28	87.55	86.10	85.70	85.70	85.31	85.47	84.90
Day 35	87.93	85.76	86.84	85.70	85.42	86.70	84.70
Difference[d]	.38	-.34	1.14	.00	.11	1.23	-.20

[a] See Table 1 for explanation of diet code names.
[b,c] Means in the same row with different superscripts differ (P<.05).
[d] Differences obtained by subtraction of availability estimate of day 28 from availability of day 35.

The apparent fecal availability of nitrogen differed among dietary treatments (P<.05) and was lowest in pigs fed the soybean meal diet. No significant differences among dried skim milk diet, the two isolated soy protein diets and the three soy protein concentrate diets were observed (Tables 4 and 5).

The digestibilities of lysine and thereonine are of particular interest because these are often present in limited amounts in diets for young pigs. The apparent fecal availability was higher for lysine and valine (P<.05) in pigs fed the dried skim milk diet than for pigs fed any of the soybean protein diets (Tables 4 and 5). The apparent availability of lysine and valine in pigs fed the dried skim milk diet, the two isolated soy protein diets and the three soy protein concentrate diets was higher (P<.01) than for pigs fed the soybean meal diet with the availability of these two amino acids in pigs fed the two isolated soy protein diets and the three soy protein concentrate diets being intermediate. Phenylalanine availability in pigs fed the dried skim milk diet during the first week postweaning was higher (P<.05) than that of pigs fed any of the soybean protein source diets; however, during the second week there were no significant differences among dried skim milk diet, the two isolated soy protein diets and the three soy protein concentrate diets. The actual digestibility of arginine and histidine was higher in pigs fed the two isolated soy protein diets and the three soy protein concentrate diets than in those fed the dried skim milk diet, but the differences were not significant.

The small increase (1 to 2%) in the apparent availability of nitrogen with increasing age of the pigs from 28 to 35 days was observed when diets containing soybean proteins were fed, but the apparent availability of nitrogen did not improve with increasing age of pigs fed the milk diet (Table 6). Pigs fed the soybean meal diet had a small improved essential amino acid availability (2.1%) with increasing age from 28 to 35 days, but pigs fed the dried skim milk diet, the two isolated soy protein diets and the three soy protein concentrate diets did not show any improved availability with increasing age.

Difference in the fecal availability among dietary treatments for the nonessential amino acids were observed for proline (P<.01) and glutamic acid (P<.01). Availability of the these two amino acids was the highest in pigs fed the dried skim milk diet and the lowest in pigs fed the soybean meal diet with the availability estimates intermediate for the two isolated soy protein and the three soy protein concentrate diets. The apparent fecal availability of the remaining nonessential amino acids was similar among the dried skim milk diet, the two isolated soy protein diets and the three soy protein concentrate diets. Pigs fed the soybean meal diet had the lowest (P<.05) nonessential amino acid availability. Availability values of amino acids for pigs fed the dried skim milk diet and the isolated soy protein diets reported in this study were fairly similar to values reported by Wilson and Leibholz (1981) which are 86.8 and 84.0% for pigs fed milk and isolated soybean protein diets, respectively. The two isolated soy protein diets and the three soy protein concentrate diets appeared to improve

Table 4. Apparent availability of nitrogen and amino acids measured over the total digestive tract for 28-day-old pigs[a].

Item	Diet[b]						
	DSM	ISP I	ISP II	SPC I	SPC II	SPC III	SBM
Pigs per Treatment	10	10	10	10	10	10	11
Initial age, days	20.9	21.0	21.0	20.9	20.9	21.0	21.0
Initial weight, lb	11.00	11.0	11.00	10.9	11.00	10.7	10.9
Nitrogen, %	92.61[d]	91.19[d]	90.71[d]	91.05[d]	90.65[d]	90.37[d]	80.06[e]
Amino acids, %							
Essential							
Arginine[c]	86.3	90.1	90.3	89.1	88.4	88.7	78.3
Histidine[c]	84.2	86.3	86.7	86.0	85.9	85.7	79.4
Isoleucine[c]	87.8	85.7	85.9	85.0	86.2	85.2	78.7
Leucine[c]	88.4	86.8	86.9	87.0	86.2	86.3	79.2
Lysine[c]	91.7[d]	87.0[e]	86.9[e]	87.2[e]	86.9[e]	86.7[e]	79.1
Phenylalanine[c]	89.4[d]	84.2[e]	84.1[e]	83.9[e]	84.4[e]	84.0[e]	79.2
Threonine[c]	81.9	80.4	80.7	80.4	81.0	80.2	73.4
Valine[c]	87.2	85.0	85.1	84.9	84.8	84.5	78.1
Mean	87.1	85.7	85.8	84.9	85.5	84.6	78.2

Table 4. (Continued).

Item	Diet[b]						
	DSM	ISP I	ISP II	SPC I	SPC II	SPC III	SBM
Nonessential							
Alanine[c]	83.2	81.7	80.9	81.4	80.3	79.9	69.9
Aspartic acid[c]	82.6	84.1	83.7	84.3	82.7	81.8	70.4
Glutamic acid[c]	85.9[d]	82.4[e]	83.0[e]	81.9[e]	82.2[e]	82.0[e]	71.3
Glycine[c]	81.3	80.9	80.4	79.7	79.2	78.3	70.2
Proline[c]	90.5[d]	86.7[e]	85.9[e]	87.0[e]	85.8[e]	86.2[e]	74.2
Serine[c]	80.6	79.7	78.9	78.4	79.1	77.9	69.2
Tyrosine[c]	90.7	89.2	88.7	89.0	87.7	87.9	80.0
Mean	85.0[f]	83.5[f]	83.1[f]	83.1[f]	82.4[f]	82.0[f]	72.2[g]

[a] One pig on the DSM diet was removed because of feed refusal.
[b] See Table 1 for explanation of diet code names.
[c] Soybean meal diet differs from other diets (P<.01).
[d,e] Means in the same row with different superscripts differ (P<.05).
[f,g] Means in the same row with different superscripts differ (P<.01).

Table 5. (Continued).

Item	Diet[b]						
	DSM	ISP I	ISP II	SPC I	SPC II	SPC III	SBM
Nonessential							
Alanine[c]	82.9	82.0	81.4	81.7	81.0	80.2	71.0
Aspartic acid[c]	82.5	84.2	83.1	84.2	82.6	82.0	72.2
Glutamic acid[c]	87.2[d]	83.1[e]	83.5[e]	82.1[e]	82.7[e]	83.2[e]	79.9
Glycine[c]	81.7	81.2	81.5	80.2	81.0	79.7	72.2
Proline[c]	90.9[d]	87.9[e]	86.2[e]	87.3[e]	87.1[e]	87.4[e]	75.6
Serine[c]	85.2	84.1	83.4	83.2	83.7	83.5	76.3
Tyrosine[c]	91.0	89.9	89.2	89.4	88.2	88.7	83.0
Mean	85.9[g]	84.6[g]	84.0[g]	84.0[g]	83.8[g]	83.5[g]	75.7[h]

[a] One pig on the DSM diet was removed because of feed refusal.
[b] See Table 1 for explanation of diet code names.
[c] Soybean meal diet differs from other diets (P<.01).
[d,e,f] Means in the same row with different superscripts differ (P<.05).
[g,f] Means in the same row with different superscripts differ (P<.01).

Table 6. Difference of apparent fecal amino acid availability estimates between two periods (first vs second week postweaning) in early weaned pigs[a].

	Diet[b]						
Item	DSM	ISP I	ISP II	SPC I	SPC II	SPC III	SBM
Nitrogen, %	-.01	1.08	1.27	1.16	1.10	1.71	2.02
Amino acids, %							
Essential							
Arginine	1.4	1.1	.4	1.1	.7	.2	2.1
Histidine	.5	.6	.3	.2	.4	.5	3.8
Isoleucine	-.1	.5	1.1	.4	.7	1.7	2.0
Leucine	-.2	.2	1.3	.7	.9	2.6	3.0
Lysine	.2	1.7	.7	1.2	.9	.3	3.5
Phenylanine	-.7	1.0	1.8	1.4	.8	1.0	2.9
Threonine	.1	3.0	2.2	2.7	1.7	2.8	2.1
Valine	-1.0	1.5	1.5	1.5	1.9	1.3	2.0
Mean	.03	1.20	1.16	1.03	1.00	1.30	2.10

Table 6. (Continued).

Item	Diet[b]						
	DSM	ISP I	ISP II	SPC I	SPC II	SPC III	SBM
Nonessential							
Alanine	-.3	.3	.5	.3	.7	.3	1.1
Aspartic acid	-.1	.1	-.6	-.1	-.1	.2	1.8
Glutamic acid	1.3	.7	.5	.3	.5	1.2	3.6
Glycine	.4	.3	1.1	.5	1.8	1.4	2.0
Proline	.4	1.2	.3	.3	1.3	1.2	1.4
Serine	4.6	4.4	4.5	4.8	4.6	5.6	7.1
Tyrosine	.3	.7	.5	.4	.5	.8	3.0
Mean	.90	1.10	.90	.90	1.40	1.50	3.50

[a] One pig on the DSM diet was removed because of feed refusal.
[b] See Table 1 for explanation of diet code names. Differences were obtained by subtraction of the apparent fecal availability estimate of second week after weaning from the fecal availability estimate of 1st week after weaning.

amino acid availability when compared to the soybean meal diet, while no significant difference was observed either between the two isolated soy protein diets or among the three soy protein concentrate diets.

These nutrient availability data are consistent with the observed differences in performance data (Sohn and Maxwell, 1990), suggesting that lower nutrient availability may explain the poor performance observed in pigs fed the soybean meal diet. From these results it can be concluded that in the 28- to 35-day-old pigs, soybean protein isolates or concentrates but not soybean meal are digested as well as milk protein.

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