EFFECT OF PROTEIN SOURCE ON NUTRIENT DIGESTIBILITY IN EARLY WEANED PIGS

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Story in Brief

Practical diets with supplemental protein from either calcium caseinate (CAS), isolated soybean protein (ISP), ethanol extracted soybean protein (ESOY) or soybean meal (SBM) were fed to 72 Yorkshire boar pigs weaned at 21 days to determine dry matter (DM), starch, nitrogen (N) and amino acid (AA) digestibility. Diets contained 1.01 to 1.03% lysine on a dry matter basis. Digestibilities were determined from fecal samples collected after 3 weeks of feeding the experimental diets. Digestibilities of DM ($P<.05$), lysine ($P<.05$), valine ($P<.05$), methionine ($P<.01$) and proline ($P<.01$) were greater for pigs fed the CAS diet than for pigs fed any of the soybean protein diets. The average apparent digestibilities for the essential amino acids (EAA) were 86.8, 82.4, 84.1 and 80.2% and for lysine were 86.2, 82.8, 83.8 and 80.1% for the CAS, ISP, ESOY and SBM diets, respectively.

(Key Words: Swine, Early Weaned Pig, Amino Acid Digestibility)

Introduction

Performance of young pigs weaned between 1 and 28 days of age is usually better when starter diets contain protein from milk than from soybean meal, soy flour or isolated soybean protein. The reasons for the milk protein superiority have not been determined. Older pigs perform equally well with protein from milk or soybean products, so an age factor must be involved.

Various treatments of SBM (alkali or acid treatment) as well as supplementation of corn-soybean meal rations, with AA and digestive enzymes in an attempt to improve the utilization of soybean protein by the early weaned pig have met with only limited success. Ethanol extraction of soy flour has been shown to prevent intestinal disorders of calves fed milk replacers containing heated soy flour but this has not been tested with early weaned pigs.

Differences observed in the rate and efficiency of gain of early weaned pigs fed either milk or soybean protein diets may be due to differences in the bioavailability of the essential amino acids (EAA) from these protein sources. Several studies have shown that the requirement for lysine (the limiting AA in common grain-SBM diets) for the 11-22 lb pig fed a grain-SBM diet is considerably higher than the .95% currently recommended by NRC (1979). Therefore, diets formulated to meet the minimum requirements for lysine as recommended by NRC (1979) may be deficient in lysine and small differences in the availability of lysine could cause large differences in pig performance. Current information on AA availability for young pigs is limited.

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This study was conducted to determine the effect of source of protein and method of processing of soybean protein upon DM, N, AA and starch digestibility for pigs weaned at 21 days of age.

Materials and Methods

Seventy-two Yorkshire boar pigs were used to study the effect of dietary protein source on nutrient availability. Twelve pigs in each of 6 replicates were weaned at approximately 21 days of age and randomly allotted within litter to one of the four dietary treatments providing a total of 18 pigs per treatment with a mean initial weight of 12 lb. One milk and 3 soybean protein sources were used to formulate practical diets (Table 1) which met NRC (1979) requirements for the 11-22 lb pig.

TABLE 1. Composition of Diets.

	Diets[a,b]			
Ingredient	CAS	ISP	ESOY	SBM
	%			
Corn (IFN 4-02-935)	87.14	83.17	77.87	69.99
Calcium caseinate[c]	9.74			
Isolated soy protein[d]		13.39		
Ethanol extracted soy protein			18.69	
Soybean meal (IFN 5-04-604)				26.67
Calcium carbonate (IFN 6-01-069)	0.87	1.21	1.15	1.19
Dicalcium phosphate (IFN 6-01-080)	1.35	1.33	1.39	1.25
Vitamin, TM premix[f]	.35	.35	.35	.35
Salt (IFN 6-14-013)	.30	.30	.30	.30
ASP-250[g]	.25	.25	.25	.25
	100	100	100	100

[a] As fed basis, calculated to contain .80% Ca and .60% P.
[b] CAS: calcium caseinate diet;ISP: isolated soybean protein diet; ESOY: ethanol extracted soybean protein diet;SBM: soybean meal diet.
[c] Ultra supreme calcium caseinate, Erie Casein Co. Inc., Erie, IL.
[d] Soybean protein grade II, United States Biochemical Corp., Cleveland, OH.
[e] Promocaf, Central Soy, Fort Wayne, IN.
[f] Supplied 4,000,000 IU vitamin A, 3,000,000 IU vitamin D, 4 g riboflavin, 20 g pantothentic acid, 30 g niacin, 800 g choline chloride, 15 mg vitamin B_{12}, 10,000 IU vitamin E, 2 g menadione, 200 mg iodine, 90 g iron, 20 g manganese, 10 g copper, 90 g zinc and 100 mg selenium per ton of feed.
[g] Each pound of ASP-250 contained 20 g Chlortetracycline, 20 g sulfamethizine and 10 g penicillin.

Protein sources were calcium caseinate (CAS), isolated soybean protein (ISP), ethanol extracted soybean protein (ESOY) and 44% crude protein solvent extracted soybean meal (SBM). Protein sources were substituted for corn on a lysine basis to provide .95% lysine as fed. All other amino acids exceeded NRC (1979) requirements and crude protein ranged from 17 to 19% among diets. Pigs were housed in individual 2.0 by 3.3 foot metal pens in an environmentally controlled feeding room maintained between 80 and 90 F. Pigs had ad libitum access to feed and water throughout the trial. Pigs remained on trial for 35 days with weights and feed intakes recorded weekly. During the third week of each replicate, chromic oxide, added to each diet at the rate of .25%, served as an indigestible marker for calculating nutrient digestibility. A fresh fecal sample was collected from each pig on the last day of the 3rd week of each replicate. Samples were lyophilyzed and ground prior to determination of DM, starch, N and AA content in both feed and feces. Amino acid concentrations were determined from acid hydrolysates by ion exchange chromatography using a Beckman model 121 automatic amino acid analyzer. Acid hydrolysis was conducted under nitrogen reflux in 6N HCl for 24 h.

Results and Discussion

The protein and amino acid composition of diets is shown in table 2. Crude protein as well as the essential amino acids (EAA) arginine, phenylalanine and threonine were highest in the soybean diets while methionine and valine were highest in the CAS diet. The remainder of the EAA were similar among all diets.

The performance data including feed intake, rate and efficiency of gain have been reported previously (Walker et al., 1984). The apparent digestibility of DM was highest in pigs fed the CAS diet averaging 2.7, 3.4 and 5.2 percentage units higher ($P<.05$) than for pigs fed the ISP, ESOY and SBM diets, respectively (table 3). The apparent digestibility of DM by pigs fed the ISP diet was similar to that observed for pigs fed the ESOY diet but higher ($P<.01$) than that observed for pigs fed the SBM diet. Dry matter digestibility was similar ($P>.1$) in pigs fed the ESOY and SBM diets. Differences in DM digestibility between pigs fed the CAS and ISP diets were due primarily to differences in N availability since the digestibilities for starch were similar among all dietary treatments ranging from a low of 98.3% in pigs fed the SBM diet to a high of 99.0% in pigs fed the CAS diet. Greater DM digestibility for ISP and ESOY than SBM may be due to the removal of complex indigestible carbohydrates during the isolation and extraction procedures.

Apparent digestibility of N differed among dietary treatments ($P<.1$) and was highest in pigs fed the CAS diet and lowest in pigs fed the SBM diet (table 3). The difference in N digestibility between pigs fed the CAS and ISP diets (3.1 percentage units) was similar to the difference in DM digestibility (2.7 percentage units) for these same protein sources. Apparent digestibility was higher for methionine ($P<.01$), lysine ($P<.05$) and valine ($P<.05$) in pigs fed the CAS diet than for pigs fed any of the soybean protein diets (table 3). The apparent digestibility of methionine and lysine was similar among pigs fed all of the soybean protein sources while digestibility of valine was higher ($P<.05$) in pigs fed the ESOY diet than in pigs fed the SBM. Other EAA for which differences among dietary treatments were observed ($P<.1$) were isoleucine and leucine.

TABLE 2. Protein and amino acid composition of diets.

Item	Diet[a,b] CAS	ISP	ESOY	SBM
Crude protein, %	17.9	19.9	19.5	19.1
Amino acids, %				
Essential				
Arginine	.78	1.31	1.30	1.24
Histidine	.51	.52	.51	.50
Isoleucine	.78	.85	.82	.80
Leucine	1.87	1.90	1.85	1.77
Lysine	1.03	1.02	1.02	1.01
Methionine	.46	.37	.34	.36
Phenylalanine	.88	1.00	.97	.94
Threonine	.72	.75	.76	.76
Valine	1.01	.95	.92	.90
Nonessential				
Alanine	.87	1.07	1.05	1.02
Aspartic acid	1.28	1.96	1.94	1.91
Cystine	.23	.40	.42	.40
Glutamic acid	3.51	3.61	3.51	3.40
Glycine	.51	.81	.81	.81
Proline	1.73	1.28	1.27	1.21
Serine	.93	1.00	1.00	.97
Tyrosine	.87	.79	.77	.77

[a]Dry matter basis.
[b]For explanation of diet code names, see table 1, footnote b.

The apparent digestibility of these AA appeared to be higher in pigs fed the CAS diet than in pigs fed any of the soybean protein diets with the greatest differences in digestibility being between the CAS and SBM diets. Differences in apparent digestibility were not observed ($P>.1$) for the remaining EAA, but, except for arginine, digestibility was higher for all of these AA in pigs fed the CAS diet than by those fed any of the soybean protein diets. Differences in the digestibility among dietary treatments for the nonessential AA were observed only for proline ($P<.01$) and tyrosine ($P<.1$) for which digestibility was highest in pigs fed the CAS diet and lowest in pigs fed the SBM diet. The apparent digestibility of the remaining nonessential AA was similar among all dietary treatments. These diets were formulated to meet the NRC (1979) requirement for lysine (.95%) for the 11-22 lb pig. This lysine level is below the level of lysine (1.15 - 1.20%) reported to provide maximum rate and efficiency of gain for young pigs fed grain-SBM diets. Since lysine digestibility was higher for CAS than for the soybean proteins, better performance would be expected.

TABLE 3. Apparent digestibility of DM, starch, N and AA measured over the total digestive tract in 42 day old pigs.

Item	Diet[a] CAS	ISP	ESOY	SBM	SE
Pigs per treatment, no[b]	17.0	18.0	17.0	17.0	
Dry matter, %	87.6[d]	84.9[e]	84.2[ef]	82.4[f]	.8
Starch, %	99.0	98.5	98.6	98.3	.3
Nitrogen, %[c]	83.7	80.6	80.8	76.2	1.1
Amino acids, %					
Essential					
Arginine	88.4	90.6	91.1	88.1	.6
Histidine	89.7	86.8	88.4	86.0	.8
Isoleucine[c]	86.1	81.0	82.6	77.6	1.2
Leucine[c]	88.4[d]	82.2[e]	85.0[e]	80.9[e]	1.2
Lysine	86.3[d]	82.8[e]	83.8[e]	80.1[e]	.9
Methionine	87.7[g]	79.6[h]	81.0[h]	78.9[h]	1.2
Phenylalanine	86.5	82.6	83.8	78.5	1.1
Threonine	82.4	77.2	80.0	75.6	1.2
Valine	85.6[d]	78.8[ef]	81.1[e]	75.7[f]	1.2
Average	86.8	82.4	84.1	80.2	
Nonessential					
Alanine	78.9	75.3	78.4	73.5	1.5
Aspartic acid	81.5	85.0	86.0	82.1	.9
Cystine	95.3	96.0	97.8	95.2	.8
Glutamic acid	90.4	87.7	89.1	86.0	.8
Glycine	75.0[g]	78.6[h]	80.4[h]	75.3[i]	1.2
Proline	93.2[g]	87.7[h]	88.2[h]	84.2[i]	.9
Serine	87.5	84.4	85.9	81.3	1.0
Tyrosine[c]	88.1	82.4	83.5	79.0	1.1
Average	86.2	84.6	86.2	82.1	

[a] For explanation of diet code names, see table 1, footnote b.
[b] One pig on the CAS diet died from causes unrelated to dietary treatment. One pig was removed from each of the ESOY and SBM diets for prolonged feed refusal.
[c] Treatment effect (P<.1).
[def] Means in the same row with different superscripts differ P<.05.
[ghi] Means in the same row with different superscripts differ P<.01.

Results of this study as previously reported (Walker, 1984) indicate that faster growth and a higher gain to feed ratio can be achieved during the first 2 weeks postweaning in pigs weaned at 3 weeks of age when casein is substituted for soybean protein but gain and efficiency was equal for the two protein sources after the 2nd week

postweaning. These differences in performance may be accounted for by the differences observed in nutrient digestibility especially for the EAA lysine and methionine.

Literature Cited

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