EFFECT OF PROTEIN SOURCE ON ILLEAL AVAILABILITY IN EARLY WEANED PIGS

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Story in Brief

Two 5 X 5 Latin square designed trials were conducted using either five 4 week old gilts or five 200 lb barrows fitted with simple ileal T-cannulas to determine the effect of protein source and age of pig upon protein and amino acid availability. The apparent availability of nitrogen (N) and amino acids (AA) in pigs fed hydrolyzed casein (HCAS), calcium caseinate (CAS), isolated soybean protein (ISP), ethanol extracted soybean protein (ESOY) and soybean meal (SBM) were determined at the ileum in 4 to 9 week old pigs and at both the ileum and over the total digestive tract in finishing pigs. The pigs were fed semi-purified diets formulated to contain 22% protein. The apparent availability of N and essential amino acids (EAA) at the terminal ileum in both early weaned and finishing pigs and over the total digestive tract of finishing pigs was higher ($P<.01$) in pigs fed HCAS, CAS, ISP and ESOY than in those fed SBM. For the early weaned pig, the apparent availability of N and AA was generally higher for the casein protein sources than for the soybean protein sources. In addition, the apparent availability of N and all AA except cystine and glycine significantly increased with increasing age of the young pigs. The apparent pre-ileal availability of lysine, threonine and methionine for early weaned pigs fed SBM was 69.3, 69.3 and 59.3%, respectively. The apparent pre-ileal availability was lower in the young pigs with an average availability for the EAA of 91.3, 89.5, 85.8, 85.2 and 70.5% compared to 95.3, 93.1, 93.4, 92.7 and 80.6% for the older pigs fed HCAS, CAS, ISP, ESOY and SBM, respectively. Apparent availability values over the total digestive tract were higher than values estimated in samples obtained at the ileum in the finishing pigs indicating a net disappearance of N and AA in the hindgut.

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

Introduction

Although weaning as early as 18 days can be an economic advantage, many swine producers experience postweaning problems with this management practice. The reduced performance accompanying early weaning is associated with a reduced feed intake and little or no weight gain. Early weaned pigs also experience a longer postweaning growth depression and higher mortality rate than those weaned later.

Several studies have reported inferior performance in early weaned pigs fed soybean protein diets compared to those fed milk protein diets. Our studies (Walker et al., 1984) have demonstrated that the effect of protein source on performance is more evident during the first 2 weeks postweaning than during the subsequent 3 week period when pigs were weaned at 3 weeks of age. The fact that the neonatal pig is subjected

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to extreme diet changes during a period when digestive capacity is undergoing rapid development may account for the higher sensitivity to dietary protein sources observed in early weaned pigs compared to that normally seen in older pigs.

Protein sources have been shown to vary not only in AA content but also in availability when measured at either the ileum or in fecal samples of growing-finishing pigs. However, studies in the early weaned pig where the effect of protein source may be even greater have not been conducted. Furthermore, it is common practice to formulate diets to barely meet the requirement for the most limiting AA. Recent studies have shown that the requirement for lysine, the first limiting AA for maximum growth in typical grain-soybean diets, may be much higher than the current NRC recommendation for pigs weighing from 11 to 22 lb. Pigs fed diets containing lysine levels below the requirement for maximum gain and efficiency of gain would be responsive to small decreases in amino acid availability.

This study was conducted to determine the apparent biological availability of dry matter (DM), starch, N and individual AA in milk and soybean proteins fed to ileally cannulated early weaned pigs and to compare these values to those of finishing pigs fed the same diets.

Materials and Methods

Five Yorkshire gilt pigs were surgically fitted with simple T-cannulas located in the distal ileum near the ileocecal junction. Pigs were removed from the sow at 18 days of age at which time the cannulas were surgically installed. Immediately following surgery pigs were returned to the sow where they remained with the rest of the litter for a 7 day recovery period. Creep feed and water were available to pigs at all times during the recovery period. After recovery the pigs were moved to an environmentally controlled feeding room where they were housed in individual elevated metal pens measuring 2.0 by 3.3 ft. Temperature in the feeding room was maintained between 80 and 90 F for the duration of the trial. After a 2 day adjustment period, the pigs were started on a 5 X 5 Latin square designed trial at 27 days of age.

Dietary treatments consisted of two milk and three soybean protein sources in semi-purified cornstarch-cerelose based diets (Table 1). Protein sources included hydrolyzed casein (HCAS), calcium caseinate (CAS), isolated soybean protein (ISP), ethanol extracted soybean protein (ESOY) and 44% crude protein solvent extracted soybean meal (SBM). Twenty-two percent crude protein diets were formulated to exceed the NRC (1979) requirement for crude protein for the 10 - 22 lb pig by 10% such that no single AA would be limiting. Chromic oxide was added as an indigestible marker for availability determinations. Each pig was fed a measured quantity of feed twice daily at 8:00 a.m. and 8:00 p.m. and allowed continuous access to the feed for a 1 hour period after which all uneaten feed was removed. To increase intake, dry diets were mixed with an equal portion of water and fed as a gruel. All uneaten and wasted feed was collected, dried and weighed so daily feed intake for each pig could be monitored. Water was available from cup waterers at all times.

Each of the five 7-day experimental periods consisted of a 4-day adjustment period followed by a 3-day collection period. Ileal samples were collected continuously on each collection day, beginning one hour after the morning feeding and continuing until either 1.75 oz of wet sample was collected for each pig or until feeding time of the evening meal. Samples were collected in plastic bags suspended from the cannula. Bags containing sample were changed at a maximum of 1 hour intervals. Ileal samples collected over the 3 collection days of each period were composited by treatment prior to lyophilyzation and grinding for laboratory analysis.

TABLE 1. Composition of Diets.

	Diet (as fed basis)[a]				
Ingredient	HCAS	CAS	ISP	ESOY	SBM
Corn starch	30.82	31.35	30.48	25.93	18.91
Cerelose	30.82	31.35	30.48	25.93	18.91
Acid hydrolysed casein[b]	25.43				
Calcium caseinate[c]		25.43			
Isolated soy protein[d]			26.11		
Ethanol extracted soy protein[e]				35.25	
Soybean meal					49.64
Solka floc	5.00	5.00	5.00	5.00	5.00
Corn oil	4.00	4.00	4.00	4.00	4.00
Calcium carbonate	.70		.79	.78	.90
Dicalcium phosphate	1.73	1.73	2.00	1.97	1.50
Vitamin, TM premix[f]	.35	.35	.35	.35	.35
Salt	.30	.30	.30	.30	.30
ASP 250[g]	.25	.25	.25	.25	.25
Chromic oxide	.25	.25	.25	.25	.25
DL-tryptophan	.35				
	100	100	100	100	100

[a] HCAS: acid hydrolyzed casein diet; CAS: calcium caseinate diet; ISP: isolated soybean protein diet; ESOY: ethanol extracted soybean protein diet; SBM: soybean meal diet.
[b] Acid hydrolyzed casein, type 1, Sigma Chemical Co. St. Louis, MO.
[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.

Dry matter, starch, N and AA content of both feed and ileal samples were determined. Amino acid concentration was determined from acid hydrolysates by ion exchange chromatography using a Beckman model 121 automatic AA analyzer. Acid hydrolysis was conducted under nitrogen reflux in 6N HCl for 24 hours.

A second study was conducted using five Yorkshire barrows averaging 200 lb liveweight with simple T-cannulas constructed of pliable tygon tubing surgically installed in the ileum of the small intestine. The experiment consisted of a 5 X 5 Latin square arrangement of treatments using the same diets (table 1) as those fed the neonatal pigs, with the exception of a .1% reduction in the amount of vitamin trace mineral premix. Each pig was fed 2.2 lb of unwetted feed twice daily at 8:00 a.m. and 8:00 p.m. with water available from nipple waterers at all times. These pigs were housed in an environmentally controlled feeding room in individual crates (2.0 by 5.3 ft) for the duration of the trial. Each of the five 7-day experimental periods consisted of a 4-day adjustment period followed by ileal collections on the 5th and 7th day of each period. Ileal samples were collected continuously on each collection day beginning 1 hour after the morning feeding and continuing until either 7.0 oz of wet sample was collected for each pig or until feeding of the evening meal. In addition, a fresh fecal grab sample was collected from each pig on both the 5th and 7th day of each period for fecal availability determination. All samples were collected, stored and analyzed in a similar manner as described for the early weaned pig study. Fifth and 7th day ileal samples within each period were composited by treatment prior to laboratory analysis while 5th and 7th day fecal samples were analyzed separately.

Results and Discussion

Early weaned pigs.

Protein and AA composition of the complete diets are shown in table 2. The two casein protein diets were similar in lysine and threonine content but higher in methoinine content than the 3 soybean protein sources. These are the AA that tend to be most limiting in diets that are commonly fed to early weaned pigs and, therefore, are of the most interest.

The apparent pre-ileal availability of DM, starch, N and individual AA in the various protein sources is shown in table 3. The apparent pre-ileal DM availability in pigs fed HCAS, CAS, ISP and ESOY was higher (P<.05) than in those fed SBM while DM availability in pigs fed CAS and ISP was higher (P<.05) than those fed ESOY. These differences, at least to some extent, reflect differences in dietary crude fiber content. The availability of starch exceeded 95% and was similar for all protein sources except in pigs fed HCAS when starch availability was slightly reduced.

The apparent pre-ileal availability of N, the EAA and the nonessential AA (NEAA), with the exception of cystine and glycine, was lower (P<.05) in pigs fed SBM than in those fed all other protein sources. The average apparent pre-ileal availability of the EAA in pigs fed SBM was 70.5% compared to 91.3, 89.5, 85.8, and 85.2% for those fed HCAS, CAS, ISP and ESOY, respectively. The apparent pre-ileal availability of both lysine and threonine was higher (P<.05) in pigs fed HCAS than in those fed ISP or ESOY while the availability of these AA was intermediate in pigs fed CAS. The apparent pre-ileal availability of methionine was similar in pigs fed HCAS, CAS, ISP or ESOY. For the remainder of the EAA, effects similar to those reported for lysine and threonine were evident for histidine, isoleucine, leucine and valine while effects similar to those reported for methionine were evident for arginine and phenylalanine. Although differences were not always significant, there was a trend for higher apparent availabilities in the casein protein sources when compared to the soybean protein sources. In addition, when CAS was compared to the average of the soybean proteins the apparent pre-ileal availability was higher (P<.05) for CAS in each of the EAA with the exception of arginine. The low value reported for the average apparent pre-ileal availability of the EAA in SBM (70.5%) is not surprising since the digestive capacity of this age pig is undergoing rapid development. In addition, the presence of proteolytic enzyme inhibitors in SBM is likely to have a greater effect in young pigs than that normally apparent in older growing-finishing pigs.

TABLE 2. Protein and amino acid composition of diets.

	Diet[a,b]			
Item	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.

A linear increase over time (P<.05) was observed for the apparent pre-ileal availability of N, all of the EAA and the NEAA with the exception of cystine and glutamic acid (Table 4). Increasing availability with increasing age has been observed for several nutrients in young animals.

TABLE 3. Apparent pre-ileal availabilities of DM, starch, N and AA in milk and soybean protein sources in early weaned pigs.[a]

	Diet[b]					
Item	HCAS	CAS	ISP	ESOY	SBM	SE
Dry matter, %[c]	80.7[de]	85.4[d]	83.0[d]	77.0[e]	65.0	1.6
Starch, %	94.5[e]	98.7[d]	98.5[d]	98.8[d]	97.3[de]	.9
Nitrogen, %[c]	86.0	84.5	81.8	83.4	68.4	2.1
Amino acids, %						
Essential						
Arginine[c]	88.8	86.7	90.9	90.5	77.8	1.6
Histidine[c]	89.5[d]	89.2[de]	84.4[de]	83.9[e]	70.3	1.8
Isoleucine[c]	93.6[d]	89.6[de]	87.7[de]	87.2[e]	73.3	2.1
Leucine[c]	93.3[d]	92.8[de]	86.9[de]	86.0[e]	72.2	2.3
Lysine[c]	92.0[d]	89.6[de]	84.1[e]	85.0[e]	69.3	2.2
Methionine[c]	93.8	92.8	85.9	82.6	59.3	4.8
Phenylalanine[c]	86.4	89.3	86.5	86.2	71.8	2.2
Threonine[c]	90.5[d]	85.3[de]	80.4[e]	81.2[e]	69.3	2.0
Valine[c]	94.1[d]	90.4[de]	85.0[e]	84.1[e]	71.2	2.2
Avg	91.3	89.5	85.8	85.2	70.5	
Nonessential						
Alanine[c]	90.9[d]	82.9[e]	83.1[e]	83.2[e]	68.5	1.9
Aspartic acid[c]	87.4	86.9	89.0	88.7	76.4	1.6
Cystine	100.0[d]	100.0[d]	70.0[e]	77.5[f]	64.0[e]	2.4
Glutamic acid[c]	90.1	90.9	89.5	89.1	77.2	2.2
Glycine	78.5[d]	72.1[d]	76.9[d]	76.7[d]	64.5[e]	2.3
Proline[c]	96.5[d]	94.3[d]	85.7[e]	85.8[e]	73.5	1.9
Serine[c]	93.6[d]	86.2[e]	87.2[e]	86.7	74.7	1.9
Tryosine[c]	90.2	94.0	88.4	88.3	74.6	2.1
Avg	90.9	88.4	83.7	84.5	71.7	

[a]Values are means of five observations.
[b]For explanation of diet code names, see table 1, footnote a.
[c]SBM differs from other diets P<.05.
[def]Means in the same row with different superscripts differ P<.05.

Pigs fed diets limiting in EAA would be responsive to small differences in AA availability. Recent studies have shown that the lysine requirement for the 11 to 22 lb pig is higher than the .95% currently recommended by NRC. Therefore, the differences in availability observed in this study may account for reduced growth and efficiency observed in pigs fed soybean protein diets compared to those fed CAS diets during the first 2 weeks postweaning in pigs weaned at 3 weeks of age and fed these same protein sources in practical diets formulated to meet minimum NRC requirements for lysine (Walker et al., 1984).

TABLE 4. Effect of time on apparent pre-ileal amino acid availability in early weaned pigs.[a]

Item	Week					
	1	2	3	4	5	
Dry matter, %	77.7	75.5	79.9	79.4	78.6	1.6
Nitrogen, %[c]	78.9	75.9	81.5	85.8	81.8	2.1
Amino acids, %						
Essential						
Arginine[b]	81.8	84.2	87.7	91.7	89.4	1.6
Histidine[c]	81.1	79.2	83.8	88.2	85.1	1.8
Isoleucine[b]	83.0	81.6	86.4	92.0	88.3	2.1
Leucine[c]	82.7	82.1	86.2	91.6	88.6	2.3
Lysine[b]	81.3	77.4	84.6	89.8	87.0	2.2
Methionine[c]	78.2	74.6	83.7	91.6	87.0	4.8
Phenylalanine[b]	80.5	79.7	84.3	88.7	86.9	2.2
Threonine[b]	78.1	75.8	82.1	86.9	83.9	2.0
Valine[c]	82.2	79.7	85.0	90.7	87.2	2.2
Nonessential						
Alanine[b]	78.5	76.2	81.5	87.9	84.4	1.9
Aspartic acid[b]	82.5	82.3	86.7	89.7	87.3	1.6
Cystine	83.3	78.9	77.7	89.2	82.3	2.4
Glutamic acid	85.1	84.4	87.8	92.0	87.5	2.2
Glycine[b]	69.1	68.4	76.3	81.0	73.9	2.3
Proline[c]	85.0	83.0	87.3	91.8	88.9	1.8
Serine[c]	83.3	80.5	86.8	90.8	87.0	1.9
Tryosine[c]	84.8	83.0	87.2	91.2	89.3	2.1

[a]Values are means of five observations.
[b]Linear effect P<.01.
[c]Linear effect P<.05.

Finishing pigs.

Significant differences were not observed between values obtained from fecal samples collected on either the 5th or 7th day of each period and, therefore, these values were averaged and analyzed as a single sample. The apparent availability of DM and starch at both the terminal ileum and over the total digestive tract is shown in table 5. The apparent DM availability was similar at the terminal ileum in pigs fed HCAS, CAS and ISP and over the total digestive tract in pigs fed HCAS, CAS, ISP and ESOY. The apparent DM availability was lower (P<.01) in pigs fed SBM than in pigs fed all other protein sources at both sites and was lower at the terminal ileum (P<.01) in pigs fed ESOY than for those fed HCAS, CAS and ISP. Dry matter disappearance from the hindgut ranged from 21.8% for SBM to 3.2% for HCAS which may be a reflection of the higher crude fiber content of SBM and the high digestibility of nutrients in HCAS. Starch availability was similar for all protein sources and approached 100% when estimated at both the terminal ileum and over the total digestive tract.

The apparent pre-ileal availability of N and all EAA was lower (P<.05) in pigs fed SBM than for those fed HCAS, CAS, ISP and ESOY (table 6). The apparent pre-ileal availability of lysine and threonine was similar for pigs fed HCAS, CAS, ISP and ESOY while that of methionine was higher (P<.05) for pigs fed HCAS than those fed either ISP or ESOY with those fed CAS being intermediate. Similar trends were evident for the remainder of the EAA and the NEAA. The average apparent pre-ileal availability was 95.3, 93.1, 93.4, 92.7 and 80.6% for the EAA and 93.2, 88.4, 88.8, 91.0 and 75%, for the NEAA in pigs fed HCAS, CAS, ISP, ESOY and SBM, respectively. These values are all higher than those observed in the early weaned pig.

TABLE 5. Apparent availabilities of dry matter and starch at the end of the small intestine and over the total tract of finishing pigs.[a]

	Diet[b]					
Item	HCAS	CAS	ISP	ESOY	SBM	SE
Dry matter, %						
Terminal ileum	88.5[d]	85.6[d]	85.7[d]	76.1[e]	61.0[f]	1.1
Total tract	91.7[d]	91.3[d]	90.3[d]	90.5[d]	82.8[e]	.5
Difference[c]	3.2	5.7	4.6	14.4	21.8	
Starch, %						
Terminal ileum	99.8	99.8	99.9	99.9	99.6	.1
Total tract	99.9	99.9	99.8	100.0	99.6	.1
Difference[c]	.1	-.1	.1	.1		

[a]Values are means of five observations.
[b]For explaination of diet code names, see table 1, footnote a.
[c]Differences obtained by subtraction of ileal availabilities from total tract availabilities.
[def]Means in the same row with different superscripts differ P<.01.

The apparent availability of the EAA measured over the entire digestive tract averaged 97.3%, 96.8%, 95.3%, 95.4% and 85.9% in pigs fed HCAS, CAS, ISP, ESOY and SBM, respectively (table 7). The apparent availability of the EAA and N over the entire tract was higher (P<.05) in pigs fed HCAS, CAS, ISP and ESOY than in those fed SBM. In addition, the availability of lysine over the entire tract was higher (P<.05) in pigs fed CAS (97.7%) than in those fed ISP (96.2%) or ESOY (95.7%) and higher (P<.05) in pigs fed HCAS (97.2%) than in those fed ESOY.

Similarly, the fecal availability of threonine was higher (P<.05) in pigs fed CAS (95.4%) than in those fed ISP (93.8%) or ESOY (93.7%) while availability was similar in pigs fed HCAS (95.0%). The fecal availability of methionine was higher ($P<.05$) in pigs fed CAS (97.7%) and HCAS (97.6%) than in those fed ISP (93.1%) or ESOY (94.7%). Similar patterns were observed for the remainder of the EAA and the NEAA. The low apparent fecal availability for AA may be due to the low apparent availability of DM in the small intestine (61%), as was previously mentioned. This would provide more energy substrate to the hindgut than would normally be expected to occur with this type diet which in turn would result in an increase of microbial AA in the feces and consequently lower fecal availability estimates.

TABLE 6. Apparent ileal availability of nitrogen and amino acids in milk and soybean protein sources in finishing pigs[a].

	Diet[b]					
Item	HCAS	CAS	ISP	ESOY	SBM	SE
Nitrogen, %[c]	92.3^{d}	88.1^{e}	90.6^{de}	89.7^{de}	79.5	1.2
Amino acids, %						
Essential						
Arginine[c]	94.7^{de}	93.1^{e}	97.0^{d}	96.1^{d}	87.3	.8
Histidine[c]	92.3	95.1	94.4	92.8	79.8	1.1
Isoleucine[c]	96.3^{d}	91.3^{e}	93.1^{e}	93.8^{de}	82.4	.9
Leucine[c]	96.7^{d}	95.4^{de}	93.3^{e}	93.3^{e}	81.8	1.0
Lysine[c]	96.7	96.3	95.4	94.3	81.8	1.2
Methionine[c]	97.7^{d}	95.8^{de}	93.8^{e}	94.2^{e}	86.1	1.0
Phenylalanine[c]	94.3	95.4	94.7	93.4	82.6	.9
Threonine[c]	92.4	84.9	87.4	85.8	67.5	2.7
Valine[c]	96.4^{d}	90.5^{e}	91.7^{de}	90.7^{e}	76.1	1.5
Average	95.3	93.1	93.4	92.7	80.6	
Nonessential						
Alanine[c]	94.6^{d}	85.0^{e}	90.5^{d}	90.1^{de}	75.2	1.8
Aspartic acid[c]	92.2	90.2	93.4	93.4	79.8	1.2
Cystine	100.0^{d}	100.0^{d}	84.5^{e}	86.4^{e}	78.8^{e}	8.5
Glutamic acid[c]	89.6^{e}	91.9^{de}	95.5^{d}	95.2^{d}	80.6	1.6
Glycine	82.5^{d}	75.5^{de}	87.0^{d}	85.3^{d}	64.1^{e}	4.5
Proline[c]	97.1	93.1	93.2	91.0	76.3	2.4
Serine	94.9^{d}	81.0^{e}	92.9^{d}	91.2^{d}	75.7^{e}	1.8
Tyrosine[c]	96.5	97.0	96.7	95.7	84.4	.8
Average	93.2	88.4	88.8	91.0	75.0	

[a] Values are means of five observations.
[b] For explaination of diet code names, see table 1, footnote a.
[c] SBM differs from other diets ($P<.01$).
[de] Means in the same row with different superscripts differ $P<.05$.

TABLE 7. Apparent fecal availabilities of nitrogen and amino acids in milk and soybean protein sources in finishing pigs.[a]

	Diet[b]					
Item	HCAS	CAS	ISP	ESOY	SBM	SE
Nitrogen, %[c]	95.5	95.4	94.4	94.8	87.5	.4
Amino acids, %						
Essential						
Arginine	96.2^{d}	96.5^{d}	97.9^{c}	97.8^{c}	91.3^{e}	.3
Histdine	96.6^{c}	97.6^{c}	96.6^{c}	96.7^{c}	88.7^{d}	.4
Isoleucine	96.6^{c}	95.4^{c}	95.1^{c}	95.0^{c}	84.4^{d}	.5
Leucine	96.8^{c}	97.0^{c}	94.9^{d}	95.4^{d}	84.8^{e}	.3
Lysine	97.2^{cd}	97.7^{c}	96.2^{de}	95.7^{e}	85.5^{f}	.4
Methionine	97.6^{c}	97.7^{c}	93.1^{d}	94.7^{d}	88.1^{e}	.7
Phenylalanine	94.8^{c}	97.3^{d}	95.6^{d}	95.7^{d}	85.6^{e}	.4
Threonine	95.0^{cd}	95.4^{c}	93.8^{d}	93.7^{d}	81.4^{e}	.5
Valine	97.3^{c}	96.4^{c}	94.6^{d}	94.6^{d}	83.5^{e}	.5
Avg	97.3	96.8	95.3	95.4	85.9	
Nonessential						
Alanine	94.5^{c}	93.0^{c}	93.4^{c}	92.9^{c}	79.9^{d}	.6
Aspartic acid	94.0^{d}	95.5^{cd}	97.1^{c}	96.7^{c}	87.4^{e}	.5
Cystine	100.0^{c}	100.0^{c}	94.1^{d}	95.3^{d}	89.9^{e}	1.2
Glutamic acid	97.9^{c}	97.5^{c}	98.0^{c}	97.7^{c}	90.7^{d}	.4
Glycine	91.6^{de}	90.8^{e}	94.6^{c}	94.2^{d}	82.5^{f}	.9
Proline	98.8^{c}	98.5^{c}	96.9^{d}	96.8^{d}	89.0^{e}	.3
Serine	96.2^{c}	94.2^{c}	96.1^{c}	95.9^{c}	86.9^{e}	.7
Tyrosine	96.7^{d}	98.1^{c}	96.1^{d}	95.6^{d}	86.3^{e}	.4
Avg	96.1	96.0	95.8	95.6	86.6	

[a] Values are means of five observations.
[b] For explanation of diet code names, see table 1, footnote a.
[cdef] Means in the same row with different superscripts differ P<.05.

Most of the apparent fecal availability estimates were larger than ileal availability estimates indicating a net disappearance of N and AA from the hindgut. Since these pigs were fed cornstarch based diets that were all highly available (greater than 99% starch availability at the terminal ileum) a net disappearance of N and AA in the hindgut would be expected.

In general, the availability of N and AA in pigs fed SBM was lower than for those fed the other dietary protein sources. This may reflect differences in proteolytic enzyme inhibitors or carbohydrate complexes within the dietary protein source and may account for the inferior growth and efficiency observed for early weaned pigs fed SBM diets compared to those fed milk protein diets. The apparent ileal availability of N and AA was higher for the older finishing pigs than for the early weaned pigs and the EAA averaged 4.0, 3.6, 7.1, 7.5 and 10.1 percentage units higher availability for pigs fed HCAS, CAS, ISP, ESOY and SBM, respectively. These differences in availability should be considered when formulating diets for young pigs especially when using SBM as a supplemental protein source and formulating diets to meet minimum NRC requirements for lysine.

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