

Effects of Replacing Spray Dried Plasma Protein With Spray Dried Porcine Intestine Hydrolysate on Ileal Digestibility of Amino Acids and Growth Performance in Early-Weaned Pigs

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ABSTRACT : A study was conducted to determine the ileal digestibility (ID) of amino acids and feeding values of spray dried plasma protein (SDPP) and spray dried porcine intestine hydrolysate (SDPI) in early-weaned pigs. Twelve pigs aged 18 days old (Landrace × Yorkshire × Duroc; 5.83 ± 0.51 kg BW) were cannulated in the terminal ileum for determination of ID of amino acids. Ninety pigs (6.28 ± 0.1 kg, 18 days old) were also employed for a feeding trial during phase I period. Treatments were: 1) 6% SDPP, 2) 6% SDPI, and 3) 3% SDPP+3% SDPI. The apparent and true ID values of the essential amino acids except leucine, methionine and valine were lower ($p < 0.01$) in SDPI than in SDPP. The average apparent ID of essential amino acids in SDPP and SDPI were 75.63 and 71.30%, and the average true ID of essential amino acids 84.83 and 80.51%, respectively. The ADG and feed conversion ratio in piglets fed the 6% SDPP diet were better ($p < 0.01$) than in those fed the 6% SDPI diet. When 3% of SDPP was replaced by SDPI, however, the growth rate and efficiency of pigs were comparable to those in pigs fed 6% SDPP. In conclusion, SDPP can be partially replaced by SDPI without any detrimental effect on growth performance in early-weaned pigs. (*Asian-Aus. J. Anim. Sci.* 2000. Vol. 13, No. 12 : 1738-1742)

Key Words : Spray Dried Porcine Intestine Hydrolysate, Digestibility, Growth, Pig

INTRODUCTION

Spray dried plasma protein (SDPP), prepared by spray-drying porcine and bovine plasma by centrifugation of blood, has been a leading protein source in the phase I diet of young pigs. Generally, SDPP increases feed intake in the very young pigs (Gatnau and Zimmerman, 1991; Hanson et al., 1993; Erner et al., 1994; Chae et al., 1999) and it has been accepted that maximum feed intake and growth responses are obtained with 6 to 8% SDPP (Gatnau and Zimmerman, 1991, 1992; Coffey and Cromwell, 1995), even though Kats et al. (1994) reported that starter pig performance is linearly improved as SDPP increased up to 10% in the diet.

However, SDPP is a relatively expensive ingredient for animal feeds and researchers have tried to find an alternative. Spray dried porcine intestine hydrolysate (SDPI) was introduced as an alternative protein source in young pigs. It is also called spray dried porcine digest (SDPD) or dried porcine solubles (DPS). The SDPI is the residual remaining (by-product) after extraction of heparin from hydrolyzed small intestines of pigs. Zimmerman (1996) reported that pigs fed diets containing 6% SDPI for 2 weeks postweaning gained faster than those fed control or 12% SDPI diets.

Experimental data are limited on comparing feeding values and ileal amino acids digestibility of the two protein sources, SDPP and SDPI. Faltys et al. (1998) conducted an experiment with 6% SDPP or SDPI in the phase I diet and reported that pigs fed SDPP gained significantly faster than pigs fed the SDPI diet. Kim (2000) reported that replacing 3% DPS in the phase I diet containing 6% SDPP did not affect daily gain of pigs, but reduced feed conversion ratio. Chae et al. (1999) reported that the apparent ileal digestibility of amino acids in SDPP is similar with those of isolated soy protein in early-weaned pigs. But digestibility of amino acids in SDPI is not available yet.

The objectives of this study were, therefore, to 1) determine the ileal digestibility of amino acids of SDPP and SDPI, and 2) investigate the possibility of replacing SDPP with SDPI for early-weaned pigs.

MATERIALS AND METHODS

Diets and animals

For a digestibility trial, SDPP (APC, USA) and SDPI (Brookside, USA) were incorporated in semi-purified cornstarch-lactose based diets. Diets were formulated to contain 18.5% crude protein, with vitamins and minerals exceeding the NRC (1998) recommendation. Chromic oxide was added as an indigestible marker to allow digestibility determination. To determine endogenous amino acid excretion, a N-free diet was also prepared (table 1).

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Twelve pigs aged 18 days old (Landrace × Yorkshire × Duroc; 5.83 ± 0.51 kg BW) were employed in a completely randomized design and housed in individual metabolic cages. Of the pigs, four were assigned to collect ileal digesta for endogenous amino acid excretions. After one day fasting, pigs were fitted with T-cannula in the terminal ileum according to the method suggested by Walker et al. (1986). And after one day fasting, each pig was fed a restricted amount of feed (5% of the body weight/day) three times daily. Diets were mixed with water and fed as a wetted mash form to improve feed intake. From the sixth day post-surgery, digesta samples were collected for 3 days. The collected samples were frozen immediately at -80°C , freeze dried (Samwon Inc., Korea), ground with a 1 mm mesh Wiley mill, and stored in a

Table 1. Ingredient and chemical composition of experimental diets for digestibility trials

Ingredient (%) ¹	SDPP	SDPI	N-free diet
SDPP	23.80		
SDPI	-	37.00	-
Corn starch	32.40	13.5	30.00
Lactose	31.70	40.00	30.00
Sucrose	5.00	5.00	9.70
Glucose	-	-	20.00
Animal fat	2.30	0.50	4.00
Limestone	0.80	1.55	1.85
Monocalcium phosphate	2.60	0.95	3.00
Salt	0.30	0.30	0.30
Vit. premix ²	0.30	0.30	0.30
Min. premix ³	0.25	0.25	0.25
Mecadox	0.10	0.10	0.20
Choline chloride (25%)	0.15	0.15	0.15
Cr ₂ O ₃	0.30	0.30	0.25
Total	100.00	100.00	100.00
Calculated composition (%)			
ME (kcal/kg)	3,530	3,235	3,520
Crude protein	18.50	18.50	-
Calcium	0.75	0.75	1.15
Phosphorus	0.58	0.50	0.63

¹ SDPP: spray-dried plasma protein; SDPI: spray-dried porcine intestine hydrolysate.

² Supplied per kilogram of diet: 9,600 IU of vitamin A, 1,800 IU of vitamin D₃, 24 IU of vitamin E, 1.5 mg of vitamin K₃ (as menadione), 1.5 mg of thiamine, 12 mg of riboflavin, 24 mg of pantothenic acid (as d-calcium pantothenate), 45 mg of niacin, 0.1 mg of biotin, 2.4 mg of pyridoxine, 0.8 mg of folic acid, and 0.05 mg of vitamin B₁₂.

³ Supplied per kilogram of diet: 38 mg of Mn, 125 mg of Fe, 187 mg of Zn, 0.5 mg of Co, 224 mg of Cu, 0.8 mg of I, and 0.25 mg of Se.

refrigerator until analysis.

For a 7-d feeding trial, a total of 90 pigs (Landrace × Yorkshire × Duroc; 18-d old and 6.70 ± 0.35 kg BW) were allotted to three treatments (3 replicates/treatment) on the basis of sex and body weight.

Table 2. Formula and chemical composition of experimental diets for a feeding trial

	SDPP	SDPI	SDPP + SDPI
Ingredient (%) ¹			
CSF-extrudate ²	32.39	29.17	36.23
Whey	20.00	20.00	20.00
Milk replacer	15.00	15.00	15.00
Lactose	10.00	10.00	10.00
Bakery by-product	5.00	5.00	5.00
Sucrose	2.00	2.00	2.00
SDPP	6.00	-	3.00
SDPI	-	6.00	3.00
Fish meal	2.00	3.00	2.00
Wheat flour	4.40	4.20	-
Soy protein concentrate	-	2.40	-
Soy oil	1.00	0.60	1.00
TCP	0.72	1.02	1.19
CaCO ₃	0.50	0.50	0.50
Vit. mixture ³	0.28	0.28	0.28
Min. mixture ⁴	0.25	0.25	0.25
Choline chloride (25%)	0.10	0.10	0.10
Lysine HCl	0.06	0.18	0.15
Salt	0.10	0.10	0.10
Apramycin	0.10	0.10	0.10
Mecadox	0.10	0.10	0.10
Total	100.00	100.00	100.00
Calculated composition (%)			
ME (kcal/kg)	3,500	3,500	3,500
Crude protein	21.30	20.50	20.50
Lysine	1.45	1.45	1.45
Methionine+cystine	1.08	0.97	1.06
Calcium	0.87	1.00	0.96
Av. phosphorus	0.48	0.58	0.55

¹ SDPP: spray-dried plasma protein; SDPI: spray-dried porcine intestine hydrolysate.

² Extruded product (47% corn, 47% soybean meal and 6% animal fat).

³ Supplied per kilogram of diet: 8,960 IU of vitamin A, 1,680 IU of vitamin D₃, 22.4 IU of vitamin E, 1.4 mg of vitamin K₃ (as menadione), 1.4 mg of thiamine, 11.2 mg of riboflavin, 22.4 mg of pantothenic acid (as d-calcium pantothenate), 42 mg of niacin, 0.1 mg of biotin, 2.2 mg of pyridoxine, 0.7 mg of folic acid, and 0.04 mg of vitamin B₁₂.

⁴ Supplied per kilogram of diet: 38 mg of Mn, 125 mg of Fe, 187 mg of Zn, 0.5 mg of Co, 224 mg of Cu, 0.8 mg of I, and 0.25 mg of Se.

Treatments were 1) 6% SDPP, 2) 6% SDPI, and 3) 3% SDPP+3% SDPI.

Diets (table 2) were formulated to contain 3,500 kcal ME/kg and 1.45% lysine with 20% dried whey, 15% milk replacer and 10% lactose. Fish meal and soy protein concentrate were varied to meet amino acid balances among diets with a least cost formulation program (Brill, USA). A corn-soy mix (47% corn, 47% soybean meal and 6% animal fat) was extruded at $130 \pm 2^\circ\text{C}$ with a moist-type extruder (Matador, Denmark), and ground with a hammer mill (2 mm screen in diameter).

Pigs were housed in 2 m \times 2 m pens. Room temperature was maintained at 28-30°C for d 0 to 7 after weaning, and pigs were allowed *ad libitum* access to water and feed during the growth assay. To determine digestibility of the experimental diets, 0.25% chromic oxide was added as an indigestible marker in the diets. A grab of sample of feces was taken from several pigs in each pen and pooled by pen on day

5th and 6th after feeding the experimental diets. Feces were dried in an air-forced drying oven at 60°C for 72 hours for chemical analyses.

Chemical and statistical analyses

Proximate nutrients of the experimental diets and intestinal digesta were analyzed according to the methods of AOAC (1990), and Cr was measured by a spectrophotometer (Contron 942, Italy). Following acid hydrolysis in 6 N HCl at 110°C for 16 hours, amino acids concentration was determined using a HPLC (Waters 486). Statistical analysis was carried out by comparing means according to Duncan's multiple range test (Duncan, 1955), using General Linear Model (GLM) Procedure of SAS (1985) package program.

RESULTS AND DISCUSSION

Profiles and ileal digestibility of amino acids

The amino acid profiles of SDPP and SDPI and

Table 3. Protein amino acid profiles and ileal digestibility of SDPP1 and SDPI used in feeding and digestibility experiments (DM basis)

	Profile (%)		Ileal digestibility (%)					
	SDPP	SDPI	Apparent		SE ³	True		SE
			SDPP	SDPI		SDPP	SDPI	
Crude protein	86.14	58.69	76.67 ^a	67.17 ^b	5.32	83.20 ^a	76.21 ^b	3.90
Amino acids ²								
Indispensable								
Arg	3.87	2.05	76.70 ^a	71.80 ^b	3.10	88.82 ^a	83.93 ^b	3.10
His	2.42	1.36	75.69 ^a	68.37 ^b	4.14	83.37 ^a	76.05 ^b	4.14
Ile	1.67	1.43	73.79 ^a	66.41 ^b	4.29	87.74 ^a	80.35 ^b	4.29
Leu	6.84	2.61	76.62	75.81	1.58	83.41	82.60	1.58
Lys	6.04	4.35	78.70 ^a	73.31 ^b	3.55	86.89 ^a	81.51 ^b	3.55
Met	1.86	0.52	78.45	74.97	2.50	83.69	80.21	2.50
Phe	3.40	1.91	76.63 ^a	73.94 ^b	2.10	87.58	84.89	2.10
Thr	5.33	2.17	75.54 ^a	71.24 ^b	2.87	83.08 ^a	78.78 ^b	2.87
Val	1.46	2.55	68.52	65.83	2.01	78.91	76.23	2.01
Sub-total/mean	32.89	18.95	75.63 ^a	71.30 ^b	2.54	84.83 ^a	80.51 ^b	2.54
Dispensable								
Ala	3.95	2.62	75.40 ^a	67.40 ^b	4.52	86.82 ^a	78.83 ^b	4.52
Asp	8.55	1.98	78.23 ^a	73.68 ^b	2.68	83.28 ^a	78.72 ^b	2.68
Cys	0.73	0.16	78.82	76.88	1.52	85.32	83.38	1.52
Glu	10.69	11.23	77.78 ^a	69.77 ^b	4.54	85.64 ^a	77.63 ^b	4.54
Gly	3.08	1.42	74.56 ^a	70.35 ^b	2.82	88.39 ^a	84.18 ^b	2.82
Pro	4.45	2.90	73.94	69.17	3.77	87.11	82.34	3.77
Ser	5.37	1.76	74.78	74.25	1.76	83.50	82.97	1.76
Tyr	1.93	1.15	75.78 ^a	71.30 ^b	2.75	87.66 ^a	83.18 ^b	2.75
Sub-total/mean	38.75	23.22	76.16 ^a	71.60 ^b	2.76	85.97 ^a	81.40 ^b	2.76
Total/mean	71.64	42.17	75.90 ^a	71.45 ^b	2.64	85.40 ^a	80.95 ^b	2.64

^{a,b} Values with different superscript of the same row are significantly differ ($p < 0.01$).

¹ SDPP: spray-dried plasma protein; SDPI: spray-dried porcine intestine hydrolysate.

² Tryptophan was not analyzed. ³ Pooled standard error.

their ileal digestibility (ID) values are presented in table 3. Total essential amino acid was lower in SDPI than in SDPP (18.95 vs 32.89%), as was crude protein content (58.69 vs 86.14%). Lysine and methionine contents were also lower in SDPI than in SDPP in proportion to their crude protein contents. Like SDPP (Hansen et al., 1993; Owen et al., 1993), methionine in SDPI is regarded as a limiting amino acid in the diets of young pigs.

The apparent and true ID values of the essential amino acids except leucine, methionine and valine were lower ($p < 0.01$) in SDPI than in SDPP. The average apparent ID of essential amino acids in SDPP and SDPI were 75.63 and 71.30%, and the average true ID of essential amino acids were 84.83 and 80.51%, respectively. In case of nonessential amino acids, the apparent and true ileal digestibilities of alanine, aspartic acid, glutamic acid, glycine and tyrosine were lower ($p < 0.01$) in SDPI than in SDPP.

The apparent ID value of essential amino acids in SDPP (75.63%) is similar with the data reported by Chae et al. (1999), but is lower than the data listed in NRC (1998). Chae et al. (1999) reported that the apparent ID values of SDPP in early-weaned (14-d old) and conventionally-weaned pigs (21-d old) were 71.2 and 77.1%, respectively. In NRC (1998), the apparent ID of the most of essential amino acids except methionine is over 84%. The apparent or true ID of essential amino acid (average) in SDPI is 4.3% lower than in SDPP, which is not severely low. The apparent ID of protein sources commonly used in young pig diets is between 70-80% (Chae et al., 1999).

Growth performance

The growth performance of pigs fed SDPP, SDPI or combination of the two protein sources is presented in table 4. The ADG and feed conversion ratio in piglets fed the 6% SDPP diet were better ($p < 0.01$) than in those fed the 6% SDPI diet. Feed intake was not affected by dietary treatments. When 3% of SDPP was replaced by SDPI, however, the growth rate and efficiency of pigs was similar as compared to the diet containing 6% SDPP.

The diet cost per gain (₩/kg weight gain) was significantly ($p < 0.01$) reduced when 3% of SDPP was replaced by SDPI in the phase I diet. In addition, the digestibility of energy was slightly higher in the diet containing SDPP than SDPI, even though there was no significant difference ($p > 0.15$).

Reduced growth rate by feeding 6% SDPI in the starter diet is in agreement with the result of Faltys et al. (1998). They reported that pigs fed SDPP gained significantly faster than those fed the SDPI at the inclusion level of 6% in the phase I diet. But this result for ADG is partially inconsistent with the result

of Kim (2000), who reported that replacing 3% DPS in the phase I diet containing 6% SDPP did not affect daily gain of pigs. Feed conversion ratio was reduced in both trials.

Indeed, SDPP is an excellent protein source in early-weaned pigs. Feed intake is increased when SDPP is included in the starter diet (Hansen et al., 1993; Ermer et al., 1994; Chae et al., 1999). The mechanism by which feed consumption is increased by SDPP is unknown (Kats et al., 1994), however, evidence from the research with plasma strongly suggests that immunoglobulins in plasma are responsible for its positive effects (Zimmerman, 1998).

In the present study, feed intake was not affected by dietary treatments. Reduced rate and efficiency of growth in pigs fed SDPI was probably attributed to the digestibility of nutrients in the experimental diet because the SDPI group showed lower energy digestibility than the SDPP group.

Zimmerman (1998) also compared pig responses with SDPP and SDPI under clean (CE) and dirty (DE) environments. The CE was an isolated nursery room that has been cleaned, disinfected and remained empty for 2 months, and DE was a nursery room that contained older nursery pigs up to the day before the experimental pigs were introduced. Pigs did not respond to feeding SDPI, but responded to SDPP. The growth response to SDPP was of greater magnitude in the DE than in the CE. In the present study, the experiment was conducted in an on-farm nursery facility, which locates near the farrowing unit. So, growth of piglets fed the SDPP diet might be improved due to the efficacy of immunoglobulins in

Table 4. Growth performance and nutrient digestibility as affected by feeding experimental diets in early-weaned pigs¹

	SDPP (6%)	SDPI (6%)	SDPP (3%) +SDPI (3%)	SE ²
Growth performance				
ADG (g)	242 ^a	203 ^b	220 ^{ab}	13.52
ADFI (g)	374	369	356	32.36
Feed/gain	1.55 ^b	1.82 ^a	1.52 ^b	0.17
Diet cost/gain (₩/kg)	1,742 ^{ab}	1,777 ^a	1,606 ^b	93
Apparent fecal digestibility (%)				
Gross energy	79.93 ^{ab}	77.91 ^b	82.41 ^a	2.23
Crude protein	77.51	77.00	79.35	2.68

^{a,b,c} Values with different superscript of the same row are significantly differ ($p < 0.01$).

¹ SDPP: spray-dried plasma protein; SDPI: spray-dried porcine intestine hydrolysate.

² Pooled standard error.

the plasma protein as compared to those fed the SDPI diet.

The SDPI could be an alternative protein source in starter pig diets because it is less expensive than SDPP. Some research data showed that pigs fed diets containing SDPI gained similar or more rapidly and efficiently than those fed diets containing dried whey (Zimmerman, 1996) and soy protein or fish meal (Faltys et al., 1998). SDPI can also be additionally used in diets containing SDPP to maximize piglet performance. The ADG of pigs during phases I and II was improved when 3% SDPI was included in a diet containing 6% SDPP (Kim, 2000). High level of SDPI in starter diets could reduce feed intake for a while. Zimmerman (1996) obtained reduced feed intake in pigs fed a 12% SDPI diet as compared to control (dried whey) and a 6% SDPI diet. But feed intake was similar in the 2nd week after feeding the 12% SDPI diet.

IMPLICATIONS

SDPP is an excellent protein source, but it is too expensive. It would appear that SDPP can be partially replaced by SDPI without any detrimental effect on growth performance in early-weaned pigs.

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