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Effect of Partial Substitution of Dietary Spray-dried Porcine Plasma or Fishmeal with Soybean and Shrimp Protein Hydrolysate on Growth Performance, Nutrient Digestibility and Serum Biochemical Parameters of Weanling Piglets

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ABSTRACT : The present experiment was conducted to study the effects of partial replacement of spray-dried porcine protein (SDPP) or fish meal with soybean and shrimp protein hydrolysate (SSPH) on growth performance, nutrient digestibility and serum biochemical parameters in weaned pigs. Two hundred and forty 21±2 d old pigs ((Pietrain×Duroc)×(Landrace×Large Yorkshire)) with initial weight of 6.9±0.5 kg were randomly allocated to five dietary treatments with six replicates per treatment and eight piglets per replicate. The control diet (T1) contained 2% SDPP and 6% fishmeal, and SDPP for experimental diets T2 and T3 was replaced with 1% and 2% SSPH, respectively, on an iso-nitrogenous basis. The fishmeal for experimental diets T4 and T5 was replaced with 1% and 2% SSPH, respectively, also on an iso-nitrogenous basis. The experimental period was 21 days. The results showed that weaned piglets fed the diets containing 1% and 2% SSPH as a replacement for SDPP had similar average daily gain (ADG), average daily feed intake (ADFI), feed/gain (F/G), diarrhea rate and serum biochemical indices e.g. blood urea nitrogen (BUN), total serum protein (TP), albumin to globulin ratio (A/G), globulin (GLO), serum glucose (GLU), and immunoglobulin G (IgG) to those fed the control diet during 0-10 d and 0-21 d of the experiment. The substitution of 1% SSPH on an iso-nitrogenous basis for fish meal appeared to be beneficial for ADG ($p = 0.59$) and ADFI ($p = 0.23$) of piglets during the overall period. The digestibility of calcium was higher ($p<0.01$) in pigs fed diets containing SSPH than on the control diet. Addition of 1% SSPH on an iso-nitrogenous basis for fish meal could increase the digestibilities of dry matter and energy of the diet. Dietary replacement of fish meal with 1% and 2% SSPH had no effect on the concentrations of BUN, TP, A/G, GLO, GLU, and IgG. In conclusion, dietary SDPP or fish meal could partially replace SSPH without any adverse effect on growth performance, nutrient digestibility and serum biochemical parameters in weaned piglets. (**Key Words :** Protein Hydrolysate, SDPP, Growth Performance, Serum Biochemical Parameter, Nutrient Digestibility, Weaned Piglets)

INTRODUCTION

Newly weaned pigs normally have a depressed feed intake and reduced growth rate (Leibbrandt et al., 1975). Special diets and management schemes have been developed to overcome nutritional problems associated with weaning. A number of studies (Liu et al., 2001; Bikker et al., 2004) have indicated that spray dried porcine protein (SDPP) is an excellent animal protein source which promotes growth performance in weanling piglets. The improved performance in weaned pigs could be due to the immunoglobulin in SDPP which may improve health of the piglets (Godfredson-Kisic and Johnson, 1997). Fish meal is widely used in the diets of young pigs as a relatively inexpensive source of readily digestible, high quality protein. The amino acid profile of fish meal protein is similar to that of the proteins in the sow's milk and in piglet body tissue (Fowler, 1997). Furthermore, fish meal is more easily hydrolyzed into oligo-peptides in the gastrointestinal tract of poultry which allows for easy absorption (Wang et al., 2004).

However, SDPP is an expensive protein source.

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Therefore evaluation of alternatives to SDPP in the diet of weaned pigs is economically important. Protein hydrolysate consists mainly of low molecular weight peptides which can be absorbed rapidly (Wu, 1998). Parisini and Scicipioni (1989) and Rooke et al. (1998) pointed out that peptides in the form of protein hydrolysate could improve growth performance of piglets. However, Richert et al. (1994) and Vente-Spreeuwenberg at el. (2004), found no improvement in growth performance by supplementing unhydrolyzed proteins with hydrolyzed proteins in the diet of early weaned pigs. Neither SDPP nor peptide supplementation affected cytokine mRNA expression (Zhao et al., 2008).

A protein mixture of dehulled soybean meal and shrimp meal was used to prepare soybean and shrimp protein hydrolysate (SSPH). It was used to evaluate the effects of partial substitution of dietary SDPP or fishmeal with SSPH on growth performance, nutrient digestibility and serum biochemical parameters of weanling piglets.

MTERIALS AND METHODS

Preparation of SSPH

A protein mixture of 30% shrimp meal and 70% dehulled soybean meal was hydrolyzed with acid protease. The hydrolysis conditions were 50°C, pH 3.5, initial substrate level 10 g protein/100 ml and the enzyme substrate ratio of 2,000 U/g protein. After the desired reaction time, the hydrolyzed protein mixture was centrifuged to remove the insoluble fraction. The supernatant containing the low molecular weight peptides was spray dried. The dry matter, crude protein, main essential amino acid profiles and the hydroxylation characteristics of the hydrolysate are presented in Table 1. The digestible energy of SSPH was estimated through its content of crude protein, crude fiber, ash and fat.

Animals and experimental design

Two hundred and forty 21±2 days-old cross-bred ((Pietrain×Duroc)×(Landrace×Large Yorkshire)) piglets with an average initial live weight of 6.9±0.5 kg were randomly distributed based on body weight to five dietary treatments of six replicate pens. Special care was taken to ensure an equal distribution of piglets from the same litter between the replicate pens of each treatment. Eight piglets (four males and four females) were kept in each pen. The control group was fed a diet (T1) supplemented with 2% SDPP and 6% fish meal. Dietary treatments were prepared by partial replacement of equivalent amounts of SDPP with 1% and 2% SSPH (T2 and T3) on iso-nitrogenous basis and partial replacement of fish meal (T4 and T5). All diets (Table 2) were formulated on an iso-nitrogenous basis according to NRC (1998) nutrient requirement for young pigs.

Table 1. The chemical composition and the hydrolysation characteristics of SSPH (%)

Item	SSPH[1]
Digestible energy (Mcal/kg)[2]	3.20
Dry matter	93.4
Crude protein	50.9
Degree of hydrolysis[3]	21.9
Essential amino acid[4]	
Arginine	3.27
Histidine	1.58
Isoleucine	1.37
Leucine	2.59
Lysine	2.84
Methionine	1.16
Phenylalanine	2.42
Threonine	2.33
Valine	2.37
Low molecular weight profile (of protein)	
10,000-3,000 Da	6.20
3,000-1,000 Da	10.12
<1,000 Da	20.35
Free amino acids	3.6

[1] SSPH = Soybean and shrimp protein hydrolysate.
[2] The digestible energy of SSPH was estimated from the results of proximate analysis.
[3] The degree of hydrolysis (DH) is the number of peptide bonds broken upon hydrolysis as % of the total number of peptide bonds present in the intact protein.
[4] Tryptophan was not determined.

Pigs were weaned, weighed, and housed in 220 cm×180 cm pens over 3 weeks from the day of weaning. Each pen was equipped with a manual feeder and two nipple drinkers. During the entire experimental period, feed and water were available. The environmental temperature was maintained at 32°C during the first week and at 28°C during the third week post-weaning. The relative humidity was 65.6-70.8% and lights were on from 06:00 to 20:00 h during the whole trial period.

Experimental procedures

Piglets were weighed in each pen on days 0, 10 and 21 of the experiment to calculate average daily gain (ADG). Feed intake was measured for the periods of days 0-10 and days 0-21 of the experiment to calculate average daily feed intake (ADFI) and feed: gain (F/G). The number of piglets with diarrhea per pen was scored every day.

In order to study the effect of SSPH on nutrient digestibility, a digestibility trial was conducted using chromic oxide (0.25%) as an indigestible indicator. The pigs were fed diets mixed with chromic oxide on day 14 and fecal samples were randomly collected from days 18 to 21 and pooled. The fecal samples were dried in a forced-air drying oven at 65°C for 60 h and ground for chemical analysis.

At the end of the experimental period, six piglets per

Table 2. The ingredient composition and nutrient content of the diets (%)

Treatments	T1	T2	T3	T4	T5
Ingredient					
Corn	56.20	55.30	54.50	55.25	54.50
Soybean meal	13.40	13.70	14.00	13.70	14.00
Puffing soybean	13.00	13.00	13.00	13.00	13.00
Whey powder	5.00	5.00	5.00	5.00	5.00
Fish meal	6.00	6.00	6.00	5.20	4.40
SDPP	2.00	1.30	0.60	2.00	2.00
SSPH	0.00	1.00	2.00	1.00	2.00
Soy oil	1.20	1.35	1.55	1.35	1.50
Calcium biphosphate	0.80	0.90	0.90	0.95	1.00
Limestone	0.90	0.85	0.80	0.90	0.95
Salt	0.15	0.15	0.20	0.20	0.20
DL-methionine	0.09	0.10	0.11	0.10	0.10
L-lysine HCl (78%)	0.29	0.30	0.32	0.30	0.31
Premix[1]	1.00	1.00	1.00	1.00	1.00
Threonine	0.00	0.05	0.08	0.03	0.07
Nutrient levels[2]					
Dry matter	87.25	87.51	87.34	87.54	87.13
Digestible energy (Mcal/kg)	3.40	3.40	3.40	3.40	3.40
Crude protein	20.70	20.60	20.73	20.68	20.75
Calcium	0.83	0.83	0.82	0.83	0.83
Total phosphorus	0.72	0.73	0.72	0.73	0.72
lysine	1.40	1.40	1.41	1.40	1.40
Methionine+cystine	0.81	0.81	0.81	0.81	0.81
Threonine	0.90	0.90	0.90	0.91	0.91

[1] Premix provided per kilogram of complete diet: vitamin A, 12,000 IU; vitamin D_3, 2,000 IU; vitamin E, 15 mg; vitamin K_3, 4.5 mg; vitamin B_1, 2 mg; vitamin B_2, 5 mg; vitamin B_6, 3.0 mg; vitamin B_{12}, 0.035 mg; niacin, 4.5 mg; pantothenic acid, 25 mg; folic acid, 0.8 mg; choline chloride, 700 mg; Fe, 100 mg; I, 0.5 mg; Co, 0.5 mg; Cu, 200 mg; Mn, 30 mg; Se, 0.3 mg; Zn, 80 mg.

[2] Dry matter, crude protein, calcium and total phosphorus were analyzed. Other nutrient levels were calculated.

treatment were randomly selected and 5 ml of blood was drawn from the pre-caval vein after an overnight fast. All blood samples were kept at room temperature (20-24°C) for 30 min to allow clot retraction before centrifugation at 3,000×g for 15 min. Serum for biochemical analysis was stored in glass vials at -80°C until analysis for various biochemical parameters.

Proximate analyses of experimental diets, feces and SSPH were carried out following the AOAC (2000) methods. Gross energy was measured by a bomb calorimeter (Model 1261, Parr Instrument Co., Milin, IL) and chromic oxide by automated spectrophotometer (Shimadzu, Japan). The amino acid composition of SSPH was determined with HPLC after hydrolysis with 6 N HCl at 110°C for 24 h. The evaluation of molecular weight distribution of peptides in SSPH was carried out by ultrafiltration (Wang, 2003).

The determination of serum urea nitrogen (BUN), total serum protein (TP), albumin:globulin (A/G), globulin (GLO), serum glucose (GLU), and immunoglobulin G (IgG), was performed with a TBA120FR automatic biochemical analyzer. The biochemical assay kits were produced by Biosino Biotechnology Company Ltd.

Statistical analysis

Statistical analysis was performed according to the general linear model (GLM) procedure of SAS v.8 (SAS, 1999). Mean values of parameters with a significant F-value in the analysis of variance were compared by Duncan's multiple range tests. Pen was used as the experimental unit for the performance and digestibility data, whereas individual pig data were used as the experimental unit for serum biochemical parameters. A level of $p<0.05$ was set as the criterion for statistical significance.

RESULTS

Growth performance

Performance data are presented in Table 3. From 0 to 10 days and 0 to 21 days after weaning, the ADG and ADFI were highest in T4, but not significantly different among treatments ($p>0.05$). Diarrhea rate and F/G were not affected by dietary treatments ($p>0.05$).

Nutrient digestibility

The results of the nutrient digestibility study are presented in Table 4. There were no differences in crude protein and phosphorus digestibilities among treatments ($p>0.05$). Dry matter and energy digestibilities of treatment

Table 3. Effect of partial substitution of dietary SDPP or fishmeal with SSPH on growth performance of weaned piglets during 0-21 d of experimental period

Item	Treatments[1]					SEM[2]	p value
	TI	T2	T3	T4	T5		
Initial weight (kg)	6.9	6.9	7.0	6.9	7.0	0.12	0.999
ADG (g)							
0-10 day	209	181	190	217	193	11	0.890
0-21 day	313	322	334	364	330	10	0.590
ADFI (g)							
0-10 day	207	194	204	223	210	18	0.730
0-21 day	398	419	414	461	419	9	0.230
Feed:gain							
0-10 day	1.02	1.17	1.09	1.05	1.07	0.05	0.920
0-21 day	1.28	1.31	1.25	1.28	1.28	0.03	0.980
Diarrhea rate (%)							
0-10 day	1.36	1.19	1.34	1.78	2.12	0.21	0.680

[1] T2 and T3: dietary SDPP was substituted on a protein-equivalent amount basis by 1% and 2% SSPH respectively; T4 and T5: dietary fish meal was substituted on a protein-equivalent amount basis by 1% and 2% SSPH respectively.
[2] Pooled standard error of means.

Table 4. Effect of partial substitution of dietary SDPP or fish meal with SSPH on nutrient digestibility of weaned piglets (%)

Item	Treatments					SEM[1]	p value[2]
	T1	T2	T3	T4	T5		
Dry matter	76.37^{b}	78.48^{ab}	76.34^{b}	81.03^{a}	76.36^{b}	0.67	0.083
Crude protein	71.14	71.65	68.68	75.59	70.99	0.99	0.285
Energy	76.85^{b}	79.13^{ab}	76.48^{b}	81.47^{a}	76.76^{b}	0.69	0.086
Calcium	71.15^{b}	77.67^{a}	80.56^{a}	76.04^{a}	77.60^{a}	0.91	0.005
Phosphorus	56.15	56.90	60.85	54.72	55.06	1.02	0.350

[1] Pooled standard error of means.

T4 were higher ($p<0.05$) than those of treatments T1, T3 and T5. Calcium digestibility in T1 was lower ($p<0.01$) than in the other dietary treatments.

Serum biochemical parameters

The values of BUN, TP, GLO, A/G, GLU and IgG determined in serum of weaned piglets of all experimental treatments are presented in Table 5 and are within the normal physiological range reported by Friendship and Henry (1996). No significant effects ($p>0.05$) were found on the concentrations of these serum biochemical parameters due to dietary treatments.

DISCUSSION

The results of this study indicated that young piglets grew faster if they ate more after weaning. Studies (Kim et al., 2000, 2001; Lai et al., 2004; Hsia, 2005) reported improvement in feed intake on diets supplemented with SDPP. The mechanism by which feed consumption was increased by SDPP was unknown (Kats et al., 1994). However, evidence showed that the presence of immunoglobulin was responsible for its positive effects (Zinnerman, 1998). Spray-dried bovine colostrum also contains an array of Ig. King et al. (2008) reported that the addition of 5 g/kg spray-dried bovine colostrum to a diet offered for two weeks after early weaning could increase villus height and decrease crypt depth. The weaning-induced reduction in villous height and amino-peptidase activity lowers the capacity of the small intestine to digest and absorb dietary proteins. Thus, it was hypothesized from this study that small peptides in ingested dietary proteins

Table 5. Effect of partial substitution of dietary SDPP or fishmeal with SSPH on serum biochemical indices of piglets

Item	Treatments					SEM[1]	p value[2]
	T1	T2	T3	T4	T5		
TP (g/L)	39.75	45.00	42.25	45.75	41.75	1.07	0.074
A/G	1.95	2.08	1.90	2.30	1.95	0.08	0.490
IgG (g/L)	2.71	2.94	2.59	2.31	2.61	0.08	0.146
GLO (g/L)	13.75	14.75	15.00	12.75	14.25	0.43	0.540
GLU (mmol/L)	3.58	5.46	3.23	3.79	4.98	0.32	0.113
BUN (mmol/L)	2.98	3.32	3.47	3.14	3.15	0.11	0.710

[1] Pooled standard error of means. [2] Probability of Duncan's multiple comparisons among five treatments.

would increase the availability of amino acids for the gut wall and therefore counteract the decrease in small intestinal integrity after weaning. However, studies of effects of protein hydrolysate supplementation on growth performance in weanling piglets produced conflicting results. Some piglet trials comparing the feeding of unhydrolysed proteins with hydrolyzed proteins showed either similar (Caine, 1997) or increased (Vente-Spreeuwenberg et al., 2004) growth rates. In this experiment, partial substitution of dietary SDPP by 1% and 2% SSPH or fish meal in diets did not affect growth performance, feed intake and diarrhea rate. Similar results were reported by Kim et al. (2000), who observed that replacing 3% spray dried porcine intestine hydrolysate in a diet containing 6% SDPP did not affect ADG or ADFI of pigs.

Weanling piglets often suffer from post-weaning diarrhea. In the pathogenesis of these diseases, enteropathogenic *Escherichia coli* strains play a major role (Nabuurs, 1998). However, in this trial, the diarrhea rates of all treatments were very low.

In this study, dry matter and energy digestibilities of the dietary treatment containing 1% SSPH as replacement of fish meal were higher than those of dietary treatment containing 2% SDPP. Calcium digestibility of dietary treatments containing SSPH was higher than that of dietary treatment containing 2% SDPP. The utilization of nitrogen from diets with small peptides was more efficient than that from diets with corresponding synthesized amino acids or natural protein as reported by Boza (1995). Parisini at al. (1989) found that the addition of peptides in the form of protein hydrolysate to the diet of growing pigs could significantly enhance daily gain, protein digestibility and feed conversion rate. In another trial, inclusion of 0.3% soybean bioactive peptides in soybean protein hydrolysate in a basal diet with no SDPP improved the growth performance of weaned piglets (Yue, 2005).

The parameters selected for the biochemical profile reflected the metabolic characteristics of weaned piglet. The total and fractionated proteins, GLU and BUN may reflect the synthetic ability of the organ. In this study, iso-nitrogenous substitution of dietary SDPP or fish meal for 1% and 2% SSPH had no effects on BUN, TP, GLO, A/G, GLU and IgG. This result indicated that SSPH, SDPP and fish meal had a similar effect on protein metabolism and immune status in weaned pigs.

In conclusion, dietary SDPP or fish meal could be partially replaced by SSPH without any adverse effect on growth performance, nutrient digestibility and serum biochemical parameters in weaned piglets.

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