Evaluation of Bio-V-Pro® as an Alternative Protein Source in Broiler Diets

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ABSTRACT : The experiment was conducted to evaluate Bio-V-Pro as an alternative protein source in broiler diets. Treatments were control, Bio-V-Pro 1% (BP 1), Bio-V-Pro 3% (BP 3), and Bio-V-Pro 5% (BP 5). During the starter period, all treated groups showed better performance than control group in weight gain and feed intake ($p < 0.05$). The best FCR was observed in BP 1 group and the worst was found in BP 5 group. For the overall period, chicks fed BP 1 and BP 3 diets gained more than the chicks fed the control and BP 5 diets. All Bio-V-Pro fed groups consumed more feed than the control group ($p < 0.05$). FCR were similar between the control and BP 1 group, but BP 3 and BP 5 groups showed higher FCR than the control group. During the starter period, all BP groups showed better utilizability of crude protein, crude ash and phosphorus than the control group ($p < 0.05$). For the finisher period, except for the BP 5 group, the nutrient utilizability was not significantly different in most nutrients.

Nutrients utilizability had a tendency (not significant) to decrease as the level of Bio-V-Pro in the diet was increased. Lysine utilizability was not affected by the dietary treatment, however, methionine utilizability was higher in BP 1 and BP 3 group than in the control group. From the results of this experiment, it seems that Bio-V-Pro is a good alternative protein source which can replace fish meal in starter diet up to 3% of the diet effectively.
(**Key Words**: Bio-V-Pro, Broiler, Growth Performance, Protein Sources)

INTRODUCTION

Feed cost was the primary factor to increase the production expenses in animal production, especially for the monogastric animals. An important challenge is to reduce the production cost in animal industry. Recently, protein sources became the limiting factor in terms of availability and cost in feed formulation whether it is originated from animal sources or vegetable sources. As a consequence, several researches have been actively conducted to find out new alternative protein sources in animal diets, such as yeast (Ringrose, 1949; Samuel and Zimmerman, 1977), single cell protein (Zimmerman and Samuel, 1977; D'Mello et al., 1976) and eprin and paprin (Han et al., 1995).

One can easily cope with the fluctuation of feed cost in the international trade market, when one has various route to provide an alternative protein sources for the animal feed production. Also it is very important to evaluate relatively unknown feed ingredients which have fairly good balanced amino acids composition.

Fish meal has been widely used as a good animal protein source in the diets for the monogastric animals, specially for young chicks. However, it is extremely expensive, and production has been decreased theseday. Thus there is a great need to replace fish meal with alternative protein sources in the animal diets. Recently, Seoul National University found that Bio-V-Pro®, an extruded mixture of animal and plant proteins of non-conventional raw materials, which was originated from India, has a relatively high crude protein content and quite a good amino acids composition. Its lysine and methionine contents were comparable with those of soybean meal and fish meal.

Thus this experiment was designed to evaluate Bio-V-Pro as an alternative protein source in broiler diets. In this experiment, the availability of proximate nutrients, amino acids and gross energy were measured and the performance of broiler fed containing graded levels of Bio-V-Pro was also examined.

MATERIALS AND METHODS

1. Experimental design

This experiment consisted of 4 treatments. Corn-

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soybean meal-fish meal based diet was used as a control, and fish meal was replaced with Bio-V-Pro at the level of 1% (BP 1), 3% (BP 3), 5% (BP 5), respectively. Each treatment had 9 replicates consisted of 6 male arbor acre broiler chicks in each replicate and represented averaging 54 birds per treatment.

2. Experimental animals, period and location

Male broiler chicks of arbor acre produced by Han Ⅱ breeding Farm (Osan, Korea) were used as experimental subjects. At one day of age, experimental animals were chosen to have uniform initial body weight and fed the experimental diets for six weeks. A randomized complete design was used in assigning chicks to treatments, in which a total of 216 chicks were used. All feeding trial, metabolic trial, chemical analysis and statistical analysis were conducted in the Animal Nutrition Laboratory, Department of Animal Science and Technology, College of Agriculture and Life Sciences, Seoul National University located in Suweon, Korea. Feeding trial initiated on April 10, 1996 and terminated on May 23, 1996.

3. Experimental diets

Experimental diets were formulated on a corn soybean meal basis to meet the NRC (1994) requirements for the starter period (table 1) and the finisher period (table 2). For starter period, the diet was formulated to 23% crude protein, 1.21% lysine, and 0.9% Met + Cys, while for

Table 1. Composition of the experimental diets for starter period (1 - 3 weeks)

	Control	Bio-V-Pro(1%)	Bio-V-Pro(3%)	Bio-V-Pro(5%)
Ingredients:				
Corn	59.22	58.75	58.16	57.34
Soybean meal	27.84	28.10	27.99	28.28
Corn gluten meal	4.51	4.51	4.97	5.20
Fish Meal	5.00	4.00	2.00	0.00
Tallow	1.02	1.08	0.91	0.85
Limestone	0.09	0.23	0.57	0.88
Tri-calcium phosphate	1.60	1.60	1.60	1.60
Vit-Min. Mix[1]	0.40	0.40	0.40	0.40
Salt	0.22	0.22	0.22	0.22
Methionine	0.05	0.06	0.08	0.09
Antibiotics	0.05	0.05	0.05	0.05
Bio-V-Pro	0.00	1.00	3.00	5.00
Lysine · HCl	0.00	0.00	0.05	0.09
Total	100.00	100.00	100.00	100.00
Chemical composition[2]:				
GE (kcal/kg)	4,075	4,034	4,027	4,007
CP (%)	23.03	23.01	23.00	23.00
Lysine (%)	1.21	1.21	1.21	1.21
Met+Cys (%)	0.91	0.90	0.90	0.90
Ca (%)	1.00	1.00	1.00	1.00
Avail. P (%)	0.45	0.45	0.45	0.45

[1] Vit,-Min. mixture contains the following per kg diet: vitamin A, 10,000 IU; vitamin D_3, 1,500 IU; vitamin K_3, 5 mg; vitamin E, 15 mg; vitamin B_2, 8 mg, vitamin B_{12}, 0.008 mg; Ca-d-pantothenate, 8 mg; niacin, 25 mg; folic acid, 0.4 mg; biotin, 0.2 mg; choline, 500 mg; pyridoxine, 1 mg; B. H. T. 125 mg; Co, 0.85 mg; I. 1.29 mg; Zn, 100 mg; Mg, 100 mg; Cu, 8.75 mg; Se, 0.15 mg; Fe, 35 mg.
[2] Calculated Value.

Table 2. Composition of the experimental diets for finisher period (4 - 6 weeks)

	Control	Bio-V-Pro(1%)	Bio-V-Pro(3%)	Bio-V-Pro(5%)
Ingredients:				
Corn	67.84	67.86	67.40	66.75
Soybean meal	20.40	20.40	20.19	20.15
Corn gluten meal	3.94	3.94	4.47	4.91
Fish Meal	5.00	4.00	2.00	0.00
Tallow	0.52	0.50	0.30	0.17
Limestone	0.42	0.42	0.75	1.07
Tri-calcium phosphate	1.21	1.21	1.21	1.21
Vit-Min. Mix[1]	0.40	0.40	0.40	0.40
Salt	0.22	0.22	0.19	0.20
Methionine	0.00	0.00	0.00	0.01
Antibiotics	0.05	0.05	0.05	0.05
Bio-V-Pro	0.00	1.00	3.00	5.00
Lysine · HCl	0.00	0.00	0.04	0.08
Total	100.00	100.00	100.00	100.00
Chemical composition[2]:				
GE (kcal/kg)	3,990	3,973	4,017	3,999
CP (%)	20.10	20.00	20.00	20.00
Lysine (%)	1.02	1.00	1.00	1.00
Met+Cys (%)	0.74	0.74	0.72	0.72
Ca (%)	0.95	0.90	0.90	0.90
Avail. P (%)	0.35	0.35	0.35	0.36

[1] Vit,-Min. mixture contains following in 1 kg of the diet; vitamin A, 10,000 IU; vitamin D_3, 1,500 IU; vitamin K_3, 5 mg; vitamin E, 15 mg; vitamin B_2, 8 mg, vitamin B_{12}, 0.008 mg; Ca-d-pantothenate, 8 mg; niacin, 25 mg; folic acid, 0.4 mg; biotin, 0.2 mg; choline, 500 mg; pyridoxine, 1 mg; B. H. T. 125 mg; Co, 0.85 mg; I. 1.29 mg; Zn, 100 mg; Mg, 110 mg; Cu, 8.75 mg; Se, 0.15 mg; Fe, 35 mg.
[2] Calculated Value.

Table 3. Nutrient composition of SBM, FM and BIO-V-PRO[1]

	SBM (44%)	FM (60%)	Bio-V-Pro
Proximate composition:			
Moisture (%)	9.11	6.35	5.98
C. Fat (%)	3.14	4.50	4.28
C. Ash (%)	6.03	16.40	–
C. Protein (%)	42.03	56.79	55.00
Gross energy (kcal/kg)	3,843	4,133	3,651
Amino acids (%):			
ASP	4.02	4.36	4.76
THR	1.38	1.91	1.81
SER	1.81	2.20	2.16
GLU	8.19	7.40	6.59
RRO	1.60	3.04	3.91
GLY	1.40	5.26	6.92
ALA	1.88	4.29	4.14
VAL	1.66	2.50	2.20
MET	0.51	1.19	1.04
ILE	1.79	1.88	1.67
LEU	2.83	4.25	3.13
TYR	1.29	1.96	3.37
PHE	2.13	2.02	2.55
HIS	1.10	1.62	1.53
LYS	2.21	3.13	2.94
ARG	3.15	3.24	3.21
Total	37.00	50.26	51.95
Fatty acids[2]:			
C 12:0	0.00	5.31	0.00
C 14:0	0.00	0.00	0.00
C 16:0	20.39	27.34	24.12
C 16:1	0.00	1.92	6.94
C 18:0	4.61	8.49	3.93
C 18:1	14.28	35.06	12.24
C 18:2	60.73	24.89	0.87
C 18:3	0.00	1.52	0.00
C 20:0	0.00	0.78	8.97
C 20:5	0.00	0.00	17.69
C 22:6	0.00	0.00	19.93
Trace elements (%):			
P	0.60	2.74	1.01
Cr	0.00	0.00	0.27
Ca	0.18	3.70	0.51
Na	0.02	0.91	0.57
Fe	0.03	0.02	0.23
K	2.32	0.74	1.12
Mg	0.35	0.28	0.52
Zn	0.00	0.00	0.01

[1] Analyzed Value, on the basis of fresh feed.
[2] Values are expressed as the percentage of total fatty acid methyl ester.
SBM: soybean meal; FM: fish meal.

finisher period, the diet was formulated to 20% crude protin, 1.0% lysine and 0.74% Met + Cys. The proximate nutrients composition of Bio-V-Pro is presented in table 3.

4. Methods of experiments

1) Feeding trial

All the chicks were raised in battery cages made of steel wire and housed in room with a constant light and air ventilation. Before the feeding trial began, the chicks were fed a commercial diet for one day. Experimental diets and drinking water were provided *ad libitum* during the entire experimental period of six weeks. Body weight and feed intake were recorded weekly on replication basis to calculate the weight gain and feed conversion ratio. Feed conversion ratio was calculated by dividing the amount of feed consumed with the corresponding body weight gain.

2) Metabolic trial

To measure the nutrient utilizability of the experimental diets, the metabolizability coefficient was calculated by total fecal collection method during seven days at the end of the starter period and finisher period, respectively. Six and four chicks per treatment for the starter period and finisher period, respectively, were chosen and caged in the metabolic cage in pair for the starter and individually for the finisher period, respectively and experimental diets and water were fed to satiation. After four days of adaptation, total excreta were collected four times a day for the three consecutive days to avoid the contamination of foreign materials such as feed, feathers and scales. Collected excreta were pooled and dried in an air-forced drying oven at 60℃ for 72 hours to gain constant dry weight and were ground with 1 mm Wiley mill for chemical analysis.

3) Chemical analysis

Analysis of proximate nutrients composition of experimental diets and excreta was conducted according to the methods of AOAC (1990), and amino acids composition was measured using an automatic amino acid analyzer pharmacia Biotech, Biochrom 20, England. Crude ash and phosphorus content were measured using the Atomic Absorption spectrophotometer (Shimadzu, AA 6401F, Japan) and gross energy content of feeds and excreta were measured using the Bomb Calorimeter (Parr Instrument Co., Model 1241, USA).

4) Statistical analysis

Statistical analysis for the present data 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

1. Nutrients composition

Analyzed nutrients composition of Bio-V-Pro are presented and compared with SBM and FM in table 3. Bio-V-Pro has an excellent crude protein content and amino acids composition compared to SBM. Bio-V-Pro has similar crude protein content with FM. Bio-V-Pro also has a pretty good fatty acids composition, it was found that Bio-V-Pro has substantial amounts of high unsaturated fatty acids which are called eicosapentaenoic acid (EPA) and docosahexaenoic acid (DHA). In terms of mineral contents, Bio-V-Pro seems has potential to be a good mineral sources for monogastric animals. Bio-V-Pro was relatively high in calcium, phosphorus, iron and magnesium content.

2. Growth performance

The effect of graded levels of Bio-V-Pro on the growth performance in growing broiler chicks are presented in table 4.

Table 4. Effects of BIO-V-PRO on the growing performance of broiler chicks

Treatment	Initial Body Weight (g)	Final Body Weight (g)	Weight Gain (g)	Feed inake (g)	F/G
Starter					
Control	49.2	615.4^{c}	566.2^{c}	933.2^{b}	1.65^{b}
Bio-V-Pro(1%)	49.1	782.6^{a}	733.6^{a}	1,097.8^{a}	1.50^{d}
Bio-V-Pro(3%)	49.2	753.2^{a}	703.9^{a}	1,109.0^{a}	1.58^{c}
Bio-V-Pro(5%)	49.2	705.5^{b}	656.3^{b}	1,138.5^{a}	1.73^{a}
PSE[1]	0.05	11.97	11.97	15.54	0.02
Finisher					
Control	615.4^{c}	1,930.5^{b}	1,315.2	2,507.9^{b}	1.91^{c}
Bio-V-Pro(1%)	782.6^{a}	2,103.9^{a}	1,321.3	2,753.8^{a}	2.08^{b}
Bio-V-Pro(3%)	753.2^{a}	2,041.9^{a}	1,288.7	2,715.3^{a}	2.11^{b}
Bio-V-Pro(5%)	705.5^{b}	1,971.9^{b}	1,266.4	2,783.3^{a}	2.20^{a}
PSE[1]	11.97	15.31	10.89	29.19	0.02
Overall					
Control	49.2	1,930.5^{b}	1,881.3^{b}	3,441.1^{b}	1.83^{c}
Bio-V-Pro(1%)	49.1	2,103.9^{a}	2,054.8^{a}	3,851.6^{a}	1.87^{bc}
Bio-V-Pro(3%)	49.2	2,041.9^{a}	1,992.6^{a}	3,824.3^{a}	1.92^{b}
Bio-V-Pro(5%)	49.2	1,971.9^{b}	1,922.7^{b}	3,921.8^{a}	2.04^{a}
PSE[1]	0.05	15.31	15.31	41.27	0.02

Average initial body weight was 49.18 g.
[1] Pooled standard error.
^{a,b,c,d} : Values with different superscripts within the same column significantly differ ($p < 0.05$).

During the starter period, all treated groups showed better performance than control group in weight gain and feed intake. Weight gain was improved by 16 to 30% with feeding Bio-V-Pro, regardless of the level of Bio-V-Pro in the diet ($p < 0.05$). Feed intake was also improved. Chicks fed diets containing Bio-V-Pro consumed more feed than the chicks fed the control diet by 18 to 22% ($p < 0.05$). Feed conversion ratio (FCR) was also improved in BP 1 and BP 3 group but in BP 5 group FCR was higher than the control group. The best FCR was observed in BP 1 group and the worst was found in BP 5 group. FCR showed the tendency that it increased linearly as Bio-V-Pro level was increased. This might be due to the low availability of the energy of Bio-V-Pro product.

However, during the finisher period, Bio-V-Pro did not improve the growth rate of the chicks. No significant difference in weight gain was found among the treatment, while feed consumption were still higher in Bio-V-Pro fed groups ($p < 0.05$). This resulted in significantly higher FCR in Bio-V-Pro fed groups ($p < 0.05$).

For the overall period, chicks fed BP 1 and BP 3 diets gained more than the chicks fed the control and BP 5 diets. All Bio-V-Pro fed groups consumed more feed than the control group ($p < 0.05$). FCR was similar

between the control and BP 1 group, but BP 3 and BP 5 groups showed higher feed conversion ratio than the control group.

From the results of this experiment, it can be concluded that Bio-V-Pro can replace fish meal effectively up to 3% of the diet, namely 60% of the fish meal in the diet.

3. Nutrient utilization

1) Starter period

Nutrient utilizability during the starter period is summarized in table 5.

Table 5. Effests of BIO-V-PRO on nutrient utilizability of broiler chicks (%)

Treatment	DM	C. Protein	C. Fat	C. Ash	P	GE
(1-3 weeks)						
Control	71.17^{ed}	52.69^{b}	78.48^{b}	36.65^{cde}	47.01^{bc}	75.40^{d}
Bio-V-Pro(1%)	74.60^{abc}	60.63^{a}	84.01^{a}	45.01^{b}	57.38^{a}	80.71^{ab}
Bio-V-Pro(3%)	73.92^{c}	60.84^{a}	84.42^{a}	50.22^{a}	57.00^{a}	79.56^{bc}
Bio-V-Pro(5%)	69.80^{e}	60.95^{a}	78.03^{b}	48.10^{ab}	54.70^{ab}	78.87^{d}
(4-6 weeks)						
Control	76.51^{a}	59.42^{ab}	80.67^{ab}	40.44^{c}	40.23^{c}	82.02^{a}
Bio-V-Pro(1%)	76.31^{a}	58.51^{ab}	83.16^{ab}	35.63^{de}	44.19^{c}	81.67^{a}
Bio-V-Pro(3%)	75.84^{ab}	56.42^{ab}	70.15^{c}	39.48^{cd}	41.88^{c}	81.35^{a}
Bio-V-Pro(5%)	72.68^{cd}	56.55^{ab}	67.72^{c}	33.85^{e}	46.43^{bc}	79.13^{c}
PSE[1]	0.48	0.82	1.27	1.13	0.47	1.50
Effect of Age (1-3 weeks vs 4-6 weeks)						
Control	0.0001	0.0407	0.3535	0.0655	0.1233	0.0001
Bio-V-Pro(1%)	0.0743	0.5000	0.7153	0.0001	0.0053	0.1791
Bio-V-Pro(3%)	0.0468	0.1657	0.0001	0.0001	0.0018	0.0178
Bio-V-Pro(5%)	0.0046	0.1681	0.0002	0.0001	0.0638	0.0001
Effect of Treatment						
Control	74.22^{a}	56.54	79.73^{ab}	38.81	43.13	79.18^{ab}
Bio-V-Pro(1%)	75.58^{a}	59.42	83.52^{a}	39.65	49.84	81.27^{a}
Bio-V-Pro(3%)	75.01^{a}	58.31	76.26^{bc}	44.08	48.36	80.58^{a}
Bio-V-Pro(5%)	71.44^{b}	58.43	72.14^{c}	39.96	49.97	77.73^{b}

[1] Pooled standard error.

^{a,b,c,d,e} Values with different superscripts within the same column significantly differ ($p < 0.05$).

Dry matter utilizability was higher in BP 1 and BP 3 group by 4.8 to 6.9 percentage units ($p < 0.05$), and energy utilizability was also higher in BP 1 and BP 3 ($p < 0.05$). All BP groups showed better utilizability of crude protein, crude ash and phosphorus than the control group ($p < 0.05$), while crude fat utilizability was not significantly different among treatments.

Therefore, it can be concluded that the better growth performance obtained in BP 1 and BP 3 during the starter period was due to the high nutrient utilizability, particulary energy, of the BP 1 and BP 3 diets. However, the mechanism through which Bio-V-Pro improved the growth performance of the chicks was not identified in this study.

2) Finisher period

For the finisher period, except for the BP 5 group, the nutrient utilizability was not significantly different in most nutrients. With the exception for crude fat and crude ash, the utilizability of the nutrient was similar among the control, BP 1 and BP 3 group. Nutrients utilizability had a tendency to decrease when the level of Bio-V-Pro in the diet increased, but no significant difference was found.

This also matches well with the results of growth performace during the finisher period. Thus, it seems that Bio-V-Pro is more effective when added in starter diets.

As shown in table 5, nutrient utilizability of finishing period showed higher value than the those of starter period and regardless of age, BP 1 and BP 3 group

showed higher dry matter, crude fat and gross energy digestibility compared to control and BP 5 group.

4. Amino acids utilizability

For the starter period, except for the BP 5 group, the amino acids utilizability was similar in most of the amino acids measured. Lysine utilizability was not significantly different among the control, BP 1 and BP 3 groups, however, methionine and cystine utilizability in BP 1 and BP 3 group was significantly higher than in the control and BP 5 group ($p < 0.05$). BP 1 group showed the highest utilizability in most amino acids measured and BP 5 group showed the lowest.

During the finisher period, unlike the starter period, the utilizability of most amino acids measured was not significantly different among the treatments.

Table 6 and 7 summarized the utilizability of the amino acids of the experimental diets during the starter period and finisher period, respectively.

Table 6. Apparent fecal utilizabilities of amino acids in experimental diets (%, 1-3 weeks)

	Control	Bio-V-Pro (1%)	Bio-V-Pro (3%)	Bio-V-Pro (5%)	PSE
EAA (%)					
THR	81.13^{ab}	85.84^{a}	81.03^{ab}	78.42^{b}	1.10
VAL	82.31^{ab}	85.64^{a}	82.33^{ab}	79.80^{b}	0.84
MET	87.46^{c}	92.54^{a}	90.45^{ab}	88.39^{bc}	0.70
ILU	86.58^{ab}	88.71^{a}	86.46^{ab}	84.20^{b}	0.72
LEU	88.30^{b}	92.18^{a}	90.03^{ab}	88.04^{b}	0.68
PHE	88.29^{ab}	90.97^{a}	89.36^{ab}	87.12^{b}	0.63
LYS	88.24^{a}	88.28^{a}	89.49^{a}	84.50^{b}	0.69
HIS	87.07^{ab}	89.86^{a}	88.32^{ab}	86.39^{b}	0.63
ARG	92.32^{ab}	92.81^{a}	91.91^{ab}	90.66^{b}	0.33
Sub-mean	86.86^{ab}	89.65^{a}	87.71^{ab}	85.28^{b}	0.65
NEAA (%)					
ASP	85.40^{a}	87.41^{a}	82.90^{ab}	79.65^{b}	1.08
SER	84.89^{ab}	88.73^{a}	85.31^{ab}	82.77^{b}	0.91
GLU	90.56^{ab}	92.52^{a}	90.19^{ab}	88.55^{b}	0.62
PRO	84.76^{b}	90.23^{a}	87.67^{ab}	85.87^{b}	0.79
GLY	71.97	76.36	64.82	70.05	2.02
ALA	85.11^{ab}	89.34^{a}	85.92^{ab}	83.22^{b}	0.87
TYR	88.81^{ab}	91.39^{a}	90.03^{a}	86.30^{b}	0.72
Sub-mean	84.50^{ab}	88.00^{a}	83.83^{ab}	82.34^{b}	0.84
Average (%)	86.68^{ab}	88.82^{a}	85.77^{ab}	83.81^{b}	0.74

^{a,b,c} Values with different superscripts within the same row significantly differ ($p < 0.05$).

Table 7. Apparent fecal utilizabilities of amino acids in experimental diets (%, 4-6 weeks)

	Control	Bio-V-Pro (1%)	Bio-V-Pro (3%)	Bio-V-Pro (5%)	PSE
EAA (%)					
THR	84.62	86.39	83.25	84.52	0.63
VAL	85.24^{a}	86.13^{a}	81.64^{b}	83.82^{ab}	0.64
MET	90.77	91.07	87.99	89.57	0.54
ILU	87.41	87.80	84.38	86.62	0.61
LEU	91.35	91.16	88.94	91.02	0.46
PHE	89.93	89.86	87.43	89.77	0.48
LYS	88.35^{ab}	88.73^{a}	85.37^{b}	88.04^{ab}	0.56
HIS	89.73	89.88	87.76	89.21	0.47
ARG	93.36	93.36	91.69	91.90	0.31
Sub-mean	88.97	89.38	86.49	88.27	0.50
NEAA (%)					
ASP	87.57	87.38	83.64	85.71	0.68
SER	89.61^{a}	87.97^{b}	86.10^{b}	87.35^{b}	0.55
GLU	91.90	91.43	89.26	90.85	0.45
PRO	88.07	88.44	86.39	87.88	0.45
GLY	71.07^{ab}	75.40^{a}	67.94^{b}	69.52^{b}	1.06
ALA	87.71^{a}	87.50^{a}	83.25^{b}	85.51^{ab}	0.71
TYR	90.62^{a}	90.34^{a}	86.48^{b}	88.95^{ab}	0.59
Sub-mean	83.84	86.92	83.29	84.79	0.72
Average (%)	86.41^{ab}	88.15^{a}	84.89^{b}	86.69^{ab}	0.53

^{a,b} Values with different superscripts within the same row significantly differ ($p < 0.05$).

IMPLICATIONS

Bio-V-Pro is a relatively unknown protein source which has fairly good amino acids and nutrient composition. Through this experiment, Bio-V-Pro appeared a good alternative protein source which can replace fish meal up to 3% in starter diets of chickens.

However, the reason of the improvement in growth performance and amino acids utilizability was not clearly shown in this study. Thus more study is required to show the mechanism in which how Bio-V-Pro improves the performance of monogastric animals including pigs.

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