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Effects of Origins of Soybean Meal on Growth Performance, Nutrient Retention and Excreta Microflora of Broilers

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ABSTRACT An experiment was conducted to determine the effects of origins of soybean meal (SBM) on growth performance, nutrients and energy retention and fecal microflora in broilers. The SBM originating from Korea, Brazil and India were used. A total of 480 broiler chicks (average initial BW, 41.8 g) were randomly allotted to 6 treatments. Each treatment had 4 replicate pens with 20 chicks per pen. Birds were fed diets containing SBM originated from Korea (domestic SBM), Brazil or India (imported SBM) and the diets were based on the total amino acid (TAA) or true digestible amino acid (TDAA). Experimental diets were fed in two phases, starter (d 0～21) and finisher (d 22～35). The overall weight gain, feed intake and FCR were better (P<0.05) in birds fed Korean SBM. During starter and finisher periods, birds fed diets containing Korean SBM had greater (P<0.05) retention of GE, DM, and CP (P<0.05) as compared with Birds fed diets containing SBM from India. In addition, diets formulated on TDAA basis had grater (P<0.05) CP retention during starter period and DM, GE and CP retention during finisher period. There were no differences (P>0.05) in the excreta microflora and overall feed cost per kg body weight gain in birds fed SBM from different origins; however, diets formulated on TDAA basis had lesser (P<0.05) feed cost per kg body weight gain in birds when compared with diets formulated on TAA basis. These results indicate that Korean SBM has better nutrients digestibility than SMB originated from Brazil and India, which contributes to the improved performance of broilers. In addition, better performance was obtained when diets were formulated on TIDAA basis.

(Key words : origin of soybean meal, growth performance, nutrient digestibility, excreta microflora, economic analysis)

INTRODUCTION

Soybean-meal (SBM) is the most commonly used feed ingredient in the diet of non-ruminant animals because of its relatively high protein contents, excellent amino acid profile and dependable supply (Kim et al., 1999; Cromwell, 2000). In pigs and poultry diets, SBM account for approximately 62% of proteinaceous ingredients (ASA, 2002). Because of the good amino acid profile, SBM is usually used to balance the dietary amino acid levels with cereal grains and their byproducts in poultry feeds. United State is a leading producer of soybean (37%), followed by Brazil (26%), China (21%), Argentina (17%) and India (4%; USDA, 2009). Unlike most plant-originated protein sources, SBM contains a relatively large amount of lysine. However, SBM is low in sulfur-containing amino acids, with methionine being the most significant limiting amino acid for poultry, followed by cystine and threonine (Eggum and Beames, 1983). Also, SBM contains some antinutritional factors such as trypsin inhibitor, lectins and lipoxygenase (Ward, 1996). These antinutritional are destroyed by heat treatment before inclusion of SBM in poultry diets. However, improper heat treatments destroy or denature the proteins in SBM, which results in the variation in nutrients contents of SBM from different batches or origins (Araba and Dale, 1990; Lee and Garlich, 1992).

Several studies have shown considerable differences in nutrient content of SBM within and among geographic regions of the world (Baize, 1997; Grieshop et al., 2003). Because of difference in environmental conditions, genetics varieties and processing conditions, SBM chemical compositions including contents of oligosaccharides, protease inhibitors and fiber differs among different geographic regions (Baker and Stein, 2009; Kumar et al., 2010). This results in the variation in nutrient digestibility and performance of food producing animals fed SBM originated from different regions (Grieshop and Fahey, 2001; Karr-Lilienthal et al., 2005; van

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Kempen et al., 2006). However, little research has been done on comparing the effects of origin of SBM on the performance and nutrients digestibility in broilers. Therefore, in this experiment, SBM obtained from three countries (Korea, Brazil and India) was evaluated for its influence on performance, nutrient retention, excreta microbial populations and economic analysis in broilers. Additionally, comparisons were made with diets formulated based on total amino acid (TAA) and true digestibility amino acid (TDAA).

MATERIALS AND METHODS

The protocol for this experiment was approved and birds were cared according to the guidelines of the Institutional Animal Care and Use Committee of Kangwon National University, Chuncheon, Republic of Korea.

1. Birds and Diets

A total of 480 broilers (initial BW, 41.8 g) were randomly allotted to 6 treatments on the basis of BW. Each treatment had 4 replicate pens with 20 chicks per pen. Broilers were fed diets containing SBM originated from Korea (domestic), Brazil or India (imported) and the diets were based on the total amino acid (TAA) or true digestible amino acid (TDAA). Korean SBM was freshly prepared (one month before experimental feeding), while SBM imported from India and Brazil were prepared 4 months before the experimental feeding. The main objective of this experiment was to compare the effect of origin of SBM when diets containing SBM from different origins were formulated based on TAA and TDAA basis. Treatment diets containing domestic and imported (Brazil and India), were formulated based on TAA and TDAA. Experimental diets were fed in two phases, starter (d 0~21) and finisher (d 22~35). Diets for starter (Table 1) were formulated to contain 3,200 kcal/kg of ME and 23.0 % of CP. Diets for finisher (Table 2) were formulated to contain 3,200 kcal/kg ME and 20.0 % of CP. All diets met or exceeded the nutrient requirements, as suggested by the NRC (1994).

The birds were housed in rice hull-covered floor pens. Each pen was provided with a self-feeder and hanging bell drinker to allow free access to feed and water. The house temperature was maintained at 34℃ for the first 5 days and then gradually reduced according to normal management practices, until a temperature of 23℃ was achieved. Lighting was provided for 23 h/d.

2. Experimental Procedures

The pen weight (at d 1, 21 and 35) and pen feed intake (FI) was noted at the end of each phase to calculate BW gain and feed conversion ratio (FCR) for starter and finisher phases. Overall FI, BW gain, and FCR were calculated for whole duration of experiment. Two nutrient retention trials were conducted by using 2 birds from each pen by housing them in individual metabolic cages. These birds were fed the diets containing chromic oxide (0.25%) during the last 7 days of each starter and finisher phase and excreta samples were collected for the last 3 days. The excreta samples of these birds collected over a 3-d period were pooled to represent 1 pen. Excreta were dried in a forced-air drying oven at 60℃ for 3 d and ground to pass through a 1-mm screen using a hammer mill (Buhler, Switzerland) for chemical analysis. Additionally, excreta samples were collected from each bird used for digestibility trial for microbial analysis.

3. Chemical and Microbial Analysis

Experimental diets and excreta samples were analyzed in triplicate for DM (Method 930.15), CP (Method 990.03), ash (method 942.05), Ca and P (Method 985.01) according to AOAC (2007) methods. Gross energy of diets and excreta were measured by a bomb calorimeter (Model 1261, Parr Instrument Co., Molin, IL), and chromium concentrations was determined with an automated spectrophotometer (Jasco V-650, Jasco Corp., Tokyo, Japan) according to the procedure of Fenton and Fenton (1979).

The microbiological assay of fecal samples was carried out by the procedure suggested by Choi et al. (2011). In short, microbial groups analyzed were *Clostridium* spp. (Tryptose sulphite cycloserine agar), *Bifidobacterium* spp. (MRS agar + 0.02% NaN_3 + 0.05% L-cystine hydrochloride monohydrate), *Lactobacillus* (MRS agar + 0.02% NaN_3 + 0.05% L-cystine hydrochloride monohydrate) and coliforms (violet red bile agar). The tryptic soy agar (No. 236950), MRS agar (No. 288130), violet red bile agar (No. 216695), plate count agar

Table 1. Formula and chemical composition of experimental starter diets (d 0~21)

	Korea		Brazil		India	
	TAA	TDAA	TAA	TDAA	TAA	TDAA
Ingredient						
Corn	51.09	51.50	50.24	51.19	52.12	52.54
Soybean meal	39.04	38.75	40.33	39.44	38.35	38.07
Corn gluten meal	2.00	2.00	2.00	2.00	2.00	2.00
Animal fat	3.50	3.50	3.50	3.50	3.50	3.50
DL-Methionine (100%)	0.20	0.05	0.22	0.05	0.24	0.06
Choline-chloride (50%)	0.10	0.10	0.10	0.10	0.10	0.10
Tricalcium phosphate	1.82	1.82	1.81	1.82	1.83	1.83
Lime stone	1.45	1.48	1.00	1.10	1.06	1.10
Salt	0.25	0.25	0.25	0.25	0.25	0.25
Minerals premix[1]	0.20	0.20	0.20	0.20	0.20	0.20
Vitamins premix[2]	0.20	0.20	0.20	0.20	0.20	0.20
Virginiamycin	0.05	0.05	0.05	0.05	0.05	0.05
Salinomycin	0.10	0.10	0.10	0.10	0.10	0.10
Total	100.00	100.00	100.00	100.00	100.00	100.00
Chemical composition (%)						
ME (kcal/kg)	3,200	3,200	3,200	3,200	3,200	3,200
CP	23.24	23.00	23.48	23.00	23.27	23.00
Ca	1.22	1.23	1.05	1.08	1.09	1.10
Available P	0.45	0.45	0.45	0.45	0.45	0.45
Lysine	1.27	1.26	1.26	1.24	1.24	1.23
Methionine	0.54	0.39	0.55	0.38	0.56	0.38
Methionine + cysteine	0.90	0.75	0.90	0.73	0.90	0.72
Threonine	0.87	0.86	0.87	0.86	0.85	0.84
Tryptophan	0.21	0.21	0.21	0.20	0.21	0.21
Isoleucine	0.97	0.97	0.93	0.91	0.89	0.89
Leucine	2.06	2.05	2.03	2.01	2.02	2.02
Valine	1.12	1.12	1.07	1.05	1.03	1.02
Histidine	0.59	0.59	0.58	0.57	0.59	0.58
Arginine	1.47	1.47	1.44	1.41	1.47	1.47
Phenylalanine	1.21	1.20	1.19	1.17	1.17	1.16

[1] Provided per kg diet: 80 mg Fe, 80 mg Cu, 100 mg Zn, 120 mg Mn, 2 mg I, 0.1 mg Co, 0.2 mg Se.
[2] Provided per kg diet: 18,000 IU vitamin A, 3,600 IU vitamin D_3, 20 mg vitamin E, 2 mg vitamin K, 2 mg vitamin B_1, 8 mg vitamin B_2, 4 mg vitamin B_6, 0.04 mg vitamin B_{12}, 24 mg pantothenic acid, 60 mg niacin, 1 mg folic acid and 0.06 mg biotin.

Table 2. Formula and chemical composition of experimental finisher diets (d 22～35)

	Korea		Brazil		India	
	TAA	TDAA	TAA	TDAA	TAA	TDAA
Ingredient						
Corn	59.39	60.09	58.23	59.85	60.36	60.92
Soybean meal	31.40	30.71	32.99	31.26	30.69	30.18
Corn gluten meal	2.00	2.00	2.00	2.00	2.00	2.00
Animal fat	3.00	3.00	3.00	3.00	3.00	3.00
DL-Methionine (100%)	0.08	-	0.09	-	0.12	-
Choline-chloride (50%)	0.10	0.10	0.10	0.10	0.10	0.10
Tricalcium phosphate	1.36	1.36	1.34	1.36	1.36	1.37
Lime stone	2.02	2.09	1.60	1.78	1.72	1.78
Salt	0.25	0.25	0.25	0.25	0.25	0.25
Minerals premix[1]	0.20	0.20	0.20	0.20	0.20	0.20
Vitamins premix[2]	0.20	0.20	0.20	0.20	0.20	0.20
Total	100.00	100.00	100.00	100.00	100.00	100.00
Chemical composition (%)						
ME (kcal/kg)	3,200	3,200	3,200	3,200	3,200	3,200
CP	20.34	20.00	20.73	20.00	20.30	20.00
Ca	1.26	1.28	1.10	1.16	1.16	1.18
Available P	0.35	0.35	0.35	0.35	0.35	0.35
Lysine	1.07	1.05	1.08	1.04	1.04	1.03
Methionine	0.39	0.31	0.40	0.30	0.41	0.30
Methionine + cysteine	0.72	0.63	0.72	0.62	0.72	0.60
Threonine	0.76	0.75	0.77	0.75	0.74	0.73
Tryptophan	0.18	0.18	0.18	0.17	0.18	0.18
Isoleucine	0.84	0.83	0.82	0.79	0.78	0.77
Leucine	1.88	1.86	1.87	1.83	1.84	1.83
Valine	0.98	0.97	0.95	0.92	0.91	0.90
Histidine	0.52	0.51	0.52	0.50	0.52	0.51
Arginine	1.26	1.24	1.24	1.20	1.26	1.24
Phenylalanine	1.06	1.04	1.05	1.02	1.02	1.01

[1] Provided per kg diet: 80mg Fe, 80 mg Cu, 100 mg Zn, 120 mg Mn, 2 mg I, 0.1 mg Co, 0.2 mg Se.
[2] Provided per kg diet: 18,000 IU vitamin A, 3,600 IU vitamin D_3, 20 mg vitamin E, 2 mg vitamin K, 2 mg vitamin B_1, 8 mg vitamin B_2, 4 mg vitamin B_6, 0.04 mg vitamin B_{12}, 24 mg pantothenic acid, 60 mg niacin, 1 mg folic acid and 0.06 mg biotin.

(No. 247940), and potato dextrose agar (No. 213400) used were purchased from Difco Laboratories (Detroit, MI), and TSC agar (CM0589) was purchased from Oxoid (Hampshire, UK).

4. Economic Analysis

The feed cost (FC) was calculated based on the price of ingredients used and this FC was used to calculate the feed cost per kg body weight gain (FCG) by using the following formula: FCG = TFI×FC/TWG; TFI = total feed intake and TWG = total weight gain per broiler (kg).

5. Statistical Analysis

Statistical analysis was conducted by using the GLM procedure of SAS (1996). Pens were used as the experimental unit for all the parameters. An independent *t*-test was used to compare among SBMs from Korean and imported origin, Korean and Brazil origin, and Korean and India origin, while additional comparisons were made among diets formulated on the basis of TAA and TIDAA. To enhance the interpretation of the results, the mean separations were analyzed using the Student-Newman-Keuls multiple range test. *P*-values of less than 0.05 were considered statistically significant.

RESULTS AND DISCUSSION

1. Growth Performance

Growth performance of broilers fed diets containing SBM from different origin is presented in Table 3. Birds fed the Korean SBM had better ($P<0.05$) weight gain (starter, finisher and overall), feed intake (starter, finisher and overall) and FCR (finisher and overall) when compared with birds fed imported SBM (India + Brazil). In addition, birds fed Korean SBM had better ($P<0.05$) weight gain (starter, finisher and overall) feed intake and FCR (finisher and overall) than birds fed diets with Brazilian SBM. Also, weight gain (starter, finisher and overall), feed intake (starter, finisher and overall) and FCR(finisher and overall) were better ($P<0.05$) in birds

Table 3. Effects of origin of soybean meal on growth performance of broilers

Item	K		Imported[1]				SEM[2]	*P*-value[3]			
			BRA		IND						
	TAA	TDAA	TAA	TDAA	TAA	TDAA		K vs I	K vs BRA	K vs IND	TAA vs TDAA
Starter (wk 0~3)											
Weight gain (g)	729[ab]	738[a]	714[bc]	725[ab]	705[c]	718[bc]	3.05	0.002	0.014	0.006	0.062
Feed intake (g)	1,200[a]	1,188[ab]	1,192[ab]	1,180[b]	1,188[ab]	1,179[b]	2.17	0.027	0.154	0.033	0.008
FCR	1.65[ab]	1.61[c]	1.67[ab]	1.63[bc]	1.69[a]	1.64[bc]	0.01	0.051	0.140	0.084	0.004
Finisher (wk 4~5)											
Weight gain (g)	957[b]	976[a]	927[d]	942[c]	899[e]	909[e]	5.81	0.001	0.001	0.001	0.213
Feed intake (g)	1,988[a]	1972[b]	1,973[b]	1,962[b]	1,931[c]	1,915[d]	5.48	0.001	0.032	0.001	0.204
FCR	2.08[c]	2.02[d]	2.13[ab]	2.08[c]	2.15[a]	2.11[bc]	0.01	0.001	0.002	0.001	0.006
Overall (wk 0~5)											
Weight gain (g)	1,685[b]	1,714[a]	1,641[d]	1,667[c]	1,603[e]	1,626[d]	7.97	0.001	0.001	0.001	0.103
Feed intake (g)	3,188[a]	3,160[b]	3,165[b]	3,142[c]	3,119[d]	3,094[e]	6.77	0.001	0.038	0.001	0.062
FCR	1.89[bc]	1.84[d]	1.93[a]	1.88[c]	1.95[a]	1.90[b]	0.01	0.001	0.009	0.001	0.001

[ab] Values with different superscripts of the same row are significantly different ($p<0.05$).
[1] BRA = Brazil; IND = India.
[2] Pooled standard error of mean.
[3] K vs I = Korean vs Imported (India and Brazil); K vs BRA = Korean vs Brazil; K vs IND = Korean vs India; TAA vs TDAA = total amino acid vs true digestible amino acid.
TAA = total amino acid; TDAA = true digestible amino acid.

fed Korean SBM diet than birds fed diets containing Indian SBM. In comparison with diets formulated on TAA basis, diets formulated on TDAA basis resulted in greater (P<0.05) feed intake (starter) and improved feed efficiency (starter, finisher and overall).

Soybean meal (SBM) is a major protein source in poultry feeds and one of the best quality ingredients. Because of the relatively good amino acid profile, it is usually used to balance the dietary amino acid levels with cereal grains and their byproducts in poultry feeds. In the present study, broiler fed the diets containing SBM originated form Korea had greater growth performance than broilers fed diets containing SBM originated from India or Brazil. Results obtained in the present study are in good agreement with data reported by Leeson et al. (1987), Lee et al. (1994) and Joo et al. (1994). Some of the previous studies also reported greater growth performance of broiler fed Korean native SBM than broiler fed SBM from Brazil or India (Park and Baik, 1997; Park et al., 2002). Greater performance of broiler fed Korean SBM might be due variation in amino acid profile of SBM from different origin and quality of nutrients due difference in storage period. In the present study, we used freshly prepared Korean SBM (one month before experimental feeding), while SBM imported from India and Brazil were prepared 4 months before the experimental feeding. It has reported that longer storage of SBM under unsecured condition results in decreased nutritional quality of SBM (Narayan et al., 1988). The discrepancy in growth performance of broilers fed diets containing SBM from different origin also might be due to variation in quality of SBM due to variation in soybean processing conditions, such as moisture, drying time and drying temperature. Over and under processing due to improper heating conditions can result in the production of poor quality SBM (Araba and Dale, 1990). Over processing of SBM results in a portion of the lysine being rendered unavailable for pigs due to Maillard reaction; whereas under processed SBM contains high concentration of antinutritional factors like trypsin inhibitors and saponins which decease the quality of SBM (Araba and Dale, 1990).

2. Nutrient Retention

Effects of origin of SBM on retention of energy and nutrients are presented in Table 4. During starter and finisher periods, the retention of GE and CP was greater (P<0.05) in birds fed the diet containing Korean SBM as compared to birds fed the diets containing imported SBM (India + Brazil); while the retention of CP during finisher period was greater (P<0.05) in birds fed diet containing Korean SBM than birds fed diet with Brazil SBM. Additionally, during starter and finisher periods, the retention of DM, GE and CP was greater (P<0.05) in birds fed diet having Korean SBM than birds fed India SBM diets. Broilers fed diets formulated on TDAA basis had greater (P<0.05) retention of CP during starter period and DM, GE and CP during finisher period as compared to birds fed diets formulated on TAA basis.

In the present study, retention of nutrients in birds fed the Korean SBM diet was greater than birds fed Indian or Brazilian SBM diets. Several studies have shown considerable differences in nutrient content of SBM within and among geographic regions of the world (Baize, 1997; Grieshop et al., 2003). Different growing conditions and the use of various soybean genotypes in these regions can affect nutrient composition including contents of oligosaccharides, protease inhibitors and fiber (Baker and Stein, 2009; Kumar et al., 2010). As a result, nutrient retention in different batches of SBM fed to nonruminants may differ (Karr-Lilienthal et al., 2005). Moreover, regional variations in processing conditions of the soybeans may also affect nutrient digestibility of SBM (Sauer and Ozimek, 1986). Thermal treatment during SBM processing, for example, is frequently applied to inactivate residual contents of trypsin inhibitors in SBM (Qin et al., 1998). However, so called under-toasting during processing of SBM may result in incomplete removal of some anti-nutritional factors (Araba and Dale, 1990) which, in turn, may decrease nutrient digestibility in these SBM. In the present study, variation in nutrients retention among birds fed diet containing SBM from different origin might be due to variation in contents of oligosaccharides, protease inhibitors and fiber in SBM from different origin. Our results indicates that the use of the Korean SBM in broiler diets could be economically advantageous to the broiler production due to its excellent protein quality, greater growth performance and digestibility of nutrients as reported in present study.

In this study, the performance and retention of nutrient in

Table 4. Effects of origin of soybean meal on apparent excreta nutrients digestibility of broilers

Item	K		Imported[1]				SEM[2]	P-value[3]			
			BRA		IND						
	TAA	TDAA	TAA	TDAA	TAA	TDAA		D vs I	D vs BRA	D vs IND	TAA vs TDAA
Starter (d 0~21)											
DM	72.04[ab]	72.29[a]	71.92[ab]	72.08[ab]	71.62[b]	71.95[ab]	0.08	0.085	0.423	0.036	0.133
GE	75.59[ab]	75.79[a]	75.20[ab]	75.38[ab]	75.07[b]	75.12[b]	0.09	0.001	0.061	0.002	0.433
CP	65.37[ab]	66.86[a]	64.19[bc]	66.46[a]	63.47[c]	64.46[bc]	0.32	0.009	0.299	0.001	0.009
Ash	39.70	39.80	39.21	39.52	38.42	38.88	0.33	0.301	0.565	0.258	0.669
Ca	29.88	30.01	29.21	29.82	29.03	29.12	0.37	0.337	0.619	0.342	0.723
P	27.58	27.30	27.58	27.55	27.14	27.13	0.51	0.937	0.937	0.761	0.920
Finisher (d 22~35)											
DM	71.66[bc]	72.78[a]	71.46[bc]	72.14[ab]	71.04[c]	71.77[b]	0.14	0.071	0.213	0.035	0.001
GE	75.56[bc]	76.62[a]	75.25[bc]	75.80[ab]	74.79[c]	75.21[bc]	0.16	0.023	0.111	0.011	0.032
CP	61.24[ab]	62.76[a]	60.51[bc]	61.29[ab]	59.52[c]	60.69[bc]	0.27	0.007	0.039	0.010	0.032
Ash	32.43	33.02	31.40	32.36	30.91	31.53	0.34	0.054	0.223	0.092	0.294
Ca	28.85	29.86	27.11	27.96	27.73	27.32	0.56	0.253	0.274	0.262	0.680
P	22.71[ab]	23.56[a]	22.05[ab]	23.23[ab]	21.13[b]	22.04[ab]	0.29	b0.099	0.452	0.018	0.094

[a~c] Values with different superscripts of the same row are significantly different (p<0.05).
[1] BRA = Brazil; IND = India
[2] Pooled standard error of mean.
[3] K vs I = Korean vs Imported (India and Brazil); K vs BRA = Korean vs Brazil; K vs IND = Korean vs India; TAA vs TDAA = total amino acid vs true digestible amino acid.

birds fed diets formulated on the basis true ileal digestible amino acid (TIDAA) had greater than birds fed diets formulated on the basis of total amino acid (TAA). This might be due to greater availability of digestible amino acids in the diets formulated on TIDAA basis than TAA basis. Greater digestibility of amino acids and CP may result in more AA reaching organ systems of the birds which results into improved growth performance.

3. Microbial Populations

Data pertaining to effects of origin of SBM on excreta microflora population are presented in Table 5. Dietary treatments had no effect (P>0.05) on the number of *Clostridium* spp., *Bifidobacterium* spp., *Lactobacillus* spp. and coliforms in the excreta during starter and finisher period. It has reported that dietary sources of fermentable carbohydrates and protein affect the host animal by improving its intestinal balance (Fuller, 1989) and creating gut micro-ecological conditions that suppress harmful microorganisms like *Clostridium* and *Coliforms* (Line et al., 1998; Pascual et al., 1999; Shim et al., 2010), and by favoring beneficial microorganisms like *Lactobacillus* and *Bifidobacterium.* In the present experiment, there were no differences in microbial population among birds fed diets containing SBM from different origin. This indicates that origin of SBM have no effects on fermentation pattern and intestinal microflora of broiler.

4. Economic Analysis

Economic analysis of broilers fed different SBM origin diets is presented in Table 6. In spite of greater total weight

Table 5. Effects of origin of soybean meal on fecal microbial populations of pigs (log10 CFU/g)

Item	K		Imported[1]				SEM[2]	P-value[3]			
			BRA		IND						
	TAA	TDAA	TAA	TDAA	TAA	TDAA		D vs I	D vs BRA	D vs IND	TAA vs TDAA
Starter (d 0~21)											
Clostridium spp.	8.63	8.59	8.67	8.67	8.63	8.68	0.012	0.658	0.728	0.672	0.870
Bifidobacterium spp.	9.55	9.56	9.58	9.56	9.60	9.58	0.010	0.056	0.145	0.101	0.873
Lactobacillus spp.	9.51	9.52	9.48	9.51	9.47	9.49	0.017	0.416	0.611	0.411	0.684
Coliforms	7.58	7.60	7.60	7.61	7.66	7.61	0.019	0.091	0.265	0.094	0.819
Finisher (d 22~35)											
Clostridium spp.	8.65	8.61	8.68	8.69	8.66	8.70	0.015	0.161	0.178	0.206	0.935
Bifidobacterium spp.	9.54	9.56	9.53	9.53	9.55	9.54	0.009	0.511	0.380	0.860	0.824
Lactobacillus spp.	9.48	9.49	9.44	9.48	9.44	9.45	0.015	0.286	0.649	0.148	0.410
Coliforms	7.71	7.70	7.72	7.71	7.74	7.73	0.021	0.659	0.854	0.583	0.822

[1] BRA = Brazil; IND = India.
[2] Pooled standard error of mean.
[3] K vs I = Korean vs Imported (India and Brazil); K vs BRA = Korean vs Brazil; K vs IND = Korean vs India; TAA vs TDAA = total amino acid vs true digestible amino acid.

Table 6. Production cost of broilers as affected by soybean meal origin

Item[1]	K		Imported[2]				SEM[3]	P-value[4]			
			BRA		IND						
	TAA	TDAA	TAA	TDAA	TAA	TDAA		D vs I	D vs BRA	D vs IND	TAA vs TDAA
Starter (d 0~21)											
FC(₩/kg)	544	537	530	522	528	520					
TWG (g/bird)	728[ab]	738[a]	713[bc]	725[ab]	704[c]	717[bc]	3.04	0.002	0.014	0.006	0.062
TFI (g/bird)	1,200[a]	1,187[ab]	1,192[ab]	1,180[b]	1,187[ab]	1,179[b]	2.17	0.027	0.154	0.033	0.008
FCG (₩/kg gain)	895[a]	864[bc]	886[ab]	849[c]	890[a]	855[c]	4.67	0.317	0.257	0.563	0.001
Finisher (d 22~35)											
FC(₩/kg)	521	516	512	505	509	503					
TWG (g/bird)	956[b]	975[a]	926[d]	941[c]	898[e]	908[e]	5.80	<0.001	<0.001	<0.001	0.213
TFI (g/bird)	1,987[a]	1,972[b]	1,972[b]	1,962[b]	1,931[c]	1,914[d]	5.48	0.001	0.032	<0.001	0.204
FCG (₩/kg gain)	1,084[a]	1,044[c]	1,090[a]	1,052[bc]	1,094[a]	1,060[b]	4.31	0.303	0.536	0.240	<0.001
Overall (d 0~35)											
TWG (g/bird)	1,685[b]	1,713[a]	1,640[d]	1,667[c]	1,603[e]	1,626[d]	7.97	<0.001	<0.001	<0.001	0.103
TFI (g/bird)	3,188[a]	3,159[b]	3,164[b]	3,142[c]	3,118[d]	3,094[e]	6.76	0.001	0.038	<0.001	0.062
FCG (₩/kg gain)	1,002[a]	967[b]	1,001[a]	964[b]	1,004[a]	970[b]	3.89	0.981	0.847	0.812	<0.001

Table 6. Production cost of broilers as affected by soybean meal origin

[a~e] Values with different superscripts of the same row are significantly different (p<0.05).
[1] FC, feed cost per kg; TWG, total weight gain per broiler; TFI, total feed intake per broiler; FCG, feed cost/kg body weight gain.
[2] BRA = Brazil; IND = India.
[3] Pooled standard error of mean.
[4] K vs I = Korean vs Imported (India and Brazil); K vs BRA = Korean vs Brazil; K vs IND = Korean vs India; TAA vs TDAA = total amino acid vs true digestible amino acid.

gain and total feed intake of birds fed Korean SBM containing diets in comparison with imported SBM from India and Brazil, the feed cost per kg body weight in birds did not differ (P>0.05) among the treatment diets. However, formulating diets on TDAA basis resulted in lower (P<0.05) feed cost per kg body when compared with diets formulated on TAA basis during starter, finisher and overall period. These results indicate that diets formulated on the TDAA basis are more economic than diets formulated on the basis of TAA.

SUMMARY

In the present study, the Korean SBM was more efficient than Brazil- and India-originated SBM in improving performance in broilers. These results indicate that domestic SBM has better nutrient digestibility than SBM imported from Brazil and India, which contributes to the improved performance of broilers. Therefore, based on the results of this experiment, it is recommended to use domestic SBM because of its excellent protein quality.

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