Effects of Three Different Soybean Meal Sources on Layer and Broiler Performance

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ABSTRACT : Soybean meal (SBM) is a major protein source in poultry feeds and one of the best quality ingredients because of the relatively high protein content, good amino acid profile and bioavailability. But soybean meal quality is largely dependent on the processing technology and origins. In this experiment, effects of three different soybean meals were evaluated in layer (experiment 1) and broiler (experiment 2). Soybean meal sources used in the experiments were the US-originated dehulled soybean meal (USDHSBM), India-originated non-dehulled soybean meal (India SBM) and Brazil-originated non-dehulled soybean meal (Brazil SBM). Experiment 1 was conducted during growing and laying periods and evaluated the interactive effects of soybean meal sources according to feeding periods on growth performance and egg quality. Experiment 2 was conducted during growing period (day 1-35) and finishing period (day 35-42). The growth performance was measured for the same periods and any possible interaction between soybean meal origins and crude protein levels was also studied. In experiment 1, chicks fed India SBM utilized feed more efficiently ($p<0.05$) than those fed Brazil SBM from day 29 to day 42. The body weights of layers during the laying period had no relation to egg production. But egg weights were significantly heavier in all the USDHSBM fed groups than other groups ($p<0.001$) and depended on feed protein source during growing period ($p<0.001$). The average egg weight of the USDHSBM fed group scored the highest value (65.4 g), followed by the Brazil SBM fed group (62.1 g) and India SBM fed group (62.1 g). There was an effect of interaction between origins of soybean meal fed group in growing and laying period on eggshell color ($p<0.01$). Eggshell was significantly stronger in the USDHSBM fed (for growing period) groups than other groups ($p<0.05$) on 31st week. Haugh's unit (HU), albumin index and yolk index of the USDHSBM fed group in growing stage were significantly superior ($p<0.001$) to other groups. In experiment 2, for the 7-week, chicks on the India SBM group gained less ($p<0.001$) weight than other groups. While daily gain of India SBM chicks was not affected by dietary crude protein level, those of the USDHSBM and Brazil SBM chicks were linearly increased as dietary crude protein level increased from 18% to 20%. The gain per feed ratio of the USDHSBM group was the highest (0.585), followed by the Brazil SBM group (0.568) and India SBM group (0.550) ($p<0.01$). Therefore, in this experiment, the use of USDHSBM with excellent protein quality and amino acid digestibility could be of advantage to the economic production of layer and broiler. ***(Asian-Aust. J. Anim. Sci. 2002. Vol 15, No. 2 : 254-265)***

Key Words : Soybean Meals, Layer, Broiler, Growth Performance, Egg Quality, Protein Source

INTRODUCTION

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. It is reported that the dehulled soybean meal is higher metabolizable energy and contains less fiber and ash by about 4% than non-dehulled soybean meal (Swick, 1995, 1998).

Like amino acid profiles of most other leguminous plants, soybean meal is low in sulfur-containing amino acids, with methionine being the most significant limiting amino acid, followed by cystine and threonine (Eggum and Beames, 1983). Soybean meal however contains a relatively large amount of lysine, which is low in most plant-originated protein sources. Although soybean meal provides some limiting amino acids such as lysine to the diets, it contains anti-nutritional factors. The anti-nutritional factors such as trypsin inhibitor, lectins and lipoxygenase must be destroyed before feeding to chicks (Ward, 1996). These factors are easily destroyed during the toasting process of soybean meal. Since the overtoasting may destroy or denature the proteins in soybean meal, proper toasting is required. In other words, soybean meal quality is largely dependent on the processing technology and it must be processed properly with heat treatment after solvent extraction.

Many researchers have investigated the effective ways of denaturing (McNaughton and Reece, 1980; Garlich, 1988; Leeson et al., 1987; Ohh, 1988). The degree of overcooking of soybean meal can be estimated by measuring KOH protein solubility while the degree of undercooking of soybean meal can be achieved by urease activity (UA) assay. It is well documented that protein solubility and UA are well correlated to growth performance in chickens (Waldroup et al., 1985; Araba and Dale, 1990; Lee and Garlich, 1992; Fernandez and Parsons,

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1993).

The purpose of the current experiment was to evaluate the effect of three different soybean meals in layer (experiment 1) and broiler (experiment 2). Soybean meal sources used in the experiments were the US-originated dehulled soybean meal (USDHSBM), India-originated non-dehulled soybean meal (India SBM) or Brazil-originated non-dehulled soybean meal (Brazil SBM). Experiment 1 was conducted during growing and laying periods and evaluated the interactive effects of soybean meal sources according to feeding periods on growth performance and egg quality. Experiment 2 was conducted during growing period (day 1-35) and finishing period (day 35-42). The growth performance was measured for the same periods and any possible interaction between soybean meal origins and crude protein levels was also studied.

MATERIALS AND METHODS

Animals and experimental procedure

Growth trial with different soybean meal sources in layers (Experiment 1) : Experiment 1 was designed in 3 (soybean meal sources of growing period) × 3 (soybean meal sources of laying period) factorial arrangement of treatments.

One thousand and fifty-six, day-old Hy-Line® brown layer chicks were assigned to 3 treatments with 8 replicates (44 chicks per replicates) and fed experimental diets for the growing period. The experimental period consisted of the growing period (Period I - day 1 to day 98) and a part of laying period (Period II - day 98 to day 280). All chicks were randomly allotted in grower cages and moved to layer cages at day 98. At day 98, 900 out of 1,056 chicks were selected and re-allotted in layer cages according to the experimental design. All general management, veterinary care and medication were followed to recommendations of Hy-Line® (Hy-Line International, 1998).

Body weight and feed consumption were measured every other weeks during the growing period. Average daily gain and feed efficiency were also calculated. Abnormal chicks and livability were recorded. Feed consumption, hen-housed egg production and egg weight were measured every week for the laying period (Period II).

Growth trial with different soybean meal sources in broilers (Experiment 2) : Experiment 2 was designed in 3 (crude protein levels) × 3 (soybean meal source) factorial arrangement of treatments.

One thousand and eighty, day-old broiler chicks (Arbor Acre®) were randomly assigned to 9 treatments with 6 replicates. The experimental period consisted of 5-week (day 1-35) growing and 1-week (day 35-42) finishing periods.

Body weight and feed intake were measured on weekly basis during the entire experimental period. Average daily gain and feed efficiency were calculated. Abnormal chicks and livability were recorded on individual pen basis.

Experimental feeds

One sample (USDHSBM) of dehulled soybean meal and two samples (Brazil SBM and India SBM) of non dehulled soybean meal were used in Experiments 1 and 2. Proximate analysis, amino acids, KOH (0.2%) solubility, urease activity index (UAI) and protein dispersibility index (PDI) were examined with these different soybean meal samples (table 1).

Diets

Layers (Experiment 1) : The composition of experimental diets was shown in table 2 for phases I-1 and table 3 for

Table 1. Analytical values of soybean meals evaluated in the experiment

Item	US Dehulled SBM	Brazil Originated SBM	India Originated SBM
Proximate analysis[1], %			
Dry matter	90.00	90.10	90.10
Crude protein	48.34	47.74	45.20
Crude fat	1.21	1.31	1.31
Crude fiber	3.96	5.05	7.22
Amino acids[2], %			
Arginine	3.55	3.67	3.24
Aspartic acid	5.36	5.41	4.99
Glutamic acid	8.50	8.55	7.85
Histidine	1.31	1.37	1.22
Isoleucine	2.06	2.03	1.77
Leucine	3.77	3.81	3.26
Lysine	3.00	3.03	2.77
Methionine	0.67	0.64	0.61
Phenylalanine	2.48	2.53	2.20
Threonine	1.85	1.83	1.67
Valine	2.17	2.17	1.91
Cystine	0.67	0.66	0.61
Tyrosine	1.64	1.64	1.41
Serine	2.39	2.51	2.30
Glycine	1.98	2.07	1.88
Alanine	1.95	2.06	1.87
KOH (0.2%) Solubility[3], %	72.7	79.8	67.7
UAI[4]	0.13	0.15	0.28
PDI[5], %	8.8	11.2	9.6

[1] Methods outlined by the AOAC (1990).
[2] Analysed by Hitachi® Amino Acid Analysis System.
[3] Evaluated by method of Araba and Dale (1990).
[4] Urease Activity Index, evaluated by method of Caskey and Knapp (1944).
[5] Protein Dispersibility Index, evaluated by method of Yasumatsu et al. (1972).

Table 2. Composition of experimental diets for starters (Phase I - 1, day 1 - 35) in experiment 1

Ingredient	US Dehulled SBM	Brazil Originated SBM	India Originated SBM
Corn	58.90	58.20	59.20
US dehulled SBM[1]	25.20	-	-
Brazil SBM[2]	-	28.50	-
India SBM[3]	-	-	28.50
Rice Bran	9.30	6.10	6.10
Cottonseed Meal	1.00	1.00	1.00
Rapeseed Meal	1.00	1.00	1.00
Beef Tallow	1.00	1.00	1.00
Tricalcium Phosphate	1.58	1.69	1.69
NaCl	0.18	0.18	0.18
Limestone	1.10	0.69	0.69
Choline Chloride, 25%	0.10	0.10	0.10
Mineral Mixture[4]	0.10	0.10	0.10
Vitamin Mixture[4]	0.10	0.10	0.10
Lysine, 80%	0.02	-	-
Methionine, 50%	0.26	0.22	0.23
Salynomycin+Enramycin	0.10	0.10	0.10
Calculated Values			
ME, kcal/kg	2,900	2,900	2,900
Crude Protein, %	19.00	19.00	19.00
Calcium, %	1.10	1.00	1.00
Available Phosphorus, %	0.50	0.50	0.50
Lysine, %	0.85	0.85	0.85
Met+Cys, %	0.59	0.59	0.59

[1] Dehulled soybean meal from US

[2] Non-dehulled soybean meal from Brazil.

[3] Non-dehulled soybean meal from India.

[4] Vitamin and mineral mixtures are formulated to meet or exceed the NRC requirements (1994).

phase I-2 (growing period) and in table 4 for phases II (laying period). Diets were least-cost formulated based on the NRC requirements (1994).

Broilers (Experiment 2) : Three experimental groups were assigned to the origins of soybean meal and each experimental group was divided into three dietary crude protein levels (standard, 1% point higher, 1% point lower) to make up 9 groups of experiment. Dietary crude protein levels for growing and finishing periods are shown in tables 5 and 6.

Experimental diets were least-cost formulated based on the NRC requirements (1994). The compositions of experimental diets are shown in table 5 (growing period) and table 6 (finishing period).

Hen day egg production and egg weight

Egg production was evaluated during laying period (30-39 week). Egg production and egg weight were measured and recorded every week.

Table 3. Composition of experimental diets for starters (Phase I - 2, day 36 - 98) in experiment 1

Ingredient	US Dehulled SBM	Brazil Originated SBM	India Originated SBM
Corn	64.20	63.10	63.10
US dehulled SBM[1]	10.00	-	-
Brazil SBM[2]	-	11.10	-
India SBM[3]	-	-	10.50
Barley	15.00	15.00	15.00
Corn Gluten Meal	2.50	2.50	2.50
Cottonseed Meal	3.00	3.00	3.00
Rapeseed Meal	2.00	2.00	2.00
Beef Tallow	0.50	0.50	0.50
Tricalcium Phosphate	1.40	1.43	1.42
NaCl	0.22	0.22	0.22
Limestone	0.76	0.73	0.72
Choline Chloride, 25%	0.02	0.02	0.02
Mineral Mixture[4]	0.10	0.10	0.10
Vitamin Mixture[4]	0.10	0.10	0.10
Methionine, 50%	0.06	0.04	0.05
Salynomycin+Enramycin	0.10	0.10	0.10
Calculated Values			
ME, kcal/kg	2,800	2,800	2,800
Crude Protein, %	16.50	16.50	16.50
Calcium, %	0.75	0.75	0.75
Available Phosphorus, %	0.30	0.30	0.30
Lysine, %	0.65	0.65	0.65
Met+Cys, %	0.49	0.49	0.49

[1] Dehulled soybean meal from US

[2] Non-dehulled soybean meal from Brazil.

[3] Non-dehulled soybean meal from India.

[4] Vitamin and mineral mixtures are formulated to meet or exceed the NRC requirements (1994).

Egg quality

Egg shell quality and egg yolk color : Egg shell quality (eggshell thickness, egg shell color, egg shell strength) and egg yolk color were evaluated at 39 weeks for laying period.

Haugh's unit, albumen index and yolk index : In order to evaluate shelf life of eggs, 70 eggs per group were stored in room temperature for 7, 21 and 35 days. Haugh's unit, albumen index and yolk index were evaluated for sampling eggs stored in room temperature at day 7, day 21 and day 35.

Statistics

Layers (Experiment 1) : The effect of origin of soybean meal on performance was analyzed by ANOVA using the SAS statistical package (SAS Institute, 1998) with the following model:

$$Y_{ijk}=\mu+O_i+S_j+(O\times S)_{ij}+e_{ijk}$$

Where Y_{ijk}=dependent variable, μ=the overall mean, O_i=the effect of origin of SBM on growing period (i= USDHSBM, the Brazil SBM and India SBM used in

Table 4. Composition of experimental diets for layers (Phase II, day 99-280) in experiment 1

Ingredient	US dehulled SBM	Brazil originated SBM	India originated SBM
Corn	56.60	56.50	56.90
US dehulled SBM[1]	6.40	-	-
Brazil SBM[2]	-	6.50	-
India SBM[3]	-	-	6.10
Wheat, Soft (Imported)	13.00	13.00	13.00
Wheat Middling (Imported)	7.00	7.00	7.00
Wheat Middling (Local)	10.00	10.00	10.00
Rapeseed Meal	2.00	2.00	2.00
Cottonseed Meal	2.00	2.00	2.00
Tricalcium Phosphate	1.34	1.34	1.33
NaCl	0.21	0.21	0.21
Limestone	1.15	1.16	1.15
Choline Chloride, 25%	0.018	0.018	0.021
Mineral Mixture[4]	0.10	0.10	0.10
Vitamin Mixture[4]	0.10	0.10	0.10
Calculated Values			
ME, kcal/kg	2,810	2,810	2,810
Crude Protein, %	18.00	18.00	18.00
Calcium, %	3.20	3.20	3.20
Available Phosphorus, %	0.32	0.32	0.32
Lysine, %	0.52	0.52	0.52
Met+Cys, %	0.49	0.49	0.49

[1] Dehulled soybean meal from US

[2] Non-dehulled soybean meal from Brazil.

[3] Non-dehulled soybean meal from India.

[4] Vitamin and mineral mixtures are formulated to meet or exceed the NRC requirements (1994).

grower feed), S_j=origin of soybean meal on laying period (j=the USDHSBM, Brazil SBM and India SBM used in layer feed), O×S=interaction, and e_{ijk}=the residual error. The standard errors of the means were calculated only from the treatments with replicates. The mortality rate of layers for the entire laying period was evaluated by chi-square test.

Broilers (Experiment 2) : The effects of origin of soybean meal and dietary crude protein levels on performance were analyzed by ANOVA using the SAS statistical package (SAS Institute, 1998) with the following model:

$$Y_{ijk}=\mu+O_i+L_j+(O\times L)_{ij}+e_{ijk}$$

Where Y_{ijk}=dependent variable, μ=the overall mean, O_i=the effect of origin of soybean meal (i=USDHSBM, Brazil SBM and India SBM used in feed), L_j=level of crude protein contents in feed (j=crude protein contents in feed), O×L=interaction and e_{ijk}=the residual error. The standard errors of the means were calculated only from the treatments with replicates. The mortality rate of broilers was statistically analyzed by chi-square test.

RESULTS

Layer (Experiment 1)

During the first 14 weeks of the experiment, all chicks were reared at good condition and showed relatively good performance compared to the standard (Hy-Line International, 1998). The mortality for the early period was 3.0%. Uniformity of individual birds is important as well as appropriate average flock weights in layer chick rearing. Desirable goal is 80% of birds to fall within 10% of mean (Hy-Line International, 1998). In the current trial, 825 out of 1,030 birds were fall between 90% and 110% of mean body weight.

The mortality rate was not significant in all groups fed soybean meals of different origins for both growing and laying periods.

Growth performance of layers : Body weight gains of chicks for the first 14 weeks of the experiment are shown in table 7. Chicks in Brazil SBM gained less ($p<0.05$) from day 29 to day 42, but those caught up with others in the following weighing period (from day 43 to day 56). Chicks in USDHSBM showed slight higher average daily gain than those in other groups but was not significantly different.

Feed consumption for the first 14 weeks are shown in table 7. Chicks in USDHSBM consumed slightly less feed than other groups but was not significantly different.

Feed efficiencies (gain per feed) for the first 14 weeks are shown in table 7. Chicks fed India SBM utilized feed more efficiently ($p<0.05$) than those fed Brazil SBM from day 29 to day 42. Interestingly, chicks fed Brazil SBM showed better feed efficiency for the following weighing period, from day 43 to day 56.

Table 8 shows the body weights of layers during the laying period and the body weights of layers had no relation to egg production.

Egg production and egg quality related performance : Hen-day egg production was not significantly different among treatments (table 9). According to the report of Lewis et al. (1996), the egg production rate itself mainly depends on photostimulus.

But egg weights were significantly heavier in all the USDHSBM (US) fed groups than other groups ($p<0.001$) (Table 9). Egg weight also depended on feed protein source of growing period ($p<0.001$). The average egg weight of the USDHSBM (US) fed group scored the highest value (65.4 g), followed by the Brazil SBM (Brz) fed group (62.1 g) and India SBM (Ind) fed group (62.1 g). The results suggest that the egg weight depends at least partly on the dietary protein sources.

Treatments 7, 8 and 9 (periodically or thoroughly fed the India SBM) showed significant inferiority in egg weights.

Table 5. Composition of experimental diets for growers in experiment 2

Treatment	1	2	3	4	5	6	7	8	9
SBM origin	US	US	US	Brazil	Brazil	Brazil	India	India	India
Dietary CP, %	19	20	21	19	20	21	19	20	21
Corn	66.00	64.00	61.40	64.60	61.00	57.80	62.60	61.00	59.50
US Dehull SBM[1]	18.44	20.07	22.27	-	-	-	-	-	-
Brazil SBM[2]	-	-	-	20.20	23.67	26.47	-	-	-
India SBM[3]	-	-	-	-	-	-	27.25	27.45	27.79
Fish Meal, 50%	2.00	2.00	2.00	1.49	1.00	1.00	1.07	0.53	0.01
Corn Gluten Meal	4.42	5.00	5.00	5.00	5.00	5.00	0.85	2.88	4.93
Cottonseed Meal	1.50	1.50	1.50	1.50	1.50	1.50	-	-	-
Rapeseed Meal	2.50	2.50	2.50	2.50	2.50	2.50	2.50	2.50	2.26
Beef Tallow	2.00	2.00	2.00	2.23	2.79	3.27	3.25	3.11	2.92
Limestone	0.32	0.39	0.42	0.39	0.38	0.37	0.25	0.26	0.28
Tricalcium Phosphate	1.79	1.62	1.57	1.65	1.69	1.68	1.69	1.74	1.78
NaCl	0.19	0.19	0.19	0.20	0.21	0.21	0.21	0.22	0.22
Choline-Cl, 25%	0.63	0.40	0.17	0.06	0.03	0.01	0.02	0.02	0.02
Na bicarbonate	-	0.03	0.03	-	-	-	-	-	-
Vit & Min Mix[4]	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10
Methionine, 50%	0.003	0.025	0.057	0.000	0.028	0.062	0.169	0.128	0.088
Vitamin E, 10%	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02
Calculated Values									
ME, kcal/kg	3,050	3,050	3,050	3,050	3,050	3,050	3,050	3,050	3,050
Crude Protein, %	19.0	20.0	21.0	19.0	20.0	21.0	19.0	20.0	21.0
Ca, %	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Phosphorus, %	0.45	0.45	0.45	0.45	0.45	0.45	0.45	0.45	0.45
Lys, %	1.10	1.10	1.10	1.10	1.10	1.10	1.10	1.10	1.10
Met + Cys, %	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90

[1] Dehulled soybean meal from US

[2] Non-dehulled soybean meal from Brazil.

[3] Non-dehulled soybean meal from India.

[4] Vitamin and mineral mixtures are formulated to meet or exceed the NRC requirements (1994).

Egg yolk color, eggshell color, eggshell thickness and eggshell strength of egg on collection week point were not significantly different among treatments. There was an effect of interaction between origins of soybean meal fed in growing and laying period on eggshell color ($p<0.01$) (table 10).

Eggshell was significantly stronger in the USDHSBM fed (for growing period) groups than other groups ($p<0.05$) on 31st week (table 10).

On eggs stored in room temperature for 7, 21 and 45 days to evaluate shelf life, Haugh's unit (HU), albumin index and yolk index of the USDHSBM group fed in growing stage were significantly superior ($p<0.001$) to other groups (table 11). It can be postulated that the egg quality might be affected by protein source during the growing period.

Egg weight of group fed USDHSBM for both growing and laying period was significantly heavier ($p<0.05$) than other groups (table 12). Egg weight was markedly affected ($p<0.001$) by origin of soybean meal fed for laying period (table 12). It is very hard to demonstrate the economical advantages of the USDHSBM. Because, egg production, one and only criteria, stands for economical performance of egg laying birds. But, mostly in Korea, the product eggs are priced per egg, not per egg weight.

It can be postulated that cumulative egg mass production per hen and economic advantages can be assumed by extra egg production (Table 13).

Broiler (Experiment 2)

Growth performance in feeding trial : Body weight gain, feed intake, and feed efficiency are shown in table 14.

For the first 2 weeks of the experiment, body weight gain of chicks increased as level of dietary crude protein increased from 19% to 21%. The growth performance for the same period was not affected by SBM source. The feed efficiency of chicks fed a diet containing the USDHSBM, however, tended to be higher than other groups.

From day 14 to 28, body weight gain was affected by level of dietary crude protein. Trend of feed consumption rate was different from that of body weight gain. Chicks fed the diets including Brazil SBM and India SBM consumed

Table 6. Composition of experimental diets for finishers in experiment 2

Treatment	1	2	3	4	5	6	7	8	9
SBM origin	US	US	US	Brazil	Brazil	Brazil	India	India	India
Dietary CP, %	18	19	20	18	19	20	18	19	20
Corn	65.80	64.70	61.70	63.50	62.00	58.80	65.10	63.50	60.90
US Dehull SBM[1]	23.43	22.50	22.05	-	-	-	-	-	-
Brazil SBM[2]	-	-	-	21.33	21.37	24.02	-	-	-
India SBM[3]	-	-	-	-	-	-	22.68	22.87	23.84
Fish Meal, 50%	-	-	-	0.64	0.00	-	0.63	0.08	
Corn Gluten Meal	1.19	3.57	4.74	2.68	4.81	5.00	2.05	4.09	5.00
Cottonseed Meal	-	-	2.00	2.00	2.00	2.00	-	-	0.59
Rapeseed Meal	3.50	3.50	3.50	3.50	3.50	3.50	3.50	3.50	3.50
Beef Tallow	3.28	2.98	3.35	3.87	3.69	4.12	3.56	3.41	3.66
Limestone	0.40	0.42	0.46	0.36	0.38	0.37	0.28	0.29	0.29
Tricalcium Phosphate	1.81	1.80	1.74	1.75	1.79	1.79	1.75	1.80	1.79
NaCl	0.18	0.18	0.18	0.16	0.17	0.18	0.17	0.17	0.18
Choline-Cl, 25%	0.045	0.054	0.039	0.011	0.018	0.000	0.019	0.024	0.012
Vit & Min Mix[4]	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10
Methionine, 50%	0.22	0.11	0.07	0.08	0.04	0.07	0.12	0.08	0.08
Calculated Values									
ME, kcal/kg	3,100	3,100	3,100	3,100	3,100	3,100	3,100	3,100	3,100
Crude Protein, %	18.0	19.0	20.0	18.0	19.0	20.0	18.0	19.0	20.0
Ca, %	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90
Phosphorus, %	0.45	0.45	0.45	0.45	0.45	0.45	0.45	0.45	0.45
Lys, %	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Met+Cys, %	0.70	0.70	0.70	0.70	0.70	0.70	0.70	0.70	0.70

[1] Dehulled soybean meal from US

[2] Non-dehulled soybean meal from Brazil.

[3] Non-dehulled soybean meal from India.

[4] Vitamin and mineral mixtures are formulated to meet or exceed the NRC requirements (1994).

more diets of 20% crude protein level than diets including 19% or 21% crude protein. However, feed intake of chicks fed a diet including the USDHSBM was linearly increased as level of dietary crude protein increased. The highest feed efficiency was achieved by chicks on the USDHSBM, being followed by Brazil SBM and India SBM. It is clear that dietary crude protein level for broiler chicks from day 14 to 28 should be 21% when the USDHSBM is used as a major protein source.

For the last 2 weeks of the experiment, chicks on the India SBM treatment gained less body weight ($p<0.001$) than those on the US and Brazil SBM. With 18% dietary crude protein, the USDHSBM group consumed more diet than other groups but with 19% and 20% dietary crude protein, Brazil SBM group consumed more diet than other groups. Chicks on the India SBM treatment consumed least amount of diet regardless of dietary crude protein level. Chicks on the USDHSBM treatment utilized diet more ($p<0.05$) efficiently than other groups. The India SBM fed chicks showed the worst feed efficiency for the same period.

For the 7-week experimental period, chicks on the India SBM group gained less ($p<0.001$) weight than other groups. While daily gain of India SBM chicks was not affected by dietary crude protein level, those of the USDHSBM and Brazil SBM chicks were linearly increased as dietary crude protein level increased from 18% to 20%. Interestingly, the weight gain of India SBM fed group tended to decrease with increasing of the crude protein level. The trend of feed efficiency was similar to that of feed intake. The feed efficiency of India SBM chicks was not affected by dietary crude protein level. The feed efficiencies of the USDHSBM and Brazil SBM chicks were linearly improved as dietary crude protein level increased. The USDHSBM chicks showed the highest feed efficiency among all of the groups during the entire experimental period.

Feed intake tended to increase and feed/gain ratio tended to decrease with increasing level of crude protein in diet. But in case of the Brazil SBM (treatments 4, 5 and 6) and the India SBM (treatments 7, 8 and 9) SBM, chicks fed 20% crude protein diet had a higher feed intake and lower feed efficiency than USDHSBM fed group ($p<0.01$). Especially, India SBM fed group showed lower feed intake and gain per feed ratio than other groups fed USDHSBM and Brazil SBM.

Table 7. Average daily gain, average daily feed intake and feed efficiency of pullets from day 1 to day 98 (mean±SD) in experiment 1

Treatment		US Dehulled SBM	Brazil Originated SBM	India Originated SBM
Average daily gain (g/d)				
	Day 1 ~ 14	5.29±0.46	5.48±0.38	5.45±0.44
	Day 15 ~ 28	12.53±0.40	12.11±0.60	12.36±0.39
	Day 29 ~ 42	11.06±0.57[a]	10.03±0.73[b]	11.06±1.20[a]
	Day 43 ~ 56	16.76±0.60[b]	17.88±0.54[a]	16.76±1.20[b]
	Day 57 ~ 77	13.06±0.68	12.60±0.98	12.89±1.31
	Day 78 ~ 98	11.72±0.31	11.26±0.42	11.01±0.77
	Day 1 ~ 98	11.72±0.18	11.61±0.24	11.64±0.14
Average daily feed intake (g/d)				
	Day 1 ~ 14	18.31±0.72	18.78±1.12	18.74±0.95
	Day 15 ~ 28	26.58±0.97	26.14±1.50	26.55±1.38
	Day 29 ~ 42	36.78±1.18	35.98±1.13	35.72±1.52
	Day 43 ~ 56	56.41±2.05	56.57±1.62	56.60±2.90
	Day 57 ~ 77	54.95±1.50	55.37±1.43	55.71±2.60
	Day 78 ~ 98	76.30±2.65	76.68±4.43	78.64±5.41
	Day 1 ~ 98	47.85±1.27	47.93±1.42	48.40±1.95
Gain/feed ratio				
	Day 1 ~ 14	0.289±0.028	0.292±0.019	0.291±0.031
	Day 15 ~ 28	0.471±0.020	0.464±0.035	0.466±0.027
	Day 29 ~ 42	0.300±0.015[a]	0.279±0.025[b]	0.309±0.026[a]
	Day 43 ~ 56	0.297±0.015	0.316±0.007	0.296±0.027
	Day 57 ~ 77	0.237±0.011	0.227±0.013	0.231±0.018
	Day 78 ~ 98	0.147±0.007	0.147±0.007	0.141±0.014
	Day 1 ~ 98	0.245±0.007	0.242±0.004	0.240±0.011

[a,b] Mean values in the same raw with different superscripts are significantly different as determined by one-way ANOVA and Duncan's multiple range test ($p<0.05$).

Table 8. Average body weights of layers from 15[th] week to 39[th] week (g) in experiment 1

Treatment	1	2	3	4	5	6	7	8	9	SEM[2]
SBM origin[1]	US/US	US/Brz	US/Ind	Brz/US	Brz/Brz	Brz/Ind	Ind/US	Ind/Brz	Ind/Ind	
15[th] week	1,185	1,169	1,178	1,196	1,201	1,217	1,196	1,188	1,158	3.46
18[th] week	1,558	1,551	1,577	1,562	1,575	1,567	1,559	1,594	1,545	19.32
21[st] week	1,635	1,640	1,635	1,622	1,652	1,649	1,630	1,656	1,610	22.41
24[th] week	1,772	1,798	1,768	1,743	1,772	1,800	1,780	1,790	1,748	27.47
27[th] week	1,899	1,879	1,766	1,771	1,889	1,929	1,901	1,904	1,877	76.97
30[th] week	2,034	1,895	1,922	1,912	1,945	1,990	1,966	1,942	1,941	61.25
33[rd] week	1,875	1,845	1,872	1,863	1,860	1,942	1,890	1,892	1,830	42.29
36[th] week	2,001	1,969	1,970	1,941	1,928	2,064	1,985	1,988	1,989	37.13
39[th] week	2,042	2,038	2,043	2,041	2,019	2,120	2,054	2,088	2,056	31.69

[1] Soybean meal origin during the starter and layer periods: US: dehulled SBM from US; Brz: non-dehulled SBM from Brazil; Ind: non-dehulled SBM from India.

[2] Standard error of means.

Also overall performance of chicks fed USDHSBM was better than those fed SBM of other origins. Although Brazil SBM showed slightly higher body weight gain and feed intake than USDHSBM group, there was no significant difference between two treatments, and the higher feed efficiency could compensate for the corresponding lack of performance. The gain per feed ratio of the USDHSBM group was the highest (0.585), being followed by the Brazil SBM group (0.568) and India SBM group (0.550) ($p<0.01$). This implies that the more profit can be accomplished by

Table 9. Egg production of birds fed experimental diet from 30th to 38th week in experiment 1

Weeks	1 (US/US)	2 (US/Brz)	3 (US/Ind)	4 (Brz/US)	5 (Brz/Brz)	6 (Brz/Ind)	7 (Ind/US)	8 (Ind/Brz)	9 (Ind/Ind)	Sig[1]	SEM[2]
Hen-day egg production, %											
30-32	67	67	65	67	63	67	67	65	67	-	3
33-35	77	77	76	81	80	73	77	77	74	-	4
36-38	77	78	75	81	79	75	76	81	77	-	4
30-38	71	71	70	73	70	70	71	71	70	-	3
Egg weight, g											
30-32	62.20^{a}	60.42^{bcd}	59.24^{ac}	61.42^{ab}	60.09^{bcd}	60.71^{bc}	61.00^{ab}	59.33^{cd}	58.97^{d}	O*, S***	2.79
33-35	64.30^{a}	62.24^{b}	62.65^{b}	64.74^{a}	62.83^{b}	62.21^{b}	64.20^{a}	61.08^{c}	61.27^{c}	O***, S***	2.38
36-38	65.76^{ab}	65.64^{ab}	65.72^{ab}	66.58^{a}	65.47^{bc}	65.91^{ab}	65.91^{ab}	64.57^{c}	64.89^{bc}	O**, S**	2.80
30-38	64.66^{a}	63.21^{b}	63.34^{b}	64.87^{a}	63.49^{b}	63.42^{b}	64.31^{a}	62.19^{c}	62.31^{c}	O***, S***	2.48

[a,b,c,d] Mean values in the same item with different superscripts are significantly different as determined by one-way ANOVA and Duncan`s multiple range test (p<0.05).

[1] Significance level of treatment factor: O=origin of soybean meal (growing period), S=origin of soybean meal (laying period), (O×S)=interaction between the origin of soybean meal during growing period at laying period: * p<0.05, ** p<0.01, ***p<0.001.

[2] Standard error of means.

Table 10. Mean values of egg yolk color[1], eggshell color[2], eggshell thickness[3] and eggshell strength[4] from 31st to 39th week in experiment 1

Item	1 (US/US)	2 (US/Brz)	3 (US/Ind)	4 (Brz/US)	5 (Brz/Brz)	6 (Brz/Ind)	7 (Ind/US)	8 (Ind/Brz)	9 (Ind/Ind)	Sig[5]	SEM[6]
Egg yolk color	8.01	8.02	8.10	8.10	8.10	8.12	8.08	8.15	8.17	O*	0.32
Eggshell color	12.07^{b}	12.70^{a}	12.61^{a}	12.69^{a}	12.46^{a}	12.62^{a}	12.73^{a}	12.08^{b}	12.82^{a}	S*	1.07
Eggshell thickness	0.359	0.360	0.361	0.351	0.356	0.362	0.355	0.361	0.362	S**	0.019
Eggshell strength	3.83	3.79	3.76	3.65	3.83	3.62	3.67	3.66	3.72	S*	0.22

[1] Evaluated by Roche Egg Yolk Color Fan.

[2] Evaluated by Egg Shell Color Fan, Samyangsa Co., Korea.

[3] in mm.

[4] Measured by Instron System, kg/cm^{2}.

[5] Significance level of treatment factor: O=origin of soybean meal (growing period), S=origin of soybean meal (laying period), (O×S)=interaction between the origin of soybean meal during growing period at laying period: * p<0.05, ** p<0.01, *** p<0.001.

[6] Standard error of means.

[a,b] Mean values in the same item with different superscripts are significantly different as determined by one-way ANOVA and Duncan's multiple range test (p<0.05).

feeding the USDHSBM.

The mortality rate was statistically analyzed by chi-square test. The result was not significant in all groups fed the experimental diets.

Overall, the USDHSBM was superior to other origins of SBM especially in feed efficiency. Also, performance of chicks fed India SBM was significantly lower than that of chicks fed USDHSBM.

Economic feasibility study based on production cost : It is very difficult to figure out the economic advantages of an ingredient as a practical value, because the price of feed ingredients and their substitutive feed ingredients changes all the time.

To examine the economic feasibility of the USDHSBM, feed cost of each growing phase (grower stage : 1~5wk/ finisher stage : 6wk) and cost to produce kg weight gain (cost/kg weight gain) were referred for comparison assuming the price of USDHSBM, the Brazil SBM and India SBM at US$274, US$237, US$221 per MT, respectively (table 15).

Depending on the origin of soybean meal and crude protein levels, feed costs of grower and finisher vary from 174.05 to 193.43 won/kg. The USDHSBM showed the lowest production cost among of the protein level groups of 20/19% and 21/20% CP. This result could be predicted in the significance of origin of soybean meal (O***) for feed

Table 11. Changes of Haugh's unit[1], albumen index[2] and yolk index[3] during the practical storage period in experiment 1[4]

Days of storage	1 (US/US)	2 (US/Brz)	3 (US/Ind)	4 (Brz/US)	5 (Brz/Brz)	6 (Brz/Ind)	7 (Ind/US)	8 (Ind/Brz)	9 (Ind/Ind)	Sig[5]	SEM[6]
Haugh's unit											
7	76.65^{ab}	77.53^{ab}	80.03^{a}	77.08^{ab}	73.08^{bc}	70.63^{cd}	70.03^{cd}	71.45^{d}	71.45^{c}	O***, (O×S)**	4.64
21	59.19^{bc}	56.92^{c}	59.65^{abc}	60.54^{abc}	64.14^{ab}	65.33^{a}	59.07^{bc}	62.04^{abc}	62.04^{abc}	O**	5.06
35	62.09^{ab}	57.80^{bcd}	63.34^{a}	58.70^{bcd}	59.70^{abc}	54.63^{d}	60.18^{abc}	56.73^{cd}	56.73^{cd}	O**, (O×S)**	3.85
Albumen index											
7	0.73^{bc}	0.78^{ab}	0.83^{a}	0.77^{ab}	0.69^{bcd}	0.67^{cd}	0.63^{cd}	0.68^{c}	0.68^{c}	O***, (O×S)***	0.08
21	0.46^{c}	0.45^{c}	0.47^{bc}	0.48^{bc}	0.54^{ab}	0.56^{a}	0.49^{bc}	0.47^{bc}	0.47^{bc}	O**	0.07
35	0.52^{a}	0.45^{abc}	0.52^{a}	0.41^{bc}	0.45^{abc}	0.39^{c}	0.44^{bc}	0.41^{bc}	0.41^{bc}	O***, (O×S)*	0.06
Yolk index											
7	0.35^{bcd}	0.36^{abc}	0.38^{a}	0.37^{ab}	0.35^{bcd}	0.33^{cde}	0.33^{de}	0.36^{abc}	0.36^{abc}	O***, (O×S)***	0.02
21	0.29	0.29	0.30	0.29	0.31	0.31	0.31	0.31	0.31	-	0.03
35	0.32^{a}	0.30^{c}	0.31^{ab}	0.30^{bc}	0.31^{ab}	0.27^{c}	0.30^{bc}	0.30^{bc}	0.30^{bc}	O***, S*, (O×S)***	0.02

[1] HU=100 log ($H+7.57-1.7W^{0.37}$), H: thick albumin height in mm; W: weight of egg in gram; [2] Thick albumen height in mm/thick albumen radius in cm; [3] Yolk height in mm/ yolk diameter in mm.

[4] Stored at room temperature (25°C, 30% relative humidity); egg samples were collected at 35th week. [5] Significance level of treatment factor: O=origin of soybean meal (growing period), S=origin of soybean meal (laying period), (O×S)=interaction between the origin of soybean meal during growing period at laying period; * $p<0.05$, ** $p<0.01$, *** $p<0.001$. [6] Standard error of means.

a,b,c,d,e Mean values in the same item with different superscripts are significantly different as determined by one-way ANOVA and Duncan's multiple range test ($p<0.05$).

Table 12. Economic evaluation based on egg weight produced from 33rd to 35th week in experiment 1

Item	Origin of SBM fed for grower	Origin of SBM fed for layer			Sig[1]	SEM[2]
		US (Dehulled)	Brazil	India		
Total egg weight/bird (g)	US (Dehulled)	1,208.51^{a}	1,073.73^{de}	1,119.29^{ac}	S***	44.26
	Brazil	1,201.62^{ab}	1,127.38^{abc}	1,117.35^{bcd}		
	India	1,194.45^{ab}	1,055.50^{cd}	1,033.25^{d}		
Feed price[3] (won/kg)	US (Dehulled)	290.79	286.02	282.95	-	-
	Brazil	290.79	286.02	282.95		
	India	290.79	286.02	282.95		
Feed price /egg weight (won/g)	US (Dehulled)	0.241	0.266	0.253	-	-
	Brazil	0.242	0.254	0.253		
	India	0.243	0.271	0.274		

a,b,c,d Mean values with different superscripts in each item are significantly different as determined by one-way ANOVA and Duncan's multiple range test ($p<0.05$).

[1] Significance level of treatment factor: O=origin of soybean meal (growing period), S=origin of soybean meal (laying period), (O×S)=interaction between the origin of soybean meal during growing period at laying period; * $p<0.05$, ** $p<0.01$, *** $p<0.001$.

[2] Standard error of means.

[3] Feed price=price/feed (won/kg)×total feed intake (2.1 kg) for 33th to 35th weeks; average feed intake=110 g/bird/day.

efficiency of table 14. Also average cost to produce kg weight gain were 322.2, 325.9 and 325.6 won at USDHSBM, Brazil and India SBM, respectively. Overall superiority was found in groups fed USDHSBM without statistical significance (table 15).

DISCUSSION

Layer (Experiment 1)

Hen-day egg production was not significantly different among treatments. According to the report of Lewis et al. (1996), the egg production rate itself mainly depends on photostimulus. This result suggested that the protein

Table 13. Economic advantage of dehulled soybean meal in egg production

SBM origin[1]	Relative production (g/day)[2]	Relative production (g/year)	Relative production (egg/bird/year)[3]	Extra Expenses of feed (won/kg)	Extra Expenses of feed (won/bird/year)[4]
US / US	8.35	3,046.19	46.86	7.84	314.78
Brazil / US	8.02	2,926.43	45.02	7.84	314.78
India / US	7.68	2,801.81	43.10	7.84	314.78
Brazil / Brazil	4.48	1,636.07	25.17	3.07	123.26
US / India	4.10	1,495.46	23.01	0.00	0.00
Brazil / India	4.00	1,461.74	22.49	0.00	0.00
US / Brazil	1.93	703.58	10.82	3.07	123.26
India / Brazil	1.06	386.73	5.95	3.07	123.26
India / India	0.00	0.00	0.00	0.00	0.00

[1] Indicates soybean meal origin during growing/laying periods.
[2] Differences betweens individual treatment and a treatment showing minimum value, i.e., 8.35=(Total egg wt. of 3 weeks of US/US-Total egg wt. of 3 weeks of India/India).
[3] Divided by weight of grade 'A' egg, 65 g.
[4] Average feed intake per bird per day = 110 g.

Table 14. Body weight gain, feed intake and feed/gain ratio of broiler chicks fed the experimental diets from day 1 to day 42 in experiment 2

Item	Week	Treatment1 Dehull US 19/18% CP	Treatment2 Dehull US 20/19% CP	Treatment3 Dehull US 21/20% CP	Treatment4 Brazil 19/18% CP	Treatment5 Brazil 20/19% CP	Treatment6 Brazil 21/20% CP	Treatment7 India 19/18% CP	Treatment8 India 20/19% CP	Treatment9 India 21/20% CP	Sig[1]	SEM[2]
Body weight gain (g)												
	1 ~ 5	1.111.28^{bc}	1,163.22^{ab}	1.205.75^{a}	1,095.62^{c}	1.186.60^{a}	1,183.88^{a}	966.32^{d}	978.42^{d}	945.41^{d}	O***, L***	26.79
	6	356.19^{b}	363.87^{ab}	369.97^{ab}	350.48^{b}	361.94^{ab}	409.77^{a}	324.52^{bc}	299.81^{c}	283.37^{c}	O***	19.96
	Total	1,467.48^{b}	1,527.10^{ab}	1.575.72^{a}	1,446.10^{b}	1,548.54^{ab}	1,593.66^{a}	1,290.85^{c}	1.278.24^{c}	1,228.79^{c}	O***, OxL*	41.29
Feed intake (g)												
	1 ~ 5	1,735.73^{cd}	1,794.72^{bc}	1,869.51^{ab}	1.801.66^{bc}	1.943.86^{a}	1,851.54^{abc}	1,543.13^{e}	1.660.67^{de}	1,584.66^{e}	O***, L**	48.42
	6	803.10^{ab}	833.14^{a}	769.98^{ab}	766.62^{ab}	847.81^{a}	868.92^{a}	770.04^{ab}	696.72^{bc}	646.79^{c}	O***	46.40
	Total	2.538.84^{bc}	2.627.86^{ab}	2.639.50^{ab}	2.568.29^{b}	2.791.67^{a}	2.720.47^{ab}	2.313.17^{d}	2.357.40^{cd}	2.231.45^{d}	O***	78.92
Gain/feed ratio												
	1 ~ 5	0.640^{ab}	0.648^{a}	0.645^{ab}	0.608^{bc}	0.610^{abc}	0.639^{ab}	0.626^{abc}	0.589^{c}	0.597^{c}	O***	0.038
	6	0.444	0.437	0.480	0.457	0.427	0.472	0.421	0.430	0.438	-	0.030
	Total	0.578^{abc}	0.581^{abc}	0.597^{a}	0.563^{abcd}	0.555^{bcd}	0.586^{ab}	0.558^{bcd}	0.542^{d}	0.551^{cd}	O***	0.009

[a,b,c] Mean values in the same item with different superscripts are significantly different as determined by one-way ANOVA and Duncan's multiple range test (p<0.05).
[1] Significance level of treatment factor: O=origin of soybean meal, L=level of dietary crude protein and (O×L)=interaction between the origin of soybean meal and level of dietary crude protein; * p<0.05, ** p<0.01, *** p<0.001.
[2] Standard error of means.

sources of feed affect the production of layer. For dozens of years, a notable number of experiments has been conducted to examine other protein sources as substitute for soybean meal in layer feed. In Lebanon, Farran et al. (1995) reported 22.5% vetch seed feeding decreased body weight, feed intake and egg production (p<0.05), compared with control. In 1996, Richter et al. (1996) examined the rapeseed meal as a protein source in layer feed. Feed intake, egg production, individual egg weight and live weight gain were reduced in hens fed 5-20% rapeseed and 10-20% rapeseed meal, even those rapeseed sources contains low level of glucosinolates. There's other sources of feed protein supply for developing countries such as neem kernel meal (NKM), rubber seed meal, cassava leaf meal, ipil leaf meal and recycled animal manure but in chicken level of those feedstuffs are limited for some reason (Ravindran, 1995;

Table 15. Feed price and production cost of broiler chicks fed experimental diets in experiment 2

	Weeks of Age	Treatment 1 Dehull US 19/18% CP	Treatment 2 Dehull US 20/19% CP	Treatment 3 Dehull US 21/20% CP	Treatment 4 Brazil 19/18% CP	Treatment 5 Brazil 20/19% CP	Treatment 6 Brazil 21/20% CP	Treatment 7 India 19/18% CP	Treatment 8 India 20/19% CP	Treatment 9 India 21/20% CP
Feed price[1], won/kg										
Grower diet	1 ~ 5	185.33	189.62	193.43	180.60	185.61	191.21	177.11	178.38	183.75
Finisher diet	6	183.33	185.99	189.58	178.72	181.96	187.36	174.05	177.32	181.67
Cost /kg wt gain, won										
	1 ~ 5	289.88	292.64	299.96	297.24	304.72	299.12	282.99	302.74	307.81
	6	415.98	426.05	397.12	392.28	426.21	399.15	417.27	413.85	416.99
	Total	320.03	324.31	322.10	320.18	333.01	324.53	315.76	328.38	332.54
			Dehulled US			Brazil			India	
Average Cost / kg wt gain, won			322.15			325.91			325.56	

[1] Calculation based on mill-door price of feed ingredient (average price of year 1999).

[a,b,c] Mean values in the same column with different superscripts are significantly different as determined by one-way ANOVA and Duncan's multiple range test ($p<0.05$).

Gowda et al., 1998).

In addition, excluding that clear superiority, dehulled soybean meal is a qualified protein sources even it was originated from plants. There's some traditional belief that animal protein sources such as fish meal contains UGFs (unknown growth factors) but was revealed as vitamin B_{12} and selenium (Creswell, 1992).

Broiler (Experiment 2)

During the entire period, USDHSBM and Brazil SBM fed group significantly was gained more weight than those fed India SBM ($p<0.001$). But weight gain of India SBM fed group was tended to decrease with increasing of the CP level. This inclination was similar to the result reported by Leeson et al. (1987), Lee et al. (1994) and Joo et al. (1994). India SBM was treated by over-heat processing and then reduced protein quality with low amino acid digestibility.

In case of the Brazil SBM (treatments 4, 5 and 6) and the India (treatments 7, 8 and 9) SBM, chicks fed 20% crude protein diet had higher feed intake and lower gain/feed ratio than USDHSBM fed group ($p<0.01$). This result was similar to that reported by Park and Baik (1997), but not consistent with the result of Chung et al. (1988). Especially, India SBM fed group showed low feed intake and gain per feed ratio.

The gain per feed ratio of the USDHSBM group was the highest, and followed by the Brazil and India SBM group. This demonstrates the higher net margin can be accomplished by feeding the USDHSBM.

Park and Baik (1997) reported similar result in broiler feeding trial of comparison with two different soybean meal sources.

In the present experiment, the inclusion of the USDHSBM increased unit feed cost than Brazil and India SBM for production of broiler. But, the favorable effects of feed efficiency were more than enough to compensate for disadvantage of high unit feed cost. Therefore, the use of the USDHSBM in broiler diets could be economically advantageous to the broiler production due to its excellent protein quality and amino acid digestibility.

CONCLUSIONS

Soybean meal is a qualified source of feed protein, and according to the origin of soybean meal, the quality varies. It is well known that dehulled soybean meal has an excellent nutrient profile and higher energy values and contains more digestible nutrients compared to non-dehulled soybean meals (Swick, 1995; Swick, 1998). It is desirable to use US dehulled soybean meal for improving egg weight as well as egg quality to get higher egg grade from consumers.

Also US dehulled soybean meal was more efficient than Brazil- and India-originated nondehulled soybean meal for the production of broilers. This good result of body weight gain or gain/feed was considered to be attributed to dehulling in USDHSBM.

Therefore, in this experiment, the use of USDHSBM with excellent protein quality and amino acid digestibility could be useful for economic production of layers and broilers.

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