Soybean Checkoff-funded Research

Project Title: Evaluation of Comparative Feeding Values of Soybean Meals of Foreign-Origin in Broilers

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Objective of the study:

The aim of this study was to evaluate comparative feeding values of soybean meals, originated from South America and India, together with a dehulled soybean meal processed in the U.S. Various methodologies such as chemical assays, in vitro and in vivo digestibility measurement were used to compare nutritional values of the meals. Feeding trials of a small room scale with young chicks and of a farm level with broilers were also conducted for this purpose. A comparative evaluation of the meals in economical aspects was also made in the broiler trial.

Summary of the study results

<u>Soybean meals sources</u>

Three soybean meals (SBM) for this study were originated from the U.S., Brazil and India. One of the SBM was imported from the U.S. in February, 2001 as dehulled, and the other two SBM, non-dehulled, from Brazil and India in spring, 2001.

<u>Proximate analyses</u>

Dehulled SBM appeared to contain more protein (47.9 %) and less crude fiber (3.6%), as expected, compared to those of the other sources of SBM; 44.2~46.6% for crude protein, 4.6~6.6% for crude fiber.

<u>Amino acid contents</u>

Levels of two major amino acids; lysine and methionine+cystine, appeared also higher in dehulled SBM, when expressed on air-dry basis, followed by the meals, in the order, from India and Brazil. Even when the data were expressed as % protein basis, the dehulled meal showed to have higher concentration (6.5 vs. 6.3%) of lysine than the other meals.

Digestibility and solubility tests

Pepsin digestibility (0.02% pepsin) test showed a value of 53.5% for dehulled meal, while those of the other SBM were in the range of 47.2~48.8%. Result of another indirect enzyme digestibility test, pepsin+pancreatin, also showed higher value for dehulled SBM than those for the other meals; 30.9% vs. 22.9~28.2%.

Dry matter digestibility from the same test resulted in the same quality pattern among the meals; 66.2, 62.3 and 63.5% for the U.S., Brazil and India, respectively. Nitrogen in dehulled meal showed 82.1% solubility in KOH solution, which was also higher than those of the other SBM; 73.1~76.6%.

Trypsin inhibitor and urease activities

Activities of trypsin inhibitor appeared 7.0, 4.8 and 6.8 mg trypsin-inhibited/g for the U.S., Brazilian and Indian SMB, respectively. Urease activities for the meals were in the ranges of 0.03~0.05 pH change. These levels of anti-nutritional factors in all the samples were within in the safe ranges.

Amino acid availability in vitro and in vivo

Lysine availabilities measured in vitro were 2.72% for the meals from the U.S. and India, while 2.55% for Brazilian meal. Actual bioavailabilities of all amino acids in the meals were measured with broilers attached with urine collection tube and cecal litigation. The bioavailability levels for most of the essential amino acids appeared significantly higher ($p<0.05$) in the dehulled meal followed by, in the order, Indian and Brazilian meals. The levels for lysine and methionine+cystine of the dehulled meal were 98 and 95.5%, respectively. Overall average levels of amino acid bioavailability were 96.9, 95.2 and 94.9% for the meals from the U.S., India and Brazil, respectively.

Protein quality evaluation in a chick trial

When the meals were fed to young chicks as the only dietary protein source in a purified-type diet, protein efficiency ratios(PER) appeared 2.37, 2.01 and 1.98, and net protein retention (NPR) was 2.94, 2.63 and 2.57 for the meals from the U.S., India and Brazil, respectively. The values for dehulled meal were significantly different from the others at $p<0.05$ level.

Broiler feeding trial

Performances of broilers fed the meals for 5 weeks tended to show significantly higher feed intake, faster growth rate and better feed/gain ratio in birds fed the diets containing dehulled meal during overall period as well in growing and developing phases. Amount of abdominal visible fat was not significantly different among the groups although the level for the birds fed the dehulled meal diet was numerically lower.

<u>Economical evaluation</u>
To compare economical aspects of the meals, ingredient prices of the three meals were calculated based on their import C.& F. prices to port Inchon. Base price of the dehulled meal , imported only once, was $225.5 /MT, and those of the other two meals were considered as $198.2 and $198.7 for Brazilian and Indian SBM, respectively, by averaging their C. & F. prices from January to September, 2001. By applying an exchange ratio of 1300 won to 1 U.S. dollar, the prices of dehulled, Brazilian and Indian meals became 293.2, 257.8 and 258.4 won/kg, respectively.

Return over production cost (feed+chick) from broiler feeding trial demonstrated margins as 609.4, 590.9 and 563.7won/kg live body weight for the U.S., Indian and Brazilian SBM, respectively.

In an attempt to compare the economical advantages of the dehulled meal, a single price, 258.1 won/kg, which was the average of the Brazilian and Indian meal prices was applied to all SBM in calculating the return over production cost. This resulted in a greater margin of 620.1 won for dehulled SBM when compared to 591.0 and 563.7 won/kg body weight of broilers fed the Indian and Brazilian meals, respectively.

<u>Conclusion and suggestion:</u>
Overall observations that the dehulled SBM from the U.S. tended to show better nutritional quality including amino acids bioavailability than the other non-dehulled SBM were also reflected in the economical evaluation in a broiler feeding trial. This higher feeding values shown in the SBM from the U.S. could hardly be explained only in association with changes in fiber content resulting from dehulling.

A further study with dehulled and non-dehulled SBM from the same sources is needed to have a better evaluation between the two types of meals.

Study 1. Proximate analyses, Ca , P and amino acid compositions of soybean meals

Materials: Three soybean meal samples obtained locally during a period from March to May, 2001.

- one dehulled soybean meal from the U.S.
- two non-dehulled soybean meals from Brazil and India.

Methods:

- Proximate analyses: AOAC methods (1990)

- NDF and ADF: Van Soest (1982)
- Ca by atomic absorption spectrometry and total P by colorimetric assay
- Amino acids: HCl hydrolysis followed by ninhydrin reaction. S-containing amino acids were separately hydrolyzed with performic acid followed by ninhydrin reaction. Auto amino acid analyzer (Hitachi L-8500) was used.

Results: Results of proximate analysis and contents of fibers soluble with neutral detergent and acid detergent and of calcium and phosphorus in soybean meals (SBM) are as shown in Table 1. Table 2 shows amino acid compositions of the SBM expressed as % air-dry matter and % of protein.

Conclusion:

1. In proximate analyses, dehulled SBM appeared to contain, as expected, higher level of crude protein (47.9%) and lower levels of crude fiber (3.6%), NDF(10.9%) and ADF (5.8%) compared to those of the other sources of SBM.

2. Amounts of two major amino acids; lysine and methionine+cystine, were highest in dehulled SBM, when expressed on air-dry basis, followed by the meals, in the order, from India and Brazil. When the data, however, were expressed as % protein basis, the contents of the two amino acids were almost the same for all SBM.

Table 1: Chemical compositions of soybean meals of various origins

	Origins of Soybean Meals		
Composition	U.S.[1]	Brazil	India
	% air-dry basis		
Moisture	11.10	11.30	11.20
Crude Protein	47.90	44.20	46.60
Crude Fat	1.80	1.70	0.90
Crude Ash	6.40	6.00	8.50
Crude Fiber	3.60	6.60	4.60
NFE[2]	29.20	30.20	28.20
NDF[3]	10.90	18.10	17.10
ADF[4]	5.80	9.80	10.60
Calcium	0.35	0.34	0.50
Total Phosphorus	0.56	0.48	0.54

[1] Dehulled soybean meal

[2] Nitrogen-free-extract

[3] Neutral detergent fiber

[4] Acid detergent fiber

Table 2: Amino acid compositions of soybean meals of various origins

	Origins of Soybean Meals		
Amino acids	U.S.[1]	Brazil	India
	% air-dry basis(% protein)		
Alanin	2.11 (4.4)	1.97 (4.5)	2.00 (4.3)
Arginine	3.47 (7.2)	3.12 (7.1)	3.50 (7.5)
Asp+Asn[1]	5.58 (11.7)	5.11 (11.6)	2.25 (11.3)
Cystine	0.71 (1.5)	0.64 (1.5)	0.65 (1.4)
Glu+Gln[2]	8.98 (18.8)	8.18 (18.5)	8.60 (18.5)
Glycine	2.08 (4.3)	1.96 (4.4)	1.98 (4.3)
Histidine	1.37 (2.9)	1.23 (2.8)	1.25 (2.7)
Isoleucine	2.14 (4.5)	1.85 (4.2)	1.93 (4.1)
Leucine	3.75 (7.8)	3.40 (7.7)	3.47 (7.5)
Lysine	3.10 (6.5)	2.79 (6.3)	2.93 (6.3)
Methionine	0.67 (1.4)	0.60 (1.4)	0.63 (1.4)
Pheylalanin	2.48 (5.2)	2.29 (5.2)	2.26 (4.9)
Serine	2.58 (5.4)	2.46 (5.6)	2.52 (5.4)
Threonine	2.04 (4.3)	1.86 (4.2)	1.92 (4.1)
Tyrosine	1.72 (3.6)	1.58 (3.6)	1.61 (3.5)
Valine	2.30 (4.8)	2.00 (4.5)	2.00 (4.3)

[1] aspartic acid + asparagine

[2] glutamic acid + glutamine

Study 2: Measurements of soybean protein quality with in vitro nitrogen solubility, pepsin digestibility and in vivo amino acid bioavailability in broilers attached with urethral tubing and cecal litigation

Materials: the same soybean meals as in Study 1.

Methods:

- Nitrogen solubility by KOH solution by Dale et al. (1988)
- Trypsin inhibitor activity by Analytical methods and procedure manual. No. 10.04 (Dalgety Agriculture Co., 1996)
- Urease activity by phenol red indicator method by Caskey et al. (1944)
- Pepsin digestibility by A.O.A.C. (1994)
- Pepsin + pancreatin digestibility by Andlauer et al. (2000)
- Available lysine by Carpenter (1960)
- Amino acid content by the same method as in Study 1.

Broiler birds: Arbor Acre, nine males with 2.0 kg mean body weight.

Cecal litigation (Poppema and Duke, 1992). Urethral tubing method was originally developed in present study to separate urine from excreta.

Results and Conclusion: Data from various measurements of nitrogen utilization (solubility) of SBM assessed by in vitro and in vivo methods are as shown in Table 3. Data in Table 4 were obtained from broilers whose ceca were surgically litigated and attached with urethral tubing. These arrangements were necessary to prevent contaminations from cecal contents and urinary amino acids to the anal samples for amino acid bioavailability measurement.

In conclusion,

1. Dehulled SBM were statistically higher ($p<0.05$) in pepsin digestibility, pepsin+pancreatin digestibility and N solubility by KOH compared to those of the other sources of SBM, suggesting a possibility of better utilization of proteins in the dehulled SBM in actual animal feeding.

2. Dehulled SBM appeared to have a significantly higher trypsin inhibitor activity than those of Brazilian SBM. However, the activity value (7.0)of the dehulled SBM is still in the safe range.

3. Overall amino acid bioavailability data were better in dehulled SBM with 96.9%, followed by the meals from India (95.2%) and Brazil (94.9%). The availability values for lysine and methionine+ cystine of the dehulled SBM (98.0 and 95,6%, respectively) were significantly higher than those of the other SBM.

4. Bioavailabilities of the other essential amino acids such as histidine, leucine, isoleucine, valine, phenylalanine and threonine were also significantly better in U.S. SBM than those in the other SBM.

5. The bioavailability of glycine in all the treatments (90.9-92.8%) appeared remarkably higher than the data previously reported by other researchers. It could be associated with the prevention of uric acid contamination to excreta by urethral tubing.

Table 3: Assessments of protein utilization of various sources of SBM by in vitro and in vivo methods

	Origins of Soybean Meals		
Measurements	U. S.	Brazil	India
Pepsin digestibility, % protein			
By 0.02% pepsin	53.5 a	47.2 b	48.8 b
By 0.2% pepsin	94.9	94.5	94.8
Pepsin + Pancreatin digestibility, % protein	30.9 a	22.9 b	28.2 a
% dry matter	66.2	62.3	63.5
N solubility by KOH % protein	82.1 a	73.1 b	76.6 b
Trypsin inhibitor activity, mg trypsin inhibited per g sample	7.0 a	4.8 b	6.8 a
Urease activity change of pH	0.05	0.05	0.03
Available lysine % protein	2.73 a	2.55 b	2.72 a

a, b $p<0.05$

Table 4: Amino acid bioavailability of the soybean meals of various origins in broiler chicks attached with urethral tubing and with cecal litigation

Amino acids	Origins of Soybean Meals		
	U.S.[1]	Brazil	India
	% air-dry basis		
Alanin	96.1 a	91.9 b	92.9 b
Arginine	98.4 a	97.8 ab	97.5 b
Asp+Asn[1]	97.3 a	96.0 b	96.4 ab
Cystine	95.9 a	91.6 c	93.8 b
Glu+Gln[2]	98.2 a	97.0 b	97.0 b
Glycine	92.8 a	91.2 ab	90.9 b
Histidine	97.4 a	96.3 b	96.1 bb
Isoleucine	97.1 a	95.4 b	94.8 b
Leucine	97.6 a	95.6 b	94.8 b
Lysine	98.0 a	95.8 b	96.4 b
Methionine	95.2 a	92.9 b	93.7 ab
Pheylalanin	97.7 a	96.0 b	96.0 b
Serine	97.7 a	96.3 b	96.4 b
Threonine	97.0 a	94.8 b	95.0 b
Tyrosine	97.5 a	95.7 b	96.5 ab
Valine	96.8 a	94.0 b	94.4 b
Average	96.9	94.9	95.2

a, b, c $p<0.05$.

[1] Aspartic acid + asparagines

[2] Glutamic acid + glutamine

Study 3. Evaluation of SBM protein quality by measurement of protein efficiency ratio (PER) and net protein retention (NPR) in young chicks

Birds: ISA-Brown, males, day-old chicks. 196 birds.

Materials and Methods:

- Experimental design: four treatments x four replications x seven birds/replication = 112 birds, Treatments are N-free diet and three SMB (U.S., Brazil, India) diets.
- Semi-purified-type diets: Purified-type ingredients such as corn starch, glucose, alpha-cellulose, and soybean oil. SBM was the only source of protein.
- SBM was adjusted to provide 13% dietary protein level. The protein level is the same as in NPU standard method in chicks (Bender and Doell, 1957).
- Feeding period: 14 days.
- PER = body weight gain (g) of chicks fed the test diet / protein intake (g) from the test diet

- NPR= [body weight gain(g) of chicks fed the test diet + weight loss (g) of chicks fed N-free diet] / protein intake (g) from the test diet

Results and Conclusion: Comparisons in protein quality between SBM from various sources are as shown in Table 5. The chicks fed the diets containing U.S. SBM appeared to gain more body weight and better feed utilization efficiency, although amount of protein supplied from the all SBM were marginal to NRC requirement level. The reason for adopting this lower level (13%)of dietary protein is to show more sensitive responses to the protein quality of the diets. These advantages of the U.S. SBM were reflected also in the measurements of PER and NPR by margins of 11-16% over those of the other SBM.

Table 5: Performances of chicks fed the experimental diets

Sources of SBM	Feed intake	Body weight gain	Feed /Gain	PER (%)	NPR (%)
	--- gram/bird ---				
N-free diet	93.0	-13.6	-	-	-
U.S,	182.0	56.0 a	3.25	2.37 a (100)	2.94 a (100)
Brazil	178.0	45.8 b	3.89	1.98 b (84)	2.57 b (87)
India	172.6	45.5 b	3.79	2.03 b (86)	2.63 b (89)

a, b $p<0.05$

Study 4: Broiler feeding trial with the soybean meals of various origins

Place for trial: Test farm, Korean Poultry Association locating at Ansung city, Kyounggi-do
Birds: 480, day-old, male, broiler chicks, Ross breed.

Experimental design: Three treatments (U.S., Brazil, and India) x 4 replications x 40 birds/replication = 480 birds.

Diets: Formulated according to nutritive levels of local commercial compound diets for broilers as shown in Table 6. All experimental diets were made with an identical formulation, meanwhile the SBM from each country was the only different ingredient.
Grower and developer diets were fed to birds for a period of three and two weeks, respectively, following the local phase-feeding pattern for broiler production. All of the nutrient levels were set to satisfy NRC requirements for broilers.

Abdominal fat: At the end of the feeding trial, eight birds with average body weight from each dietary group were sacrificed to measure visible fat weight in the abdomen. The fat weight was expressed as % empty body weight. The empty body weight was obtained by removing residues in the gastrointestinal tract of the birds.

Table 6: Formulations for starter and finisher diets

Ingredients	Starter	Finisher
	%	
Corn, yellow	54.78	55.75
Wheat	4.00	8.00
Soybean meal	22.0	18.0
Corn gluten meal	6.00	6.00
Lupin	2.00	3.00
Rapeseed meal	1.50	1.00
Wheat bran	3.00	2.00
Soybean oil	3.00	3.00
Tricalcium P	1.90	1.70
Limestone	0.70	0.63
DL-methionine	0.20	0.06
L-lysine	0.16	0.15
Antibiotics	0.10	0.10
Antioxidant	0.01	0.01
Coccidiostat	0.05	-
Miscellaneous[1]	0.60	0.60
Nutrients calculated		
AMEn, kcal/kg	3050	3100
Protein, %	21.1	19.7

1) Contains salt 0.3, vitamin mixture 0.1, mineral mixture 0.1 and choline-chloride 0.1.

Results: Broiler performances

Broiler performances during each growing phase are as shown in Tables 7, 8 and 9. During the starter phase (0-3 weeks of age), birds fed the U.S. SBM consumed significantly more diet and grew faster than those fed the Brazilian SBM ($p<0.05$). Performances of birds fed the diets containing SBM from Brazil and Indian were not significantly different. There were no overall differences in feed/gain ratios among the dietary treatments (Table 7).

The same trends in more feed intake and faster body weight gain of the birds fed the dehulled SBM from U.S. compared to the birds of the other dietary groups continued to show during the growing period from 4 to 5 wk of age (Table 8) and for a whole experimental period (0-5 wk of age) as shown in Table 9. The feed/gain ratio of the dehulled SBM group during the growing period appeared significantly better (1.73 vs. 1.87) than that of birds fed the Brazilian SBM ($p<0.05$). The feed utilization ratio of the SBM from Indian appeared in the middle without statistical significant differences with those of the other dietary groups. The same pattern of the feed/gain ratio (Table 9) appeared in whole experimental periods with a best efficiency of 1.62 (U.S.) and with Indian SMB in the middle (1.66).

Amount of abdominal visible fat at the end of feeding trial expressed as % of body weight were lowest (13.6%) in the birds fed the dehulled SBM and highest (17.1%) in the birds fed the Brazilian SBM. The birds fed the Indian SBM appeared to have a level of 14.6% of the fat, which was again in the middle of the other two groups (Table 9).

Table 7: Performance of broilers fed the diets containing SBM of various origins for 0-3 weeks

Origins of SBM	Feed Intake	Body Weight Gain	Feed/Gain
------ g/bird ------			
U.S.	816.1 a	570.0 a	1.43
Brazil	741.8 b	527.5 b	1.41
India	802.5 ab	555.4 ab	1.44
SEM	11.0	6.9	0.01

a, b p <0.05

Table 8: Performance of broilers fed the diets containing SBM of various origins for 4-5 weeks

Origins of SBM	Feed intake	Body weight gain	Feed/Gain
-------- g/bird ---------			
U.S.	1605.7 a	928.4 a	1.73 a
Brazil	1462.0 b	783.7 b	1.87 b
India	1520.0 b	846.7 b	1.80 ab
SEM	20.0	25.7	0.01

a, b. p <0.05

Table 9: Overall performance of broilers fed the diets containing SBM of various origins for a period of 5 weeks

Origins of SBM	Feed intake	Body weight gain	Feed/Gain	Abdominal fat weight
	g/bird	g/bird		% B.W.
U.S.	2421.9 a	1498.4 a	1.62 a	13.6
Brazil	2203.8 c	1311.3 c	1.68 b	17.1
India	2322.7 b	1402.2 b	1.66 ab	14.6
SEM	20.0	25.7	0.01	0.08

a, b, c p <0.05

Evaluation of an economical feasibility of dehulled SBM in broiler diets: Data in Table 10 show prices of individual ingredients used in formulating the test diets. The prices of ingredients except the SBM represent actual local market prices in summer, 2001. The prices of individual SBM were calculated by averaging the C. & F. import prices to port Inchon during a period from January to September, 2001. The average prices appeared to be $198.2 and $198.7/MT for Brazilian and Indian SBM, respectively. Dehulled SBM was imported to lnchon in February, 2001, from the U.S. at a C. & F. price of $225.5/MT. The import prices in U.S. dollar were converted into Korean won by adapting the exchange ratio of 1300 won to 1 U.S. dollar. Consequently, the price of dehulled SBM appeared 13.6% higher than the regular SBM price per ton basis.

The economic feasibility of dehulled SBM was compared in two different point of views as shown in Table 11. Firstly, the prices representing actual average import cost for individual SBM was used to calculate the return over the production cost in raising broilers. The other way to compare the economical advantages among the SBM sources was to apply a single price to all the SBM to calculate a return over the production cost. The single price, 258.1 won/kg SBM, was obtained by averaging the prices of SBM from Brazil and India.

The production cost included only feed and chicks. The price of day-old broiler chick was considered 500 won/bird, and broiler selling price, 1281 won/kg live bird, was based on annual average wholesale price in Seoul area during a period from September, 2000 to August, 2001 (Korean Poultry Association, 2001).

When individual prices for each SBM were applied, the returns over production cost per kg bird weight appeared 609.4, 563.7 and 590.9 won for birds fed the diets containing SBM from the U.S., Brazil and India, respectively. This result demonstrated that net income/kg bird in the group fed the dehulled SBM were 45.7 and 18.5 won higher than those fed the SBM from Brazil and India, respectively.

Meanwhile, when applying a single price to all SBM, further increases in returns over production cost per kg bird weight appeared for the group fed dehulled SBM compared to those fed SBM from the other sources. The net income/kg bird for the group fed the dehulled SMB was 56.4 and 29.1 won higher than those fed the SMB from Brazil and India, respectively.

Conclusion:

Birds fed the diets containing dehulled SBM tended to perform better in body weight gain and feed utilization efficiency with statistically significant differences ($p<0.05$) compared to those fed the other sources of regular SBM. The price of dehulled SBM (293.2 won/kg) based on actual import price was higher than those of the other regular SBM (257.8 and 258.4 won for Brazilian and Indian, respectively). However, the return over production cost of the group fed the dehulled SBM was higher with a margin of 18.5-45.7 won/kg live bird weight compared to those fed the regular SBM diets.

The reason for these economical advantages from feeding dehulled SBM to broilers could only be explained in association with higher protein quality of the meal, i.e., better amino acid balance and digestibility, although marketing price of the dehulled SMB was 13.6% higher than the other regular SBM per weight basis.

Table 10: Prices of feed ingredients used for test diets

Ingredients	Cost (won/kg)
Corn, yellow	149.0
Wheat	167.0
Soybean meal[1]	
U.S.	293.2
Brazil	257.8
India	258.4
Corn gluten meal	445.0
Lupin kernel	258.0
Rapeseed meal	186.0
Wheat bran	123.0
Soybean oil	550.0
Vitamin premix	3490.0
Mineral premix	800.0
DL-methionine(100%)	3400.0
L-lysine-HCl	2500.0

[1] Calculated from actual average C. & F. Inchon for individual SBM during from January to September, 2001 and with an exchange rate of 1300:1 (won:dollar).

The average C. & F. price for Brazilian and Indian SBM were $198.29 and 198.76, respectively. The C. & F. Inchon for dehulled SBM from the U.S. in February, 2001 was $225.50/MT.

Table 11: Return over feed cost of broilers fed diets containing various sources of SBM

	Origins of SBM		
Diets	U.S.	Brazil	India
Calculated based on individual SBM cost			
	Feed cost, won/kg		
Starter diet	224.90	217.11	217.25
Finisher diet	216.03	209.66	209.77
	Return over production cost, won		
Feed cost/bird	530.4	467.6	493.2
Production cost[1]	1030.4	967.6	99.32
Broiler income/bird	1967.6	1728.3	1843.8
Return over production	937.2	760.7	850.6
Return/kg bird	609.4	563.7	590.9
% of Return/kg bird	108.1	100.0	104.8
Calculated based on a single price for all SBM[2]			
	Feed cost, won/kg		
Starter diet	217.18	217.18	217.18
Finisher diet	209.71	209.71	209.71
	Return over production cost, won		
Feed cost/bird	514.0	467.7	493.1
Production cost	1014.0	967.7	993.1
Broiler income/bird	1967.6	1728.3	1843.8
Return over production	953.6	760.6	850.7
Return/kg bird	620.1	563.7	591.0
% of Return/kg bird	171.9	100.0	133.9

[1] Production cost includes costs for feed and birds.

[2] The single price applied, 258.1 won/kg SBM, was the average price of Brazilian and Indian meals.

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