家禽誌 25(2) : 91~98(1998) K.J. Poult. Sci. 25(2) : 91~98(1998)

Economic Evaluation of Two Imported Soybean Meals and Two Dietary Protein Levels for Broilers

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육계에 대한 두 종류의 수입대두박과 두 가지의 단백질 수준의 경제성 비교

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ABSTRACT

In order to compare economics of soybean meals (SBMS) imported from Brazil and the U.S., a feeding trial was conducted with 480 commercial broiler chicks (Abor Acres strain) for 38 days. The Brazilian SBM was brownish in color and the protein solubility in 0.2 % KOH solution was 63.4 %. The U.S. SBM, on the other hand, was a dehulled SBM, and uniform in color (light yellow) and particle size. The protein solubility value of the latter was 76.6 %. Two dietary protein levels (19 % and 21 %) were used for each source of SBM (2×2 factorial). Chicks fed diets containing the U.S. SBM grew significantly faster ($P<0.05$) and utilized feed more efficiently than chicks fed diets containing Brazilian SBM. Chicks fed diets containing 21 % CP showed better growth performance and profitability than those fed the 19 % CP diets. The price of the U.S. SBM was higher but the feed cost per unit gain was lower than the Brazilian SBM. Results suggest that there are over-cooked SBMs being traded on the Korean market, and attention should be given to not only the price but also the quality of SBMs.

(Key words : imported soybean meal, dietary protein level, broiler, economics)

INTRODUCTION

Because of its excellent quality and abundant availability, soybean meal (SBM) is widely used for animal feeds including broiler diets. The annual consumption of SBM by the Korean feed industry ranges from 1.5 to 1.8 million metric tons. About one half of this amount is imported, mostly from Brazil, China, and India. Although some essential amino acids such as lysine and methionine are limiting in SBM, it is truely one of the best plant protein sources for broiler feeding. However, its protein quality varies widely depending upon processing technique and facility (Paik et al., 1975a,b; Heo et al., 1990; Kim et al., 1995; Han and Choi, 1988).

The SBM protein contains urease and trypsin

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inhibitor. Being anti-nutritional, these two proteins must be denatured before feeding. An effective way of denaturation is toasting at a proper temperature for a certain period (Garlich, 1988a,b; McNaughton and Reece, 1980; Leeson et al., 1987; Ohh, 1988). Too much heat, however, will reduce the quality of storage protein in SBM, eventually impairing the broiler performance (Chae et al., 1984 ; Han et al., 1987; Ponger and Matrai, 1976 ; Rackis, 1987; Sibbald, 1980). Damage to protein may occur in various forms, such as the oxidation of sulfur in cysteine and methionine, the reaction of lysine or other amino acids with aldehydes, and the formation of cross-linkages between amides and carboxyl groups.

Due to its modernized facilities and techniques, the locally-produced SBMs in Korea have been in good quality so far. Imported SBMs, on the other hand, have been inconsistent with its quality probably due to various toasting techniques used (Joo et al., 1994; Lee et al., 1994; Paik, 1988). Over-toasted SBM impairs not only the biological value but also the performance of broilers, even worse than the raw SBM at the worst (Han and Choi, 1988 ; McNaughton and Reece, 1980 ; Ponger and Matrai, 1976). However, foreign SBMs have been imported based on the criteria of price per unit protein. When purchasing SBMs, one should take the fact into consideration that the best buy of SBM would be with prices based on the amount of utilizable protein. This feeding trial was conducted to evaluate the economics of two imported SBMs, one from Brazil and the other from the U.S., at two dietary protein levels for broiler poduction.

MATERIALS AND METHODS

1. Soybean meal and experimental design

SBMs from Brazil and the U.S. were used in this trial. The Brazilian SBM, imported in pelleted form, is being widely used in Korea. The U.S. SBM, which was not available in Korea at the time of this trial, was obtained directly from the U.S. solely for this feeding trial. The latter was a dehulled SBM, but still contaminated with fair amounts of soybean hulls. Since some Korean feed mill companies were producing broiler diets with somewhat lower levels than that recommended by NRC (1984), two dietary protein levels (19 % and 21 %) were employed for each SBM treatment, making it a 2×2 factorial design.

Data were subjected to a one-way analysis of variance and means were compared by the Duncan's new multiple range test (1955). All statements of significance are based on a probability of less than 0.05.

2. Experimental birds and diets

Four hundred and eighty of d-old male broiler chicks (Abor Acers) were randomly allotted to 48 pens. There were four dietary treatments (2×2 factorial), and 12 replicates (pens) per treatment. All pens of raised wire-floor cages, were housed in a windowless broiler farm building. Birds had free access to diets and water for 38 days.

The small differences in the formulae (Table 1) caused by using different SBMs were made up with grain portion of the diet, resulting in minor variations in the energy contents among experimental diets. However, the protein contents were similar with each other at two different protein levels regardless of SBM sources.

Proximate compositions of SBMs were analyzed by the method of AOAC (1980), and an amino acid autoanalyzer (LKB 4150 Alpha

Table 1. Formulae and chemical compositions of experimental diets

Protein level / SBM source	Protein levels and SBM[1] sources			
	19%		21%	
	Brazil	U.S.	Brazil	U.S.
Ingredients(%);				
Corn, yellow	51.54	52.22	44.60	45.28
Wheat, hard	10.00	10.00	10.00	10.00
Brazilian SBM(44.24%)	26.24	–	31.95	–
U.S. SBM(45.42%)	–	25.56	–	31.27
Rapeseed meal	4.00	4.00	4.00	4.00
Lupin kernel	2.00	2.00	2.00	2.00
Yellow grease	2.58	2.58	3.92	3.92
Tricalcium phosphate	1.77	1.77	1.74	1.74
Limestone	0.52	0.52	0.50	0.50
Salt	0.25	0.25	0.25	0.25
MHA[2](85%)	0.25	0.25	0.28	0.28
L-lysine · HCl(98%)	0.23	0.23	0.14	0.14
Premix[3]	0.62	0.62	0.62	0.62
	100.00	100.00	100.00	100.00
Chemical composition[4](%);				
ME(kcal/kg)	3,000	3,000	3,000	3,000
CP	19.15	19.15	21.23	21.23
Lys	1.14	1.14	1.20	1.20
Met+Cys	0.85	0.85	0.92	0.92
Ca	0.90	0.90	0.90	0.90
Available P	0.45	0.45	0.45	0.45

[1] Soybean meal.

[2] Methionine hydroxy analogue.

[3] Contains coxistac, 0.1%; mineral mixture, 0.1%; vitamine mixture, 0.08%; roxarsone, 0.05%; virginiamycin, 0.05%; ethoxyquin, 0.02%; and choline (22%) 0.22%.

[4] Calculated values.

Amino Acid Analyzer) was used to measure the major amino acids contents of SBMs.

3. Calculation of feed costs

Because the U.S. SBM was not circulated in Korea, its price was estimated using CIF (cost, insurance, and freight) price and foreign currency exchange rate at the time of this study, and used to calculate the feed costs. Average CIF price of the Brazilian and the U.S. SBMs were $278 and $296/MT (provided by American Soybean Association, Korea), respectively, and the exchange rate was ₩896/$, and accordingly the prices for Brazilian and U.S. SBMS were ₩249,088/MT and ₩265,216/MT, respectively. These prices were then used for the calculation of unit feed costs.

RESULTS AND DISCUSSION

1. Physico-chemical evaluation of SBMs

Chemical compositions of SBMs used in this trial are shown in Table 2. The Brazilian SBM was brownish with some dark red particles, indicating that it might have been over-heated during processing. The U.S. SBM, on the other hand, was very uniform with respect to its particle size and color (light yellow), suggesting a good quality. Too much heat will change the color of SBM more than anything else, and the brownish color can be an indication of damaged protein. Too much heat reduces digestibility and availability of amino acids, and thereby the performance of broilers (Garlich, 1988a; McNaughton and Reece, 1980).

Table 2. Chemical composition and protein solubility of soybean meals (SBM) from Brazil and the U.S.

Items	Brazilian SBM	U.S. SBM
Proximate analysis, %		
Dry matter	87.45	88.23
Crude protein	44.24	45.42
Crude fat	1.41	0.90
Crude fiber	7.27	3.94
Major amino acids, %		
Arginine	2.75	2.83
Cystine	0.79	0.88
Glutamate	8.85	9.40
Histidine	1.08	1.09
Isoleucine	1.85	1.92
Leucine	3.21	3.28
Lysine	2.55	2.65
Methionine	0.64	0.65
Penylalanine	2.26	2.32
Threonine	1.72	1.78
Valine	2.05	2.15
Protein solubility[1]	63.43	76.55

[1] Analyzed by the method of Araba and Dale (1990).

The protein solubility in a 0.2 % KOH solution (Araba and Dale, 1990) is known to be a good indicator of the degree of heat damage in SBM and appears to be very closely related to the growth of broilers (Araba and Dale, 1990; Joo et al., 1994; Lee et al., 1990). Joo et al.(1994) found that KOH protein solubility ranged from 63 to 75 % in SBMs prepared in Korea, South America, the U.S., India, and China, and suggested that SBMs with values lower than 70 % would have been over-toasted. The protein solubilities shown in Table 2 indicate that the Brazilian SBM was evidently over-toasted.

2. Growth rate

The growth of broiler chicks was significantly affected by different sources of SBM ($P<0.05$) at each dietary protein level (Table 3). The U. S. SBM improved average daily gain by 8.6 % (40.6 vs. 44.1 g/d/bird) at the 19 % protein level, and 6.8 % at the 21 % protein level (44.2 vs. 47.2 g/d/bird) over Brazilian SBM. Several workers reported that the color of SBM and the protein solubility could be good indicators of over-toasted SBM, and the growth of broiler chicks could be impaired when over-toasted SBMs were used (Araba and Dale, 1990; Joo et al.,1994; McNaughton and Reece, 1980).

The growth of chicks was also improved ($P<0.05$) by raising dietary protein level from 19 % to 21 % in both sources of SBM, indicating that the dietary protein level 19 % is not sufficient to meet the requirement.

3. Feed intake and feed conversion ratio

The birds consuming the U.S. SBM increased daily feed intake at the 19 % protein level compared to birds consuming the Brazilian SBM

Table 3. The performance of broiler chicks as affected by different soybean meal (SBM) sources and dietary protein levels

Protein level / SBM source	Protein levels and SBM sources			
	19%		21%	
	Brazil	U.S.	Brazil	U.S.
BW, g/bird				
Initial	47±1	46±2	46±2	46±1
Final	1,587±86^{c}	1,722±76^{b}	1,726±44^{b}	1,839±74^{a}
Gain	1,541±86^{c}	1,676±77^{b}	1,680±45^{b}	1,794±74^{a}
ADG[1], g/d/bird	40.6±2.3^{c}	44.1±2.0^{b}	44.2±1.2^{b}	47.2±2.0^{a}
Feed intake, g/bird	3,110±191^{b}	3,248±125^{a}	3,023±66^{b}	3,090±133^{b}
ADFI[2], g/d/bird	81.8±5.0^{b}	85.5±3.3^{a}	79.5±1.7^{b}	81.3±3.5^{b}
FCR[3]	2.02±0.05^{a}	1.94±0.10^{b}	1.80±0.06^{c}	1.72±0.03^{d}

$^{a\text{-}d}$ Values($\bar{x}$ ±SD) within rows bearing the same superscripts do not differ significantly ($P>0.05$).

[1] Average daily gain.

[2] Average daily feed intake.

[3] Feed conversion ratio, feed/gain.

($P<0.05$), but not at the 21% protein level. The feed conversion ratio (FCR, feed/gain) was significantly decreased by feeding the U.S. SBM. At the 19% dietary protein level, FCR for U.S. SBM was decreased by 4.0% compared to that for Brazilian SBM (1.94 vs. 2.02). In the case of 21% protein level, the value was decreased by 7.4% (1.87 vs. 2.02). Increasing the protein level from 19% to 21% decreased the FCR significantly for both SBM sources.

4. Effect of SBM sources

The effects of SBM sources on the performance of broiler chicks are shown in Table 4. Chicks fed diets containing SBM from the U.S. showed significantly better performance than did chicks fed diets containing Brazilian SBM ($P<0.05$). The U.S. SBM improved daily weight gain by 7.3%, feed intake by 3.7%, and feed conversion ratio by 3.7% over Brazilian SBM.

Table 4. The performance of broiler chicks as affected by different soybean meals regardless of dietary protein level

	Soybean meal sources	
	Brazil	U.S.
BW, g/bird		
Initial	46±2	46±2
Final	1,664±95^{b}	1,783±95^{a}
Gain	1,618±96^{b}	1,738±95^{a}
ADG[1], g/d/bird	42.6±2.5^{b}	45.7±2.5^{a}
Feed intake, g/bird	3,061±139^{b}	3,163±150^{a}
ADFI[2], g/d/bird	80.6±3.7^{b}	83.3±4.0^{a}
FCR[3]	1.90±0.12^{a}	1.83±0.13^{b}

$^{a, b}$ Values($\bar{x}$ ±SD) bearing the same superscript do not differ significantly ($P>0.05$).

[1] Average daily gain.

[2] Average daily feed intake.

[3] Feed conversion ratio, feed/gain.

There was a significant difference in feed conversion ratio between the two SBMs.

5. Effect of dietary protein level

Table 5 shows that dietary protein level affects the performance of broiler chicks regardless of SBM sources. The reason for testing dietary protein level 19% in this feeding trial was that some commercial feed mill companies were using this level for commercial broiler feed formulation. Chick growth was greatly improved (42.4 vs. 45.7 g/d/bird) with less feed (83.8 vs. 80.4 g/d/bird) by raising the dietary protein level from 19 to 21%. This, in turn, resulted in a remarkable improvement in feed conversion ratio (1.98 vs. 1.76).

Table 5. The performance of broiler chicks as affected by dietary protein levels regardless of soybean meal sources

	Protein levels	
	19%	21%
BW, g/bird		
Initial	46.1±1.7	46.0±1.4
Final	1,658±104[b]	1,782±83[a]
Gain	1,613±105[b]	1,736±84[a]
ADG[1], g/d/bird	42.4±2.8[b]	45.7±2.2[a]
Feed intake, g/bird	3,183±170[a]	3,056±108[b]
ADFI[2], g/d/bird	83.8±4.5[a]	80.4±2.8[b]
FCR[3]	1.98±0.09[a]	1.76±0.06[b]

[a,b] Values ($\bar{x}$ ±SD) within rows bearing the same superscript do not differ significantly (P>0.05).

[1] Average daily gain.

[2] Average daily feed intake.

[3] Feed conversion ratio, feed.gain.

6. Economic evaluation

In Table 6 are summarized the results of economic evaluation on the two sources of SBM and two dietary protein levels. At the 19% dietary protein level, the use of SBM from the U.S. increased the feed price by ₩4.24 per kg (₩235.75 vs. ₩231.51), and the feed cost for broiler production ₩52.32/bird (₩766.86 vs. ₩714.44/bird). However, the feed cost per kg weight gain was ₩6.06 lower (₩457.56 vs. ₩463.62) in the U.S. SBM group, mainly due to the improved body weight gain. A similar trend was found at the 21% dietary protein level. These results suggest that, in spite of the higher SBM price, the use of good quality soybean meal is important in enhancing the performance of broiler chicks on the one hand, and could be economically more profitable for the broiler farmers on

Table 6. Effect of soybean meal sources (SBM) and dietary protein levels on feed cost/gain for broiler chicks

Protein level / SBM source	Dietary protein level and SBM source			
	19%		21%	
	Brazil	U.S.	Brazil	U.S.
Feed intake, kg/bird	3.086	3.253	3.023	3.090
Feed cost, ₩/kg	231.51	235.74	244.09	249.24
BW gain, kg/bird	1.541	1.676	1.680	1.794
Total feed cost, ₩/bird	714.44	766.86	737.88	770.15
Feed cost/gain, ₩/kg	463.62	457.56	439.21	429.29
Index of feed cost/gain	100	99	95	93

the other. In addition, it turned out that broiler farmers benifitted more by using the 21% protein diet instead of the 19% protein diet.

적 요

미국산 대두박 또는 브라질산 대두박의 급여가 육계의 성장능력 및 경제성에 미치는 효과를 비교·검토하기 위하여 480수의 육계병아리 (아바 에이커)를 가지고 38일 동안 사양시험을 실시하였다. 본 시험에서 사용한 브라질산 대두박은 펠렛 형태로 배합사료 공장에서 사용하는 것을 그대로 이용하였고, 미국산 대두박은 본 시험을 위하여 미국으로부터 직접 구해온 탈피 대두박이었다. 시험사료의 단백질 수준은 각 대두박 급원별로 19%와 21% 두 개의 수준으로 하여서, 전체적인 실험설계는 2×2 요인실험이었다. 시험사료는 각 단백질 수준별로 에너지 수준을 동일하게 한 가루형태로 제조하였다. 대두박 색에 대한 육안검사, 0.2% KOH 용액 단백질 용해도 검사, 그리고 아미노산 분석치 등으로 미루어 브라질산 대두박은 생산과정 중에 열처리가 과도했으며, 미국산 대두박은 그 품질이 양호한 것으로 사료되었다. 시험 결과 육계의 증체량은 미국산 대두박 급여구가 브라질산 대두박 급여구에 비하여 사료단백질 19% 수준에서는 8.6%, 그리고 21% 수준에서는 6.8% 더 많았고, 사료전변율도 4% 정도 개선되었다 ($P<0.05$). 육계 kg당 사료비를 검토한 결과, 비록 미국산 대두박이 가격이 높아 배합사료 단가를 상승시켰지만, 육계 증체량과 사료전변율을 개선시켜서, 육계생산 사료비는 오히려 낮아졌다. 이는 배합사료를 제조하는 입장에서는 단가가 비싼 미국산 대두박을 사용하는 것이 불리하지만, 육계 농민의 입장에서는 가격이 비싸더라도 품질이 우수한 대두박을 사용하는 것이 경제적으로 유리함을 시사하여 준다고 하겠다. 또한 육계사료의 단백질 수준을 19%로 하는 것보다 21%로 하여 주면, 육계의 생산능력도 향상되고 ($P<0.05$), 경제적으로도 농민에게 더 많은 이익을 초래함을 알 수 있었다.

(색인 : 수입대두박, 사료 단백질 수준, 육계, 경제성)

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