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Nutritional Values of Rice Bran and Effects of Its Dietary Supplementations on the Performances of Broiler Chickens

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생미강의 영양적 가치와 사료 내 첨가가 육계 성적에 미치는 영향

신영근 · 김관응 · 신승철 · 유선종 · 김성권 · 안병기 · 강창원†

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ABSTRACT Two experiments were conducted to evaluate the nutritional values of rice bran and to examine effects of its dietary supplementation on broiler performances. In the first experiment, true metabolizable energy(TME), nitrogen corrected true metabolizable energy(TMEn), and true amino acid availability(TAAA) values of the rice bran were determined by force-feeding sixteen roosters(ISA-Brown). In the second experiment, 3-week-old male broiler chickens(Avian) were divided into four groups and fed each one of four experimental diets containing 0, 5, 10 or 15% rice bran for 21 days. TME and TMEn values of the rice bran(dry matter basis) were 3.25 kcal/g and 3.12 kcal/g, respectively, and the average TAAA value of the 16 amino acids was 76.21%. The average feed intake and body weight gain of the birds fed diets containing rice bran were apparently greater than those of the control group although the differences were not significant statistically. From the results, it can be concluded that feed formulation using bioavailability values, such as TMEn and TAAA, is an effective method for protecting the high variation in growth performances and that rice bran can be used for broiler feeds to 15% without any significant negative effects.

(Key words: rice bran; TMEn; TAAA, growth performances, broiler chickens)

INTRODUCTION

Rice is an ancient cereal grain and forms the staple food for over two-thirds of the world's human population(Farrell and Hutton, 1990). There is 567 million tons of rice produced annually, about 91% in the Asian region(FAO, 1998). Ten percent of original paddy rice is removed as bran and polish in the milling process. Rice bran(RB) obtained from rice milling has been used as a major cereal by-product widely available for animal feeding(Farrell, 1994). Inspite of its abundance in this region, RB has not been fully utilized for feeding domestic fowls mainly because feeding birds with diets containing high amount of the ingredient resulted in high variation in animal performances. Some of the problems were believed to attribute to its endogenous components or its available nutrients, which have not been studied in depth.

Maust et al.(1972) reported that although RB has the high gross energy value, its lignocellulose and silica content is considered to be responsible for its low metabolizable energy (ME) value as compared to those of other tropical feedstuffs. Obtaining accurate values for ME and then using values in dietary formulation to compensate for the deficiencies in RB could resolve the problems on the low availability in energy. Fernandez et al.(1995) and Zuprizal et al.(1993) have suggested that formulation of diets using vegetable protein ingredients with low quality on an available amino acid basis is superior to formulation on the basis of total amino acid content. Thus, information on the bio-availabilities of energy and amino acids

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in feedstuffs enables more accurate diet formulation and a greater control of diet quality.

This study was conducted to determine biological values of energy and amino acids and thus to evaluate the feeding values of RB. To investigate its feeding value, male broiler chicks were fed diets containing corn and soybean meal only(corn-SBM control diet) or diets containing increasing levels of RB from 5% to 15% that were formulated to be equal in metabolizable energy value and digestible amino acid to the corn-SBM control diet.

MATERIALS AND METHODS

1. Analytical and Digestibility Evaluation of Ingredients

Domestic RB obtained from southern area was first analyzed for dry matter, crude protein, ether extract, crude fiber, and crude ash by the methods outlined by the AOAC(1990). Amino acid contents in RB were determined by amino acid analyzer (L-8500 A, Hitachi)[1] following hydrolysis in 6N HCl for 22 h at 110℃(Spackman et al., 1958). Methionine and cystine were determined on samples that had been oxidized in performic acid prior to acid hydrolysis according to the method of Moore (1963). Chemical composition and amino acid profiles of rice bran are shown in Table 1.

For true metabolizable energy(TME) and nitrogen corrected true metabolizable energy(TMEn) assessment, Single Comb White Leghorn roosters were used. The assay was conducted as described by Sibbald(1979) with some modification. Following a 24-h of feed withdrawnal, twelve roosters were given 30g of RB via crop intubation. Four additional roosters were deprived of feed for a 48-h period following the initial 24-h period. This group served as a control to correct for metabolic fecal and endogenous urinary losses. All excreta were collected for 48-h, and dried, then lyophilized for determination of gross energy by the adiabatic oxygen bomb calorimeter(1261 model, Parr)[2].

The amino acid digestibility was measured using the same procedures as for TMEn assay. The TAAA values were determined and corrected for metabolic fecal and endogenous urinary amino acids, as described by Likuski and Dorrell (1978).

Table 1. Chemical composition of rice bran

Chemical analysis	Rice bran
	-------------- % --------------
Dry matter	89.72
Crude protein	15.55
Ether extract	25.83
Crude fiber	14.02
Crude ash	9.92
Amino acids	
Alanine	0.96
Arginine	1.16
Aspartic acid	1.49
Cystine	0.32
Glutamic acid	1.87
Glycine	0.82
Histidine	0.40
Isoleucine	0.43
Leuine	1.01
Lysine	0.78
Methionine	0.30
Phenylalanine	0.65
Serine	0.71
Threonine	0.62
Tyrosine	0.47
Valine	0.71

2. Feeding Trial

One-day old male broiler chicks were fed commercial diets for three weeks posthatching. Following an overnight period without feed, a total of 72 chicks were randomly assigned into four groups with 3 replicates of 6 birds each and fed one of four experimental diets(0, 5, 10, or 15% rice bran containing diets) for 21 days. The chicks were raised in a temperature-controlled windowless house under continuous lighting.

The RB containing test diets were formulated to be equal in the contents of true available lysine and sulfur containing amino acids to those of the corn-SBM control diet(21% CP, 3,080 kcal

[1] Hitachi Instruments Service Co., Ltd., Tokyo, 151 Japan.

[2] Parr Instruments Co., Moline, IL 65265, USA.

TMEn/kg). As shown in Table 2, all diets contained adequate levels of nutrients as recommended by the National Research Council(1994). The experimental diets and water were provided ad libitum. Body weight and feed intake of each group were measured weekly and feed conversion ratio (feed intake: gain) was calculated.

Table 2. Ingredients and chemical composition of experimental diets*

Ingredients	Control	RB 5%	RB 10%	RB 15%
Yellow corn	58.81	56.04	51.50	50.00
Corn gluten meal	6.00	5.00	5.00	6.00
Soybean meal	27.82	24.60	23.94	20.21
India rapeseed meal	0.00	2.00	2.00	0.00
Limestone	0.59	0.53	0.57	0.62
Tricalcium phosphate	2.01	1.85	1.81	1.83
Salt	0.37	0.27	0.28	0.39
Choline-Cl	0.10	0.00	0.00	0.04
Animal fat	3.37	3.68	3.86	4.99
Lysine HCl	0.26	0.16	0.16	0.69
DL-methionine	0.27	0.30	0.29	0.36
Mineral mix[1]	0.11	0.11	0.11	0.11
Vitamin mix[2]	0.12	0.12	0.12	0.12
Salinomysin	0.10	0.10	0.10	0.10
Zn bacitracin	0.10	0.10	0.10	0.05
Rice bran	0.00	5.00	10.00	15.00
Total	100.00	100.00	100.00	100.00
Calculated Analysis				
Dry matter, %	87.63	87.70	87.76	87.85
Crude protein, %	21.00	20.00	20.00	20.00
Ether extract, %	5.73	6.69	7.44	7.61
Crude fiber, %	3.10	3.56	3.91	3.76
Crude ash, %	5.51	5.42	5.67	5.96
Ca, %	0.85	0.85	0.85	0.85
Available P, %	0.47	0.47	0.47	0.47
ME, kcal/kg	3,080	3,080	3,080	3,080

* RB, rice bran.

[1] Mineral mixture provided following nutrients per kg of diet: Mn, 77 mg; Zn, 57.2 mg; I, 1.32 mg; Se, 0.11 mg; Cu, 27.5 mg.

[2] Vitamin mixture provided following nutrients per kg of diet: vitamin A, 15,600 IU; vitamin D_3, 3,129 IU; vitamin E, 15.6 mg; vitamin K_3, 0.91 mg; vitamin B_1, 1.3 mg; vitamin B_{12}, 0.026 mg; niacin, 52 mg; oxystat, 65 mg; biotin, 0.039 mg, folacin, 0.39 mg; pyridoxine, 1.3 mg; riboflavin, 13 mg; pantothenic acid, 15.6 mg.

3. Statistical Analysis

The main effects of diet on feed intake, weight gain and feed conversion ratio among treatment were statistically analyzed by General Linear Models procedures of the SAS program(2002). Significant differences among main effect means were determined by the method of Duncan's multiple range test (Duncan, 1955).

RESULTS AND DISCUSSION

1. Analytical and Digestibility Evaluation of Ingredients

Chemical compositions of RB used in this study are shown in Table 1. The proximate analyses of RB resulted in dry matter of 89.72%, crude protein of 15.55%, ether extract of 25.83%, crude fiber of 14.02%, and crude ash of 9.92%. Reported chemical analyses of RB widely vary. Houston(1972) reported crude protein values of 9.8~15.4%, ether extract of 7.7~22.4%, and crude ash of 7.1~20.6%. The wide range for each chemical component is probably caused by adulteration with rice hulls of little nutritive value. On the other hand, Warren and Farrell(1990a) found that the quality of Australian RB was considerably uniform with crude protein ranging from 13.4~17.3% and ether extract ranging from 20.4~23.4%. Chemical compositions found in RB are comparable with the values reported by Warren and Farrell(1990a). Amino acid contents in RB are also shown in Table 1. These results are in good agreement with respective values determined in good RB samples from South East Asia(Creswell, 1987). Farrell(1994) suggested that the profiles of essential amino acids in good RB samples from South East Asia and Australia show a good balance, generally better than in cereal grains. RB used in this study had considerably good chemical composition and amino acid balance.

The TME and TMEn values determined in conventional roosters for RB are presented in Table 3. The TME and TMEn values were 3.25 kcal/g and 3.12 kcal/g, respectively. These were slightly higher values than found by Maust et al.(1972) for

RB (3.03 kcal/g). Ali and Leeson(1995) observed that apparent metabolizable energy of rice polishing was 3.34 kcal/g. The TAAA for RB is presented in Table 4. The TAAA of lysine, methionine and arginine were 74.85%, 85.81%, and 86.75%, respectively. TAAA values, except for valine and isoleucine, ranged from 72% to 86%. The mean TAAA value of 16 amino acids was 76.21%. Ali and Leeson(1995) reported that true digestibility of amino acids in rice polishing was 79.41%. The mean TAAA values reported herein were slightly lower than those values for many vegetable protein sources obtained previously(Green and Kiener, 1989; Lee et al., 1995). Warren and Farrell(1990b) suggested that RB contains relatively high NDF and this may have negative effects on nutrient availability by non-ruminant animals. Most probably the lower values of TMEn and TAAA might be due to higher quantities of fibrous substrates such as cellulose, hemicellulose, and lignin in RB.

Table 3. Energy values of rice bran (dry matter basis) *, **

	TME	TMEn
	----------- kcal/g -----------	
Rice bran	3.26±0.03	3.12±0.03

* TME, true metabolizable energy; TMEn, nitrogen corrected true metabolizable energy.

** Values are presented means±SE.

Table 4. True amino acid availability of rice bran (dry matter basis) *

Amino acids	Availability
	----------- kcal/g -----------
Alanine	75.42±1.28
Arginine	86.75±0.75
Aspartic acid	73.26±1.35
Cystine	80.97±1.31
Glutamic acid	81.20±1.08
Glycine	84.23±1.49
Histidine	78.53±1.15
Isoleucine	62.23±2.12
Leuine	72.08±1.50
Lysine	74.85±1.33
Methionine	85.81±0.90
Phenylalanine	72.63±1.55
Serine	77.51±1.35
Threonine	73.05±1.48
Tyrosine	75.14±1.48
Valine	65.68±1.81
Mean	76.21

* Values are presented means±SE.

2. Growth Performances in Feeding Trial

Growth performances are shown in Table 5. Although there were no significant differences, the average feed intake of treated groups was higher than that of the control. Body weight gains of the treated birds were slightly greater as compared to those of control group. Feed conversion ratio appeared to be improved in the 15% RB diet group as compared to those of the other groups, but not significantly. This indicates that RB could replace corn and soybean meal at 15% level on equal TMEn and available amino acid basis in diets of broiler chickens.

Generally, body weight gains were poorer with increasing of RB supplemented level but the point at which this occurs varies. Kratzer et al.(1974) reported that increasing the level of RB in the diet to 60% caused a significant and consistent depression in the growth of broiler chickens. Warren and Farrell (1990b) suggested that RB supplementation up to 20% produced few ill effects, but there was a linear decline in growth and feed intake for each increment in dietary rice bran when given to growing chickens. These previous studies were based

Table 5. Effects of rice bran supplementation on weekly weight gain, feed intake and feed conversion ratio in broiler chickens*, **

	Control	RB 5%	RB 10%	RB 15%
Weekly weight gain, g/week/bird	379.20±17.1	379.50±9.8	382.00±11.9	411.30±14.6
Feed intake, g/day /bird	93.60± 4.8	95.10±4.8	96.20± 2.3	99.60± 4.0
Feed conversion ratio	1.71± 0.03	1.73±0.05	1.75± 0.06	1.68± 0.08

* RB, rice bran.

** Values are presented means±SE.

on a ME and total amino acid, which may result in poor growth performances. In this study, up to 15% level of RB in the broiler feed resulted in an acceptable growth rate when TMEn and TAAA levels in the experimental diets were provided.

To the contrary, Ali and Leeson(1995) reported that weight gain was significantly reduced for chickens fed diet containing 20% RB although the test diet was formulated to contain equal amounts of digestible protein with corn-SBM based control diet. There are numerous studies showing a significant decline in performance with increasing supplementation of RB in diets for domestic fowl(Farrell, 1994). The reason for the poor performance may be associated with the presence of anti-nutrient factors such as phytate, trypsin inhibitor, and antithiamine factor (Ravindran and Blair, 1991), the high fiber content in the meal, or low energy and amino acid availability or digestibility. From the results shown in Table 5, the growth performances in chickens fed 15% RB containing diet were as good as those of corn- SBM control diet group. There were no negative effects on physiological status in chickens fed 15% RB containing diet. Thus, it seems that supplemental level of 15% is suitable for broiler feeds without any significant negative effects on broiler performances.

An additional concern with the use of RB in poultry diets is its high amount of fiber, which yields low available energy for the non-ruminant animals. Although Maust et al.(1972) reported that RB has the high gross energy value, its lignocellulose and silica content is considered to be responsible for its low metabolizable energy value as compared to those of other tropical feedstuffs. The problems of low availability of energy could be resolved by obtaining accurate values for ME and then using values in dietary formulation to compensate for the deficiencies in RB. In this study, it has been confirmed that feed formulation using bioavailability values such as TMEn and TAAA, is an effective method for protecting the high variation in animal performances.

In conclusion, RB can be used for broiler feeds to 15% without any significant negative effects on broiler performances and replaced corn and soybean meal on equal TMEn and available amino acid basis in diets of broiler chickens.

적 요

본 실험은 생미강(生米糠)을 부존 사료 자원으로 사용하기 위한 사료적 가치 평가와 육계의 생산성에 미치는 영향을 구명함과 동시에 TAAA와 TMEn을 이용한 사료배합의 필요성을 검증하기 위하여 실시하였다. 실험 1에서는 종계 수탉을 공시하여 생미강을 강제 급여함으로서 TME, TMEn 그리고 TAAA를 측정하였고, 실험 2에서는 대조구, 생미강(5, 10, 15%) 첨가구의 4개 처리구에 처리당 3반복 반복당 6수로 완전 임의 배치하여 사양실험을 실시하였다. 생미강의 TME와 TMEn은 건물기준으로 각각 3.25 kcal/g와 3.12 kcal/g이었고, 16개 아미노산의 평균 생체 이용율(TAAA)은 76.21% 이였다. 3주령부터 6주령까지 실시한 사양실험에서 생미강 첨가구에서 사료섭취량이 다소 증가하는 경향을 나타내었지만, 유의한 차이는 인정되지 않았다. 증체량과 사료요구율에 있어서도 생미강 첨가구에서 다소 높은 경향을 보였으나 유의한 차이는 인정되지 않았다. 본 실험 결과 TMEn과 TAAA를 기초로 사료를 배합할 경우 부존원료의 이용에 의한 성장성적의 저하를 막을 수 있었고, 생미강을 15%까지 첨가하여도 아무런 부정적인 영향 없이 사료를 배합할 수 있어 부존 사료 자원으로 이용할 수 있음이 입증되었다.

(색인어: 생미강, TMEn, TAAA, 성장 성적, 육계)

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