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Nutritional Values of Red Pepper Seed Oil Meal and Effects of Its Supplementation on Performances and Physiological Responses of Broiler Chicks

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ABSTRACT : Two experiments were conducted to evaluate the feeding values of red pepper seed oil meal (RPSOM) and to investigate its dietary supplementation on broiler performances. In Exp. 1, nutritional values of RPSOM were evaluated by analyzing chemical composition and determining true metabolizable energy (TME), nitrogen corrected TME (TMEn) and true available amino acid (TAAA). RPSOM contained 22.50% of CP, 4.75% of ether extract, 27.70% of crude fiber, 4.73% of crude ash and 49.97 ppm of xanthophylls. The contents of capsaicin and dihydrocapsaicin were 34 mg and 31 mg/100 g DM, respectively. The values of TME and TMEn determined by force-feeding 16 roosters were 1.73 kcal/g and 1.63 kcal/g DM, respectively. The average TAAA value of 17 amino acids was 85.22%. In Exp. 2, a total of 225 Ross male broiler chicks, 3 weeks old, were randomly divided into 9 groups of 25 birds each and assigned to three experimental diets containing 0 (control), 5 or 10% RPSOM fed *ad libitum* for 3 weeks. No significant differences were observed in growth performances and carcass characteristics. The level of serum cholesterol in the 10% RPSOM group was significantly lower than that of the control group (113.92 vs. 137.50 mg/dl). The dietary RPSOM at 5 and 10% levels increased the content of C18:2 ω6 in leg muscle compared with the control group. The results suggested that RPSOM can be included into broiler feed up to 10% without any negative effects on broiler performances and physiological responses and used as a non-conventional plant protein source, if its nutritional values are well evaluated. (**Key Words** : Red Pepper Seed Oil Meal, TMEn, Capsaicin, Serum Cholesterol, Fatty Acid Composition, Broiler Chicks)

INTRODUCTION

Red pepper (*Capsicum annuum* L.) comes from fruits in the capsicum family, and intact or dried powder as well as seed oil is used to achieve the characteristically hot flavor of various cooking. The Korean red pepper is a key ingredient in many kinds of important Korean processed foods and recognized as the second most important agricultural product. There is 150,000-200,000 M/T of dried red pepper produced annually in Korea (Korean Ministry of Agriculture and Forestry, 2000). Red pepper seed oil meal (RPSOM), which is the high-protein residue obtained from oil extraction of red pepper seed, is receiving increased attention as a feed ingredient due to its abundance in this region. But it has not been fully utilized for feeding domestic fowls mainly because only limited information is available on RPSOM, especially its available energy and amino acids.

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Kim et al. (1999) reported that increasing levels of RPSOM in broiler diets resulted a slight decline in growth performances. The reason for the poor performance may be associated with the presence of anti-nutrient factors, the high fiber content in the meal, or low energy and amino acid availability or digestibility. It is recognized that information on the availabilities of energy and amino acids in feedstuffs enables more accurate diet formulation and a great control on diet quality (Green and Kiener, 1989). Fernandez et al. (1995) and Zuprizal et al. (1993) have been 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. It is desirable, therefore, that RPSOM be evaluated for its potential use as feed ingredient for poultry. This study was conducted to determine biological values of energy and amino acids in RPSOM. To investigate its feeding value, male broiler chicks were fed diets containing corn and soybean meal only (C-SBM control diet) or diets containing increasing levels of RPSOM from 5% to 10% that were formulated to be equal in ME value and available

Table 1. Chemical and amino acid composition of red pepper seed oil meal [1]

Chemical analysis	RPSOM
Dry matter (%)	91.10
CP (%)	22.50
Ether extract (%)	4.75
Crude fiber (%)	27.70
Ash (%)	4.73
Ca (%)	0.35
P (%)	0.90
Amino acids	
Alanine (%)	1.07
Arginine (%)	1.59
Aspartate+asparagines (%)	2.12
Cystine (%)	0.44
Glutamate+glutamine (%)	4.41
Glycine (%)	1.07
Histidine (%)	0.53
Isoleucine (%)	0.86
Leucine (%)	1.66
Lysine (%)	0.94
Methionine (%)	0.32
Phenylalanine (%)	1.08
Serine (%)	0.99
Threonine (%)	0.88
Tyrosine (%)	0.64
Valine (%)	4.41
Capsaicin (ppm)	340
Dihydrocapsaicin (ppm)	310

[1] RPSOM, red pepper seed oil meal.

amino acids to the C-SBM control diet.

MATERIALS AND METHODS

Analytical and digestibility evaluation of ingredients

RPSOM samples were first analyzed for DM, CP, ether extract, crude fiber, and xanthophylls by the methods outlined by the AOAC (1990). Capsaicin and dihydrocapsaicin were determined by HPLC (JASCO, Tokyo, Japan) as described by Saria et al. (1981). Amino acid contents in RPSOM were determined by amino acid analyzer (Hitachi Instruments Service Co., Ltd., Tokyo, 151, Japan) following hydrolysis in 6 N HCl for 22 h at 110°C (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 and amino acid compositions of RPSOM 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 withdrawn, twelve roosters were given 30 g of RPSOM via crop intubation. Four additional roosters were deprived of feed for 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, lyophilized for determine gross energy by the adiabatic oxygen bomb calorimeter (1261 model, Parr Instruments Co., Moline, IL 65265).

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). This method is relatively rapid and less expensive than other procedures, and thus suited to the practical need for evaluation of feedstuffs in terms of amino acid potency.

Feeding trial

One-day old Ross male broiler chicks were fed commercial diets for 3 weeks post-hatching. Following an overnight period without feed, the chicks were randomly assigned into four groups such that the average body weights were similar for each group and fed one of three experimental diets (0, 5, or 10% RPSOM containing diet) for 21 days. The chicks were raised in a temperature-controlled windowless house under continuous lighting. The RPSOM containing test diets were formulated to be equal in the contents of true available lysine and sulfur containing amino acids to those of the C-SBM control diet (19% CP; 3,190 kcal TMEn/kg) and all diets were formulated to meet or to exceed the recommendation of NRC (1994). All the chicks were provided free access to feed and water. Room temperature was maintained at 25±3°C and 23/1 h light/dark cycle was kept throughout the experimental period. Animal facilities and husbandry were similar to conditions described by An et al. (2003). Feed intake and body weight of each group were recorded weekly.

At the end of experimental period, 10 chicks from each group were randomly selected. The blood was drawn from wing vein using sterilized syringes for determination of the various blood profiles. The concentration of total cholesterol was estimated according to the colorimetric method using cholesterol diagnostic kit (Cholesterol E kit, Youngdong Medical Corporation). The activity of glutamic-oxaloacetic transaminase (GOT) and glutamic-pyruvic transaminase (GPT) were also estimated according to the colorimetric method GOT-GPT assay kit (BCS GOT-GPT assay kit, Bio Clinical System Corporation), following the manufacturer's direction.

The total lipid of leg muscle was extracted with a mixture of chloroform and methanol (2:1, v/v) by the method of Folch et al. (1957). Lipid extracts obtained were methylated according to the methods of An et al. (1995) with some modification. Fatty acid methyl esters were

Table 2. Ingredients and chemical composition of experimental diets[1]

Ingredients	Control	RPSOM 5%	RPSOM 10%
Yellow corn	63.34	58.76	56.24
Corn gluten meal	2.37	1.78	3.19
Soybean meal	24.95	23.99	19.81
Fish meal	3.00	3.00	3.00
Animal fat	3.77	4.85	5.00
Tricalcium phosphate	1.21	1.23	1.28
Limestone	0.49	0.47	0.45
Salt	0.33	0.34	0.34
DL-methionine	0.14	0.16	0.15
Lysine-HCl	-	-	0.07
Choline-Cl	0.10	0.12	0.17
Salinomycin	0.10	0.10	0.10
Mineral mix.[2]	0.10	0.10	0.10
Vitamin mix.[3]	0.10	0.10	0.10
Red pepper seed oil meal	-	5.00	10.00
Total	100.00	100.00	100.00
Calculated values			
DM (%)	87.84	88.25	88.55
CP (%)	19.00	19.00	19.00
Ether extract (%)	6.76	7.91	8.17
Crude fiber (%)	2.62	3.95	5.09
Crude ash (%)	4.98	5.10	5.12
Ca (%)	0.90	0.90	0.90
Avail. P (%)	0.35	0.35	0.35
TMEn (kcal/kg)	3,190	3,190	3,190

[1] RPSOM, red pepper seed oil meal.

[2] Mineral mixture provided following nutrients per kg of diet: Co, 0.4 mg; Mn, 60 mg; Zn, 40 mg; I, 0.8 mg; Se, 0.2 mg; Cu, 8 mg.

[3] Vitamin mixture provided following nutrients per kg of diet: vitamin A, 12,000 IU; vitamin D_3, 2,000 IU; vitamin E, 30 mg; vitamin K_3, 2.5 mg; vitamin B_1, 2 mg; vitamin B_{12}, 0.02 mg; niacin, 30 mg; biotin, 0.1 mg, folacin, 1 mg; pyridoxine, 3 mg; riboflavin, 6 mg; pantothenic acid, 15 mg.

extracted with hexane and measured by gas-liquid chromatography (HP 5890 II Series, Hewlett-Packard, Atlanta, USA) using 0.32 mm I.D.×60 m capillary column (SUPELCOWAX-10, Supelco Ltd., Pennsylvania, USA). The initial column temperature was programmed at 150°C and increased to 220°C at 4°C/min. The injector and detector were set at 250°C and 260°C, respectively. The peaks were identified by comparison with standard mixture of fatty acid methyl esters (Lipid standard, Sigma Ltd., St. Louis, USA). Fatty acid composition of free fatty acid fraction was expressed as a weight percentage of total fatty acids.

The main effects between treated groups were subjected to ANOVA using the GLM procedure of SAS (2002), and significant differences were determined using Duncan's multiple range test at the level of $p<0.05$ (Duncan, 1955). Percentage data were transformed to arc sine percentages before square root percentages ANOVA was performed.

Table 3. Energy values of red pepper seed oil meal (dry matter basis)[1, 2]

	TME	TMEn
Red pepper seed oil meal (kcal/kg)	1.73±0.01	1.63±0.05

[1] TME, true metabolizable energy; TMEn, nitrogen corrected true metabolizable energy.

[2] Values are presented means±SE.

Table 4. True amino acid availability of red pepper seed oil meal (dry matter basis)[1]

Amino acids	Availability (%)
Alanine	82.47±1.25
Arginine	89.08±2.09
Aspartate+asparagine	84.02±3.62
Cystine	81.40±2.30
Glutamate+glutamine	89.18±1.03
Histidine	79.31±4.09
Isoleucine	85.34±4.12
Leucine	86.95±3.06
Lysine	85.75±2.93
Methionine	87.55±2.71
Phenylalanine	84.21±3.28
Serine	84.27±3.06
Threonine	82.73±4.04
Tyrosine	81.17±4.07
Valine	94.89±1.03
Mean	85.22

[1] Values are presented means±SE.

RESULTS AND DISCUSSION

According to the chemical analysis, RPSOM contained 22.50% of CP, 4.75% of ether extract, 27.70% of crude fiber, 4.73% of crude ash and 49.97 ppm of xanthophylls and is comparable with the values reported by RDA (1988). The contents of capsaicin and dihydrocapsaicin are 34 mg/100 g and 31 mg/100 g on DM basis, respectively (Table 1). Kim et al. (2002) were reported that the amounts of capsaicin and dihydrocapsaicin in various Korean red pepper powders were 41.54±33.42 mg/100 g and 31.66±25.19 mg/100 g, respectively. The ratio of capsaicin and dihydrocapsaicin in RPSOM used this study was 1.10 and this ratio is similar to the data reported by Ku et al. (2001) with ratio of 0.97 to 2.12.

The TME and TMEn, and TAAA values determined in roosters for RPSOM are presented in Table 3 and 4. The TME and TMEn values were 1.73 kcal/g and 1.63 kcal/g on DM basis, respectively. The TAAA of lysine, methionine and threonine were 85.75%, 87.55% and 82.73%, respectively. TAAA values, except for histidine, ranged from 81.17% to 94.89%. The average TAAA value of 17 amino acids was 85.22%. The mean TAAA values reported for herein were slightly lower than those values for soybean and sunflower meals as obtained previously (Green and

Table 5. Dietary effects of red pepper seed oil meal supplementation on growth performances and carcass characteristics in broiler chickens[1, 2]

	Control	RPSOM 5%	RPSOM 10%
Feed intake (g/bird/day)	105.59±3.13	108.41±1.77	108.35±0.91
Weight gain (g/bird/day)	49.33±1.19	50.25±0.91	48.35±0.48
Feed conversion rate	2.14±0.02	2.16±0.02	2.24±0.04
Liver (g/100 g BW)	2.13±0.21	2.30±0.13	1.87±0.12
Breast muscle (g/100 g BW)	7.04±0.20	6.99±0.16	7.14±0.15
Leg muscle (g/100 g BW)	8.71±0.11	8.96±0.26	9.30±0.24
Abdominal fat (g/100 g BW)	2.07±0.17	2.23±0.13	1.83±0.15

[1] RPSOM, red pepper seed oil meal. [2] Values are presented mean±SE.

Table 6. Dietary effects of red pepper seed oil meal supplementation on blood profiles in broiler chickens[1, 2]

	Control	RPSOM 5%	RPSOM 10%
GOT (U/L)	225.00±6.64	218.17±9.31	217.83±5.25
GPT (U/L)	13.67±1.02	15.33±0.80	14.50±1.02
BUN (mg/dl)	1.67±0.12	1.86±0.23	1.75±0.12
Total cholesterol (mg/dl)	137.50±9.54 [a]	125.08±7.81 [ab]	113.92±7.13 [b]

[1] RPSOM, red pepper seed oil meal; GOT, glutamic-oxaloacetic transaminase; GPT, glutamic-pyruvic transaminase; BUN, blood urea nitrogen.

[2] Values are presented mean±SE.

[a, b] values with different superscript were significantly differ ($p<0.05$).

Table 7. Dietary effects of red pepper seed oil meal supplementation on the fatty acid composition of leg muscle[1, 2]

Fatty acids[3]	Control	RPSOM 5%	RPSOM 10%
	------------ (%) ------------		
C14:0	1.19±0.01	1.22±0.01	1.32±0.04
C16:0	23.46±0.22	22.13±0.12	21.68±0.30
C16:1 ω-7	6.17±0.34	5.20±0.14	5.24±0.20
C18:0	7.38±0.31	7.72±0.26	7.43±0.27
C18:1 ω-9	39.71±1.36	38.78±0.41	38.62±0.66
C18:2 ω-6	14.62±0.70 [b]	17.07±0.21 [ab]	17.78±0.35 [a]
C18:3 ω-3	0.86±0.01	0.85±0.01	0.68±0.20
C20:3 ω-9	0.33±0.03	0.32±0.01	0.30±0.02
C20:4 ω-6	1.50±0.13	1.62±0.10	1.68±0.15
Total SFA	32.06±1.42	31.13±0.91	30.44±1.02
Total MUFA	46.78±1.55	45.06±1.15	45.34±0.63
Total PUFA	18.75±0.72 [b]	21.61±0.35 [a]	21.97±0.34 [a]
Total ω-6	16.46±0.41 [b]	19.11±0.31 [a]	19.64±0.42 [a]

[1] RPSOM, red pepper seed oil meal; SAF, saturated fatty acid; MUFA, monounsaturated fatty acid; PUFA, polyunsaturated fatty acid.

[2] Values are presented mean±SE.

[3] Number of carbon atom: number of double bonds, followed by the position of the first double bond relative to the methyl end.

[a, b] Values with different superscript were significantly differ ($p<0.05$).

Kiener, 1989). It was postulated that the lower values of TMEn and TAAA were attributed to higher quantities of crude fiber (27.70%) in RPSOM.

Growth performances are shown in Table 5. The average feed intake of treated groups was slightly higher than that of the control, but not significantly. Body weight gain of the 5% RPSOM diet group was slightly greater as compared to that of control group. There was no significant difference in feed conversion rate between the control and treated groups. Some studies showed a slight decline in performance with increasing supplementation of RPSOM in diets for broiler chicks (Kim et al., 1999). The reason for the poor performance may be associated with the presence of anti-nutrient factors, 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 diet containing 10% RPSOM were as good as those of C-SBM control diet group. This indicates that RPSOM could be replaced corn and soybean meal at 10% level on equal TMEn and available amino acid basis in diets of broiler chickens. 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. Furthermore, the dietary capsaicin and dihydrocapsaicin might not cause antinutritional effect on the chicks in this experiment.

The levels of serum GOT, GPT and blood urea nitrogen were not affected by RPSOM feeding. Relative liver and abdominal fat weights (g/100 g BW) were also similar in all the dietary groups. Measurement of serum GOT and GPT activities indicative of liver damage in bird is a valuable tool to determine a safe inclusion rate for non-conventional feedstuff (Diaz et al., 2003). It was also observed that excessive inclusion of crambe meal, a locally produced non-conventional feedstuff, resulted in elevation of serum GOT level (Kloss et al., 1996). RPSOM appeared safe at an inclusion rate of 10% and will be recommended at this point without having adversary effect on physiological status.

RPSOM feeding at level of 10% resulted in a significant decrease in serum total cholesterol than that of control as shown in Table 6. Dietary capsaicin and dihydrocapsaicin have been reported to reduce the level of serum cholesterol in experimental animals fed cholesterol-enriched diets

(Negulesco et al., 1987; 1989). It has been referred to decreased cholesterol synthesis, increased cholesterol excretion, or both as possible mechanisms with respect to reduction in blood cholesterol level. Srinivasan and Sambaiah (1991) reported that red pepper could stimulate the conversion of cholesterol to bile acids, an important pathway of excretion of cholesterol. Further study is required to clarify dietary RPSOM on tissue cholesterol metabolism.

The levels of C18:2 ω6 and total polyunsaturated fatty acid in the leg muscle of chicks fed 10% RPSOM were significantly increased compare to those of control group (Table 7). The dietary RPSOM at 5 and 10% levels increased the rates of total ω6 and total polyunsaturated fatty acids than that of control group. It is assumed that preformed C18:2 ω6 in RPSOM is effectively deposited into chicken meat.

In conclusion, RPSOM can be used for broiler feeds to 10% 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.

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