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Full Length Research Paper

Utilization of poultry by-product meal in diets for broiler chickens

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This study evaluated diets containing poultry by-product meal (PBM) formulated on an equivalent digestible amino acid (AA) basis compared to a corn-soybean meal (SBM) diet. Three PBM (A, B, and C) produced in commercial rendering plants were evaluated. Mean true digestibility coefficients (percentages) for 15 AA in PBM A, B, and C were 81.75, 67.80 and 66.31, respectively. In a chick trial, 1-wk-old male chicks were fed from 8 to 21 and 21 to 42 days of age, a corn-SBM diet or diets containing 5 or 10% PBM formulated to be equal in digestible AA to the corn-SBM diet. From 8 to 21 d post hatch, feed efficiency of chicks fed 5 or 10% PBM A or 5% PBM C was equivalent to that of chicks fed the corn-SBM diet; however, dietary inclusion of 5 or 10% PBM B or 10% PBM C depressed feed efficiency even on a digestible AA basis. Chicks fed from 21 to 42 days of age, a diet containing 10% PBM B, had significantly lower weight gain and feed efficiency than chicks consuming the corn-SBM diet; however, diets containing 5 or 10% PBM A and C or 5% PBM B yielded weight gain and feed efficiency that was similar to the corn-SBM diet. The results of this study indicated that up 10% inclusion of two of the three PBM in chick diets had no detrimental effects on performance if the diets were formulated to contain adequate levels of digestible AA.

Key words: Broiler chicks, digestible amino acid, poultry by-product.

INTRODUCTION

Protein supplements in poultry diets represent one of the major items of cost. Alternate sources of these supplements might have a beneficial effect on production cost (Bhargava and Neil, 1975). Poultry by-product meal is a product resulting from waste generated during poultry meat processing. Research showed that PBM has substantial nutritional value for poultry; however, the nutritional quality may vary greatly among samples (Main and Doghir, 1981, 1982; Pesti, 1987; Han and Parsons, 1990; Elkin, 2002). We have shown that the digestibility of AA varies greatly among poultry by-product meals due to processing system and temperatures (Jafari et al., 2011). The variability in protein quality of PBM is one of the most important concerns, and often limitation, in its use in poultry diets.

Previous work showed that dietary inclusion of 5% PBM did not significantly affect chick growth in comparison to the corn-soybean meal (SBM) diet (Gohl, 1981; Escalano and Pesti, 1987; Pesti, 1987; Hassanabadi et al., 2008). However, with a higher inclusion rate of 10 or 15% PBM in those studies, growth and feed efficiency were decreased below that of chicks fed a corn-SBM diet. Our study also showed that the performance of chicks fed 10% PBM on a total AA basis was lower than that of chicks fed with corn-SBM diet (Jafari et al., 2011). The reduced chick performance obtained with the 10 or 15% PBM diets was hypothesized to be due to differences in digestible amino acid (AA) levels among the diets, because all diets were formulated on a total AA basis and the digestibilities of the AA in the PBM were found to be substantially lower than those in

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Table 1. Chemical composition of poultry by-product meals[1].

Components	Poultry by-product sample		
	A	B	C
	(%)		
Moisture	8.84	1.91	9.16
Crude protein	57.60	62.44	50.48
Crude fat	19.72	22.21	22.80
Ash	6.04	6.18	10.65
Calcium	1.35	1.70	1.80
Phosphorus	0.83	1.36	1.57
Amino acids[2]			
Asp	4.59 (3.31)	4.99 (2.85)	3.90 (1.91)
Thr	2.45 (2.07)	2.68 (1.85)	1.95 (1.13)
Ser	3.01 (4.66)	3.36 (3.81)	2.54 (2.81)
Glu	6.97 (5.57)	7.38 (4.47)	5.65 (3.40)
Ala	3.20 (2.65)	3.67 (2.51)	2.83 (1.90)
Cys	1.14 (0.68)	1.31 (0.59)	0.95 (0.44)
Val	4.05 (3.46)	4.20 (2.93)	2.73 (1.60)
Met	1.11 (0.93)	1.20 (0.82)	0.97 (0.64)
Ile	2.80 (2.39)	2.97 (2.37)	2.14 (1.71)
Leu	5.00 (4.27)	5.34 (3.47)	3.97 (2.80)
Tyr	2.00 (1.73)	2.17 (1.61)	1.53 (1.03)
Phe	3.57 (3.06)	3.79 (2.67)	3.12 (2.50)
His	1.17 (0.95)	1.20 (0.89)	1.17 (0.84)
Lys	2.47 (1.91)	2.34 (1.71)	1.86 (1.18)
Arg	4.09 (3.66)	4.31 (3.18)	3.17 (2.49)
TMEn (kcal/g)	3.674	3.657	3.254

[1]Expressed on air-dry basis. [2]Values not in parentheses are total amino acid concentrations; values in parentheses are digestible amino acid concentrations. Digestible amino acid values were determined using the precision fed cecectomized rooster assay, with four roosters per sample.

corn and soybean meal (NRC, 1994). Therefore, the objective of this study was to evaluate the performance of chicks fed diets containing 5 or 10% PBM formulated on a digestible AA basis in comparison with a corn- SBM diet from 8 to 21 and 21 to 42 days of age.

MATERIALS AND METHODS

Ingredient analyses

Three poultry by-product meal (A, B, and C) were obtained from commercial rendering plants that used different processing procedures (Jafari et al., 2011). All samples were analyzed for DM, N, ether extract, ash, Ca, and P according to the procedures of the Association of Official Analytical Chemists (2000). Amino acid concentrations in the PBM were determined using ion-exchange chromatography following hydrolysis in 6 N HCl for 22 h at 110°C (Spackman et al., 1958). Analyses of methionine and cystine were conducted following performic acid oxidation by the method of Moore (1963) except that samples were diluted with water and lyophilized to remove excess performic acid. The chemical compositions of the PBM are presented in Table 1. The TMEn and true digestible AA coefficients of the PBM were determined using the precision-fed cecectomized rooster assay (Jafari et al., 2011). The total and digestible nutrient concentrations varied greatly among samples.

Chick assays

One-week-old male chicks resulting from the cross of New Hampshire males and Columbian Plymouth Rock females were used in chick assay. Chicks were housed in thermostatically controlled starter batteries with raised wire floors in an environmentally regulated room. Feed and water were supplied for ad libitum consumption and light was provided 24 h daily. The chicks were fed with a 24% CP corn-SBM pretest diet during the first 7 days posthatching. Following an overnight period without feed, the chicks were weighed, wing-banded, and allotted to dietary treatments as described by Sasse and Baker (1973). Chick assay was conducted to evaluate the growth performance of chicks fed diets containing 5 or 10% PBM formulated on a digestible AA basis compared to a corn-SBM diet from 8 to 21 days (Table 2) and 21 to 42 days of age (Table 3). The analytical values for the PBM in Table 1 and NRC (1994) table's values for corn and SBM were used for the diet formulations. The diets containing PBM were formulated to contain levels of digestible AA that were equivalent to levels in the corn-SBM diet or that were equal to the NRC (1994)

Table 2. Composition of diets containing 5 or 10% of poultry by- product meal (PBM) formulated on a digestible amino acid base from 8 to 21 d of age[1].

Ingredient and composition	Level of poultry by- product meal						
	Corn-SBM	5% PBM A	10% PBM A	5% PBM B	10% PBM B	5% PBM C	10% PBM C
	(%)						
Corn grain, ground	52.39	56.92	61.48	58.09	63.82	55.56	58.76
Soybean meal (44 % CP)	38.43	30.84	23.20	29.96	21.45	31.84	25.21
PBM	0	5	10	5	10	5.00	10.00
Soybean oil	4.74	2.97	1.55	2.74	1.57	3.44	2.14
Dicalcium phosphate	1.45	1.34	1.19	1.21	0.73	1.16	0.88
Ground Limestone	1.70	1.62	1.23	1.63	0.98	1.64	1.59
Iodized Salt	0.47	0.42	0.37	0.42	0.37	0.42	0.37
Vitamin mix[2]	0.25	0.25	0.25	0.25	0.25	0.25	0.25
Trace Minerals mix[3]	0.25	0.25	0.25	0.25	0.25	0.25	0.25
Choline-Cl (60%)	0.10	0.1	0.1	0.1	0.1	0.10	0.10
L-Lys HCL	-	0.09	0.19	0.13	0.27	0.11	0.23
DL-Met	0.22	0.19	0.19	0.21	0.22	0.21	0.23
Calculated or analytical composition[4]							
TMEn (kcal/kg)	3200	3200	3200	3200	3200	3200	3200
Crude protein	21.50	21.50	21.50	21.50	21.50	21.50	21.50
Crude fat	6.99	6.34	5.68	6.27	5.54	6.92	6.83
Calcium	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Avail. Phosphorus	0.45	0.45	0.45	0.45	0.45	0.45	0.45
Sodium	0.20	0.20	0.20	0.20	0.20	0.20	0.20
Digestible Arg	1.24	1.23	1.23	1.20	1.14	1.21	1.16
Digestible His	0.76	0.75	0.75	0.72	0.70	0.73	0.72
Digestible Ile	1.06	1.06	1.05	1.04	1.03	1.04	1.02
Digestible Leu	1.89	1.91	1.93	1.89	1.85	1.87	1.85
Digestible Lys	1.05	1.05	1.05	1.05	1.05	1.05	1.05
Digestible Met + Cys	0.81	0.81	0.81	0.81	0.81	0.81	0.81
Digestible Phe + Tyr	1.95	1.96	1.95	1.91	1.89	1.93	1.89
Digestible Thr	0.73	0.70	0.68	0.69	0.68	0.71	0.69
Digestible Val	1.16	1.20	1.20	1.16	1.17	1.12	1.10

[1] Diets formulated to meet or exceed the NRC (1994) digestible amino acid requirements. [2]Provided per kilogram of diet: vitamin A, 9000 IU; cholecalciferol, 2000 IU; vitamin E, 18 IU; vitamin B12, 0.015 mg; riboflavin, 6.6 mg; d-pantothenic acid, 10 mg; niacin, 30 mg; menadione sodium bisulfite, 3 mg. [3]Provided as milligrams per kilogram of diet: manganese, 100 from manganese oxide; iron, 50 from iron sulfate; zinc, 100 from zinc oxide; copper, 10 from copper sulfate; iodine, 0.99 from ethylene diamine dihydroiodide; selenium, 0.2 from sodium selenite. [4]All values except corn and soybean meal were analyzed values. The values for corn and soybean meal were derived from the NRC (1994).

total AA requirement, whichever was lower. Diets were formulated to provide 21.5% (8 to 21 days) or 20% (21 to 42 days) protein and 3,200 kcal TMEn/kg and to meet all other NRC (1994) nutrient requirements. The seven diets were fed to four groups of seven male chicks from 8 to 21 and 21 to 42 days posthatching.

Statistical analysis

Data from chick assay was subjected to ANOVA for completely randomized designs using SAS® (SAS Institute, 1985). Statistical significance of differences among treatments was assessed using the Duncan's test (Steel and Torrie, 1980).

RESULTS AND DISCUSSION

From 8 to 21 days of age, weight gain and feed efficiency of chicks fed 5 or 10% PBM A or 5% PBM C were not significantly different ($P > 0.05$) from those chicks fed with corn-SBM diet (Table 4). Dietary inclusion of 5% PBM B or 10% PBM C resulted in similar weight gain, but lower feed efficiency ($P < 0.05$) than the corn-SBM diet. Dietary inclusion of 10% PBM B depressed weight gain and feed efficiency ($P < 0.05$) compared to the corn-SBM diet (Table 4). Therefore, from 8 to 21 days of age, performance

Table 3. Composition of diets containing 5 or 10% of poultry by- product meal (PBM) formulated on a digestible amino acid base from 21 to 42 d of age[1].

Ingredient and composition	Level of poultry by- product meal						
	Corn-SBM	5% PBM A	10% PBM A	5% PBM B	10% PBM B	5% PBM C	10% PBM C
				(%)			
Corn grain, ground	58.54	62.93	67.49	64.09	68.28	61.56	64.76
Soybean meal (44 % CP)	34.03	26.59	18.95	25.71	17.41	27.59	20.96
PBM	0	5	10	5	10	5	10
Soybean oil	3.62	1.89	0.11	1.16	0.50	2.36	1.05
Dicalcium phosphate	1.24	1.13	1.02	1.01	0.90	0.96	0.67
Ground limestone	1.55	1.48	1.40	1.49	1.42	1.50	1.44
Iodized salt	0.34	0.29	0.24	0.29	0.24	0.29	0.24
Vitamin mix [2]	0.25	0.25	0.25	0.25	0.25	0.25	0.25
Trace minerals mix [3]	0.25	0.25	0.25	0.25	0.25	0.25	0.25
Choline-Cl (60%)	0.10	0.10	0.10	0.10	0.10	0.10	0.10
L-Lys HCL	-	0.02	0.12	0.05	0.19	0.04	0.16
DL-Met	0.07	0.08	0.07	0.10	0.11	0.10	0.12
Calculated or analytical composition[4]							
TMEn (kcal/kg)	3200	3200	3200	3200	3200	3200	3200
Crude protein	20	20	20	20	20	20	20
Crude fat	6.08	5.47	4.79	5.40	4.98	6.04	5.96
Calcium	0.9	0.9	0.9	0.9	0.9	0.9	0.9
Avail. Phosphorus	0.4	0.4	0.4	0.4	0.4	0.4	0.4
Sodium	0.15	0.15	0.15	0.15	0.15	0.15	0.15
Digestible Arg	1.16	1.14	1.13	1.11	1.09	1.11	1.08
Digestible His	0.71	0.73	0.72	0.70	0.67	0.70	0.69
Digestible Ile	0.99	1.00	1.00	0.99	0.97	0.98	0.96
Digestible Leu	1.81	1.83	1.85	1.80	1.77	1.79	1.77
Digestible Lys	0.90	0.90	0.90	0.90	0.90	0.90	0.90
Digestible Met + Cys	0.67	0.67	0.67	0.67	0.67	0.67	0.67
Digestible Phe + Tyr	1.83	1.85	1.84	1.80	1.77	1.81	1.78
Digestible Thr	0.68	0.65	0.63	0.64	0.62	0.67	0.65
Digestible Val	1.08	1.14	1.15	1.11	1.11	1.09	1.06

[1] Diets formulated to meet or exceed the NRC (1994) digestible amino acid requirements. [2] Provided per kilogram of diet: vitamin A, 9000 IU; cholecalciferol, 2000 IU; vitamin E, 18 IU; vitamin B12, 0.015 mg; riboflavin, 6.6 mg; d-pantothenic acid, 10 mg; niacin, 30 mg; menadione sodium bisulfite, 3 mg. [3] Provided as milligrams per kilogram of diet: manganese, 100 from manganese oxide; iron, 50 from iron sulfate; zinc, 100 from zinc oxide; copper, 10 from copper sulfate; iodine, 0.99 from ethylene diamine dihydroiodide; selenium, 0.2 from sodium selenite. [4] All values except corn and soybean meal were analyzed values. The values for corn and soybean meal were derived from the NRC (1994).

of chicks fed diets containing 5 or 10% PBM B or 10% PBM C formulated on a digestible AA basis was inferior ($P < 0.05$) to that of chicks fed the corn-SBM diet. From 21 to 42 days of age, only dietary inclusion of 10% PBM B depressed weight gain and feed efficiency ($P < 0.05$) compared to the corn-SBM diet (Table 5). weight gain and feed efficiency of chicks fed diets containing 5 or 10% PBM A and C or 5% PBM B were not significantly different ($P > 0.05$) than those of chicks fed the corn-SBM diet.

However, formulation of diets on a digestible AA basis still yielded performance that was inferior to the corn-SBM diet in some cases (e.g., feed efficiency of chicks fed 5 or 10% PBM B or 10% PBM C from 8 to 21 d or 10% PBM B from 21 to 42 d). The explanation for the latter differences is unknown, but there are several possible reasons. First, the true digestibility assay may have overestimated the amounts of TSAA or Lys that were bioavailable for protein synthesis, especially in chicks less than 21 d of age. This explanation is supported by the finding that performance of chicks fed diets containing 5% PBM B or 10% PBM C from 21 to 42 d, but not from 8 to 21 d of age, yielded performance similar to the corn-SBM diet. Batterham (1992) and

Table 4. Growth performance of chicks fed a corn-soybean meal diet or diets containing poultry by- product meal (PBM) formulated on digestible amino acid (AA) basis from 8 to 21d of age[1].

Dietary treatment[2]	Formulation method	Daily weight gain (g)	Daily feed intake (g)	Feed: gain[3] (g: g)
1. Corn soybean meal	Digestible AA	36.11^{ab}	60.10^{ab}	1.665^{c}
2. 5 % PBM A	Digestible AA	35.00^{ab}	58.46^{ab}	1.670^{c}
3. 10 % PBM A	Digestible AA	37.43^{a}	61.37^{a}	1.640^{c}
4. 5 % PBM B	Digestible AA	34.65^{b}	60.13^{ab}	1.738^{b}
5. 10 % PBM B	Digestible AA	31.98^{c}	57.85^{b}	1.812^{a}
6. 5 % PBM C	Digestible AA	35.79^{ab}	59.68^{ab}	1.668^{c}
7. 10 % PBM C	Digestible AA	34.92^{ab}	60.78^{ab}	1.740^{b}
SEM		0.79	0.97	0.02

$^{a–b}$ Means within a column with no common superscript differ significantly ($P < 0.05$). [1] Means of four groups of seven male chicks from 8 to 21 d posthatching; average initial weight was 107.8 g. [2] All diets supplied 21.5% CP and 3,200 Kcal TME_n/kg. [3] Single degree of freedom contrasts were not significant ($P > 0.05$) for feed efficiency for Treatments 2 and 3 vs 1, and for Treatments 6 and 7 vs 1, but were significant ($P < 0.05$) for Treatments 4 and 5 vs 1.

Table 5. Growth performance of chicks fed a corn-soybean meal diet or diets containing poultry by- product meal (PBM) formulated on digestible amino acid (AA) basis from 21 to 42d of age[1].

Dietary treatment[2]	Formulation method	Daily weight gain (g)	Daily feed intake (g)	Feed: gain[3] (g: g)
1. Corn soybean meal	Digestible AA	77.07^{a}	148.8^{ab}	1.931^{b}
2. 5 % PBM A	Digestible AA	74.81^{ab}	150.8^{ab}	2.018^{ab}
3. 10 % PBM A	Digestible AA	76.71^{a}	153.5^{a}	2.001^{ab}
4. 5 % PBM B	Digestible AA	77.53^{a}	150.0^{ab}	1.937^{ab}
5. 10 % PBM B	Digestible AA	69.35^{b}	141.2^{b}	2.038^{a}
6. 5 % PBM C	Digestible AA	75.83^{ab}	146.7^{ab}	1.935^{ab}
7. 10 % PBM C	Digestible AA	74.99^{ab}	149.1^{ab}	1.988^{ab}
SEM		2.07	2.89	0.03

$^{a–b}$ Means within a column with no common superscript differ significantly ($P < 0.05$). [1] Means of four groups of seven male chicks from 21 to 42 d posthatching. [2] All diets supplied 20% CP and 3,200 Kcal TME_n/kg. [3] Single degree of freedom contrasts were not significant ($P > 0.05$) for feed efficiency for Treatments 2 and 3 or 4 and 5 or 6 and 7 vs 1.

Fernandez and Parsons (1996) reported that AA digestibility assays may overestimate AA bioavailability in some cases. Second, the precision fed rooster assay may have overestimated the TMEn value of the PBM for chicks relative to the corn and SBM. The latter explanation seems possible, because the differences in performance from the PBM diets vs the corn-SBM diet were much greater for feed efficiency than growth. Third, it is possible that some component of the low-quality of PBM B and C other than AA level was detrimental to chick performance. Fernandez et al. (1995) reported that diets containing 30 or 40% cottonseed meal on a digestible AA basis yielded poor chick performance that could not be overcome with AA supplementation. Douglas and Parsons (1999) also suggested that part of depression in chick performance from feeding 15% spent hen meal on a digestible AA basis was not associated with dietary AA or TMEn levels.

The results of this study further confirm earlier studies (Main and Doghir, 1981, 1982; Escalano and Pesti, 1986; Pesti, 1987; Han and Parsons, 1990; Hassanabadi et al., 2008) that PBM has substantial nutritional value for poultry; however, the nutritional quality may vary greatly among samples. Moreover, our results indicate that up to 10% of PBM could be included in chick diets with no detrimental effects on performance if the diets were formulated to contain adequate levels of digestible AA. Previous studies on cottonseed meal (Fernandez et al., 1995) and several byproduct ingredients (Rostagno et al., 1995) have also shown that formulation of poultry diets on a digestible AA basis is superior to formulation on a total AA basis when using ingredients that have AA

digestibilities that are lower than those in corn and SBM.

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