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Nutritional evaluation of poultry by-product meal in broiler chickens

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Abstract. This experiment was conducted to determine the apparent protein digestibility, metabolizable energy (AME) and metabolizable energy correction of zero nitrotion (AME_n) of poultry by-product meal (PBPM) from two industrial poultry slaughter houses on Ross 308 male broiler chickens. The experiment consisted of seven dietary treatments and three replicates per treatment with three broiler chickens male per replicate in a compeletely randomized design. Dietary treatments consisted of a control corn-soybean diet, and levels 3, 6 and 9% PBPM produced by slaughter house 1 and levels 3, 6 and 9% PBPM produced by slaughter house 2. Chromic oxide was added to the experimental diets as indigestible marker. Apparent protein digestibility, AME and AME_n of each diets were determined with two methods of sample collection of ileum and excreta in 21-28d of age. Use of PBPM had no significant effect on performance of broiler chicks during period of digestibility experiments ($P>0.05$). Results indicated that there were significant differences in apparent protein digestibility, AME and AME_n in PBPM groups vs control group by excreta sampling procedure ($P<0.05$). The apparent protein digestibility, AME and AME_n based on ileum sampling procedure significantly decreased in level 9%PBPM slaughter house 2 ($P<0.05$). The site of measurement had no significant effect on protein digestibility AME and AME_n among experimental treatments ($P>0.05$), but ileal protein digestibility was significantly greater than excreta as concern the two sampling methods ($P<0.05$).
Key words: protein digestibility, sampling site, performance, broiler chicken

چکیده. این آزمایش جهت تعیین قابلیت هضم ظاهری پروتئین، انرژی قابل متابولیسم ظاهری(AME) و انرژی قابل متابولیسم ظاهری تصحیح شده برای ازت (AMEn) آرد ضایعات طیور از دو کشتارگاه صنعتی بر روی جوجه های گوشتی نر سویه تجاری راس 308 انجام شد. آزمایش شامل هفت تیمارآزمایشی و سه تکرار و به ازائ هر تکرار سه قطعه جوجه گوشتی بود. جیره های آزمایشی شامل یک جیره شاهد ذرت- سویا و سطوح 3، 6 و 9درصد آرد ضایعات تولید شده از کشتارگاه 1 و سطوح 3، 6 و9 درصد آرد ضایعات طیور از کشتارگاه 2 بود. اکسید کروم به عنوان مارکر غیر قابل هضم به جیره های آزمایش اضافه شد. قابلیت ظاهری پروتئین ، انرژی قابل متابولیسم ظاهری و انرژی قابل متابولیسم تصحیح شده ازت هر جیره با دو روش نمونه گیری از محتویات ایلئوم و فضولات در28-21 روزگی تعیین شد. استفاده از آرد ضایعات دو کشتارگاه طیور تاثیر معنی داری بر روی عملکرد جوجه های گوشتی درطی آزمایشات قابلیت هضم نداشت ($P>0.05$). نتایج این آزمایش نشان داد که قابلیت هضم ظاهری پروتئین، انرژی قابل متابولیسم و انرژی قابل متابولیسم تصحیح شده ازت تفاوت معنی داری را در گروه های آرد ضایعات طیور در مقابل گروه شاهد با روش نمونه برداری فضولات داشت ($P<0.05$). قابلیت هضم ظاهری پروتئین، انرژی قابل متابولیسم و انرژی قابل متابولیسم تصحیح شده ازت در سطح 9 درصد آرد ضایعات کشتارگاه 2 کاهش معنی داری با روش نمونه برداری از محتویات ایلئوم نشان دا د($P<0.05$). مکان نمونه گیری اثر معنی داری بر روی قابلیت هضم ظاهری پروتئین، انرژی قابل متابولیسم و انرژی قابل متابولیسم تصحیح شده ازت در بین تیمارهای آزمایشی نداشت ($P>0.05$)، اما در بین دو روش نمونه گیری، قابلیت هضم ایلئومی پروتئین بطور معنی داری بیشتر از قابلیت هضم پروتئین فضولات بود($P<0.05$).
کلمات کلیدی: قابلیت هضم پروتئین، مکان نمونه گیری، عملکرد، جوجه گوشتی

Introduction. About 60-70% of the cost of poultry production is attributed to feeds. Furthermore, a critical cost appraisal of poultry feed formulate shows protein especially protein of animal origin, to be the most expensive per unit cost (Oluyemi & Roberts 2000). Poultry by-product meal (PBPM) is normally made from viscera, heads and feet by conventional dry-rendering methods (Ersinsamli & Levent Ozduven 2006). PBPM are widely used in broiler diets, and the accurate information on their energy content are of importance to renderers and the nutritionists (Dale & Batal 2002). The chemical compositin, mineral contents and protein quality of PBPM can vary greatly depending on the raw material source and ash content (Johnson & Parsons 1997), storage time of raw material prior to rendring (Tamim & Doerr 2003), processing method, processing pressure and temperature (Robbins & Firman 2006), and needs to be evaluated continuously (Jahanian Najafabadi et al 2007). Determination of the chemical composition of PBPM is important in estimating its metabolizable energy and

measurement of its mineral content especially calcium and phosphorus in the balanced diets (Leesoon & Summers 2001).

The PBPM of good quality is considered to contain 58 to 63% crude protein, 12 to 20% ether extract, and 18 to 23% ash (Ravindran & Blair 1993). The average gross energy (GE) of the PBPM samples is 5645 kcal/kg (Jahanian Najafabadi et al 2007). Johnson & Parsons (1997) reported a value of 5652 kcal/ kg GE for one low ash PBPM sample. Pesti et al (1986) reported a value of 4842 kcal/kg for the average GE of eight PBPM samples and demonstrated that the lower GE value is due to the lower ether extract and higher ash contents of samples. These researchers showed there is high negative correlation (-0.89) between MEn and ash content and high positive correlation (+0.78) between MEn and GE. Animal protein meals digestibility is dependent on chemical and physical protein characteristics, antinutritional factors, diet fiber content and processing methods. Usually, animal meals sources are processed by temperature (Sibbald 1987). High and low temperature can decrease amino acids bioavailability but temperature and pressure are probably the most effective parameters (Parsons et al 2000). A decrease in amino acids digestibility may be due to decrease in amino acids concentrations and amino acid breakdown by temperature or due to Maillard reaction between amino acids and carbohydrate (Parsons et al 1992).

The AME and protein digestibility of PBPM have been reported by many researchers. Protein and energy digestibility coefficients were reported as being 87% and 77% respectively (Bureau et al 1999). The AME of feed ingredients may depend on the age, genotype and gender of bird (Huang et al 2006). The effect of PBPM in broiler chickens was reported by many researchers. Hossain et al (2003) evaluated the effects of PBPM in the diets of broiler chickens and observed the increased performance and profitability and suggested the rate of inclusion of PBPM in diet may be 8% or even at a higher rate. The ileal digestibility assay has two distinct advantages over that based on excreta analysis. First, the modifying action of the hindgut microflora on protein composition is avoided (Whitacre & Tanner 1989). Secondly, the complication arising from the combined voiding of faeces and urinary amino acids and nitrogen is over come (Webb 1990).

In practical nutrition, estimation protein and energy digestibility of the diet are very important. Determination of protein and energy requirement and bioavailable of nutrients feed are basis of diet formulation (Macleod 1994). The aim of this study was to determine the apparent protein digestibility, AME and AME_n of different levels PBPM 1 and 2 from 21-28d in broiler chickens.

Material and Method. A total of 63 male broiler chicks (Ross 308 strain) were obtained from a local farm. The birds were randomly distributed to 21 pens (three male broilers per pen). There were seven treatment groups with three replicates and three chicks per replicate. Dietary treatments consisted of a control corn- soybean diet, and leves 3, 6 and 9% dietary treatments of $PBPM_s$ 1 or 2. Feed was offered ad- libitum and water was freely available during the whole period. The chemical compositon of two PBPM and composition dietary treatments are shown in Tables 1 and 2. The amount of feed intake, feed conversion ration, weight gain and protein efficiency ratio were recorded during digestibility experiments (21-28d). After the acclimatization period, the birds were given their respective diets ad-libitum for 4d and were fasted for 24h. The birds were then allowed to consume the respective diets for one hour period (Kadim et al 2002). Following this step, excreta were collected for 48h on a tray placed under each pen. Excreta samples were oven dried (at 60℃ for 48 h) ground and stored for analysis (Scott & Hall 1998). At day 28, ileal digesta was collected from contents of the lower half of the ileum from three chicks per pen (killed by cervical dislocation). Contents were pooled immediately, frozen dryied and ground for later chemical analyses (Ravindran et al 2005). Chromic oxide (0.3%) was used in diets to evaluate the passage time of feed through the gastrointestinal tract from 21-28d (Khaksar & Golian 2009). The AME value of each diet was determined using the following equation (Scott et al 1998).

$$\text{AME(kcal/k g)} = \text{GE}_{\text{diet}} - \left[GE_{excreta\ /\ ileum} \times \left(\frac{M_{diet}}{M_{excreta\ /\ ileum}} \right) \right]$$

Table 1

Composition of experimental diets 21-28d(%)

		PBPM 1			PBPM 2		
Feed Ingredients	control	3	6	9	3	6	9
Corn	58.22	60.74	63.26	65.79	60.74	63.26	65.79
Soybean meal	33.79	29.01	24.22	19.43	29.01	24.22	19.43
PBPM	0	3	6	9	3	6	9
Corn oil	4.4	3.67	2.93	2.19	3.67	2.93	2.19
Calcium carbonate	1.4	1.4	1.4	1.4	1.4	1.4	1.4
Dicalcium phosphate	1.1	1.1	1.1	1.1	1.1	1.1	1.1
Salt	0.32	0.32	0.32	0.32	0.32	0.32	0.32
Mineral premix[1]	0.18	0.18	0.18	0.18	0.18	0.18	0.18
Mineral premix[2]	0.18	0.18	0.18	0.18	0.18	0.18	0.18
Cocci acetate	0.10	0.10	0.10	0.10	0.10	0.10	0.10
Vitamin E	0.10	0.10	0.10	0.10	0.10	0.10	0.10
DL- methionine	0.10	0.10	0.10	0.10	0.10	0.10	0.10
L- Lysine	0.10	0.10	0.10	0.10	0.10	0.10	0.10
Calculated analysis	-	-	-	-	-	-	-
AME(kcal/ kg)	3100	3100	3100	3100	3100	3100	3100
Crud protein	19.38	19.38	19.38	19.38	19.38	19.38	19.38
Calcium(%)	0.88	0.96	1.04	1.11	0.96	1.04	1.11
Phosphorous, available(%)	0.34	0.38	0.42	0.46	0.38	0.42	0.46
Sodium(%)	0.14	0.15	0.16	0.17	0.15	0.16	0.17
Methionine+ systine(%)	0.75	0.75	0.75	0.75	0.75	0.75	0.75
Lysine(%)	1.13	1.1	1.08	1.05	1.1	1.08	1.05

[1]Each kg of vitamin supplement containing: vit A: 3600000 IU, Vit D3: 800000 IU, Vit E: 7200 IU, Vit K3: 800 mg, Vit B1: 6mg, Biotin: 40 mg, choline choloride: 100000 mg and Anti oxidant: 40000mg.
[2]Each kg of mineral supplement containing: Manganese: 39680 mg, Zinc: 33880 mg, Cpper: 4000 mg, Iodine: 400 mg and Selenium: 80 mg

The correction of AME to zero nitrogen retention was done for determination of AME_n (Meng & Slominski 2005; Scott & Boldaji 1997).

$$\text{AMEn(kcal/ kg)} = \text{GE}_{\text{diet}} - \left[GE_{excreta\ /ileum} \times \left(\frac{M_{diet}}{M_{excreta\ /ileum}} \right) \right] - 8.22 \times \left\{ N_{diet} - \left[N_{excreta\ /ileum} \times \left(\frac{M_{diet}}{M_{excreta\ /ileum}} \right) \right] \right\}$$

Where: AME (kcal/kg)= Apparent metabolizable energy, GE_{diet} = Gross energy diet, $GE_{excreta/ileum}$: Gross energy in samples, M_{diet} = concentration marker in diet, $M_{excreta/ileum}$= concentration marker in samples. N_{diet} = concentration nitrogen in diet, $N_{excreta/\ ileum}$ = concentration nitrogen in samples.

Apparent digestibility of protein was calculated as following (Kluth & Rodehutscord 2006).

$$\%\text{Digestibility} = 100 - \left[100 \times \left(\frac{M_{diet}}{M_{excreta/ileum}} \times \frac{N_{excreta/ileum}}{Ndiet} \right) \right]$$

Where: $N_{excreta/ileum}$ = concentration of nutrient in samples, N_{diet} = concentration of nutrient in diet.

Data were analyzed as compeletely randomized design using SAS 1998. Means were compared using Duncans multiple rang test at ($P<0.05$).

Table 2

Chemical composition PBPM 1 and 2 (%)

PBPM type	Dry matter	Crude Protein	Ether Extract	Gross Energy (kcal/kg)	Ash	Ca	Na	K
PBPM 1	89.65	60.77	12.34	4459.73	13.37	3.21	1.01	0.7
PBPM 2	92.1	62.24	17.45	4786.36	17.44	3.52	1.24	0.9

Results and Discussion. Effect of different levels of dietary treatment on the performance of broiler chickens is presented in Table 4. Using different levels of $PBPM_s$ 1 and 2 decreased feed intake and weight gain vs control. The highest feed intake was in control group. Jackson et al (1982) reported that essential amino acids imbalances in diet decreases biological value of the diet and decreases feed intake. The poor quality and lower palatability of PBPM in comparison with control treatment might be other reasons for lower feed intake by the broiler chickens. The highest and the lowest weight gain were observed with control group fed diets with 9% $PBPM_s$ 1 and 2 respectively. By increasing levels of PBPM and its lower effect on weight gain is probably due to methods of processing especially heat treatment. The results of the present study are in accord with findings of Escalona & Pesti (1987). Heat processing of protein sources may change L- amino acids to form of D- amino acids which may decrease its digestibility and amino acids availability (Rao et al 1984). Using of higher levels PBPM had adverse effect on feed conversion ratio (FCR). Therefore birds fed 3% of $PBPM_s$ 1 and 2 had better FCR among the treatments. This effect of PBPM on FCR is in agreement with findings of (Mendoca Junior & Gensen 1989) but disagreement with the results of Fraga et al (1989) which observed improved FCR with diets contain of different levels PBPM. The highest protein efficiency ratio (PER) was observed with treatment contain 3% $PBPM_s$ 1 and 2. Similar findings were observed by (Kirkpinar et al 2004). The different levels of PBPM 2 had better PER than PBPM 1. The different observation in of PER among PBPM groups may be due processing methods. The PER values of animal meals are influenced by many factors including raw material source, ash content and processing temperature (Robbins & Firman 2006).

Effects of $PBPM_s$ 1 and 2 on apparent protein digestibility, AME and AME_n are shown in Table 3. Using 9% PBPM 2 decreased ileal protein digestibility, AME and AME_n ($P<0.05$). The highest ileal protein digestibility were observed in two treatments: control and 3% PBPM 1 and the lowest one in 9% PBPM 2 ($P<0.05$). The highest ileal AME and AME_n was observed in two treatments 3% and 6% PBPM 1 and the lowest it in 9% PBPM 2 ($P<0.05$). Results of this experiment in term of digestibility agree with findings of

(Kirkpinar et al 2004). The differences observed in digestibility are probably due to processing methods (Opstved et al 1984). Method of processing especially heat treatment may contribute to the nutrition values of ingredients such as protein (Dale 1996). Lysine is very sensitive to heat and the low digestibility of lysine in protein meals may reflect the amount of heat used in processing of the meals. The variations in digestibilities of amino acids in animal meals are likely to be due to differences in raw ingredients, time between slaughter and rendering and the duration of the temperature used in rendering process (Skurray 1974).

Over heating causes the formation of disulfide bonds and consequently increases the passage rate of protein through the gastrointestinal tract (Opstved et al 1984). The change in pressure is the other factor that reduces protein quality and amino acids digestibility of PBPM. As pressure increased from 45 to 60 psi for 20 min reduction in digestibility of all amino acids were observed. The exact mechanism by which pressure processing decreases amino acid digestibility is unknown, but it may be associated with racemization of amino acid or cross- linkage between AA (Shirley & Parsons 2000). The excreta protein digestibility, AME and AME_n increased in PBPM groups vs control group. The lower digestibility in control group may be due to high feed intake and rate of feed passage of gastrointestinal tract. This is to be expected, since with lower digestibility a significant quantity of undigested protein will reach the large intestine, providing substrate for microbial thus resulting in lower digestibility values of the excreta (Ravindran et al 1999). Shires et al (1987) and Huang et al (2006) also reported that a number of factors such as rate of passage, feed intake or nutrition adequacy of test diets.

Table 3

Apparent protein digestibility, AME and AME_n values of diets with different levels of $PBPM_s$ 1 and 2 during stages experiment digestibility (21-28d)

	dietary treatments(%)							
		PBPM 1			PBPM 2			
	Control	3%	6%	9%	3%	6%	9%	SEM
Excreta								
CP(%)	64.55^{b}	76.7^{a}	72.91^{ab}	76.37^{a}	76.21^{a}	75.3^{a}	75.56^{a}	1.28
AME(kcal/kg)	2831^{b}	3127^{a}	3074^{a}	3152^{a}	3128^{a}	3138^{a}	3125^{a}	38.2
AMEn(kcal/kg)	2814^{b}	3108^{a}	3056^{a}	3133^{a}	3108^{a}	3119^{a}	3106^{a}	28.5
Ileum								
CP(%)	90.14^{a}	89.17^{a}	86.42^{ab}	85.29^{ab}	86.5^{ab}	87.1^{ab}	82.03^{b}	0.73
AME(kcal/kg)	3151^{ab}	3229^{a}	3195^{a}	3114^{ab}	3030^{ab}	3140^{ab}	2978^{b}	34.6
AMEn(kcal/kg)	3128^{ab}	3206^{a}	3173^{a}	3092^{ab}	3008^{ab}	3118^{ab}	2957^{b}	30.5

Means within each row without a common superscript differ significantly ($P<0.05$)

Table 4

Effect of $PBPM_s$ 1 and 2 on performance broiler chickens (21-28d)

		PBPM 1			PBPM 2			
Parameter	control	3	6	9	3	6	9	SEM[3]
Feed intake(g/d)	131.52^{a}	119.02	114.97	121.48	120.71	121.04	119.47	2.1
Weight gain(g/d)	64.94	64.08	53.62	52.3	63.72	61.36	59.95	2.12
FCR[1](g/g)	2.02	1.91	2.21	2.33	1.92	2.26	2.06	0.07
PER[2](g/g)	2.7	2.65	2.41	2.35	2.54	2.5	2.25	0.1

[1]FCR(g/g)= feed intake/ weight gain, [2]PER(g/g)= weight gain/ protein intake, [3]SEM= standard error mean
a- none of means are significant different ($P>0.05$)

Physiological status is related to growth or maintenance that may influence apparent digestibility measurements. Few studies have been conducted to compare ileal and excreta analysis for the determination of nutrient digestibility in chickens (Kadim et al 2002; Ravindran et al 1999).

Ravindran et al (1999) reported apparent ileal and excreta based digestibility values of amino acids for a wide range of feedstuffs. This difference between ileal and excreta digestibility values were dependent on the type of ingredient in the diets, the differences in methodology employed to measure amino acid digestibility and the rate of feed inclusion in the assay diet (Kadim et al 2002). In this experiment, we also found that the apparent protein digestibility, AME and AME_n value, were greater in ileum than excreta sampling. This lower digestibility in excreta compared with ileum is probably due to three reasons: First, deamination of amino acids leads mainly to the formation of ammonia, which may be absorbed, but not utilized by the bird, so is excreted in the form of uric acid. Secondly, intestinal microflora in the hindgut have a substantial effect on the amount of individual amino acids excreta in faeces. Some estimates this as high as 25% of excreta potein (Parsons et al 1982). Thirdly, decreasing metabolizable energy of diets may affect of the protein digestibility estimates in excreta; beacause, in this situation, a great part of protein are catabolized and energy recovery of them is utilized by bird, resulting to increasing of N component excretion in Urine (Leeson et al 1996). Scott et al (1998) also shown that the difference between excreta and ileum may be due to the action of microflora posterior to the ileum or high feed intake by broiler. These findings agree with results which are shown in Table 4.

Table 5

Effect of different sites (excreta and ileum) of sampling on apparent protein digestibility, AME and AMEn dietary treatments

	Site of sampling			Site of sampling	
Dietary treatment	Excreta	Ileum	Dietary treatment	Excreta	Ileum
Control			Control		
CP%	64.55[a]	90.14	CP%	64.55	90.14
AME(kcal/kg)	2831	3151	AME(kcal/kg)	2831	3151
AME_n(kcal/kg)	2814	3128	AME_n(kcal/kg)	2814	3128
PBPM 1			PBPM 2		
3%			3%		
CP%	76.7	89.17	CP%	76.21	86.50
AME(kcal/kg)	3127	3229	AME(kcal/kg)	3128	3030
AME_n(kcal/kg)	3108	3206	AME_n(kcal/kg)	3108	3008
6%			6%		
CP%	72.91	86.42	CP%	75.3	87.1
AME(kcal/kg)	3074	3195	AME(kcal/kg)	3138	3140
AME_n(kcal/kg)	3056	3173	AME_n(kcal/kg)	3119	3118
9%			9%		
CP%	76.37	85.29	CP%	75.56	82.03
AME(kcal/kg)	3152	3114	AME(kcal/kg)	3125	2978
AME_n(kcal/kg)	3133	3092	AME_n(kcal/kg)	3106	2957

a-none of means are significant different (P>0.05)

Table 6

Apparent digestibility of protein, AME and AME_n values between the two sampling methods

	Site of sampling		
Component	Excreta	Ileum	Means
Protein(%)	73.94^b	86.67^a	80.3
AME(kcal/kg)	3082^a	3120^a	3101
AMEn(kcal/kg)	3063^a	3097^a	3080

Means within each row without a common superscript differ significantly (P<0.05)

Kadim et al (2002) analyzed amino acids digestibility of ileum and excreta content of broiler feedstuff and concluded that digestibility values measured at the terminal ileum provide a more reliable measure of amino acid availability than those measured in the excreta.

Table 7

Apparent protein digestibility, AME and AME_n values of dietary treatments from excreta samples in independed comparisons

Compare type	Protein(%)	AME(kcal/kg)	AME_n(kcal/kg)
Control vs PBPM 1 and 2	64.55^b vs 75.51^a	2831^b vs 3124^a	2814^b vs 3105^a
Control vs PBPM 1	64.55^b vs 75.32^a	2831^b vs 3117^a	2814^b vs 3099^a
Control vs PBPM 2	64.55^b vs 75.69^a	2831^b vs 3130^a	2814^b vs 3111^a
PBPM 1 vs PBPM 2	75.32^a vs 75.69^a	3117^a vs 3130^a	3099^a vs 3111^a

Means within each row without a common superscript differ significantly (P<0.05).

Table 8

Apparent protein digestibility, AME and AME_n values of dietary treatments from ileum samples in independent comparisons

Compare type	Protein(%)	AME(kcal/kg)	AME_n(kca/kg)
Control vs PBPM 1 and 2	90.14^a vs 86.08^b	3151^a vs 3114^a	3128^a vs 3092^a
Control vs PBPM 1	90.14^a vs 86.96^a	3151^a vs 3179^a	3128^a vs 3157^a
Control vs PBPM 2	90.14^a vs 85.21^b	3151^a vs 3049^a	3128^a vs 3027^a
PBPM 1 vs PBPM 2	86.96^a vs 85.21^a	3179^a vs 3049^b	3157^a vs 3027^b

Means within each row without a common superscript differ significantly (P<0.05).

Table 7 shows there are no differences in protein digestibility, AME and AME_n value PBPM 1 vs PBPM 2. Table 8 shows there is no difference in protein digestibility, but AME and AME_n values had higher (P<0.05) in PBPM 1 vs PBPM 2.

Conclusion. The results of this experiment shown that there were no differences in protein digestibility, AME and AME_n values of both PBPM 1 and 2, up to 6% when compare with each other. But at levels of 9% they shown different values (PBPM 1 was higher than 2 when compare with control diets). Therefore, due to the acceptable cost of PBPM, it is possible to use of it up to 6% in feeding broiler chicken.

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