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Effect of substituting fish meal with poultry by-products meal in broiler diet on nitrogen excretion and litter characteristics

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This study was carried out to investigate the effects of dietary replacment of fish meal (FM) with poultry by-product meal (PBM) at 0, 25, 50, 75 and 100% using 360 one day-old Arian broiler chicken. The mean weight gain, feed intake and feed conversion ratio were significantly decreased in the birds fed on diets containing greater levels of PBM as compared to the control birds during 1 to 21 days of age (P<0.01). Replacement of FM at different levels with PBM significantly affected serum concentrations of urea and uric acid (P<0.05). The serum concentrations of urea and uric acid were lower in the birds that received 100%-PBM containing diets. The mean nitrogen content of litter was similar among the experimental diets, while the moisture content of litter tended to be lower for the birds fed on diets containing 25% PBM as compared to the other birds (P<0.10). Litter pH was similar among the dietary. Treating the litter samples by alum significantly decreased their pH values (P<0.01). The results suggest that, substitution of FM with PBM at different levels had no impact on nitrogen contents of litter.

Key words: Nitrogen excretion, broiler chicken, poultry by-product meal.

INTRODUCTION

Litter management in poultry production, as a means to reduce ammonia emission, has received increasing attention in modern poultry houses. It is well documented that high concentrations of ammonia in poultry houses have detrimental effects on the productive performance and health of the birds (Koerkamp, 1994; Al Homidan et al., 2003; Ritz et al., 2004). Moreover, concerns have arisen with regard to ammonia emission from poultry litter as it may contribute to acidic precipitations (Apsimon et al., 1987). Van der Hoek, 1998 Atmospheric ammonia plays an important role in such precipitations. It has been reported that livestock wastes are the dominant source of ammonia emission in Europe, which is increased by 50% during 1950 to 1980 (Apsimon et al., 1987; Van Aerdenne et al., 2001).

Ammonia volatilization from poultry houses is mainly due to microbial break down of nitrogenous compounds of litter, predominantly uric acid, by uricase (Kimberly et al., 2008; Schefferle, 2008). Different approaches have been implemented to reduce ammonia emission from poultry houses. Among the others, dietary manipulations and litter treatments are effective means to control ammonia emission at poultry houses level. Litter treatments include ammonia-reducing strategies which provide a better in-house environment for birds (Khosravinia, 2006; Choi et al., 2008). Dietary manipulations have the

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potential to reduce the manure production and nutrients excretion by improving the efficiency of feed utilization in poultry. Therefore, such dietary manipulations may decrease the production of precursors necessary for gaseous as well as odorants emissions (Blair et al., 1999).

The reduction in mass of nutrient input and modification of nutrient form are two feeding strategies for reducing ammonia emission from poultry houses. The former, reduces the ammonia emission by lowering the dietary concentrations of nutrients which are involved in the production of ammonia, such as dietary protein without having any detrimental effects on birds performance (Angel et al., 2006; Applegate et al., 2008). While, the latter reduces the nutrients emissions by altering the chemical forms of the nutrients being excreted from birds. Acidification of diets (Keshavarz, 1991; Koerkamp, 1994; Wu et al., 2007) and dietary inclusion of feed additives (such as urease inhibitors) (Amon et al., 1995) are among the approaches which are considered to reduce the emission of nutrients by converting them to non-volatile forms.

It is also possible to reduce nitrogen excretion and ammonia emission form poultry houses by including dietary protein sources with higher biological values. Therefore, the current study investigates the effects of dietary replacement of fish meal with poultry by-product meal on blood urea and uric acid and certain physic-chemical characteristics of litter in broiler chickens.

MATERIALS AND METHODS

Experimental diets

Poultry by-product meal (PBM) was manufactured using heads, legs and spent carcasses without inclusion of viscera. Pre-cooked material was hydrolyzed under pressurized steam, de-oiled, dried and ground using a hammer mill. The material was then blended and sampled for further chemical analyses. The samples were analyzed for dry matter, crude protein, ether extract, ash, calcium and phosphorus (AOAC, 1980). Metabolizable energy corrected for nitrogen (ME_n) was estimated using the prediction equation from NRC (1994):

ME_n (kcal/kg) = (31.02 × crude protein %) + (74.23 × ether extract %).

The chemical compositions of the PBM used in the current study were reported by Khosravinia and Mohamadzadeh (2006). Experimental diets were prepared by substituting fish meal (FM) by PBM at the levels of 0, 25, 50, 75 and 100%. All experimental diets were formulated to be iso-caloric and iso-proteinous (Table 1). The diets were offered to the birds for *ad libitum* consumption.

Experimental flock and data collection

Three hundred and sixty one-day old straight run Arian chicks were randomly allocated to 30 pens (at density of 0.09 m^2/bird) furnished with wood shavings as litter in an open system partially controlled house. Each of five experimental diets was offered to six pens of 12 chicks each. Data on weight gain and feed intake were recorded at days 1 to 21 and 21 to 42 of experiment. All birds were slaughtered to evaluate the carcass related traits at day 42. At the same time, approximately 200 g of litter samples were taken from the top layer of 50 mm depth at 10 predetermined locations in each pen. The litter sample from each pen was then thoroughly mixed and two sub samples of 50 g were taken in which litter moisture and litter pH was determined, respectively. The sub sample considered for pH measurement was further divided in two parts while one part was cautiously mixed with aluminium sulfate [alum, $Al_2(SO_4)_3 \cdot 14H_2O$] (10 g/ kg) and the other part remained intact. The nitrogen content of litter samples was measured at day 42 according to AOAC (1999). The pH of litter samples were determined with (0.1 percent, w/w) and without blending with alum.

Statistical analysis

Considering each pen as an experimental unit, data pertained were subjected to one-way analysis of variance using GLM procedure of SAS® (SAS institute, 1998). The statistical model consisted of the fixed effect of experimental diets. Differences between treatments were analysed by a Duncan's multiple range test. For all statistical analysis, significance was declared at P<0.05. The difference between alum treated and non-treated litter samples were examined using t-test. Prior to statistical analysis, percentage data were subjected to *arc sine* transformation.

RESULTS

The effects of FM with PBM on common economic parameters of the birds are presented in Table 2 and are discussed in detail by Khosravinia and Mohamadzadeh (2006). Briefly, weight gain, feed intake and feed conversion ratio were significantly decreased in birds fed on diets containing greater levels of PBM during 1 to 21 days of age (P<0.01). No significant differences were demonstrated in all productive performance indicators as well as carcass weight, carcass yield and mortality percentage during 22 to 42 and 1 to 42 days for the birds fed on diets differing for PBM/FM inclusion level (Table 2; P>0.05).

There were significant differences between the experimental diets with regard to serum urea and uric acid concentrations (Table 3). Full substitution of FM with PBM significantly decreased the serum concentrations of urea and uric acid in the treated birds as compared to the control birds. The birds fed on diets in which 25% of FM was replaced with PBM had the lowest litter nitrogen content among the experimental treatments (Table 4; P < 0.05). The birds fed on diets containing 100% PBM instead of FM experienced the wettest litter (19.2%, Table 4). Dietary substitution of FM by PBM at the level of 25% significantly lowered the litter nitrogen content as well as litter moisture (Table 4; P<0.05). The experiment-tal diets had no significant effect on the litter pH (Table 4; P > 0.05). Addition of 10 g/kg alum into the litter samples significantly lowered the pH value of the samples (Table 4).

DISCUSSION

Inclusion of PBM in starter diets caused significant decrease in productive performance of the birds (Table 2). Silva et al. (2002) reported the same results when PBM was

Table 1. Ingredient and chemical composition of the experimental diets.

Ingredient (%)	PBP[1] (%) in starter diets (1 - 21 days)					PBP (%) in grower diets (22 - 42 days)				
	0	25	50	75	100	0	25	50	75	100
Yellow maize	60.0	60.4	61.6	62.3	63.2	61.5	62.9	63.6	64.0	63.9
Soybean meal	22.0	22.4	22.4	22.6	23.0	18.4	18.8	19.4	19.5	19.6
Wheat	6.05	5.50	4.35	3.55	2.55	10.0	8.10	7.20	6.65	6.90
Wheat bran	0.00	0.00	0.00	0.00	0.00	0.85	0.90	0.60	0.95	0.80
Fish meal	8.00	6.00	4.00	2.00	0.00	5.00	3.75	2.50	1.25	0.00
PBP meal	0.00	2.00	4.00	6.00	8.00	0.00	1.25	2.50	3.75	5.00
Fat	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Bone meal	1.50	1.35	1.35	1.35	1.25	1.50	0.50	1.50	1.17	1.17
$CaCo_3$	0.60	0.55	0.45	0.35	0.30	0.80	0.80	0.80	0.77	0.60
Salt (NaCl)	0.25	0.20	0.15	0.15	0.15	0.20	0.15	0.15	0.20	0.22
V+MM[2]	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50
DL-Methionine	0.10	0.00	0.10	0.10	0.15	0.15	0.15	0.15	0.15	0.15
L-Lysine	0.15	0.10	0.10	0.20	0.10	0.10	0.10	0.10	0.10	0.15
Vitamin C	0.10	0.10	0.10	0.10	0.10	0.00	0.00	0.00	0.00	0.00
Calculated nutrient composition (%)										
ME (kcal/kg)	3001	3001	3001	3001	3001	3001	3001	3001	3001	3001
Crude protein	21.50	21.50	21.42	21.41	21.4	18.70	18.70	18.70	18.70	18.70
Crude fiber	3.10	3.10	3.10	3.10	3.10	3.10	3.10	3.10	3.10	3.10
Available Ca	0.91	0.90	0.91	0.93	0.93	0.90	0.94	0.97	0.90	0.87
Available P	0.44	0.42	0.42	0.41	0.38	0.38	0.38	0.39	0.35	0.35
Lysine	1.20	1.20	1.20	1.20	1.20	1.05	1.03	1.01	1.00	1.00
Methionine	0.53	0.41	0.48	0.46	0.49	0.51	0.49	0.48	0.47	0.45
Met.+ Cyst.	0.81	0.70	0.80	0.77	0.79	0.76	0.75	0.75	0.74	0.73

[1]Poultry by products; [2]Vitamin + mineral mixture: supplied mg/kg diet.

included at 50 and 100% level in maize-soybean meal practical diets. The lower performance of the birds fed on PBM in the early ages may have been due to its lower digestibility of this protein source as compared to fish meal. This can be demonstrated by the higher nitrogen excretion (in terms of litter N% in this study) and poorer metabolizability of nitrogen in the birds fed with PBM containing diets as reported by Silva et al. (2002) and Kirkpinar et al. (2004).

There are evidences which suggest that dietary manipulation through incorporation of perfect combinations of different protein sources into broiler diets is a useful means to reduce litter nitrogen content and subsequently ammonia emission from poultry houses (Ferguson et al., 1998). The results of the current study showed that the source of dietary protein has a remarkable effect on blood concentrations of uric acid and urea (Table 3). Such effects are expected to be reflected in the nitrogen (N) content of faeces and litter. However, litter samples did not differ in nitrogen content and no consistent trend in nitrogen content of litter were observed for increased substitution levels of FM with PBM. Nonetheless, the nitrogen content was numerically lower for the litter samples which were collected from the pens pertaining to the birds fed with diets in which FM was replaced with PBM by 25% (Table 4). As confirmed by Silva et al. (2002), this implies that inclusion of perfect combination of different protein sources in broiler diets might be a useful means to reduce litter nitrogen content and subsequently ammonia emission from poultry houses. The mean litter moisture and pH at day 42 was not significantly affected by dietary inclusion of PBM inclusion ($P>0.05$). However, litter samples from the pens assigned to the birds fed on control diets (containing no PBM) tended to be higher as compared to those fed with 25% PBM-included diets ($P<0.1$; Table 4). Due to high ambient temperatures, the values recorded for litter moisture were generally low in the current study. There is a well known association between litter pH and ammonia emission from litter (Fergusen et al., 1998). Higher nitrogen content in litter provides uerolytic bacteria with a precursor which results in a higher level of NH_3 and consequently a higher pH value.

Dietary inclusion of protein sources with greater biological value lead to greater nitrogen retention and subsequently resulted in higher growth rates in birds. Moreover, it would be expected that dietary inclusion of a protein source with a higher biological value causes a lower serum

Table 2. Effect (mean ± S.E.) of substituting fish meal with poultry by-product on weight gain, feed intake, feed conversion ratio, carcass weight (CW), carcass yield (CY) and morality (Mor.) of broiler chickens.

Parameter	Level of substituting fish meal with Poultry by -product (%)					PBP effect
	0	25	50	75	100	
Weight gain (g)						
1-21d	462.9±7.19[a]	437.4±6.39[b]	439.1±8.27[b]	435.1±9.65[b]	427.5±5.21[b]	*
22-42d	1200.3±24.51	1176.3±22.45	1191.1±25.87	1211.6±19.97	1212.6±30.11	NS
1-42d	1663.2±28.51	1613.7±24.01	1630.1±32.88	1647.3±18.47	1640.6±33.41	NS
Feed intake (g)						
1-21d	944.3±19.11[a]	903.5±7.69[a]	846.3±22.74[b]	836.3±11.97[b]	829.5±23.36[b]	***
22-42	2698.0±105.2	2475.7±54.7	2600.3±122.3	2703.3±73.6	2535.7±83.9	NS
1-42d	3642.3±122.3	3379.2±53.0	3446.7±132.9	3539.7±72.6	3365.2±99.4	NS
Feed conversion ratio (feed intake : weight gain)						
1-21d	2.040±0.037[ab]	2.065±0.034[a]	1.927±0.054b[c]	1.922±0.027[c]	1.940±0.050[c]	***
22-42d	2.247±0.109	2.104±0.037	2.183±0.084	2.231±0.087	2.091±0.072	NS
1-42d	2.189±0.089	2.094±0.026	2.115±0.072	2.148±0.063	2.052±0.064	NS
CW (g)	1254.6±6.84	1202.5±49.40	1201.9±20.49	1229.1±15.82	1217.6±31.09	NS
CY (%)	73.72±1.06	72.81±1.93	72.62±0.54	72.92±0.58	72.47±1.14	NS
Mor. (%)	6.94±2.5	5.55±1.75	8.33±2.15	7.50±3.56	6.94±2.56	NS

[A-C]Means with in a row with no common superscript differ significantly (P<0.05). *P<0.05, **P<0.01, ***P<0.001, NS, non significant.

Table 3. Effects of experimental treatments on serum urea and uric concentrations of birds.

R. level[1] (%)	Serum (mg/dl)	
	Urea	Uric acid
0	3.25± 0.22[ab]	3.16± 0.31[ab]
25	3.55± 0.21[a]	4.15± 0.73[a]
50	3.67± 0.26 [a]	3.68± 0.37[a]
75	3.25± 0.18[ab]	3.22± 0.27[ab]
100	2.83± 0.17[c]	2.63± 0.27[b]
SEM[2]	0.006	0.032
	P > F	
R. level[1] (%)	0.0464	0.0325

[1]R. level: Replacement level of fish meal with poultry by-products. [2]Standard error of means. [a-c] Means within a column with no common superscript differ significantly (P<0.05).

concentrations of urea and uric acid concentrations as compared to those with lower biological values (Hevia and Clifford, 1977). Therefore, urea and more decisively uric acid can be used as influential criteria to assess the bio-availability of a protein source alone or in combination with different protein sources for broilers. Indeed, our data supported such an idea. The birds fed on diets containing 100% FM showed higher weight gain as compared to the other birds at days 1 to 21. Many studies reported that, manipulation of protein sources in poultry diets can alter the nitrogen content of litter and thereby ammonia emission (Hai and Blaha, 2000; McGrath et al., 2005). In most of such studies, dietary inclusion of either protein sources with high biological values or synthetic amino acids were the main policy (Angel et al., 2006; Richert and Sutton, 2006).

Inclusion of 10 g/kg alum in litter samples significantly decreased the litter pH in all treatments (Table 4; P<0.05). The pH lowering effect of alum in poultry litter was also confirmed by Do et al. (2005). The prominent advantage of alum-reduced pH is lowered microbial activity. Therefore, alum is an effective chemical treatment in reducing ammonia (NH_3) emissions and solubility of certain nutrients in poultry litter (Smith et al., 2001).

Conclusion

In conclusion, the results of current study suggest that FM can be totally replaced by PBM in broiler diets without increasing the nitrogen content of the litter. It is possible that the slight differences in blood uric acid and urea of the birds fed the different experimental diets were reflected as faecal nitrogen so that little differences were observed in nitrogen content of litter among the Experimental treatments. It is also possible that the immediate initiation of huge urolytic activity of litter microbes obliterated faecal nitrogen resulting in almost similar nitrogen content in the litter.

Table 4. Effects of experimental treatments on litter nitrogen, litter moisture and litter pH.

R. level[1] (%)	Litter N (%)	Litter moisture (%)	Litter* pH (-alum)	Litter* pH(+alum)
0	1.77± 0.06[ab]	17.57 ± 1.13[ab]	6.07±0.1[a]	4.99±0.1[a]
25	1.70± 0.04[b]	15.17± 0.64[b]	6.08±0.1[a]	4.81±0.2[a]
50	1.79± 0.06[a]	16.90± 1.19[ab]	6.02±0.2[a]	5.06±0.1[a]
75	1.76± 0.06[ab]	16.80± 0.65[ab]	6.02±0.1[a]	4.88±0.1[a]
100	1.75± 0.04[ab]	19.23± 1.12[a]	6.23±0.1[a]	4.82±0.2[a]
SEM[2]	0.047	0.047	0.055	0.066
		P > F		
R. level[1]	0.8106	0.0920	0.7819	0.7227

[1]R. level: Replacement level of fish meal with poultry by-products. [2]Standard error for pooled means. [a-c]Means within a column with no common superscript differ significantly (P<0.05). *The difference between pH +alum and pH -alum was significant ($\hat{t}$ =-13.62, P<0.05).

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