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Determination of the Order of Amino acid Limitation in Slaughterhouse Poultry by-product Meal in African catfish diet by Amino acid Addition Assay

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ABSTRACT

An 8-week feeding trial was carried-out to more clearly establish and compare the order of amino acids (AAs) limitation in Slaughterhouse Poultry by-product (SPB) using AA addition assays in African catfish (*Clarias gariepinus*) diets. Seven isonitrogenous (40% crude protein) diets were formulated. Control diet (fish meal; FM) without amino acid supplementation contained 40% of FM and 20% of SBM which contribute 28% and 9.40% of crude protein, respectively, and formulated to meet all known nutrient requirements of catfish based on nutrient requirement values proposed by the NRC (2011). Diet 2 (SPB) contained SPB as the sole animal protein without amino acid supplementation. The SPB diet was individually supplemented in the other five diets with 1.2%Lys (SPB^{+Lys}), 0.4%Met (SPB^{+Met}), 0.1%Try (SPB^{+Try}), 1.2%Arg (SPB^{+Arg}) and a combination of 1.2%Lys+0.4%Met+0.1%Trp+1.2%Arg (SPB^{+Mix}). Final weight of the fish fed FM diet increased 5 fold, while the group fed SPB^{+Lys} and SPB^{+Mix} increased 3 fold, respectively. However, fish weight fed diets SPB, SPB^{+Met} SPB^{+Try}, and SPB^{+Arg} were duplicated at the end of the experiment. The least FCR value of 1.20 was obtained for group fed FM which produced the best growth performance followed by group fed SPB^{+Lys} and SPB^{+Mix} (1.52 and 1.66, respectively). Significant difference was observed for protein efficiency ratio (PER) of all experimental diets. Among the SPB diets used in the present study, the fish fed SPB^{+Lys} and SPB^{+Mix} had significantly ($P<0.05$) higher final body weight, WG, FI, FCR, SGR, PER, PR and ER than those of the groups fed diets SPB, SPB^{+Met}, SPB^{+Try} and SPB^{+Arg}. In this study, Lysine was found to be the first-limiting AA in SPB and deficiencies in African catfish performance were ameliorated by supplementing a 100% replacement diet with sufficient Lysine to match levels in a hypothetical diet in which all protein (40%) was provided by African catfish.

Keywords: African catfish, Slaughterhouse Poultry by-product, Amino acids.

INTRODUCTION

The African catfish (*Clarias gariepinus*), an air breathing fish, is a major warm water aquaculture species in Africa and Asia (Khan and Abidi, 2011). It is highly appreciated as an excellent aquaculture species for intensive culture because of their resistance to diseases, ability to tolerate a wide range of environmental conditions, high stocking densities and relative fast growth rate under intensive culture (Nyina-wamwiza *et al*., 2007).

Protein is one of the most expensive components of aquaculture diets (Khan and Abidi, 2011 and Liu *et al*., 2011). Animal protein sources, especially fish meal (FM), have relatively high cost, limited supply, and variable quality. The development of commercial aquatic feeds has been traditionally based on FM as the main protein source because of its high protein content and balanced essential amino acid (EAA) profile (Nguyen *et al*., 2009). However, the limited supply of FM, coupled with its increased demand in feeds for livestock and poultry, is likely to reduce the dependence on FM in aquatic feeds (Thompson *et al*., 2008). Finding alternative protein sources for FM in the diet, either partially or completely, included terrestrial plant meals and animal by-products, have become the focus of research from the view point of producing a stable supply of commercial diets at a reduced price (Hardy, 2010).

Replacement of FM in practical diets without reducing the performance would result in more profitable production of catfish. Therefore, the evaluation of other commercially available and potential alternative ingredients is necessary to insure future availability of sustainable and cost-effective aquatic feeds for the aquaculture industry (Waldemar, 2011).

Slaughterhouse poultry by-product meal (SPB) is rendered from the waste generated from small scale poultry slaughterhouse as Egyptian consumers prefer live slaughter. SPB differ with PBM as it included feather (Sevgili and Ertürk, 2004). This by-product can consider potential alternative feedstuffs to fishmeal because of its high protein contents (60-65% CP) and low price compared with the FM (Thompson *et al*., 2007). SPB is high in ether extract (EE), ash and indigestible components (feathers, etc.), reduced digestibility (Sevgili and Ertürk, 2004). Thus, SPB varies in nutritional value and composition depending on the processing and the materials included in the meal (Nengas *et al*., 1999).

Formulation of the practical diet at optimal protein level and an ideal essential amino acid (EAA) profile is a pre-requisite for fish growth (Peres and Oliva-Teles, 2009). Contents of the EAA, especially lysine (Lys), methionine (Met), arginine (Arg) and tryptophan (Try), are generally limiting amino acids in economical alternative protein sources (Xue *et al*., 2012). The deficiency of an EAA will lead to poor utilization of the dietary protein (Jia *et al*., 2012). A study by Wang and Persons (1998) indicated that cystine, tryptophan, threonine and lysine were the first four limiting amino acids in PBM, while methionine may be slightly limiting in PBM protein in poultry diet. However, Main and Doghir (1982) reported that methionine and lysine were the first and second limiting amino acids in PBM, respectively, in poultry diet.

The present study was design to develop nutritionally balanced practical diets for the *Clarias gariepinus* based on the nutrient requirement of this species using SPB as mean protein source. No data about the limiting amino acids in SPB are available, therefore, the specific objective of this study was to more clearly establish and compare the order of AA limitation in SPB using AA addition assays.

MATERIALS AND METHODS

Fish and experimental conditions

An 8-week feeding trial was carried out at the laboratory of fish nutrition, Faculty of Agriculture, Cairo University, Egypt. African catfish (*Clarias gariepinus*) were purchased from a local commercial hatchery located in El-Morshedy, Abbassa area, Abou-Hammad, Sharkia Governorate, Egypt. Fish were acclimatized to experimental conditions for 7 days prior to the feeding trial. Two hundred and fifty two catfish fingerlings (5.36±0.03g) were randomly divided and distributed into 7 different groups with 3 replicates containing 12 fish each. The experiment was set up as a substitution experimental design, with seven diets fed in triplicate. The experiment was conducted in plastic tanks (70-L capacity) provided with well water having an average temperature of 25-28 °C. Compressed air was used to maintain the oxygen supply above 7 mg L^{-1}. The fish culture tanks were covered with black plastic to prevent the fish escape. Fishes were counted and weighed at every 2 weeks and not fed on morning period of weighing day.

Experimental diets and feeding

SPB was obtained from Ismailia investment company (El-wafa company, 31G region, kilometer 21, Ismailia desert hay way, Egypt). The chemical composition of the ingredients used in this study is presented in Table 1. Seven isonitrogenous (40% crude protein) diets were formulated (Table 2). Control diet (FM) without amino acid supplementation contained 40% of FM and 20% of SBM which contribute 28% and 9.40% of crude protein, respectively, and formulated to meet all known nutrient requirements of catfish based on nutrient requirement values proposed by the NRC (2011). Diet 2 (SPB) contained SPB as the sole animal protein without amino acid supplementation. The SPB diet was individually supplemented in the other five diets with 1.2%Lys (SPB^{+Lys}), 0.4%Met (SPB^{+Met}), 0.1%Trp (SPB^{+Try}), 1.2%Arg (SPB^{+Arg}) and a combination of 1.2% Lys + 0.4 % Met + 0.1% Trp + 1.2 % Arg (SPB^{+Mix}). The analysed AA profiles of the experimental diets and the AA requirements according to NRC (2011) are tabulated in Table 3.

The experimental diets were prepared by blending the ingredients into a homogenous mixture, and then the mixture was passed through laboratory pellet mill. The pellets were then dried overnight under forced air at room temperature and stored at 4 °C until used. Fish were fed to apparent satiation three times daily (at 09 am, 1 and 5 pm) for 56 days. Daily feed consumption was recorded for each tank by weighing the feed at the start and end of each day. To avoid excess feeding, food was offered with great care by giving small amounts of food at a time to ensure that fish ate all the food particles offered.

Table 1 ***Composition of the dietary protein ingredients (g kg^{-1})***

Item	FM	SBM	SPB
Dry matter	918.2	902.2	948.4
Crude protein	698.2	415.6	615.0
Lipid	89.5	45.0	123.6
Ala	50.7	19.5	29.4
Asp	43.4	31.4	41.3
Glu	60.1	41.7	65.6
Gly	65.8	23.0	40.4
Pro	42.5	30.5	53.1
Ser	28.0	21.2	45.6
Tyr	23.6	16.6	19.0
Arg	48.5	31.8	39.3
His	15.1	11.3	6.4
Iso	32.6	20.3	26.7
Leu	52.4	34.4	43.0
Lys	52.9	28.0	20.9
Met	20.2	6.0	7.9
Cys	6.7	7.0	31.9
Phe	27.8	22.1	28.2
Thr	41.1	17.6	26.6
Val	38.0	20.9	35.1
Try	7.0	6.3	5.0

Chemical analysis

At the beginning of the trial, a pooled sample of 40 fish was collected to serve as an initial fish sample. At the end of the feeding trial, all fish were anaesthetized with t-amyl alcohol and killed by a cephalic blow. The fish were pooled, autoclaved, ground into homogeneous slurry, oven-dried, reground and stored at -20 ^{0}C in a freezer until analysed. Diet, ingredients, and fish samples were analyzed for dry matter (DM) and ash content according to AOAC (1995) methods, for crude protein (N x 6.25) by the Kjeldahl method using a Kjeltech auto-analyzer (Model 1030, Tecator, Hoganas, Sweden), and for crude fat (Bligh and Dyer 1959). Amino acids were analyzed at the Regional Center for Food and Feed (Giza, Egypt) using method 994.12 (AOAC 2005). Dietary gross energy was calculated using the conversion factors of 23.7, 39.5 and 17.2 kJ g^{-1} for protein, lipid, and carbohydrate, respectively (Brett and Groves 1979).

Table 2. *Formulation and proximate composition (g kg^{-1} dry weight basis) of experimental diets.*

Ingredients	FM	SPB	SPB^{+Lys}	SPB^{+Met}	SPB^{+Try}	SPB^{+Arg}	SPB^{+Mix1}
Corn	200.0	193.6	180.0	190.0	192.4	180.0	170.0
Soybean meal	200.0	200.0	200.0	200.0	200.0	200.0	200.0
Fish meal	400.0	0.0	0.0	0.0	0.0	0.0	0.0
SPB	0.0	455.9	457.5	455.9	456.1	457.7	461.5
Wheat	89.5	90.0	90.0	90.0	90.0	89.8	79.0
Starch	50.0	0.0	0.0	0.0	0.0	0.0	0.0
Salt	5.0	5.0	5.0	5.0	5.0	5.0	5.0
Vit C	0.5	0.5	0.5	0.5	0.5	0.5	0.5
Carboxy methyl cellulose	5.0	5.0	5.0	5.0	5.0	5.0	5.0
Soybean oil	40.0	40.0	40.0	40.0	40.0	40.0	40.0
Vitamin & Mineral Premix[2]	10.0	10.0	10.0	10.0	10.0	10.0	10.0
Lysine	0.0	0.0	12.0	0.0	0.0	0.0	12.0
Methionine	0.0	0.0	0.0	4.0	0.0	0.0	4.0
Tryptophan	0.0	0.0	0.0	0.0	1.0	0.0	1.0
Arginine	0.0	0.0	0.0	0.0	0.0	12.0	12.0
Chemical composition (g kg^{-1})							
Dry matter	935.43	932.52	932.05	935.50	937.68	931.51	941.03
Crude protein	378.50	409.00	424.00	405.50	412.00	424.00	438.50
Crude lipid	85.78	109.18	111.14	128.01	113.83	142.86	132.24
Crude Ash	111.74	73.73	75.19	69.00	77.90	82.19	71.79
Gross energy (KJ g^{-1})	19.59	21.03	21.14	21.50	21.08	21.73	21.76

[1]1.2%Lys+0.4%Met+0.1%Trp+1.2%Arg

[2]Provides per kg of diet: retinyl acetate, 3000 IU; cholecalciferol, 2400 IU; all-rac-α-tocopheryl acetate, 60 IU; menadione sodium bisulfite, 1.2 mg; ascorbic acid monophosphate (49% ascorbic acid), 120 mg; cyanocobalamine, 0.024 mg; d-biotin, 0.168 mg; choline chloride, 1200 mg; folic acid, 1.2 mg; niacin, 12 mg; d-calcium pantothenate, 26 mg; pyridoxine. HCl, 6 mg; riboflavin, 7.2 mg; thiamin. HCl, 1.2 mg; sodium chloride (NaCl, 39% Na, 61% Cl), 3077 mg; ferrous sulfate ($FeSO_4.7H_2O$, 20% Fe), 65 mg; manganese sulfate ($MnSO_4$, 36% Mn), 89 mg; zinc sulfate ($ZnSO_4.7H_2O$, 40% Zn), 150 mg; copper sulfate ($CuSO_4.5H_2O$, 25% Cu), 28 mg; potassium iodide (KI, 24% K, 76% I), 11 mg; Celite AW521 (acid-washed diatomaceous earth silica), 1000 mg Agri-Vet Company, Cairo, Egypt

Table 3. *Amino acid composition of experimental diets (g kg^{-1} dry diet).*

Amino acid	FM	SPB	SPB^{+Lys}	SPB^{+Met}	SPB^{+Try}	SPB^{+Arg}	SPB^{+Mix*}	Amino acid requirement of catfish[1]
	D1	D2	D3	D4	D5	D6	D7	
Non-essential amino acid								
Ala	25.6	18.7	18.6	18.7	18.7	18.6	18.7	-
Asp	24.5	25.9	25.9	25.9	25.9	26.0	26.1	-
Glu	33.7	39.5	39.5	39.5	39.5	39.5	39.7	-
Gly	31.7	23.8	23.8	23.8	23.8	23.8	23.9	-
Pro	25.2	32.4	32.3	32.4	32.4	32.3	32.4	-
Ser	16.3	25.9	25.9	25.9	25.9	25.9	26.0	-
Tyr	13.6	12.8	12.8	12.8	12.8	12.8	12.8	-
Essential amino acid								
Arg	26.5	25.0	25.0	25.0	25.0	**37.1**	**37.1**	10.3
His	8.8	5.6	5.6	5.6	5.6	5.6	5.6	3.7
Iso	17.8	16.9	16.9	16.9	16.9	16.9	17.0	6.2
Leu	30.1	28.7	28.6	28.7	28.7	28.6	28.6	8.4
Lys	27.3	15.6	**27.6**	15.6	15.6	15.6	**27.6**	12.3
Met	14.2	21.5	21.6	**25.6**	21.5	21.6	**25.6**	15.0
Phe	16.5	18.2	18.1	18.2	18.2	18.2	18.2	4.6
Thr	20.6	16.2	16.2	16.2	16.2	16.3	16.3	12.0
Val	20.3	21.0	21.0	21.0	21.0	21.0	21.1	7.1
Try	4.18	3.66	3.66	3.66	**4.7**	3.66	**4.7**	5.3

[1]*NRC (2011)*

Water quality measurement

Temperature was measured every day and pH was monitored in the tanks. The temperature was measured directly in the water column one time every day after feeding using a mercury thermometer suspended at 20-cm depth. The pH was measured directly in the water column of plastic tanks every week during experiment by pH mater (Orion pH meter, Abilene, TX, USA).

Statistical analysis

Data of fish growth performance, feed utilization and carcass traits were statistically analyzed by one-way analysis of variance (ANOVA), using Duncan's post hoc ANOVA test for individual comparisons ($P \leq 0.05$) level of significance. All statistics were performed using SPSS 17.0 (SPSS, Chicago, IL, USA).

RESULTS

Nutrient composition of the experimental diets

The proximate and amino acid composition of the imported FM and SPB are listed in Table 1. Both protein sources contained high protein levels in the range of 698.2-615 g kg^{-1} and moderate levels of crude lipid at 89.5–123.6 g kg^{-1}. The amino acid composition in SPB particularly, Arg (39.3 g kg^{-1}), Met (7.9 g kg^{-1}), Lys (20.9 g kg^{-1}) and Try (5 g kg^{-1}) are limited essential amino acid compared to FM (48.5, 20.2, 52.9 and 7 g kg^{-1}, respectively).

The proximate and amino acid composition of the experimental diets are tabulated in Table 2. The analysed values of crude protein, crude lipid and gross energy of the experimental diets were laid in the ranges of 368.50-424 g kg^{-1} diet, 85.78-142.86 g kg^{-1} diet and 19.59-21.76 KJ g^{-1} diet, respectively. The amino acid composition in diets reflected the composition of the protein sources. Arginine, methionine, lysine and tryptophan contents of the experimental diets were reduced when FM was totally replaced by slaughterhouse poultry by-product meal. However, the levels of these AAs increased in diets supplemented with these crystalline amino acids (Table 3).

Growth performance and feed utilization

The water quality parameters were within the acceptable range for African catfish. Fish appeared healthy at the end of the experiment and no mortality during the experimental period was observed. The initial weights of the experimental fish for all treatments did not vary significantly (Table 4).

The performance of catfish fingerlings are significantly differed ($P<0.05$) in terms of final weight, WG, FI, FCR, SGR, PER, PR and ER. Growth response and feed utilization were less in groups fed diets with SPB compared to those fed the control diet that sustained FM. Final weight of the fish fed FM increased 5 fold, while the group fed SPB^{+Lys} and SPB^{+Mix} increased 3 fold, respectively. However, fish fed diets SPB, SPB^{+Met} SPB^{+Try}, and SPB^{+Arg} were doubled at the end of the experiment (Table 4). The lowest FCR value of 1.20 was obtained for group Fed FM which showed the best growth performance followed by group fed SPB^{+Lys} and SPB^{+Mix} (1.66 and 1.52, respectively). Fish fed SPB^{+Lys} and SPB^{+Mix} had significantly ($P<0.05$) higher final weight, WG, FI, FCR, SGR, PR and ER compared to the groups fed diets SPB, SPB^{+Met} SPB^{+Try}, and SPB^{+Arg}. Significant ($P>0.5$) differences in the PER figures of all the experimental diets were noticed (Table 4).

Whole-body proximate composition

Body composition of *Clarias gariepinus* fed different experimental diets are figured in Table 5. The whole-body moisture and crude protein content did not differ significantly ($P>0.05$). Fish fed SPB^{+Mix} had significantly ($P<0.05$) higher levels of fat and less ash than fish fed the other diets. The group fed SPB^{+Mix} recorded the least ($P<0.05$) crude lipid content.

DISCUSSION

Experimental diets were formulated to meet all nutrient requirements of African catfish fingerlings. Fish fed with SPB produced the lowest performance and feed utilization of all the experimental diets compare with fish fed FM diet. The diets containing SPB gave significantly limited final weight, WG, FCR, SGR, PR and ER., being worsened when total replacement of FM by SPB. Their poor performance may be due to limiting amino acid (Arg, Met, Lys and Try) content (Nengas *et al*., 1999), feather, connective tissue and skin contents which are considered to be difficult for fish to digest (Hardy, 2000), subjection of the product to high temperature (150-200ºC) for a long time (10 hours) during the processing (Nengas *et al*., 1999), or combination of all. High temperature during the raw material processing leads to amino acid losses and thus, digestibility of protein and amino acids is reduced (Li and Robinson, 2013). According to the National Research Council (1993), crude protein digestibility of poultry by-products are lower than those reported for FM.

Table 4. ***The performance of experimental treatments.***

Parameters	FM	SPB	SPB^{+Lys}	SPB^{+Met}	SPB^{+Try}	SPB^{+Arg}	SPB^{+Mix*}	SEM[1]
Mean initial weight (g/fish)	5.43	5.43	5.43	5.28	5.41	5.34	5.36	0.03
Mean final weight (g/fish)	28.80^{a}	10.56^{d}	15.29^{c}	10.52^{d}	11.19^{d}	10.75^{d}	16.96^{b}	1.72
Weight gain (g/fish)[2]	23.43^{a}	5.13^{d}	9.86^{c}	5.24^{d}	5.79^{d}	5.42^{d}	11.60^{b}	1.71
Feed intake (g)	28.18^{a}	14.46^{de}	16.36^{bc}	13.48^{e}	16.16^{bc}	15.31^{cd}	17.65^{b}	1.29
FCR (feed: gain)[3]	1.20^{b}	2.82^{a}	1.66^{b}	2.60^{a}	2.84^{a}	2.83^{a}	1.52^{b}	0.19
SGR[4]	3.00^{a}	1.19^{d}	1.85^{c}	1.23^{d}	1.30^{d}	1.26^{d}	2.06^{b}	0.17
PER[5]	2.26^{a}	0.96^{c}	1.42^{b}	0.96^{c}	0.94^{c}	0.84^{c}	1.52^{b}	0.13
PR [6]	26.07^{a}	7.47^{b}	10.10^{b}	7.07^{b}	8.68^{b}	7.36^{b}	13.60^{b}	1.79
ER [7]	21.73^{a}	8.48^{b}	9.81^{b}	7.19^{b}	7.98^{b}	7.84^{b}	13.42^{b}	1.37
Survival rate	100.00	100.00	100.00	100.00	100.00	100.00	100.00	0.00

Lys+Met+Try+Arg
[1]Pooled standard error of a means.
[2]Weight gain (WG) = Final body weight (g) – Initial body weight (g).
[3]Feed conversion ratio (FCR) = feed intake (g) /body weight gain (g).
[4]Specific growth rate (SGR) = (In final body wt - In initial body wt) / feeding days X 100.
[5]PER= body weight gain (g) / protein intake (g).
[6] Protein retention = 100 x (the total protein gain in fish body (g) / the total protein consumed (g)).
[7]Energy retention = 100 x (the gross energy gain of the fish / gross energy in the feed consumed (g)).
Mean in the same raw with different superscription are significantly different (P≤0.05) by Duncan's test.

Table 5 ***Chemical composition of the whole body (g kg^{-1}) of African catfish fed the experimental diets for 8 weeks***

Composition	Initial	FM	SPB	SPB^{+Lys}	SPB^{+Met}	SPB^{+Try}	SPB^{+Arg}	SPB^{+Mix}	SEM[1]
Moisture	713.83	778.11	746.14	775.81	773.53	759.99	755.87	747.72	4.87
Crude protein	143.09	130.64	139.27	134.97	135.58	142.41	142.69	148.08	2.25
Crude lipid	43.39	56.26	58.97	51.67	50.30	54.34	55.26	62.78	1.40
Ash	97.36	33.39	48.44	34.42	35.16	42.96	39.72	34.05	1.71

[1]Pooled standard error of a means.
Mean in the same raw with different superscription are significantly different (P≤0.05) by Tukey's test.

Imbalanced amino acid concentration is associated with lower protein synthesis or increased degradation, or simultaneous change in both components of protein turnover (Hansen *et al*., 2007).Therefore, it is necessary to satisfy the dietary essential amino acid needs fish by formulating amino acid-balanced fish feeds.

In the present study, supplementation of the SPB diet with each of Met, Try or Arg had no positive effect, except for SPB^{+Lys} and SPB^{+Mix} which enhanced fish growth performance and feed utilization. The latter finding was probably due to the fact that Lys was much more limiting than the others in SPB. Wang and Parsons (1998) indicated that cystine, tryptophan, threonine and lysine were the first four limiting amino acids in PBM, while methionine may be slightly limiting in PBM protein in poultry diet. However, Main and Doghir (1982) reported that methionine and lysine were the first and second limiting amino acids in PBM, respectively, in poultry diet.

Up to 40% of protein in practical diets for African catfish could be provided by PBM before significant reduction in performance (Abdel-Warith *et al*., 2001). Total replacing protein provided by fishmeal (24.5% total crude protein) with PBM produced a little bit reduction in performance indices of tilapia and a large increase in the profit index for the replacement diets (El-Sayed, 1998). Hybrid tilapia fed a replacement diet in which PBM provided 17% crude protein, or 60% of dietary protein, exhibited equivalent weight gains, feed conversions and protein efficiencies as fish fed a fishmeal-based control diet (Fasakin *et al*., 2005). Juvenile red drum were able to use up to 13% crude protein or 30% of the total dietary protein provided by either PBM or enzyme-digested PBM with no differences in performance with respect to fish fed a fishmeal-based control diet (Kureshy *et al*., 2000). Nengas *et al*. (1999) were able to replace 50% of the protein provided by fishmeal, or 18% crude protein, with PBM in diets for gilthead sea bream; however, reduction in growth performance was seen at the 75% level of fishmeal replacement. Similarly, Quartararo *et al*. (1998) were able to replace 27% of the protein provided by fishmeal, or 12% crude protein, with protein from PBM and supplemental Met (0.34%) and Lys (0.24%) in diets for Australian snapper, but reduction in weight gain and specific growth rate were evident at higher levels of replacement. Nevertheless, an economic analysis revealed that up to 50% replacement of fishmeal protein with PBM was cost-effective in Australian snapper diets in spite of the reduced performance at that level of substitution. Yang *et al*. (2004) also found PBM was able to replace 50% of the protein provided by fishmeal in diets for gibel carp. On the other hand, Emre *et al.* (2003) observed drastic reduction in growth and nutrient retention of mirror carp fingerlings fed diets containing as little as 33%PBM without amino acid supplementation.

Some studies have shown that PBM could replace even 100% of FM without significant decrease in fish growth (Saadiah *et al*., 2011). The differences between the present results and those is probably because of the better amino acids profile of the PBM diet used there versus those of the SPB diet evaluated in study reported here in Similarly, the use of PBM in fish diets has been reported to reduce growth in some carnivorous fish, especially when totally replacing FM in the diet (Rawles *et al*., 2011).

The worest FCR value was observed in the treatment with 100% SPB, this may be due to the high ash content of SPB, which produced a faster gut transit rate, and force fish to feed more associated with poor feed efficiency and growth performance (Goda *et al*., 2007).

In the present study, the African catfish fed diets with different protein sources had the PER values in the range of 0.84-2.26. The PER depend on the weight gain in relation to protein. Protein intake depends on the source of protein in the diet (Mohanta *et al*., 2013). Therefore, the source of protein may be responsible for the wide variation on PER values.

The proximate compositions of the initial and final carcass are recorded in Table 5. Whole body compositions of African catfish fed diets containing 100%PBM were not significantly differed. These findings are in agreement with the values reported by Emre *et al*. (2003). The final body crude lipid levels are higher (Emre *et al*., 2003) and ash is lower (Nengas *et al*., 1999) than initial levels. However, final body protein level obtained in this trial was slightly lower compared to initial value except for fish fed SPB^{+Mix}. This is contradictory findings reported by Hasan and Das (1993).

The data revealed that L-lysine was found to be first-limiting AA in the SPB. Deficiencies in African catfish performance were ameliorated by supplementing the 100% replacement diet with sufficient L-lysine to match levels in a hypothetical 40% protein diet formulated for the African catfish.

REFERENCES

Abdel-Warith, A.; Russell, P.M. and Davies, S.J. (2001). Inclusion of a commercial poultry by-product meal as a protein replacement of fish meal in practical diets for African catfish *Clarias gariepinus* (Burchell 1822). Aquacult. Res., 32, 296–305.

AOAC (1995). Official Methods of Analysis. Association of Official Analytical Chemists.Washington, DC.

AOAC (2005). International Official Methods of Analysis. 18th ed. Association of Official Analytical Chemists, Gaithersburg, MD.

Bligh, E.G. and Dyer, W.J. (1959). A rapid method of total lipid extraction and purification. Canadian J. Biochem. and Physiol., 37:911-917.

Brett, J. R., and Groves, T. D. D. (1979). In “Fish Physiology” (W. S. Hoar, D. J. Randall, and J. R. Brett, eds.), Vol. VIII, pp. 279–352. Academic Press, New York.

El-Sayed, A.F.M. (1998). Total replacement of fishmeal with animal protein sources in Nile tilapia, *Oreochromis niloticus (L.)*, feeds. Aquacult. Res. 29(4): 275-280.

Emre, Y.; Sevgili, H and Diler, B. (2003). Replacing Fish Meal with Poultry By-Product Meal in Practical Diets for Mirror Carp (*Cyprinus carpio*) Fingerlings. Turkish J. Fisheries and Aquatic Sci. 3:81-85.

Fasakin, E.A.; Serwata, R.D. and Davies S.J. (2005). Comparative utilization of rendered animal derived products with or without composite mixture of soybean meal in hybrid tilapia (*Oreochromis niloticus 9 Oreochromis mossambicus*) diets. Aquaculture 249:329-338.

Goda, A.M.; El-Haroun, E.R. and Chowdhury, M.A.K. (2007). Effect of totally or partially replacing fish meal by alternative protein sources on growth of African catfish *Clarias gariepinus* (Burchell, 1822) reared in concrete tanks. Aquacult. Nutr., 38: 279-287.

Hasan, M.R. and Das, P.M. (1993). A Preliminary study on the use of poultry offal meal as dietary protein source for the fingerlings of Indian major carp, *Laboe rohita* (Hamilton). Kaushik, S.J. and Luquet, P. (Eds.), Fish Nutrition Practise, Institut National de la Recheche Agronomique, Paris: 793-801.

Hansen, A.C.; Rosenlund, G.; Karlsen, O.; Koppe, W. and Hemre, G.I. (2007). Total replacement of fi sh meal with plant proteins in diets for Atlantic cod (*Gadus morhua*). I: effects on growth and protein retention. Aquaculture 272: 599– 611.

Hardy, R.W. (2000). New developments in aquatic feed ingredients, and potential of enzyme supplements. L.E. Cruz-Suárez, D. Ricque-Marie, M. Tapia- Salazar, M.A. Olvera-Novoa, and R. Civera-Cerecedo, (Eds.), Avaces en Nutrición Acuicola V. Memorias del V Simposium Internacional de Nutrición Acuicola, Mérida, Yucatán, Mexico: 216-226.

Hardy, RW. (2010). Utilization of plant proteins in fish diets: effects of global demand and supplies of fishmeal. Aquacult. Res., 41:770-776.

Khan, M.A. and Abidi, S.F. (2011) Dietary arginine requirement of Heteropneustes fossilis fry (Bloch) based on growth, nutrient retention and hematological parameters. Aquac. Nutr., 17(4): 418–428.

Kureshy, N.; Davis, D.A. and Arnold, C.R. (2000). Partial replacement of fishmeal with meat and bone meal, flash dried poultry by-product meal, enzyme-digested poultry by-product meal in practical diets for juvenile red drum. N. Am. J. Aquacult., 62:266-272.

Jia, W.; Biao, Y.; Min, X.; Xiufeng, W.; Yinhua, Z. and Peng, L. (2012). Apparent digestibility coefficients of several protein sources, and replacement of fishmeal by porcine meal in diets of Japanese seabass, *Lateolabrax japonicus*, are affected by dietary protein levels. Aquacult. Res., 43:117–127.

Li, M.H. and Robinson, E.H. (2013). Evaluation of hydrolyzed poultry feathers as a dietary ingredient for pond-raised Channel catfish. North American J. Aquacult. 75:85–89.

Liu, X.Y.; Wang, Y. and Ji, W.X. (2011). Growth, feed utilization and body composition of Asian catfish (*Pangasius hypophthalmus*) fed at different dietary protein and lipid levels. Aquacult. Nutr., 17(5):578–584.

Main, M.A. and Doghir, N.J. (1982). Bioassay of limiting amino acids in poultry by-product meal. Pak. Vet. J., 2: 161–163.

Mohanta, K.N.; Subramanian, S. and Korikanthimath, V.S. (2013). Evaluation of different animal protein sources in formulating the diets for Blue Gourami, *Trichogaster Trichopterus* Fingerlings. J. Aquacult. Res. Development, 4:2

Nengas, I.; Alexis, M.N. and Davies, S.J. (1999). High inclusion levels of poultry meals and related by products in diets for gilthead sea bream, *Sparus aurata L*. Aquaculture, 179:13-23.

Nguyen, T.N.; Davis, D.A. and Patrick, S.I. (2009). Evaluation of alternative protein sources to replace fish meal in practical diets for juvenile tilapia, *Oreochromis* spp. J. World Aquacult. Soc., 40(1):113–121.

NRC (2011). Nutrient requirements of fish and shrimp. National Research Council of the National Academies Washington, D.C (U.S.), 363pp.

NRC. (1993). Nutrient Requirements of Fish. National Academy Press, Washigton DC: 114 pp.

Nyina-wamwiza, L.; Wathelet, B. and Kestemont, P. (2007). Potential of local agricultural by-products for the rearing of African catfish, *Clarias gariepinus* in Rwanda: effects on growth, feed utilization and body composition. Aquac. Res., 38: 206–214.

Peres, H. and Oliva-Teles, A. (2009). The optimum dietary essential amino acid profile for gilthead seabream (*Sparus aurata*) juveniles. Aquaculture, 296:81–86.

Quartararo, N.; Allan, G.L. and Bell, J.D. (1998). Replacement of fish meal in diets for Australian snapper, *Pagrus auratus*. Aquaculture, 166: 279-295.

Rawles, S.D.; Thompson, K.R.; Brady, Y.J. Metts, L.S.; Aksoy, M.Y. Gannam, A.L. Twibell, R.G.; Ostrand, S. and Webster, C.D. (2011). Effects of replacing fish meal with poultry by-product meal and soybean meal and reduced protein level on the performance and immune status of pond-grown sunshine bass (*Morone chrysops*× *M. saxatilis*). Aquacult. Nutr., 17; e708–e721.

Saadiah, I; Abol-Munafi, A.M. and Che Utama, C.M. (2011). Replacement of fishmeal in cobia (Rachycentron canadum) diets using poultry by-product meal. Aquacult Int., 19(4): 637-648.

Sevgili, H. and Ertürk, M.M. (2004). Effect of replacement of fish meal with poultry by-product meal on growth performance in practical diets for rainbow trout, *Onchorynchus Mykiss*, Akdeniz Üniv Zir Fak Dergisi, 17:161-167.

SPSS (2009). Software Program of Statistical Analysis, Version 17.0 Edition for Windows. SPSS Inc., Chicago, IL, USA..

Thompson, K.R.; Metts, L.S.; Muzinic, L.A.; Dascupta, S.; Webster, C.D. and Brady, Y.J. (2007). Use of turkey meal as a replacement for menhaden fish meal in practical diets for sunshine bass grown in cages. N. Am. J. Aquacult., 69:351-359.

Thompson, K.R.; Rawles, S.D.; Metts, L.S.; Gannam, A.L.; Brady, Y.J. and Webster, C.D. (2008). Digestibility of dry matter, protein, lipid, and organic matter of two fish meals, two poultry by-product meals, soybean meal, and distillers dried grains with solubles in practical diets for sunshine bass, *Morone chrysops* × *M. saxatilis*. J. World Aquacult. Soc., 39(3):352–363.

Waldemar, R.J., (2011). Development of alternative-protein-based diets for the intensive production of florida pompano *Trachinotus carolinus* L. Msc thesis. Alabama: Auburn University.

Wang, X. and Persons, C.M., (1998). Order of amino acid limititations in poultry by-product meal. Brit. Poultry Sci., 69:113-116.

Xue, M.; Yun, B.; Wang, J.; Sheng, H.; Zheng, Y.; Wu, X.; Qin, Y. and Li, P. (2012). Performance, body compositions, input and output of nitrogen and phosphorus in siberian sturgeon, Acipenser baerii brandt, as affected by dietary animal protein blend replacing fish meal and protein levels. Aquacult. Nutr., 18:493-501.

Yang, Y.; Xie, S.; Cui, Y.; Lei, W.; Zhu, X. and Yang, Y. (2004). Effect of replacement of dietary fish meal by meat and bone meal and poultry by-product meal on growth and feed utilization of gibel carp, Carassius auratus gibelio. Aquac. Nutr., 10:289-294.

تحديد ترتيب الأحماض الأمينية المحددة لاستخدام مسحوق مخلفات مجازر الدواجن فى علائق القراميط الأفريقى باستخدام طريقة الاضافة

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أجريت هذه الدراسة بهدف تحديد ترتيب الأحماض الأمينية المحددة لاستخدام مسحوق مخلفات مجازر الدواجن فى علائق القراميط الافريقى باستخدام طريقة الإضافة. واستخدمت ٧ علائق متماثلة فى محتوى البروتين الخام (٤٠ %). عليقة الكنترول تحتوى على ٤٠% مسحوق السمك و ٢٠% مسحوق فول الصويا و بدون إضافة أحماض أمينية، و تم تكوين العليقة لتغطى بالاحتياجات الغذائية لأسماك القراميط الأفريقى. أما فى العليقة الثانية تم إحلال مسحوق السمك بنسبة ١٠٠% باستخدام مسحوق مخلفات مجازر الدواجن و بدون إضافة أحماض امينية. ثم تم إضافة الليسين و المثيونين و التربتوفان و الأرجنين منفردا فى العلائق SPB^{+Lys} ، SPB^{+Met}، SPB^{+Try} و SPB^{+Arg} على التوالى ثم مجمعة فى العليقة رقم ٧. وغذيت بها أسماك القراميط ثلاث مرات يوميا حتي الشبع. وكانت هناك فروق معنوية فى النمو و كفاءة الإستفادة من الغذاء. أسماك القراميط التى غذيت على عليقة SPB سجلت أقل معدل نمو و كفاءة الإستفادة من الغذاء مقارنة بالمجموعة التى غذيت على عليقة الكنترول. المجموعة التى غذيت على عليقة الكنترول سجلت أعلى وزن نهائى حيث زادت بمعدل ٥ إضعاف فى نهاية التجربة بينما المجموعات التى غذيت على علائق SPB^{+Lys} و SPB^{+Mix} تضاعفت ٣ مرات، أما المجموعة التى غذيت على علائق SPB و SPB^{+Try} و SPB^{+Met} و SPB^{+Arg} تضاعفت مرة واحدة فقط. المجموعة التى غذيت على SPB^{+Met} سجلت اقل وزن نهائى. افضل معامل تحويل غذائى (١,٢٠) سجلت للمجموعة التى غذيت على عليقة الكنترول مع عدم وجود فروق معنوية بينها و بين المجموعات التى غذيت على SPB^{+Lys} و SPB^{+Mix} (١,٥٢ و ١,٦٦ على التوالى). المجموعات التى غذيت على SPB^{+Lys} و SPB^{+Mix} سجلت أفضل معدل نمو و كفاءة الإستفادة من البروتين مقارنة بالمجموعات التى غذيت على SPB، SPB^{+Met} ، SPB^{+Try} و SPB^{+Arg}. المجموعة التى غذيت على عليقة الكنترول سجلت أعلى كفاءة الإستفادة من البروتين بينما المجموعة التى غذيت على SPB^{+Arg} سجلت أقل قيمة. من النتائج المتحصل عليها يمكن إستنتاج ان الليسين يعتبر الحامض الأمينى المحدد الأول فى مسحوق مخلفات مجازر الدواجن و إضافة الليسين فى علائق القراميط المحتوية على نسب عالية من مسحوق مخلفات مجازر الدواجن تحسن النمو.

الكلمات الدالة: القراميط الأفريقى، مسحوق مخلفات مجازر الدواجن، أحماض أمينية