EFFECTS OF REPLACING FISH MEAL WITH POULTRY BY-PRODUCT MEAL ON GROWTH PERFORMANCE FEED UTILIZATION AND WHOLE BODY COMPOSITION OF AFRICAN CATFISH (*CLARIAS GRAIEPINUS)*

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Abstract

A 14 - week feeding trial was contacted in semantic pond to evaluate the use of poultry by-product meal (PBM) in practical diets for African catfish (*Clarias gariepinus*) fingerlings (40.5 g ±0 .56) as replaced for fish meal. Five isonitrogenous diets (30 % protein) were formulated in which poultry by-product (PBM) replaced 0.0%, 25%, 50%, 75%, and 100% of the protein supplied by herring fish meal (HFM). Fish were fed daily the tested diets at the rate of 3% of body weight. Feed was offered 6 days a week, 2 times a day (9.00 and 14.00). At the end of the feeding trial, fish growth indicated as final weight, weight gain, weight gain % and specific growth rate was insignificantly decreased up to 75 % poultry by-product meal (PBM) ($P>0.05$), while the lowest growth recorded in fish group fed 100 % poultry by-product meal (PBM) with insignificant differences ($P>0.05$). No significant difference in survival rate was observed due to the increment in poultry by-product meal (PBM) level in the tested diets. Feed intake was significantly decreased, while feed conversion ratio increased due to the increment in poultry by-product meal (PBM) level in the tested diets. Protein efficiency ratios were significantly decreased due to the increment in poultry by-product meal (PBM) level in the tested diets. No significant changes were observed in dry matter, crude protein, total lipids and ash in fish body composition at all tested diets compared with control diet.

These results support the use of poultry by-product meal (PBM) as an important animal protein source to replace HFM protein up to 75 % in practical diet for African catfish fingerlings.

Key words: poultry by-products (PBM), Fish meal (HFM), African catfish (*Clarias gariepinus*), economic Evaluation, growth rate, feed utilization, whole body composition.

INTRODUCTION

Aquaculture is the fastest expanding food production system in the world. This rapid development largely depends upon fish meal, a major protein source, which constitutes 40-60 % of the total cost of feed production for aquaculture (Hardy and Tacon, 2002). The continuous increasing demand for fish meal use in animal feed especially in aqua feed has resulted in fish meal becoming difficult to obtain and more expensive. Therefore, the search for alternatives to fish meal is an international research priority (Hardy and kisser, 1997; Abdelghany, 2003; Abdelghany *et al*., 2005 and Ahmad, 2008). The shortage in world production of fish meal coupled with the increased demand for fish meal in feeds for livestock and poultry is likely to reduce the dependence on fish meal as a single protein source in aqua feeds (El-Sayed, 1999). Therefore, fish nutritionists have made several attempts to partial or totally replacement of fish meal with less expensive locally available protein sources.

Poultry by-product processing in formal and informal abattoirs in Egypt produces tremendous quantities of by–product (meat, offal, blood, bone, etc.). Recycling of these wastes gave two advantages 1– less environmental pollution 2– an acceptable source of animal protein in the diet of fish which is a big challenge in the pursuit of sustained production of inexpensive fish feed. Poultry by-product meal is a rich source of animal protein (> 59 % CP on dry matter basis) and is less expensive than fish meal, and requires successive studies evolving its use as partial or complete substitute to the traditionally utilized fish meal. Therefore, this study was carried out to evaluate the use of poultry by- product meal

(PBM) as a herring fish meal (HFM) substitute in practical diets for African catfish and its relation to fish growth, feed utilization, whole-fish body composition.

MATARIALS AND METHODS

This study was carried out at the central laboratory of aquaculture research, Abbassa, Abo-hammad, El- Sharkia Governorate, Egypt during the year 2008. The trail was carried out on African catfish.

Experimental treatments:

The initial body weight of finger lings averaged about 40.5 grams for African catfish while the corresponding body length was 25 cm. Fish were holed in a concrete pond for one week as an acclimatization period there graded and divided in to five groups.

Diet preparation and feeding regimen:

Five diets were formulated to be isonitrogenous, isoenergetic, isolipidic and consideration was also given equivalence of other components such as fiber and ash. On average, the diets provided 30.4% crude protein and digestible energy contents of 3.96 K CAL DE/g. The composition of diets is shown in Table 1, control contained herring fish meal (HFM) as a sole source of animal protein. Diet 5 contained poultry by-product meal (PBM) as a sole source of animal protein, diets 2-4 contained mixtures of (HFM) and (PBM) as a source of animal protein. Supplements with the proportion of each were adjusted so that each of the two ingredients provided similar graded levels of animal protein in the diet.All the diets contained a constant level of plant protein from soybean meal (SBM) and corn meal to complete the protein requirements in the diets. The proximate chemical composition of the main ingredients in the diets was analyzed and shown in table2.

In the present study, the poultry by – product meal was a product brought from the Egyptian company of poultry (Mariottia, Giza, Egypt). It consists of the rendered, clean parts of the carcass of slaughtered poultry, such as necks, feet, intestines, blood and skin exclusive of feathers, except such amounts as might occur unavoidably in good processing practices. The diets were prepared palletized, stored as previously described by Abdelghany (2003).

Table 1. Showed Ingredients and chemical composition of the experimental diets (on dry matter basis).

Ingredients %	**% Replacement of HFM by PBM in experimental rations**				
	0	**25**	**50**	**75**	**100**
HFM	9.01	6.83	5.4	2.2	0
PBM	0	2.94	5.8	8.8	11.7
Soybean meal	52.57	52.57	52.57	52.57	52.57
Corn meal	18.25	18.25	18.25	18.25	18.25
Starch	4	3.4	3.3	2.02	2.09
Corn oil	1.8	1.44	1.09	1.07	1.0
Cod - liver oil	1.9	2.72	2.6	2.7	3.2
Cellulose	6.5	6.06	5.1	6.7	5.4
Vitamin mixture[1]	2	2	2	2	2
mineral premix[2]	4	3.83	3.9	3.8	3.8
Total	100.03	100.04	100.01	100.11	100.01
Chemical analyses (%on dry matter basis)					
Moisture	8.32	8.26	8.86	8.63	8.53
Crude protein	30.58	30.28	30.52	30.18	30.21
Ether extract	9.13	9.16	9.22	9.36	8.88
Ash	8.78	8.7	8.45	8.59	8.9
Crude fiber	5.49	5.6	5.45	5.42	5.43
NFE[3]	46.02	46.26	46.36	46.45	46.58

[1] Vitamin premix (per kg of premix): thiamine, 2.5 g; riboflavin, 2.5 g; pyridoxine, 2.0 g; inositol, 100.0 g; biotin, 0.3 g; pantothenic acid, 100.0 g; folic acid, 0.75 g; para-aminobenzoic acid, 2.5 g; choline, 200.0 g; nicotinic acid, 10.0 g; cyanocobalamine, 0.005 g; a-tocopherol acetate, 20.1 g; menadione, 2.0 g; retinol palmitate, 100,000 IU; cholecalciferol, 500,000 IU.

[2] Mineral premix (g/kg of premix): $CaHPO_4.2H_2O$, 727.2; $MgCO_4.7H_2O$, 127.5; KCl 50.0; NaCl, 60.0; $FeC_6H_5O_7.3H_2O$, 25.0; $ZnCO_3$, 5.5; $MnCl_2.4H_2O$, 2.5; $Cu(OAc)_2.H_2O$, 0.785; $CoCl_3.6H_2O$, 0.477; $CaIO_3.6H_2O$, 0.295; $CrCl_3.6H_2O$, 0.128; $AlCl_3.6H_2O$, 0.54; Na_2SeO_3, 0.03.

[3]Nitrogen-FreeExtract(calculated by difference) = 100 – (protein + lipid + ash + fiber).

Fish culture technique:

Fingerlings of African catfish were collected from the nursery ponds of the Central, Laboratory for Aquaculture Research, Abbassa, Abo-Hammad, elSharkia, Egypt. Fish (40.5 g) were acclimated for one week in a concrete pond where they were fed a commercial diet containing 30% crude protein.

Fifteen concrete ponds were used for the experiment. (5 treatments × three replicates). Each concrete pond (2.5 x 2.5 x1 m) was supplied with compressed air via air-stones from air pumps, and water supply was provided from the Ismailia irrigation canal, which was stored in fiberglass tank before use. Each pond was stocked with 40 fish (average initial body weight 40.5 g). The daily feeding rate was 3 % of fish body weight during the course of the experiment. Feed was offered to fish two times daily, 6 days a week. All fish from each pond were collected every two weeks for group-weighing and the ration was readjusted accordingly. At the end of the experiments, fish were collected, counted, group weighed per treatments. The parameters of growth and feed utilization were calculated.

Proximate analysis of diet and fish:

At the start of the experiment, 50 fish were taken and kept frozen for proximate chemical analyses. At the end of the experiment, the basal diet and 15 fish from each treatment were chemically analyzed according to the standard methods of AOAC (1990) for determination of moisture, crude protein, total lipids, and ash. Moisture content was estimated by draying samples in an oven at 85 ^{o}C till constant weight and calculating weight loss. Nitrogen content was measured using a microkildahl apparatus and crude protein was estimated by multiplying nitrogen content by 6.25. Lipid content was determined by ether extraction for 16 hours and ash was determined by combusting samples in a muffle furnace at 550 ^{o}C for 6 hours. Crude fiber was estimated according to Goering and Van Soest (1970).

Growth parameters:

Growth performance was determined and feed utilization was calculated as following:

Weight gain = $W_2 – W_1$;

Weight gain % = (weight gain /Initial weight) ×100

Specific growth rate (SGR) = 100 ($\ln W_2 – \ln W_1$) / T; where W_1 and W_2 are the initial and final weight, respectively, and T is the number of days in the experimental period;

Feed conversion ratio (FCR) = feed intake / weight gain;

Feed efficiency ratio (FER) = (weight gain / feed intake)×100;

Protein efficiency ratio (PER) = weight gain / protein intake

Statistical analysis:

The obtained data in this study are presented as means ± SD of three replicates and analyzed by one-way ANOVA to test the effect of PBM inclusion in fish diet according to Snedecor and Cochran (1982). All differences among means were considered significant at P □ 0.05 using Duncan's multiple range test (Duncan ,1955).

Economical evaluation:

The cost of feed to raise unit biomass of fish was estimated by a simple economic analysis. The estimation was based on local retail sale market price of all the dietary ingredients at the time of the study. These prices (in LE/kg) were as follows: herring fish meal, 12.0; PBM, 2.25; soybean meal, 2.0; corn meal, 1.40; wheat bran, 1.40; starch, 2.0; fish oil, 7.0; corn oil, 5.0; vitamin premix, 7.0; mineral mixture, 3.0; cellulose 3.0. An additional 50.0 LE/ton was added as a manufacturing cost.

RESULTS

The chemical analysis of the ingredients (HFM, PBM, SBM, and CNM) is presented in Table (2). Based on the results, poultry by-product meal (PBM) analysis is a good alternative protein source and may replace HFM protein in fish diets.

Table 2. Showed proximate chemical analysis of HFM, PBM, SBM and CNM (% on dry matter basis).

Chemical analysis	Herring fish meal (HFM)	Poultry by – product meal (PBM)	Soybean meal (SBM)	Corn meal (CNM)
Dry matter	92.5	85.52	93.81	88.37
Crude protein	71.26	59.75	45.62	9.3
Total lipids	14.18	14.19	6.27	5.47
Ash	11.05	10.98	7.87	1.2
NFE*	2.81	14.78	34.79	68.89
Crude fiber	0.7	0.3	5.42	15.14
GE/100 g diet**	536.7	531.7	459.6	388.4

*Nitrogen-Free Extract (calculated by difference) = 100 – (protein + lipid + ash+ fiber).

**Gross energy was calculated from (NRC, 1993) as 5.65, 9.45, and 4.1 kcal/g for protein, lipid, and carbohydrates, respectively.

Table 3. Showed Growth performance and feed utilization of African catfish fed diets containing different levels of PBM.

Items	PBM levels (%)				
Growth performance	**0**	**25**	**50**	**75**	**100**
Initial weight (g)	40.90 ± 0.3[a]	40.85 ± 0.05[a]	40.96 ±0.05[a]	40.95 ±0.05[a]	40.80 ±0.1[a]
Final weight (g)	172.20 ± 1.3[a]	172.90 ±2.0[a]	169.60 ±1.2[a]	171.85 ±1.85[a]	160.90 ±1.70[b]
Weight gain (g)	131.30 ±1.41[a]	132.05 ±2.5[a]	128.65 ±1.35[a]	130.90 ±1.8[a]	120.10 ±1.80[a]
Weight gain%	321.02 ±7.2[a]	323.26 ±5.41[a]	314.18 ±4.45[a]	319.65 ±4.01[a]	294.37 ±5.13[b]
SGR (%/d)	1.36 ± 0.01[a]	1.37 ± 0.01[a]	1.35 ±0.01[a]	1.36 ±0.01[a]	1.30 ±0.01[a]
FI (g feed/ fish)	247.95 ±0.51[a]	251.52 ±0.54[a]	245.47 ±0.47[a]	246.75 ±3.91[a]	231.16 ±2.18[a]
FCR	1.88 ±0.01[a]	1.90 ±0.03[a]	1.91 ±0.01[a]	1.88 ±0.06[a]	1.92 ±0.05[a]
FER	52.95 ±0.30[a]	52.50 ±0.93[a]	52.40 ±0.45[a]	53.07 ±1.57[a]	51.96 ±1.27[a]
PER	1.92 ±0.01[a]	1.91 ±0.03[a]	1.92 ±0.01[a]	1.93 ±0.06[a]	1.89 ±0.05[a]
Cost (LE/ ton diet)	2850	2660	2470	2160	1920

The same letter in the same row is not significantly different at P < 0.05.

Initial body weigh at all experimental treatments did not differ significantly (Table 3). The present study showed that growth performance of the group of fish fed diet containing 100% substitution had significantly(P > 0.05) lower final body weight and weight gain than those fed diet containing 25,50 and 75% substitution of fish meal with PBM . Diet utilization (feed intake, FCR, FER, and PER) was not significantly (P > 0.05) affected by PBM inclusion levels.

The whole-body composition of African catfish of moisture, crude protein, fat and ash at the end of the study are shown in Table 4. The group of fish fed diet containing 100% substitution had significantly

(P ‹ 0.05) lower protein than those fed diet containing 25,50 and 75% substitution of fish meal with poultry by-product meal (PBM) .The highest value of ether extract is shown in group fed diet containing 100% substitution of fish meal with poultry by-product meal (PBM) but the lowest value of ether extract was shown in group fed diet containing 75 % substitution of fish meal with poultry by-product meal (PBM) but no significant differences were found among groups of 0, 25 and 50% substitution of fish meal with poultry by-product meal (PBM). The highest ash levels were shown in fish fed diet containing 75% substitution of fish meal with PBM but the lowest value of ash was shown in that fed diet containing 0 % substitution of fish meal with poultry by-product meal (PBM). But no significant differences were found among the fish groups of 0, 25, 50 and 100% substitution of fish meal with poultry by-product meal (PBM).

Economic evaluation showed that diets containing higher levels of PBM were cheaper than diets containing higher levels of HFM (Table 5). As poultry by-product meal (PBM) inclusion in the diets increased up to 100 % level of replacement for HFM-protein, the cost of 1 ton was reduced since control = 2850 LE, while the cost of 1 ton from diet containing 100 % PBM = 1920 LE. One ton from diet containing 100 % PBM was less with 930 LE when compared with control diet.

Table 4. Showed Proximate chemical analyses (%on dry matter basis) of whole African catfish fed diets containing different levels of PBM.

Items	**PBM levels (%)**				
	0	**25**	**50**	**75**	**100**
Moisture	71.62 ±0.72[a]	70.38 ±2.50[a]	72.22 ± 0.81[a]	71.52 ±1.17[a]	73.90 ±0.84[a]
Crude protein	76.43 ±0.35[a]	76.10 ±0.36[a]	76.10 ±0.42[a]	75.17 ±0.15[b]	73.47 ±0.18[c]
Total lipid	8.17 ±0.12[b]	8.13 ±0.12[b]	7.82 ±0.18[b]	7.06 ±0.26[c]	11.61 ±0.23[a]
Ash	17.02 ±0.65[b]	17.30 ±0.46[b]	17.47 ±0.28[ab]	18.61 ±0.33[a]	17.20 ±0.29[b]

The same letter in the same row is not significantly different at $P < 0.05$.

Table 5. Showed Economical evaluation of the experimental diets

Poultry by-product levels					
Items	**0.0 control**	**25%**	**50%**	**75%**	**100%**
Price/kg feed, P.T	2.85	2.66	2.47	2.16	1.92
Reduction in feed cost	100	6.66	13.33	24.21	32.63
F.C.R (kg feed) kg gain	1.88	1.90	1.91	1.88	1.92
Feed cost/ kg gain, P.T	5.35	5.05	4.71	4.06	3.68
Reduction cost in kg gain	100	5.60	11.96	24.11	31.21

DISCUSSION

In the present study, African catfish fed the experimental diets were active on all the experimental diets and grew efficiently without external signs of nutritional deficiency.

Partial or complete replacement of HFM with PBM in experimental diets for African catfish in the present study resulted in dietary amino acid profiles that meet the requirement of this species.

These results showed that the amino acid profile of protein from PBM is a good as HFM and quality of protein in terms of the quantitative essential amino acid of both ingredients are similar.

Growth performance (final body weight, weight gain, weight gain % and specific growth rate) of African catfish fed diets containing various levels of PBM was similar to that of fish fed a control diet in this study. The results of growth performance and feed utilization clearly indicated that protein from PBM is digested and utilized in a manner similar to that of HFM and its use in practical diets for African catfish is feasible.

Yang *et al.* (2004) showed that poultry by-product generally was efficiently substitute up to 50% of fish meal protein in aquatic diets as well as When high quality poultry by-products meals were used for many species at rate up to 100% replacement (Wepster *et al*.,2000)..

Abdel-Warith (2002) reported significant differences in the final average body weights amongst African catfish fed the six respective diets. Fish fed the fish meal (LT94) based control diet demonstrated the highest mean final body weight (175.5 g) resulting in a 10-fold increase in weight from the start of the study. However, the lowest value (103.8 g) was observed for catfish fed the 100% inclusion level of PBM in the diet replacing the entire fish meal component. The control diet supported the highest weight gain of 159.9 g while fish fed the 100% PBM diet exhibited the lowest weight gain of 87.39 g. It was apparent that above 40% inclusion, PBM resulted in a significant reduction in growth performance for weight gain in African catfish.

Abdelghany *et al.* (2005) reported that fish fed diets in which PBM replaced up to 100% of the protein supplied by HFM showed that growth performance in terms of final weight (g/fish), weight gain (g/fish), percent carcass weight, growth rate (g/fish) that was comparable to fish fed HFM-based diet.

The present results coincide with the findings of Abdelghany *et al.* (2005) who observed no significant difference (P>0.05) in final weight of monosex Nile tilapia which were fed diets for 90 days in which 10%, 25%, 50%, 75%, 90% and 100% of the herring fish meal had been replaced with a poultry by-product meal.

These observations suggested that the PBM diets contained all the necessary growth factors required by African catfish. In addition, the isoniterogenous, isolipidic, and isocaloric nature of the experimental diets explained why there was no disparity in fish growth and feed utilization.

In the present study, African catfish fed diets in which PBM replaced up to 100% of the protein supplied of HFM had similar feed utilization efficiency (FI, FCR, FER and PER) to fish fed the HFM-based diet. Partial and totally replacement with PBM of HFM protein in African catfish diets did not affect FER and PER when compared with fish fed HFM.

Dry matter and protein contents in whole-fish body received PBM were not significantly affected due to PBM inclusion in fish diets up to 75% of substitution. These results indicated that partial or complete replacement of PBM for HFM-protein did not alter the nutritional value of fish produced. These results also suggested that African catfish efficiently ingested, digested, assimilated and utilized protein from PBM similar to HFM.

Abdel-warith (2002) reported that fish fed the fish meal based control diets and the 20,40, and 60% PBM protein diets did not yield any variation in the protein content whilst fish fed the 80 and 100% PBM. Conrad et al. *(1988*) who observed no significant difference (P > 0.05) in fish growth and feed utilization of channel catfish fingerling fed on diets for 85 days in which 50 and 100 % of HFM had been replaced with a spray–dried waste egg product.

El-marakby *et al*. (2010) who observed no significant difference (P > 0.05) in fish growth and feed utilization of channel catfish fingerlings fed on diets in which up to 60% of herring fish meal (HFM) had be replaced with poultry hatchery waste meal (PHWM).

Seden, M.E.A. and Mohammad H. Ahmed. (2011) who reported that the growth performance (final body weight, weight gain, growth rate, and specific growth rate) of African cat fish fed diet containing various levels of PBM were similar to those of fish fed a control diet. fish survival was 100% in all treatments. Fish diets in which PBM replaced up to 100% of the protein supplied by HFM had similar feed utilization efficiency (FI, FCR, PER, APU and EU) compared to the fish fed the HFM-based diet. The partial and totally replacement of PBM protein in the diets for African cat fish did not affect FER and PER when compared with the fish fed HFM. The proximate chemical composition (dry mater, crude protein, total lipid and ash) of whole- fish body were not significantly affected by PBM inclusion in fish diets.

Safwat A. A. Gomaah. (2006) reported that the chemical composition (% dray mater) of C.gariepinus fish during the experimental period. It show that ash percentage was significantly affected by all factors (season, treatment and their interaction. On the other hand, the protein and fat content were affected significantly by both season and its interaction with treatment, but they were not affected significantly by treatment. both D35 and D70 had a slightly lower fat content, but they had a slightly higher protein and ash content. While, the moisture percentage was significantly affected by the season , but it was not affected significantly by both treatment and its interaction with season there were no significantly difference ($p>0.05$) between treatment in the items of growth in ; final body weight , total weight gain, daily weight gain and specific growth rate%. The D35 had the lowest feed conversion ratio, FCR with significant difference when compared with D0 which had the highest value. But the was no significant difference when compared with that of D70.

NG, W-K et al. (2001) reported that there were significant difference (<0.05) for moisture (73.4-75.1 %), crude lipid (4.8-7.1 %) and crude protein (13,5-14.4 %) percentages (% on wet weight basis) of C. gariepinus fed diet with increasing percentage of fish meal with the larvae of the beetle, mealworm, (tenebrio molitor) for 7 weeks.

A M Goda et al. (2007) The growth performance of the catfish fed diets containingPBM-75%, PBM-100%, MBM-75%, SBM-75% andSBM-100% were not significantly different than the fish fed the control diet (P40.01). Fish fed the diet containing MBM-100% recorded the lowest fish growth ($P \leq 0.01$) compared with the control diet . Feed conversion ratio was lowest for the PBM-75%(2.31) treatment, while the highest values were recorded for the MBM-75% (3.32) and MBM-100%(3.14) treatment respectively .Concerning the influence of diets on proximate composition of whole carcass, there was no significant differences ($P \geq 0.01$) for whole-body ash and gross energy contents. However, fish fed thePBM-100% treatment recorded lower protein content ($P \geq 0.01$) compared with the control diet. Other wise , fish fed SBM-100% or PBM-75% recorded higher values for lipid and gross energy contents compared with the control diet ($P \leq 0.01$), while, lower significant differences (P≤0.01) were recorded for fish fed diets containing MBM-75%.

Nguyen and Yu (2003) indicated that both MBM and PBM can replace FM up to 80% without affecting the growth of river cat fish, Pangasianodon hypophthalmus.

CONCULUSION

As a conclusion of this study, it is suggested that without amino acid supplementation, PBM could safely replace up to 75 % of HFM in practical diets for African catfish. These results may allow for formulation of less expensive diets for African catfish and may reduce the diet cost for producers.

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إحلال مخلفات مجازر الدواجن محل مسحوق السمك وتأثيرها على معدلات النمو، كفاءة الغذاء، التركيب الكيماوى للجسم فى أسماك القرموط الأفريقي

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الملخـــــص العربـــــى

تم تغذية أصبعيات أسماك القرموط الأفريقى(٤٠.٥ جرام) على علائق تتفق فيما بينها فى نسب البروتين(٣٠ %) والدهون (٩%) ولكنها تختلف فى نسب إحلال مخلفات مجازر الدواجن محل مسحوق السمك، حيث كانت نسب الإحلال كالآتى : ٢٥ ، ٥٠ ، ٧٥ ، ١٠٠ % على أساس محتوى البروتين.

أظهرت النتائج أن احلال مخلفات مجازر الدواجن محل مسحوق السمك حتى نسبة ٧٥ % على أساس محتوى البروتين لم يؤثر معنويا على نمو أسماك القرموط الأفريقى ولا كفاءة تحويل الغذاء و التركيب الكيماوى لجسم الأسماك المرباه فى أحواض خرسانية ، وذلك بالمقارنة بالأسماك التى تناولت العليقة الكنترول والخالية من مسحوق مخلفات مجازر الدواجن.

وأن نسبة الأسماك الحية فى نهاية التجربة كانت عالية ومتماثلة إحصائيا فى المعاملات المختلفة، ونستنتج من هذه الدراسة أنه يمكن إحلال مخلفات مجازر الدواجن محل مسحوق السمك حتى نسبة ٧٥ % فى علائق أسماك القرموط الأفريقى على اعتبار أنه مصدر رخيص الثمن للبروتين.