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USE OF POULTRY HATCHERY WASTE MEAL AS PARTIAL AND TOTAL REPLACEMENT OF FISH MEAL IN PRACTICAL DIET FOR AFRICAN CATFISH (*CLARIAS GARIEPINUS*)

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ABSTRACT

A 12-week experiment was conducted to evaluate the use of poultry hatchery waste meal (PHWM) in practical diet for African catfish, *Clarias gariepinus* (9-11 g). Six isonitrogenous (35% crude protein) and isolipidic (10.11%) diets were formulated in which PHWM replaced 0%, 20%, 40%, 60%, 80%, or 100% of the protein supplied by herring fish meal (HFM). Fish were fed one of the tested diets at 5 % of body weight for the first eight weeks and 3 % for the rest four weeks. Results showed that African catfish fed PHWM up to 60% exhibited similar growth performance. The lowest fish growth was obtained at 80% and 100% PHWM. Feed intake (FI), feed efficiency ratio (FER), protein efficiency ratio (PER) and apparent protein utilization (APU) decreased significantly, while feed conversion ratio (FCR) increased significantly for diets containing 80% and 100% PHWM. Fish survival rate at all treatments ranged from 93.33 to 96.67% without significant difference among them. At the end of the experiment, moisture, protein, and ash contents in fish body decreased significantly, while total lipid increased significantly with increasing the PHWM level in the diets. In conclusion, PHWM could be used as a protein source to replace fish meal protein up to 60% in practical fish diets. Moreover, the economic evaluation showed that a diet containing 60% PHWM reduced the feed cost by 23.42%.

KEYWORDS: Poultry hatchery waste, African catfish, *Clarias gariepinus*, growth performance, feed utilization, body composition, economic evaluation.

INTRODUCTION

Fish meal (FM) is traditionally the major animal protein supplement in fish diets but it is an expensive ingredient. Fish meal is the most desirable animal protein ingredient in aqua feeds because of its high protein content, balanced amino acid profile, high digestibility, and palatability (*Hardy and Tacon 2002*). The shortage in world production of FM coupled with the increased demand for livestock and poultry feeds is likely to reduce the dependence on FM as a single protein source in aqua feeds (*Dong et al. 1993; El-Sayed 1999*). Therefore, fish nutritionists have made several attempts to partially or totally replace FM with less expensive and locally available protein sources.

Poultry hatchery waste meal (PHWM) includes shells from hatched chicks' infertile eggs, dead embryos in the shell and dead chicks (*Hamm and Whitehead 1982*). This waste is creating disposal problem in large hatcheries, especially when the annual total production of hatchery by–product waste in Egypt ranged between 25.2 and 30.0 ton yearly *(Egyptian Ministry of Agriculture 1999*). Accordingly, a more desirable solution way is the conversion of this waste into valuable feedstuffs.

African catfish, *Clarias gariepinus*, is a widely distributed and cultivated in Africa because of its tolerance to a wide range of temperature, low oxygen, and high growth rate (*Hecht et al. 1996; Oteme et al. 1996*). Moreover, this fish has high nutritive value, good taste, and fewer bones. Therefore, the present study was conducted to evaluate the use of PHWM as HFM substitute in practical diet for African catfish fingerlings and its effect on growth parameters, feed utilization, whole fish-body composition and economic evaluation.

MATERIALS AND METHODS

Poultry hatchery waste meal preparation

Poultry hatchery waste meal (PHWM) was obtained from the hatchery of a private poultry production farm in Hehia, Sharkia, Egypt, after egg incubation and chick hatching on 21^{th} day. PHWM was boiled in water for 10–15 min to kill all microorganisms that may be existed. The boiled PHWM was dried at 65 °C in an oven for 24 hours. Afterwards, it was grinded through the feed grinding mill. After cooling, it was oven-dried again at 105 °C for 24 hours. The grounded PHWM was stored in plastic bags at 4°C to avoid rancidity until used.

Preparation of the tested diets

The ingredients used in diets formulation were chemically analyzed (Table 1). Six isonitrogenous (35% crude protein) diets were formulated on dry matter basis to evaluate the nutritional value of PHWM for African catfish where PHWM replaced 0.0, 20, 40, 60, 80, or 100% of the protein supplied by HFM (Table 2). The ingredients were thoroughly mixed and blended with additional 100 mL of water per kg diet to make a paste. The pastes were separately passed through a grinder, and palletized (1-mm diameter) in a paste extruder. The diets were oven-dried at 85 °C for 24 hours and stored in plastic bags in refrigerator (- 2 °C) until use.

Fish culture system

This study was carried out at Central Laboratory for Aquaculture Research, Abbassa, Abou-Hammad, Sharkia, Egypt. African catfish, *C. gariepinus* (9 - 11 g) were obtained from Abbassa fish hatchery and acclimated to laboratory condition for two weeks and were fed a commercial diet containing 25 % crude protein. Fifteen fish were frozen at –20 °C for proximate analysis at the beginning. Acclimated fish were distributed randomly at 10 fish/100-L glass aquarium. Fish were fed one of the tested diets at 5 % of body weight for the first eight weeks and 3 % for the rest four weeks. Each aquarium was supplied with well–aerated tap water from a storage fiberglass tank. Each aquarium was supplied with air produced by a small compressor. Three quarters of aquarium's water was siphoned every day for removing fish excreta and refilled with well-aerated tap water. The photoperiod was east on a 12 hour light – dark cycle using fluorescent tubes as the light source.

Chemical analysis of diets and fish

The tested diets and whole-fish body from each treatment at the beginning and at the end of experiment were analyzed according to the standard methods of *AOAC* (*1990*) for moisture, protein, fat and ash. Moisture content was estimated by drying the samples in an oven (GCA, model 18EM, precision scientific group, Chicago, Illinois, USA) at 85 °C to constant weight and weight loss was calculated. Nitrogen content was measured using a microkjeldahl apparatus Labconco

(Labconco Corporation, Kansas, Missouri, USA) and crude protein was estimated by multiplying nitrogen content by 6.25. Total lipids content was determined by ether extraction in the multi-unit extraction Soxhlet apparatus (Lab-Line Instruments, Inc., Melrose Park, Illinois, USA) for 16 hours and ash was determined by combusting samples in a muffle furnace (Thermolyne Corporation, Dubuque, Iowa, USA) at 550 °C for 6 hours. Crude fiber was estimated according to *Goering and Van Soest* (*1970*). Gross energy was calculated according to *NRC* (*1993*).

Analysis of water quality parameters.

Water samples were collected biweekly from each aquarium before water changing. Water temperature and dissolved oxygen were measured with a YSI model 58 oxygen meter (Yellow Spring Instrument Co., Yellow Spring, Ohio, USA). While the pH degree was measured using a pH–meter (Digital Mini-pH Meter, model 55, Fisher Scientific, USA). Unionized ammonia was measured using HACH kits (HACH Co., Loveland. Colorado. USA).

Growth Parameters

At the end of the experiment, fish were collected, counted, and weighed. Growth performance was estimated and feed utilization was calculated as following:

Weight gain = W2 – W1; Where W1 and W2 are the initial and final fish weigh, respectively.

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

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

Apparent protein utilization (APU %) = 100 (protein gain in fish / protein intake in diet).

Economical evaluation

The cost of feed required to produce a unit of fish biomass was estimated using 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, 8; soybean meal, 2.0; corn meal, 1.50;

starch 2.0, Limestone 1.0; fish oil, 9.0; corn oil, 6.0; vitamin premix, 7.0; mineral mixture and 3.0; PHWM, 2.

Statistical analysis

The obtained data were subjected to one-way ANOVA and differences between means were tested at the 5% probability level using Duncan test. All the statistical analyses were done using SPSS program version 10 (SPSS, Richmond, USA) as described by *Dytham* (*1999*).

RESULTS AND DISCUSSION

The values of water quality parameters showed that temperature range was 27 – 29 °C, dissolved oxygen range was 5.7–6.1 mg/L, pH range was 7.9–8.2 and total ammonia range was 0.7–0.9 mg/L. All values were within the tolerance limits for warm water fish species (*Boyd 1990*) and did not differ significantly (P>0.05) among all treatments.

The using of animal conventional sources to partially or entirely replace expensive FM protein has been a goal of fish nutritionists for many years. The present study was conducted to evaluate the use of PHWM as a one of these conventional sources. The present study showed that there was no significant difference in fish growth when fed 0.0, 20, 40, and 60% PHWM (Table 3). At the same time, fish growth at 80 and 100% PHWM was reduced. This reduction may be because PHWM has less amount of crude protein than HFM, PHWM has low levels of essential amino acids as compared with HFM, and/or HFM has apparent amino acids availability higher than PHWM (*El-Garhy 2003*). Moreover, *Cowey* (*1992*) reported that the deficiency in one or more amino acids could limit protein synthesis and/or fish growth.

The high improvement via the replacement of HFM by PHWM in the present study coincide with the results obtained by *Ibrahim* (*1997*) who found that the growth performance of Nile tilapia, *Oreochromis niloticus* was not affected by replacement of fish meal by HPWM up to 75 % in fish diet, while the complete replacement of fish meal protein by HPWM reduced fish growth. *El-Garhy* (*2003*) reported that Nile tilapia fed on diets containing 50% poultry by–product waste or 25% HPWM instead of fish meal had the highest fish growth. *El-Haroun et al.* (*2009*) reported that feather meal, poultry by product meal, blood meal, and meat and bone meal have good potential for use in rainbow trout diets at 30% levels of incorporation. On the other hand, *Conrad et al.* (*1988*) found 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. *Khattab* (*1996*) replaced 60 to 100% of crude protein of local fish meal by HPWM in Nile tilapia diets and found that there no significant difference in fish growth or feed utilization.

Feed intake decreased significantly at 80 and 100 % PHWM, while FCR increased significantly (P<0.05) by the increase of PHWM level up to 80 and 100% (Table 4). Moreover, no significant difference was observed in PER except that of 100 PHWM. Similarly, APU value reduced at control (0% PHWM).

The obtained results evoked that PHWM could replace HFM up to 60 % in practical diets without affecting fish growth. The high inclusion of PHWM (80 and 100%) in practical fish diet does not appear encouraging judging from the poor FCR. There was a significant difference (P<0.05) in feed intake, FCR, PER, and APU as a result of the effects of the different treatments.

The proximate chemical composition of whole fish body after the feeding trial was shown in Table (5). No significant difference in moisture content of whole-fish body at all treatments. Crude protein and ash contents in fish fed 80 and 100% PHWM were significantly lower (P<0.05) than that received the other diets. Total lipids content increased to reach the maximum value at 80 and 100% PHWM. These results agreed with those reported by *Khattab* (*1996*) and *El-Garhy* (*2003*); they showed that the PHWM levels in Nile tilapia diets increased the dry matter and total lipids in fish carcass, while the ash content decreased. On the other hand, *Takagi et al.* (*2000*) did not found significant changes in whole-body composition of yearling red sea bream due to the inclusion of PBM (with 6.7% fat) in fish diets. *Yang et al.* (*2006*) found no significant changes were observed in whole–body moisture and fat content resulted from the different replacement of fish meal with poultry by-product meal.

The economic evaluation showed that diets containing higher levels of PHWM were cheaper than diets containing higher levels of HFM (Table 6). As PHWM inclusion in the diets increased up to 100% level of replacement for HFM–protein, the cost of diet to produce one kg weight gain of African catfish was gradually reduced, thereby increasing profitability of producers. The reduction in feed cost at 60% PHWM was 23.42%.

The present study reveals that the inadequacy of total replacement of HFM by PHWM in practical diets for African catfish fingerlings. It could be concluded from the present study that PHWM is a promising protein source in fish diets and it may replace FM up to 60 %.

Table 1. Proximate chemical analysis of feed ingredients (on Dry matter basis) used in the experimental diets.

Items	Herring fish meal (HFM)	Poultry hatchery waste meal (PHWM)	Soybean meal (SBM)	Corn meal (CNM)
Dry matter	92.50	91.77	93.8	88.37
Crude protein	71.26	43.66	46.16	9.30
Total lipids	14.18	25.23	1.27	5.47
Ash	11.05	22.12	7.87	1.2
NFE	2.17	4.98	39.28	68.89
Crude fiber	0.70	4.01	5.42	15.14
GE/100 g diet*	536.65	505.57	434.24	388.38

*Gross energy (GE) was calculated from NRC (1993) as 5.65, 9.45, and 4.11 kcal / g for protein, lipid, and carbohydrates, respectively.

Table 2. Formulation of feed ingredients and chemical analysis (on DM-basis) of experimental diets fed to African catfish for 12 weeks.

Ingredients	PHWM levels (%)					
	0.0	20	40	60	80	100
Herring fish meal	14.04	11.21	8.40	5.61	2.80	0.0
PHWM	0.0	4.62	9.25	13.88	18.51	23.13
Soybean meal	50.40	50.40	50.40	50.40	50.40	50.40
Corn meal	18.94	18.94	18.94	18.94	18.94	18.94
Corn oil	3.53	3.53	3.53	3.53	3.53	3.53
Cod liver oil	3.01	2.24	1.48	0.71	0.0	0.0
Starch	5.40	4.78	4.12	3.30	2.54	1.0
Vitamin premix [1]	1.00	1.00	1.00	1.00	1.00	1.00
Mineral premix [2]	2.00	2.00	2.00	2.00	2.00	2.00
Limestone	1.68	1.28	0.88	0.63	0.28	0.00
Total	100	100	100	100	100	100
Chemical analysis (%)						
Dry matter	91.24	91.33	91.41	91.25	91.11	91.28
Crude protein	35.11	35.04	35.17	35.22	34.99	35.21
Total lipids	10.07	10.11	10.21	9.98	10.13	10.34
Ash	10.00	10.14	10.32	10.21	10.41	10.55
Crude fiber	5.18	5.11	5.21	5.51	5.31	4.98
NFE3	39.64	39.60	39.09	39.09	39.16	38.92
GE (kcal/100g) 4	456.45	456.28	455.85	453.96	454.37	456.61

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

[4] Gross energy (GE) was calculated from NRC (1993) as 5.65, 9.45, and 4.11 kcal/g for protein, lipid, and carbohydrates, respectively.

Table 3. Growth performance of African catfish fed different levels of poultry hatchery waste (PHWM) as a replacer for herring fish meal (HFM) on protein unit basis for 12 weeks.

Items	PHWM levels (%)					
	0.0	20	40	60	80	100
Initial weight (g)	10.23 ±0.18	10.30 ±0.12	10.17 ±0.20	10.20 ±0.15	10.30 ±0.15	10.20 ±0.21
Final weight (g)	63.430^{a} ±0.58	64.30^{a} ±0.38	63.80^{a} ±0.95	64.23^{a} ±1.07	60.40^{b} ±1.60	57.37^{c} ±1.02
Weight gain (g)	53.20^{a} ±0.44	54.00^{a} ±0.35	53.63^{a} ±0.78	54.03^{a} ±0.91	50.10^{b} ±0.79	47.17^{c} ±0.55
Weight gain %	520.07^{a} ±6.46	524.40^{a} ±6.48	527.70^{a} ±5.85	529.71^{a} ±1.49	486.43^{b} ±3.83	462.80^{c} ±4.79
Daily growth rate (g/day)	0.633^{a} ±0.01	0.643^{a} ±0.02	0.640^{a} ±0.01	0.643^{a} ±0.01	0.593^{b} ±0.02	0.563^{c} ±0.01
Survival rate (%)	96.67 ±3.33	93.33 ±3.33	96.67 ±3.33	96.67 ±3.33	93.33 ±3.33	93.33 ±3.33

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

Table 4. Feed utilization of African catfish fed different levels of poultry hatchery waste (PHWM) as a replacer for herring fish meal (HFM) on protein unit basis for 12 weeks.

Items	PHWM levels (%)					
	0.0	20	40	60	80	100
Feed intake (g feed/fish)	79..50[a] ± 0.27	80.43[a] ± 0.98	80.07[a] ± 1.07	80.67[a] ± 0.67	77.03[b] ± 0.55	74.50[c] ± 0.30
Feed conversion ratio	1.50[b] ± 0.01	1.50[b] ± 0.01	1.49[b] ± 0.01	1.49[b] ± 0.02	1.54[ab] ± .01	1.58[a] ± 0.03
Feed efficiency ratio	66..86[a] ± 0.35	66.30[a] ± 0.46	66.99[a] ± 0.68	66.98[a] ± 0.86	66.12[a] ± 0.82	64.17[b] ± 0.16
Protein efficiency ratio	2.09[a] ± 0.02	2.10[a] ± 0.01	2.09[a] ± 0.03	2.08[a] ± 0.03	2.08[a] ± 0.03	2.01[b] ± 0.02
APU	36.25[b] ± 0 .31	36.75[ab] ± 0.75	37.66[ab] ±.0.68	38.12[a] ± 0.57	36.99[ab] ± 0.39	36.78[ab] ± 0.13

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

Table 5. Proximate chemical composition (%; on dry weight basis) of whole body of African catfish fed different levels of poultry hatchery waste (PHWM) as a replacer for herring fish meal (HFM) on protein unit basis for 12 weeks.

Items	PHWM levels (%)					
	0.0	20	40	60	80	100
Moisture	73.74 ±0.47	73.72 ±0.61	73.09 ±0.69	72.75 ±0.60	72.57 ±0.46	72.06 ±0.70
Crude protein	66.81[a] ±0.56	66.37[a] ±0.35	66.09[ab] ±0.55	65.70[ab] ±0.39	65.12[ab] ±0.36	64.44[b] ±0.72
Total lipid	11.83[c] ±0.40	11.51[c] ±0.52	12.69[bc] ±0.76	13.65[bc] ±0.61	14.42[ab] ±0.82	16.14[a] ±0.97
Ash	20.83[a] ±0.61	20.61[a] ±0.64	19.82[ab] ±0.34	19.16[abc] ±0.60	18.67[bc] ±0.26	17.70[c] ±0.67

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

Table 6. Economic efficiency for production of one Kg gain of African cat fish fed different levels of poultry hatchery waste (PHWM) as a replacer for herring fish meal (HFM) on protein unit basis for 12 weeks.

Items	PHWM levels (%)					
	0.0	20	40	60	80	100
Price/kg feed P.T	3.16	2.88	2.67	2.42	2.19	2.00
Reduction in feed cost	0.0	8.86	15.51	23.42	30.70	36.71
FCR (kg feed/kg gain	1.50	1.50	1.49	1.49	1.54	1.58
Feed cost/kg gain P.T	4.74	4.32	3.98	3.61	3.37	3.16
Reduction cost/kg gain	0.0	8.86	16.03	23.84	28.90	33.33

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استخدام مسحوق مخلفات مفرخات الدواجن وإحلالها محل مسحوق السمك فى علائق أسماك القرموط الافريقى

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المعمل المركزي لبحوث الثروة السمكية-العباسة – أبو حماد – شرقية

الملخص العربى

استهدفت هذه التجربة دراسة تغذية إصبعيات القرموط الافريقى (٩ – ١١ جم) بعلائق متساوية فيما بينها فى نسب البروتين (٣٥ %) والدهون (١٠,١ %) ولكنها تختلف فى نسب إحلال مسحوق مخلفات مفرخات الدواجن محل مسحوق الأسماك حيث كانت نسب الإحلال هى صفر ، ٢٠ ، ٤٠ ، ٦٠ ، ٨٠ ، ١٠٠% على أساس وحدة البروتين. وتم تغذية الأسماك بمعدل تغذية ٥ % لمدة ٨ أسابيع ثم تم خفض معدل التغذية الى ٣ % لمدة الأربعة أسابيع الباقية والتغذية مرتين يوميا لمدة ستة أيام فى الأسبوع لمدة 12 أسبوع. أوضحت النتائج وجود زيادة نمو الأسماك بزيادة إحلال مسحوق مخلفات مفرخات الدواجن محل مسحوق السمك المستورد حتى ٦٠ % والتى حققت أعلى نمو للأسماك وذلك بالمقارنة بالأسماك التى تناولت العليقة الضابطة والخالية من مسحوق مخلفات مفرخات الدواجن. كما وجد أن أقل نمو عند مستوى إحلال ٨٠ و ١٠٠ %. كانت نسبة الأسماك الحية فى نهاية التجربة عالية ومتماثلة إحصائيا فى المعاملات المختلفة. وجد أيضا زيادة معنوية فى الغذاء المستهلك ومعدل الإستفادة من البروتين والقيمة الإنتاجية من البروتين بينما حدث نقص معنوى فى معامل التحويل الغذائى بزيادة مستوى الإحلال حتى ٦٠ % بينما حدث نقص معنوى فى الغذاء المستهلك ومعدل الإستفادة من البروتين والقيمة الإنتاجية للبروتين و زيادة قيم معامل التحويل الغذائى عند مستوى إحلال ٨٠ و ١٠٠ %. لم تتأثر نسبة الرطوبة فى جسم الاسماك بنسب الإحلال المختلفة بينما حدثت زيادة فى كمية الدهون المترسبة بزيادة نسبة الإحلال من مسحوق مخلفات مفرخات الدواجن بعكس الرماد والذى انخفضت كميته بزيادة نسبة مسحوق مخلفات مفرخات الدواجن فى علائق القرموط الافريقى. نستنتج من هذه الدراسة أنه يمكن استخدام مسحوق مخلفات مفرخات الدواجن كمصدر للبروتين منخفض التكاليف محل مسحوق الأسماك المستوردة والمرتفع الثمن حتى نسبة ٦٠ % دون التأثير على إنتاج أسماك القرموط الافريقى . أظهر التقييم الاقتصادي للعلائق أن إحلال مسحوق مخلفات مفرخات الدواجن محل مسحوق السمك المستورد بنسبة ١٠٠% بالعليقة كان الأرخص من حيث السعر بين المعاملات ومن حيث تكلفة وحدة الزيادة فى الوزن المكتسب بالأسماك و كانت نسبة انخفاض تكلفة العلف عند نسبة احلال ٦٠% من مسحوق مخلفات مفرخات الدواجن ٢٣,٤٢% .