Abbassa International Journal for Aquaculture

Volume (4) Number (1), 2011

ISSN 1687-7638

Egyptian Society for Water, Aquaculture and Environment

Abbassa, Abou Hammad, Sharkia, EGYPT

ISSN 1687-7638

ABBASSA INTERNATIONAL JOURNAL FOR AQUACULTURE

Published by

Egyptian society for water, aquaculture and environment,
Central Laboratory for Aquaculture Research (CLAR),
Agricultural Research Center (ARC), Giza, Egypt

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GENERAL INFORMATION

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Abbassa Int. J. Aqua., V0l.4 No.(1) 2011. *27-42*

THE PARTIAL AND TOTAL REPLACEMENT OF FISH MEAL BY POULTRY BY-PRODUCT MEAL IN DIETS FOR AFRICAN CATFISH (*CLARIAS GARIEPINUS*)

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Received 2/ 5/ 2011 *Accepted 29/ 5/ 2011*

Abstract

This study was conducted to evaluate the use of poultry by-product meal (PBM) in practical diets for African catfish, *Clarias gariepinus*. Six diets were formulated in which PBM replaced 0.0 (control), 20, 40, 60, 80, or 100% of the protein supplied by herring fish meal (HFM). All diets are isonitrogenous (35.0 % crude protein) and isolipidic (8.0% crude lipid). In this study, each treatment was represented by three 100-L aquaria and each aquarium was stocked by 10 fish (6.1±0.1 g). The experimental diets were provided at a rate of 4 % of fish live body weight twice a day, 6 days a week for 12 weeks .The obtained Results demonstrated that PBM had good potential as a complete substitute of the protein supplied by HFM for African catfish. No significant changes were observed in growth performance, feed conversion, and protein utilization compared to fish fed the control diet (100% HFM–based diet). The partial or complete replacement of PBM protein for HFM–protein in the diets did not affect fish proximate composition (dry mater, crude protein, fat, or ash) compared to the control group. Moreover, the economic evaluation showed that a diet containing 100% PBM reduced the feed cost by 28.52%. In conclusion**,** this study clearly indicates that PBM can serve as a complete replacement for fish meal in cat fish diets.

Keywords: Poultry by-product meal, African catfish, growth performance, feed utilization, body composition, economic evaluation.

INTRODUCTION

In fish farming, fish feed represents 50–60% of the production costs and protein itself represents about 50% of feed costs in intensive culture. Fish meal is traditionally the major animal protein supplement in fish diets, but it is an expensive ingredient. In addition, the dwindling fish meal supply can no longer meet the expanding fish feed industry as a result of aquaculture development (Dong *et al.*, 1993). The shortage in world production of fish meal, coupled with 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, the major challenge facing fish nutritionists is the development of commercial, cost effective fish feeds using locally available, cheap and unconventional resources (El-Sayed, 2004).

Poultry by-product processing in formal and informal abattoirs in Egypt and worldwide produces tremendous quantities of by–products such as meat, offal, blood, bone, etc. Poultry by-product meal (PBM) contains > 65 % crude protein on dry matter basis and is less expensive than fish meal Abdelghany *et al.* (2005). That makes PBM as an acceptable source of animal protein in animals and fish diets. Also, its use could reduce its discharge into the environment. Therefore, many studies are required to evaluate its use as partial or complete substitute to fish meal in practical fish diets.

African catfish, Clarias gariepinus, is considered as a candidate of freshwater fish for aquaculture because of its tolerance to a wide range of temperature, low oxygen, high salinity levels, and high fecundity and growth rate (Hecht *et al*., 1996 and Ote´me´ *et al.* 1996). Moreover, this fish has high nutritive value, good taste, and fewer bones. Therefore, the present study was carried out to evaluate the partial and total replacement of PBM as a protein source for HFM protein in practical diets for African catfish.

MATERIALS AND METHODS

Diet preparation and feeding regimen

In the present study, PBM was brought from 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 chemical analysis of feed ingredients and EAA profile of HFM and PBM are present in Table (1) and Table (2), respectively. Six diets were formulated to be isonitrogenous (35.0 % crude protein) and isolipidic (8.0% crude fat; Table 2). Diet – 1 (control) contained herring fish meal (HFM) as a sole source of animal protein, whereas diet 6 contained PBM as a sole source of animal protein .In Diets 2 - 5 contained mixtures of HFM and PBM as sources of animal protein supplements with the proportions of each adjusted so that each of the two ingredients provided similar graded levels of animal protein in the diet. Graded levels of protein replacements were 20%, 40%, 60 %, 80% or 100% respectively (Table 3). All diets contained a constant level of plant protein from soybean meal (SBM), corn meal (CM) to satisfy the protein requirements of African catfish. The ingredients of each diet 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^{o}C for 24 hours and stored in plastic bags in refrigerator (- 2^{o}C) until use.

Fish culture technique

This study was carried out at the Central Laboratory for Aquaculture Research, Abbassa, Abou-Hammad, Sharkia, Egypt. African catfish, *C. gariepinus* fingerlings were obtained from Abbassa fish hatchery and acclimated to laboratory condition for two weeks and they were fed a commercial diet containing 30 % crude protein. Twenty fish were frozen at –20^{o}C for proximate analysis at initial. Acclimated fish (5 – 7 g) were distributed randomly at a rate of 10 fish/100-L glass aquarium .Fish were fed one of the tested diets at 4 % of body weight for the first eight weeks and 3 % for the rest four weeks. Each aquarium was supplied with well–aerated tap water. Each aquarium was also supplied with compressed air produced by a small compressor. The photoperiod was set on a 12 hour light – dark cycle using fluorescent tubes as the light source. Half of aquarium water was siphoned every day for removing the excretory products and refilled with well-aerated tap water.

Proximate analysis of diets and fish

The tested diets and whole-fish body from each treatment at the beginning and at the end of the experiment were analyzed according to the standard methods of AOAC (1990) for moisture, crude protein, total lipids and ash. Moisture content was estimated by drying the samples in an a drying oven(GCA, model 18EM, precision scientific group, Chicago, Illinois, USA). at 85^{o}C to constant weight and calculating weight loss.Nitrogen content was determined 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 as ether extract in the multi-unit extraction Soxhlet apparatus (Lab-Line Instruments, Inc., Melrose Park, Illinois, USA) for 16 hours.Ash was determined by combusting samples in a muffle furnace (Thermolyne Corporation, Dubuque, Iowa, USA) at 550^{o}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. Water temperature and dissolved oxygen were measured with an oxygen meter (YSI model 58; Yellow Spring Instrument Co., Yellow Spring, Ohio, USA). The pH value was measured using a pH–meter (Digital Mini-pH Meter, model 55, Fisher Scientific, USA**).** total ammonia was measured using HACH kits (HACH Co., Loveland. Colorado. USA).

Growth performance

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

Weight gain = W2−W1;

Specific growth rate (SGR) = 100 (lnW2 − lnW1) / T; where W1 and W2 are the initial and final fish weight, respectively and T is the number of days (feeding period),

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

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

Apparent protein utilization (APU, %) = 100 × (protein gain/ protein intake),

Energy utilization (EU, %) = 100 (energy gain / energy intake).

Economical evaluation

The cost of feed required to produce a unit of fish biomass was estimated using a simple economic analysis based on the local market price of all ingredients at the time of the study. These prices (in LE/kg) were as follows: herring fish meal, 10; soybean meal,3.0; corn meal, 2.0; starch 3.0; fish oil, 9.0; corn oil, 6.0; vitamin premix, 9.0; mineral mixture 3.0 and PBM, 2.5.

Statistical analysis

The obtained data of fish growth, feed utilization, survival rate, and proximate chemical composition were subjected to one-way ANOVA. 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 28 – 29 °C, dissolved oxygen range was 5.3–6.3 mg/L, pH range was 7.8–8.1 and total ammonia range was 0.6–0.9 mg/L. All values were within the tolerance limits for warm water fish species (Boyd, 1984).

Initial body weight did not differ significantly (Table 4). All African catfish became accustomed to the experimental diets and were observed to feed actively throughout the duration of this study. At the end of the study, the growth performance (final body weight, weight gain, growth rate, and specific growth rate) of African catfish fed diets containing various levels of PBM were similar to those of fish fed a control diet.Fish Survival was 100 % in all treatments. These observations suggested that the PBM diets contained all the necessary growth factors required by African catfish. The isoniterogenous, isolipidic, and isocaloric nature of the experimental diets explained why there was no disparity in growth response of fish and efficiency of feed utilization. The 100% replacement of HFM by PBM in the present study coincide with the results obtained by Diab and Ahmad (2008),who reported that Nile tilapia fed diets, in which PBM replaced up to 100% of the protein supplied by HFM, had similar growth performance .On the other hand, El-Marakby *et al*. (2010) found that African catfish was not affected by replacement of fish meal by poultry hatchery waste meal up to 80 %, after which fish growth was reduced. Contrarily, 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% replacement, while the complete replacement of fish meal protein by PBM reduced fish growth. Also, the present study did not coincide with the results obtained by previous studies for red tilapia, Oreochromis niloticus x O. mossambicus (Abdelghany, 2003), gibel carp, Carassius auratus gibelio (Yang *et al*.

2006), and Nile tilapia (Ahmad, 2008). These results do not coincide with the results of the present study with African catfish possibly due to one or more of the following reasons:

In the present study, 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 (Table 5).The partial and totally replacement of PBM protein in the diets for African catfish did not affect FER and PER when compared with the fish fed HFM. These results coincide with the results of Diab and Ahmad (2008) who found that PBM can replace HFM in Nile tilapia diets at 100% level without significant retardation in feed efficiency. Also, these results agreed with the results of Abdelghany *et al.* (2005) who reported that Nile tilapia fed diets in which PBM replaced up to 100% of the protein supplied by HFM had similar FCR, FER, PER and APU to that fed the HFM–based diet. On the other hand, Yang *et al.* (2006) found that feed utilization estimated for gible carp diet containing different PBM levels were higher than those in fish fed the control diet.

1-Fish species have different attractiveness, palatability and/or acceptability for certain ingredients in the diets (Fowler, 1991). In the present study, there were no significant differences ($P > 0.05$) in amount of feed consumption by fish among treatments (Table-5).

2-Different sources of PBM may have varied nutrient compositions, processing methods, different amounts of constituents (bone, offal, meat, blood…etc.), and digestibility. Dong *et al.* (1993) found differences in proximate composition and protein digestibility among samples of PBM from different manufacturers that varied from reported tabular values.

3-The prepared diets could meet the nutrient requirements of a species (i.e. African catfish) but not the others species.

The proximate chemical composition (dry matter, crude protein, total lipid and, ash) of whole-fish body were not significantly affected by PBM inclusion in fish diets (Table 6). These results indicated that the partial or complete replacement of HFM by PBM – protein did not alter the nutritional value of the fish produced. These results also suggested that African catfish efficiently ingested, digested, assimilated and utilized protein from PBM similar to HFM. Similar resalts were obtaind by Diab and Ahmad (2008) who reported that the partial or complete replacement of HFM by PBM did not affected body composition (dry matter, protein, fat and ash) of Nile tilapia. Yang *et al.* (2006) found no significant changes in whole–body moisture and fat content resulted from the different replacement levels of fish meal with poultry by-product meal. 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.

The economic evaluation showed that diets containing high levels of PBM were cheaper than diets containing higher levels of HFM (Table ٧). The cost of diet to produce one kg fish gain was gradually reduced, there by increasing the profitability of producers. The reduction in feed cost to produce one kg fish gain using the diet containing 100% PBM compared with the control diet was 28.52%. In this ranged Abdelghany *et al*. (2005) found that the highest reduction in feed costwas obtained by diet containing 100 % PBM for Nile tilapia.

Table 1. Proximate chemical analysis of feed ingredients (on DM – basis) of dietary ingredients.

Items	Herring fish meal (HFM)	Poultry by-product meal (PBM)	Soybean meal (SBM)	Corn meal CM
Dry matter	92.50	85.52	93.8	89.17
Crude protein	72.02	59.75	44.11	9.30
Total lipids	13.98	14.19	1.27	3.57
Ash	11.05	10.98	7.87	1.20
NFE	2.25	12.78	40.33	82.79
Crude fiber	0.70	2.30	6.42	3.14
GE / 100 g diet*	548.27	524.22	426.98	406.56

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

Table 2 . Essential amino acids (EAA) profile (g / 100 g protein) for HFM and PBM as % of dietary protein.

A.A. Profile	HFM	PBM
Arginine	6.41	6.42
Histidine	2.30	1.72
Lysine	7.45	4.94
Isoleucine	4.36	4.04
Leucine	7.20	6.82
Methionine	2.90	1.80
Cystine	1.03	1.56
Phenylalanine	3.75	3.14
Tyrosine	3.05	1.61
Threonine	4.04	3.31
Tryptophan	1.06	0.80
Valine	5.98	4.87

Table 3. Formulation of feed ingredients and chemical analysis (on DM-basis) of experimental diets fed to African catfish for 12 weeks.

Ingredients	PBM levels (%)					
	0.0	20	40	60	80	100
HFM	15.51	12.41	9.30	6.21	3.10	0.0
PBM	0.0	3.73	7.48	11.21	14.96	18.69
Soybean meal	49.22	49.22	49.22	49.22	49.22	49.22
Corn meal	22.23	22.23	22.23	22.23	22.23	22.23
Corn oil	2.72	2.72	2.72	2.72	2.72	2.72
Cod liver oil	2.14	2.14	2.14	2.14	2.14	2.14
Starch	5.18	4.55	3.91	3.27	2.63	2.00
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
Total	100	100	100	100	100	100
Chemical analyses:						
Dry matter	91.04	90.96	91.04	90.96	91.15	91.18
Crude protein	35.03	34.96	35.20	35.05	34.94	35.15
Total lipids	8.09	8.26	8.02	7.87	8.19	7.76
Ash	9.10	9.07	9.10	8.69	8.88	9.11
Crude fiber	6.09	5.96	6.13	5.95	6.14	6.08
NFE[3]	41.69	41.75	41.55	42.44	41.85	41.90
GE (kcal/100g)[4]	445.72	447.17	445.44	446.83	446.81	444.14

[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; α-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 according to NRC (1993) as 5.65, 9.45, and 4.11 kcal/g of protein, lipid, and carbohydrates, respectively.

Table 4. Growth performance of African catfish fed six formulated diets containing poultry by product meal (PBM) at graded replacement levels for herring fish meal (HFM) on protein unit basis over a 12 weeks feeding trial.

Items	PBM levels (%)					
	0.0	20	40	60	80	100
Initial weight (g)	6.1 ±0.1	6.2 ±0.1	6.2 ±0.1	6.1 ±0.1	6.1 ±0.1	6.1 ±0.1
Final weight (g)	52.8 ±1.4	51.5 ±1.2	52.7 ±1.2	53.2 ±1.6	52.6 ±1.1	51.8 ±1.5
Weight gain (g)	46.7 ±1.4	45.3 ±1.2	46.5 ±1.2	47.1 ±1.6	46.5 ±1.1	45.5 ±1.5
Growth rate (g/day)	0.56 ±0.0	0.5 ±0.0	0.55 ±0.0	0.56 ±0.0	0.55 ±0.0	0.5 ±0.0
SGR (% g/day)	2.56 ±0.03	2.5 ±0.02	2.55 ±0.03	2.58 ±0.02	2.56 ±0.05	2.5 ±0.04
Survival rate (%)	100	100	100	100	100	100

Table 5. Feed utilization efficiency of African catfish fed six diets containing poultry by product meal (PBM) at graded replacement levels for herring fish meal (HFM) on protein unit basis over a 12 weeks feeding trial.

Items	PBM levels (%)					
	0.0	20	40	60	80	100
Feed intake (g feed/fish)	65.9 ±0.7	64.5 ±0.7	64.6 ±0.7	65.7 ±0.7	64.5 ±0.3	64.2 ±0.4
Feed conversion ratio	1.4 ±0.0	1.4 ±0.0	1.4 ±0.1	1.4 ±0.0	1.4 ±0.0	1.4 ±0.1
Protein efficiency ratio	2.2 ±0.1	2.1 ±0.1	2.3 ±0.1	2.2 ±0.1	2.2 ±0.1	2.2 ±0.1
APU (%)	44.5 ±2.7	38.9 ±3.2	42.1 ±2.3	42.2 ±2.2	39.8 ±2.4	40.4 ±3.6
EU (%)	25.7 ±1.6	22.3 ±1.7	24.9 ±1.4	24.2 ±1.4	23.3 ±1.5	22.9 ±2.1

Table 6. Proximate composition (%on dry weight basis) of whole body of African catfish fed six diets containing poultry by-product meal (PBM) at graded replacement levels for herring fish meal (HFM) on protein unit basis over a 12weeks feeding trial.

Items	**PBM levels (%)**					
	0.0	**20**	**40**	**60**	**80**	**100**
Dry matter	27.7 ±1.1	27.1 ±0.8	27.2 ±1.0	27.1 ±1.0	27.8 ±1.0	27.0 ±0.7
Crude protein	69.7 ±0.3	69.7 ±0.6	68.1 ±0.6	69.1 ±0.6	68.7 0.4±	69.5 ±1.1
Ether extract	17.1 ±0.1	17.4 ±0.1	18.4 ±0.6	18.٥ ±0.2	18.2 ±0.1	18.0 ±1.0
Ash	13.2 ±0.2	13.9 ±0.46	13.5 ±0.6	13.5 ±0.2	14.2 ±0.2	13.6 ±0.5

Table 7. Economic efficiency for production of one Kg gain of African cat fish fed six diets containing poultry by-product meal (PBM) at graded replacement levels for herring fish meal (HFM) on protein unit basis over a 12 weeks feeding trial.

Items	**PBM levels (%)**					
	Control 0.0	**20 %**	**40 %**	**60 %**	**80 %**	**100 %**
Price/ kg feed, L.E	4.13	3.90	3.66	3.23	3.17	2.95
Reduction in feed cost,%	0.0	5.57	11.38	21.79	23.24	28.57
Feed cost / kg gain L.E	5.82	5.54	5.09	4.52	4.41	4.16
Reduction in feed cost / kg gain,%	0.0	4.81	12.54	22.36	24.23	28.52

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الإحلال الكلى والجزئي لمسحوق الأسماك بمسحوق مخلفات مجازر الدواجن في علائق أسماك القرموط الإفريقي

مدحت السعيد سيدين ، محمد حسن أحمد

قسم بحوث تغذية الأسماك – المعمل المركزى لبحوث الثروة السمكية–

مركز البحوث الزراعية – وزارة الزراعة – مصر

الملخص العربى

أجريت هذه الدراسة بهدف تقييم إمكانية إستبدال مسحوق الأسماك بمسحوق مخلفات مجازر الدواجن في علائق أسماك القرموط الأفريقي ودراسة مدى تأثير ذلك على مقاييس النمو المختلفة وكفاءة الاستفادة من الغذاء والتركيب الكيماوى للجسم بالإضافة إلى جدوى هذه العلائق اقتصاديا. بعد أقلمة الأسماك لمدة أسبوعين،تم توزيعها عشوائيا فى ١٨ حوضاً زجاجاً سعة الواحد منها ١٠٠ لتر بمعدل ١٠ سمكات لكل حو بمتوسط وزن(٦,١جم/سمكة). قسمت الأحواض إلى ٦ معاملات بمعدل ثلاث أحواض لكل معاملة. تم اخذ ١٠ سمكات لتحليلها والتعرف على تركيب الجسم عند البداية. غذيت الأسماك على العلائق التجريبية حيث كانت جميعها تحتوى على ٣٥,٠ % بروتين و٨,٠% دهن، حيث تغذت المعاملة الأولى (كنترول) على عليقة أساسية تحتوى على مسحوق أسماك، أما المعاملات ٢ ، ٣ ، ٤ ، ٥ ، ٦ تم فيها إحلال مسحوق مخلفات مجازر الدواجن محل مسحوق الأسماك بنسب ٢٠% ،٤٠% ،٦٠% ،٨٠% ،١٠٠% على التوالي على أساس نسبة البروتين. تغذت الأسماك على العلف المقدم بمعدل ٤% من وزن الجسم حيث قدم العلف على مرتين يوميا لمدة ٦ أيام في الأسبوعاً لمدة ١٢ اسبوع. تم وزن الاسماك فى كل حوض كل اسبوعين لمتابعة نمو الأسماك وتعديل كمية الغذاء المقدم حسب التغير في نمو الأسماك. فى نهاية التجربة تم جمع الأسماك وعدها ووزنها كما تم اخذ عينة عشوائية من كل معاملة لتحليل التركيب الكيماوى لجسم الأسماك، كما تم تحليل البيانات إحصائيا. أشارت النتائج النهائية إلى عدم وجود اختلافات معنوية في مقاييس النمو والكفاءة الغذائية وتركيب الجسم بين المعاملات المختلفة والكنترول. كما أشارت هذه الدراسة إلى إمكانية الإحلال الكلى لمسحوق الأسماك بمسحوق مخلفات مجازر الدواجن حيث يؤدى ذلك لخفض تكاليف العليقة بنسبة ٢٨,٥٢% مع إعطاء نفس الكفاءة الإنتاجية. من خلال هذه الدراسة يمكن التوصية باستخدام مسحوق مخلفات مجازر الدواجن محل مسحوق الاسماك بنسبة ١٠٠% فى علائق أسماك القرموط الافريقى.